The Effects of Tax Competition on Consumption Taxation, Corporate Investment, and Property Taxes

Dissertation

zur Erlangung des Doktorgrades

der Wirtschafts- und Sozialwissenschaftlichen Fakultät

der Eberhard Karls Universität Tübingen

vorgelegt von

Georg Ulrich Thunecke

aus Bonn

Tübingen

2022

Tag der mündlichen Prüfung:	24.10.2022
Dekan:	Prof. Dr. phil. Ansgar Thiel
1. Gutachter:	Prof. Dr. oec. publ. Georg Wamser
2. Gutachter:	Prof. Dr. rer. pol. Frank Stähler

Acknowledgements

First and foremost, I want to thank my supervisors and co-authors Professor Georg Wamser and Professor Frank Stähler for their support, guidance, enthusiasm for economics, and encouragement. The productive discussions and exchange of ideas have provided a stimulating research environment that helped me grow both personally and professionally. I am very grateful to Georg Wamser for sparking my interest in Public Economics and International Taxation early in my studies and his perpetual support throughout my time in Tübingen. Without his vision and support, I would never have pursued an academic career and for that I am deeply indebted to him. I am also grateful to Frank Stähler for igniting my curiosity in International Economics and his guidance in challenging times. Words cannot express the importance of our long and insightful discussions during the long and difficult months of the Covid-19 pandemic, which improved many aspects of this dissertation and encouraged me to pursue an academic career. I will forever be thankful for your mentorship and inspiration!

The time at the the School of Business and Economics at the University of Tübingen would not have been the same without my wonderful colleagues. I want to thank my co-authors Sean Mc Auliffe, Georg Wamser, Valeria Merlo, Andreas Schanbacher, Georg Schneider, Frank Stähler, and Elias Steinmüller for their hard work and insightful feedback on our joint work. I am grateful to David Kurfess, Ferdinand Springer, Kristina Strohmaier, Peter Eppinger, Camila Cisneros Acevedo, Denise Konrad, David Gremminger, Stefanie Ehmann, Jonas Adolph, Alexander Reining, and Kristina Uhl for creating a cooperative and engaging research environment. I am especially grateful to Jaqueline Hansen for our countless discussions, perpetual exchange of ideas, and the unrelenting support throughout this journey. You are an invaluable colleague, sparring partner, and friend. Andrea Tulli's and Giacomo Brusco's constructive criticism and insistent advice have motivated me to improve and grow. I am also indebted to Professor Wilhelm Kohler for his patience, support, and for deepening my understanding of Microeconomic Theory. I am grateful to Ronald Davies for his support, feedback, and giving me the opportunity to spend five wonderful months at the University College Dublin. Andreas Schanbacher, Georg Schneider, Nils Scherrer, and Tobias Hahn have provided outstanding research assistance. This dissertation has greatly benefited from the interaction with professors, guest researchers, and fellow doctoral students as well as from internal seminars in Tübingen. Moreover, participants at conferences and workshops in München, Mannheim, Oxford, Mainz, Linz, and Dublin have helped improve my work through their invaluable comments and suggestions. I am especially indebted to the participants of the BRS for frequently providing an open, productive, and pleasant working atmosphere.

This dissertation would not have been possible without the continuous support, patience, and appreciation of friends and mentors. Your presence, especially during the Covid-19 pandemic, has kept me going and pursuing my goals. I thank my friends for enduring my monologues and bad moods as well as forgiving me my sporadic disorganization. Hannes Döring, your calm and rational nature have guided me through difficult times and have often given me the clarity to overcome my challenges. I am also grateful to Marian Rümmele for discussing my econometric problems with me at length, while also accompanying me through the difficult Covid months. I have been blessed with outstanding mentors in my life that have always pushed me out of my comfort-zone and helped me grow. Throughout my first steps in academia, Elias Steinmüller has been a great aid through his feedback, supervision, and humor. During my stay at the University College Dublin, Nora Strecker has become an invaluable friend and mentor. Thank your for your persistent professional and personal support in overcoming my hardships and improving my work. Barbara Skalitza has not only been a mentor, but also a friend, and her perpetual insistence in excellence and coherence as well as encouragement have set me up to accomplish my goals.

My family has been a source of unwavering support and love that has given me the strength to reach my goals and made me the person I am today. My wonderful parents Anneliese and Arno have always believed in me and in doing so provided the means and guidance to reach my goals. My siblings Meike and Christoph have always been a source of joy and a safe harbor during troubling times. I am eternally grateful to them for believing in me and accompanying me on my journey. Finally, I want to thank my wonderful partner Anne for her unconditional love and unshakable support. Her patience, lighthearted nature, and frankness have gotten me through the highs and lows of this endeavor and for that I cannot thank her enough.

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Chapter 1

Introduction

One of the fundamental theorems of Public Economics is the inverse elasticity rule proposed by Ramsey (1927). It states that taxes should be inversely related to the demand elasticity and, thus, highest for inelastic or immobile tax bases. Nevertheless, governments around the globe raise significant revenues from arguably mobile tax bases like personal income, capital gains, and corporate profits. On average, OECD countries raised 60% of their tax revenue from these bases between 2000 and 2018.[1] However, throughout the past decades, tax systems around the world have undergone substantial changes due to globalization and digitization which have created far-reaching economic, social, and political challenges and opportunities. One of the most prominent challenges for governments is raising tax revenue from increasingly mobile capital and corporate profits. This inability to raise sufficient revenues from mobile bases is particularly relevant as countries turned to public spending to alleviate the economic consequences of several crises throughout the past decades, including the 2008 financial crisis, the European debt crisis in 2010, as well as the ongoing Covid-19 pandemic.

In recent years, governments have pushed for multilateral action to curb international tax competition and tax avoidance by multinational enterprises, resulting in the planned introduction of a global minimum corporate tax under the OECD BEPS initiative. However, even without multilateral action, governments have been able to consolidate their finances by increasingly raising revenue from less elastic or immobile tax bases. On the one hand, governments have shifted the

[1] Calculation is based on the World Revenue Longitudinal Database of the IMF.

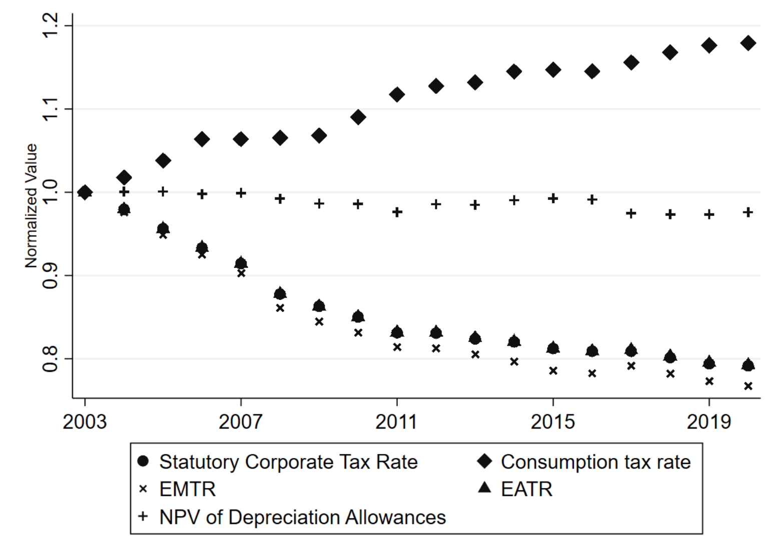
personal income tax burden to relatively immobile workers in the middle class while high incomes have been subject to lower taxes (see Egger et al., 2019). On the other hand, they substantially increased consumption taxation. As consumption takes place where value is created, the latter development also relates to the debate on destination-based taxation to curb tax avoidance (see e.g., Auerbach et al., 2017). In line with the Ramsey Rule, this development might be desirable from an efficiency standpoint as tax revenue is raised more efficiently. From an equity perspective, however, the general shift to the taxation of immobile bases might be problematic and further exacerbate inequalities within and across countries caused by globalization.

This dissertation investigates questions of the taxation of mobile versus immobile tax bases with a particular focus on (effective) corporate, consumption, and property tax rates. It consists of three self-contained chapters dealing with the effects of international tax competition on consumption taxation, the heterogeneous investment effects of effective corporate tax rates, and the spatial dimension of tax policy spillovers in German municipalities. A substantial part of this dissertation builds on a self-collected corporate and consumption tax regime database as part of the RSIT International Tax Institutions Database. The corporate tax regime database includes information on the statutory corporate tax rate (STR) as well as depreciation allowances and methods for six different asset categories. The panel is unbalanced and covers 221 countries and jurisdictions from 2001 to 2020.[2] From this information we calculate forward-looking effective marginal (EMTRs) and average corporate tax rates (EATRs) following Devereux and Griffith (1998) and Devereux and Griffith (2003).[3] Both the EMTR and EATR incorporate the statutory tax rate and the generosity of the depreciation regime to measure the incentives for a marginal and discrete investment project respectively. The consumption tax database contains information on the standard and reduced consumption tax rates as well as the number of different tax rates and the type of consumption tax that is applied for an unbalanced panel of 204 countries and jurisdictions from 2003 to 2020. For a detailed documentation

[2]These asset categories are buildings, machinery, office equipment, computers, vehicles and intangible fixed assets.

[3]For a detailed description of this calculation see Steinmüller et al. (2019) and Chapter 3.

Figure 1.0.1: *Development of Normalized Average Tax Measures 2003 to 2020*



on the assumptions taken for the construction of the corporate tax regime dataset see Appendix A and for the consumption tax database see Appendix B. This data is an essential part of this dissertation and constitutes the basis for Chapter 2 and 3.

In the following, I will briefly describe some key trends in corporate and consumption taxation over the past two decades. Looking at Figure 1.0.1, we observe a strong reduction in the average statutory corporate tax rate. While the net-present value of depreciation allowances and, thus, the statutory corporate tax base has been largely unchanged, the STR fell by approximately 20% or 5.85 percentage points compared to its 2003 level. With the corporate tax base unchanged, the average EATR has developed almost identically as the statutory corporate tax rate while the EMTR has decreased even more compared to the 2003 level.[4] Looking at Figure 1.0.2, we observe that the majority of countries around the world has reduced their statutory corporate tax rate. This pattern is especially pronounced in Europe, North America, and Northern Africa, where the majority of countries has experienced statutory corporate tax rate decreases of more than 5 percentage points. Only very few countries significantly raised their corporate tax rates throughout the past 20 years. Exceptions include Chile,

[4]Remember that Figure 1.0.1 depicts the development of the different tax measures and that the levels of the EMTR and EATR are lower than the STR by definition.

El Salvador, Equatorial Guinea, Latvia, and Honduras. Thus, the developments depicted in Figure 1.0.1 are not driven by a few significant reductions in the STR of some countries, but appear to be a global trend.

Turning to the changes in consumption tax rates, Figure 1.0.1 illustrates a pronounced increase in consumption tax rates. They rose by roughly 20% compared to their 2003 level. Given these developments, governments around the globe have chosen to decrease the tax burden on mobile corporate profits, while broadly increasing the burden on arguably immobile consumption spending. Figure 1.0.3 indicates that the picture is less clear than for corporate taxation. While several countries in Europe like Germany, Portugal, Spain, and Greece exhibit substantial increases in their consumption tax rates, several countries have also decreased their rates including Austria, Belgium, the Czech Republic, Denmark, and Sweden. Countries in Asia, on the contrary, have largely decreased consumption taxes with the exception of India and Japan. Africa and Latin America exhibit mixed consumption tax patterns with substantial increases and decreases on either continent. Generally, the absolute percentage point changes in the consumption tax are substantially smaller than the corporate tax rate changes. However, consumption tax rate levels are also smaller while the consumption tax base is significantly broader, allowing for equivalent revenue generation even with smaller rate changes. While this development is potentially efficiency enhancing, it raises concerns about equity as low income households are often disproportionately more affected by taxes on immobile tax bases. Additionally, new evidence suggests that value-added taxation potentially has substantial effects on trade and, thus, welfare (see Schneider et al., 2022). These findings contradict the commonly held opinion that trade is unaffected by value-added taxation implying that relying more heavily on the taxation of consumption might also be undesirable from a welfare perspective. The rest of this dissertation further explores the taxation of mobile and immobile tax bases on different levels of analysis. All in all, the results of this dissertation imply that the mobility of a tax base is important for tax policy setting. Nevertheless, political factors and institutional constraints also play an important role.

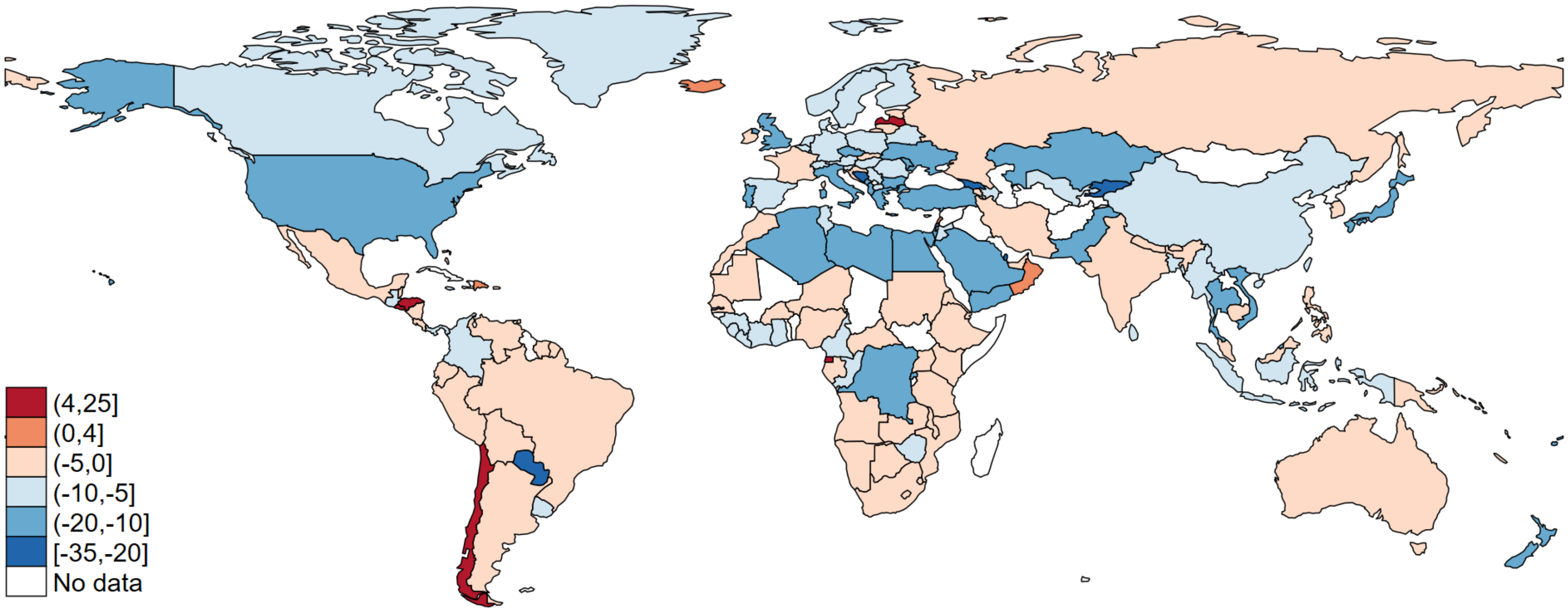
Chapter 2 investigates whether the developments presented in Figure 1.0.1

are interdependent, i.e., whether falling corporate tax rates due to increased tax competition result in rising consumption tax rates. More specifically, the research question Chapter 2 addresses is: Are governments shifting the burden of corporate tax competition to consumption? The chapter answers this question in three steps by first looking at the relationship between corporate and consumption tax rates. To investigate this relationship I estimate the tax policy response function by regressing the corporate on the consumption tax rate. These tax rates are generally interdependent and often simultaneously determined. Consequently, naively estimating this relationship using an Ordinary Least Squares (OLS) estimator would yield biased results. In order to resolve this endogeneity problem, I employ an instrumental variable (IV) approach exploiting the fact that governments are competing in corporate tax rates. The slope of the tax policy reaction function is equal to -0.35 implying that, on average, a one percentage point decrease in the corporate tax rate results in a 0.35 percentage point increase in the consumption tax rate. In a second step, I look at the relationship between the tax rate and revenue estimating a Laffer-Curve relationship. This implies regressing tax revenue on the tax rate and the second order polynomial of the tax rate to identify both mechanical and behavioral revenue responses to tax rate changes. I find that the rate-revenue relationship of both corporate and consumption taxes follows an inverted U-shape. In a final step, I utilize these results to evaluate whether governments have been able to fully compensate revenue losses from corporate tax rate decreases through consumption tax increases. I combine the results from the first two steps and find that governments, on average, are able to fully compensate for corporate tax revenue losses by substituting to consumption taxation. Thus, governments are able to deal with the revenue repercussions of corporate tax competition by shifting the tax burden from mobile corporate profits to immobile consumption spending. Consequently, the debate on corporate tax competition overemphasizes economic efficiency and understates equity concerns.

Chapter 3 of this dissertation is joint work with Sean Mc Auliffe and Georg Wamser. It explores the substantial heterogeneity in investment responses to corporate tax changes across different industries, firm-group characteristics, and country-specific circumstances. The investment response is measured by the semi-tax-elasticity of investment which indicates the percent change in investment following a one percentage point change in the (effective) corporate tax rate. Chapter 3 answers two research questions: Do firms exhibit heterogeneous semi-tax-elasticities of investment? And if so, which firm characteristics drive this heterogeneity? In order to measure heterogeneity across firms, we propose a new approach to calculate forward-looking effective corporate tax rates (FLETRs) that vary at the country-year-industry-level. These FLETRs incorporate industry-country-specific asset compositions as well as financing capital structures and capture the tax incentives a firm faces in a given country and industry more adequately than the previous literature. Building on the *EUKLEMS & INTANProd* database as well as Bureau van Dijk's *Orbis* database, we are able to either directly retrieve or impute asset and financing structures and, thus, FLETRs for 221 countries, 19 industries, and 20 years. Using these FLETRs, we estimate semi-tax-elasticities of firms' tangible fixed assets based on 24 million firm-entity observations from the *Orbis* database. In a first step, we find an average aggregate semi-tax-elasticity of -0.45 w.r.t. FLETR changes across all countries, industries, and years. Thus, a one percentage point increase in the FLETR results, on average, in a 0.45 percent reduction of a firms' investment in tangible fixed assets. This result is robust to alternative estimation specifications. In a second step, we focus on different subgroups of firms to identify the size and determinants of heterogeneous semi-tax-elasticities among these subgroups. We find substantially heterogeneity in semi-tax-elasticities based on industry, firm-group, and country-specific characteristics. Firms operating in the manufacturing and transportation sector exhibit substantially larger semi-tax-elasticities than firms in the wholesale business which show only small and statistically insignificant responses. Firms reporting positive profits and with low profit-shifting opportunities are characterized by large and statistically significant semi-tax-elasticities. Additionally, country-specific characteristics like high GDP Growth, less developed capital markets and/or low GDP per capita appear to be important determinants of the tax sensitivity of investments. Firms located in these countries exhibit large and statistically significant semi-tax-elasticities.

Chapter 4 of this dissertation is joint work with Valeria Merlo, Andreas Schanbacher, and Georg Wamser. In this chapter, we investigate the size, type, and scope of tax policy spillovers among German municipalities. More specifically, the chapter answers two research questions. First, are local governments engaging in tax or yardstick competition? Second, how are tax policy responses distributed across space? To answer these questions, we exploit two quasi-exogenous policy interventions in the states of North-Rhine Westphalia (NRW) and Hesse. Following the financial crisis in 2008, public debt of many German municipalities reached unsustainable levels. As a result, several states introduced debt reduction programs (DRPs) with the goal to consolidate municipal budgets through expenditure cuts and tax increases. Hesse and NRW both introduced DRPs which quasi-exogenously assigned municipalities to be eligible/forced to participate. In order to investigate if and how German municipalities compete in local tax instruments, we exploit this quasi-exogenous assignment of municipalities into the DRPs in Hesse and NRW. The analysis proceeds in three steps. First, we quantify the local business and property tax rate increases of Hessian and NRW municipalities subject to the DRPs. Second, we estimate the tax policy spillover to municipalities located in Hesse or NRW which are not participating in the DRPs. Lastly, we analyze the spatial dimension of these spillovers. In order to construct an adequate control group for all three steps of the analysis, we employ Propensity Score Matching (PSM) to identify comparable municipalities from a pool of municipalities in states without a DRP. For the analysis, we use a generalized Difference in Differences (DiD) estimator. Municipalities subject to these DRP exhibit substantial increases both in the local business as well as the property tax rates. Furthermore, we also identify considerable tax policy spillovers of the DRPs to untreated municipalities in Hesse and NRW. Tax increases are especially pronounced for the property tax rates ranging ranging from 7.7 to 9.9 percentage points. The fact that we observe tax policy spillovers in the property tax rates indicates that German municipalities engage in yardstick competition. As the property tax base is immobile, this finding cannot be rationalized by strategic tax policy setting, i.e., tax competition. The spatial analysis illustrates that the policy spillovers decrease in the distance to the nearest treated units. This decline is most pronounced for the property tax rates, further underlining that local governments engage in yardstick competition. Additionally, these results demonstrate that geographical neighbors also respond to policy shocks even if they are not directly targeted. Thus, choosing geographical neighbors as a control group, as is often done in the literature, does not allow for an unbiased identification of policy effects.

Figure 1.0.2: *Change in the Statutory Corporate Tax Rate from 2003 to 2020*



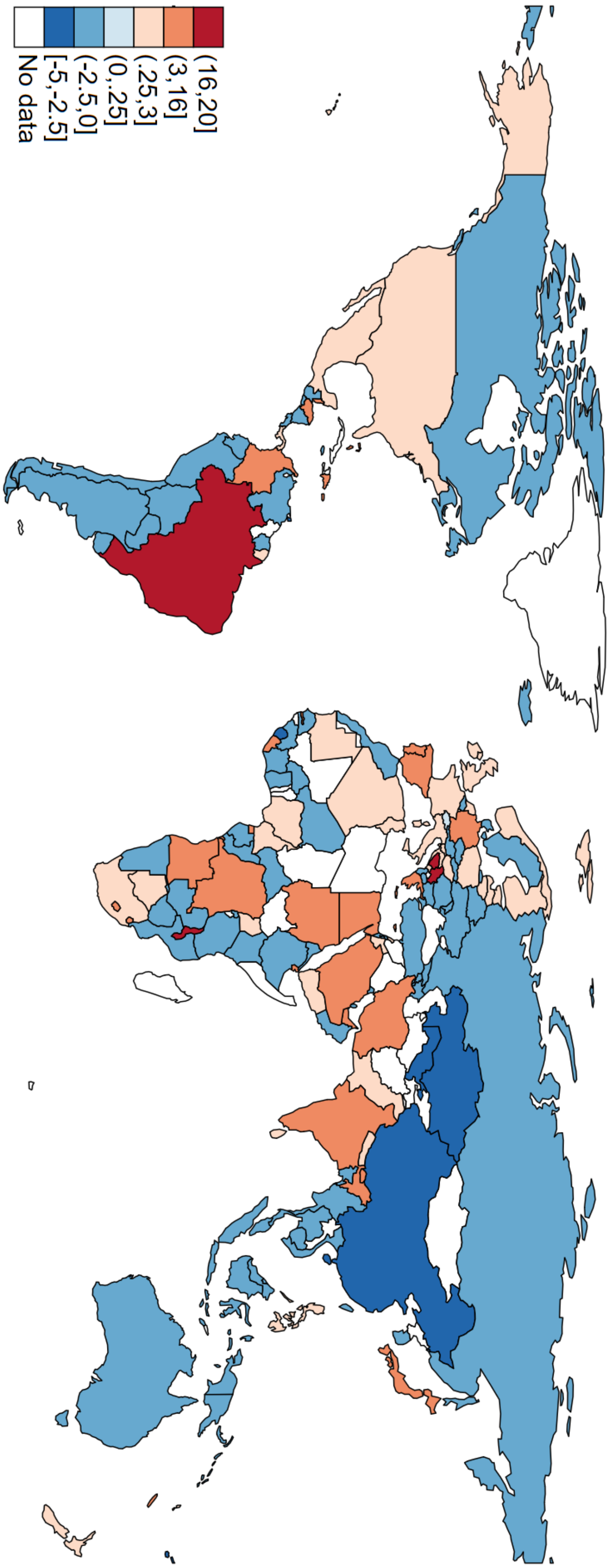


Figure 1.0.3: *Change in the Standard Consumption Tax Rate from 2003 to 2020*

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Chapter 2

Are consumers paying the bill? How international tax competition affects consumption taxation

ABSTRACT

This paper empirically investigates whether governments are substituting from corporate to consumption taxation due to tax competition using a novel self-collected data set of corporate and consumption tax regime information. I estimate the slope of the tax policy reaction function between corporate and consumption tax rates exploiting the cross-sectional interdependence of corporate tax rates for an instrumental variable approach. Additionally, I analyze the rate-revenue relationship of both tax instruments to evaluate the overall revenue implications of corporate tax competition. I find that, on average, a one percentage point decrease in the corporate tax rate leads to a 0.35 percentage point increase in the consumption tax rate. Furthermore, governments can fully compensate for revenue losses from tax competition by substituting to consumption taxation.

2.1 Introduction

Recent corporate tax policy developments like the US Tax Cuts and Jobs Act of 2017 or the G7 proposal for the introduction of a global minimum corporate tax rate are the result of inter-governmental competition for increasingly mobile capital. Greater capital mobility and, thus, an increasing intensity in tax competition are caused by globalization which has also fueled distributional inequality and subsequently the demand for public spending (see Hines Jr and Summers, 2009). It has long been argued that tax competition results in an underprovision of public goods as governments set inefficiently low corporate tax rates and are, therefore, unable to raise sufficient revenues.[1] Figure 2.1.1 indicates that corporate tax rate-cutting has been prevalent throughout the past two decades. Average STRs decreased by roughly 21% (5.68 percentage points) from 2003 to 2020.[2] Meanwhile, base-broadening did not take place as depreciation allowances exhibit very little within-country variation over time. Thus, the tax burden on corporate profits has decreased substantially throughout the past two decades. Given this development, the concerns about an underprovision of public goods appear to be justified. However, government spending has not only remained stable, but even increased in the wake of recent economic crises, including the global financial crisis in 2008, the European debt crisis, and the ongoing Covid-19 pandemic. Given the increase in public expenditures and the simultaneous decrease in STRs, governments must raise the necessary funds from other tax bases.

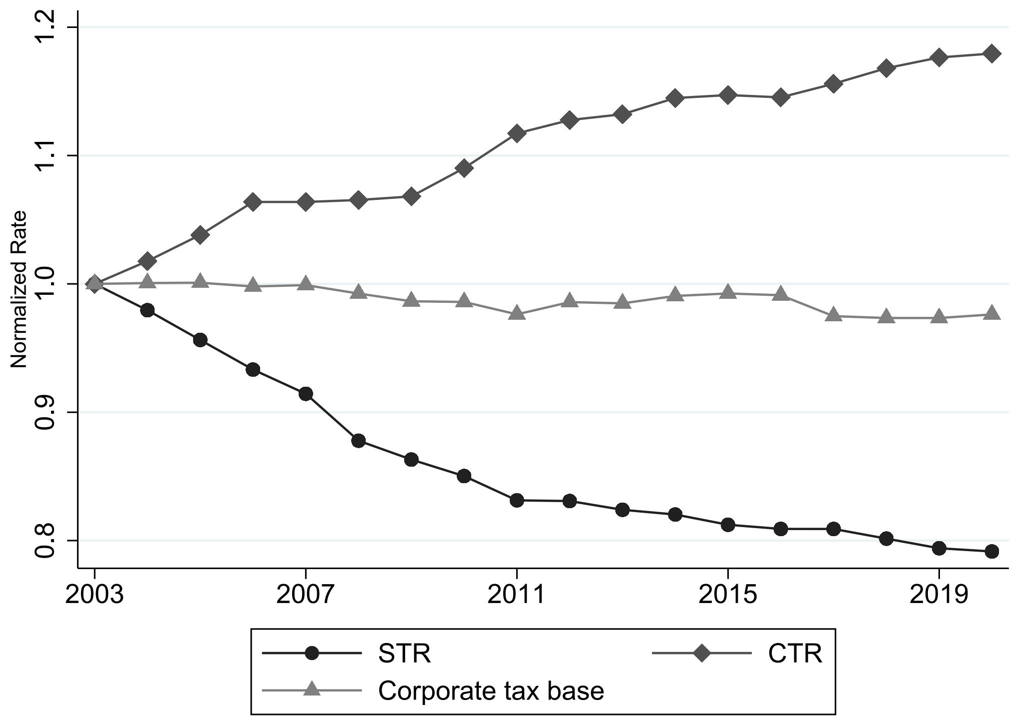
Consumption is an apparent option to raise the necessary revenues from, due to its widespread availability, broad base, and low administrative cost. Figure 2.1.1 documents a substantial increase in consumption taxation. Average consumption tax rates (CTRs) have increased by roughly 16.9% (2.17 percentage points). Judging from this descriptive evidence, governments raise the revenue needed to consolidate public budgets from (less mobile) consumption. As a result, the burden of decreasing STRs appears to fall on consumption, potentially leaving consumers to pay the bill for corporate tax competition. While taxing consumption may be economically efficient, due to the limited mobility of the tax base, it raises concerns about equity, as consumption taxes tend to fall disproportionately on low-income individuals (see Metcalf, 1997;

[1] See for example the seminal contributions of Oates (1972), Wilson (1986) and, Zodrow and Mieszkowski (1986).

[2] Note STRs exhibit a sharp downward trend over the past half century (see Devereux et al., 2002; Loretz, 2008; Steinmüller et al., 2019).

Hines Jr and Summers, 2009). Subsequently, the main consequence of tax competition may not be an underprovision of public goods, but rather a shift in the composition of the overall tax revenue away from corporate taxation to other potentially less mobile tax bases.

Figure 2.1.1: *Development of the Average STR and CTR 2003-2020*



The figure is based on a balanced panel of 155 countries. All values are normalized to the 2003 value.

While the downward pressure on STRs and the adverse revenue effects from corporate tax competition are well studied and widely acknowledged[3], the potential spillovers to other non-corporate tax instruments are often neglected. Disregarding the fact that governments can raise revenues from other potentially less elastic tax bases might lead to false conclusions. Consequently, the debate on corporate tax competition might overestimate the threat of underprovision of public goods, while underestimating equity concerns. There is a surprisingly small empirical literature looking at the interaction between national tax policy instruments across different tax bases in general and at the interdependence of corporate and consumption tax policy in particular. This paper addresses this research gap by investigating the research question: Are governments

[3]For a survey of the empirical literature see Gordon and Hines Jr (2002), Büttner (2003), and Leibrecht and Hochgatterer (2012).

shifting the burden of corporate tax competition to consumption? This question will be answered within three sub-questions: Are consumption tax rates substitutes for corporate tax rates? How is tax revenue affected by the changes in corporate and consumption tax rates? Are governments able to compensate corporate tax revenue losses through consumption tax revenue? For the analysis, I am using a novel panel of corporate and consumption tax regime information covering more than 190 countries over the period from 2003 to 2020. The relationship between corporate and consumption tax rates is identified by estimating the slope of the tax policy reaction function using an instrumental variable (IV) approach. To resolve the simultaneity in setting different domestic tax instruments, I exploit the cross-sectional interdependence of corporate tax policies (i.e., tax competition) to instrument for domestic STRs. I find that corporate tax rates are substitutes for consumption tax rates. On average, a one percentage point decrease in the STR results in a 0.35 percentage point increase in the CTR. Based on this result, the downward trend in corporate tax rates rationalizes 91.6% of the increase in consumption tax rates throughout the past two decades. Furthermore, the rate-revenue relationship of both tax instruments follows an inverted U-shape (Laffer-Curve) pattern. Using these results, I conduct a back-of-the-envelope calculation to illustrate the importance of considering consumption taxation in the context of tax competition. Governments on average set corporate and consumption tax rates well below the revenue-maximizing policy. Consequently, decreases in STRs result in net revenue losses which are more than offset by increases in the consumption tax. Thus, governments can deal with the revenue repercussions of corporate tax competition and maintain a stable level of public expenditure by substituting to other tax bases. As a result, the debate on tax competition appears to overemphasize efficiency concerns, while neglecting equity concerns.

This paper contributes to three strands of the literature. First, it adds to the literature that analyzes the effects of international corporate tax competition on other non-corporate tax policy instruments and the overall tax mix. The study by Loretz (2008) analyzes the co-development of various tax instruments in the OECD from 1982-2007. The author illustrates a diverging development of personal and corporate income taxes compared to depreciation allowances and consumption tax rates. While the former two experienced a stable and significant decrease over the observational period, the latter two exhibit the opposite pattern. The author concludes that this development is caused by corporate tax competition and that governments compensate for falling STRs by increasing consumption tax rates and broadening the corporate tax base. Hines Jr and Summers (2009) investigate the effect of globalization on the tax revenue mix. The authors demonstrate that small and more economically open countries rely increasingly on consumption rather than corporate or personal income tax revenue. They conclude that globalization leads to greater reliance on revenues from immobile tax bases. Similarly, Genschel and Schwarz (2012) analyze the consequences of corporate tax competition on the autonomy of OECD governments to independently set national tax instruments. The authors illustrate that countries of all sizes substitute from corporate to consumption taxation due to tax competition. The existing literature descriptively documents that EU and OECD governments are substituting from corporate to consumption taxation due to globalization and intensifying tax competition. The paper at hand is the first to directly estimates the tax reaction function between corporate and consumption tax rates. Furthermore, the analysis is based on a global panel allowing for a generalization of the results beyond the OECD/EU context.

Second, this paper contributes to the empirical literature analyzing the effects of corporate tax rate changes on tax revenue. Clausing (2007) uses a panel of OECD countries from 1979 to 2002 to estimate the relationship between corporate tax rates and revenues using an OLS regression. Her results indicate that this relationship follows an inverted U-shape with a revenue-maximizing STR of 33%. Devereux (2007) replicates these results using a panel of 20 OECD countries from 1986 to 2004. However, when using log revenues, he only finds weak evidence for any relationship between corporate tax rates and revenues. Kawano and Slemrod (2016) also analyze a panel of OECD countries for the years 1980 to 2004. In contrast to the previous literature, they additionally control for unobserved time invariant country characteristics. They also find evidence for an inverted U-shape relationship which is less pronounced, compared to previous findings, implying a higher revenue-maximizing tax rate. Steinmüller et al. (2019) analyze the relationship between STRs and corporate tax revenues for a panel of 142 countries from 2004 to 2016 controlling for time and panel fixed effects. They also find an inverted U-shape relationship. While the relationship between tax rates and revenues is well-studied for corporate taxation, evidence on this relationship for other non-corporate tax instruments remains scarce. This paper adds to this literature by expanding the analysis of the rate-revenue relationship to consumption taxation providing a more complete analysis of the overall revenue consequences of tax competition.

Third, this paper contributes to the empirical literature on corporate tax competition estimating direct policy reaction functions. Devereux et al. (2008) estimate corporate tax reaction functions for a time series of 21 OECD countries from 1982-

1999. They find that countries compete both in statutory and forward-looking effective tax rates. According to their analysis the downward trend of STRs can almost entirely be attributed to intensifying corporate tax competition. Overesch and Rincke (2011) derive similar results in a dynamic setting for a larger (1983-2006) and broader (32 countries) time series. They also find strong cross-sectional dependencies in STRs which can explain the downward trend in statutory tax rates. Egger and Raff (2015) investigate corporate tax competition in both tax rates and the tax base for 43 European countries between 1982 and 2005. They conclude that countries not only compete in STRs but also in the tax base. Crivelli et al. (2016) analyze corporate tax rate and base spillovers for 173 countries from 1980 to 2013. They find evidence for tax base and rate spillovers which appear to be especially relevant for developing countries. The key result of the empirical tax competition literature is that corporate tax rates are interdependent across countries. I built on this result by exploiting this cross-sectional interdependence for an unbiased identification using an IV approach. To resolve the simultaneity problem of corporate and consumption tax setting, I instrument for the domestic corporate tax rate using a weighted average of all other countries' corporate tax rates. This study adds to the literature by focusing on the interaction between different tax instruments within a country rather than across countries. To the best of my knowledge, no study has previously utilized an IV approach exploiting corporate tax competition as an instrument for domestic policy spillovers.

The remainder of the paper is structured as follows. Section 2.2 establishes the setting and outlines the key assumptions of the analysis. The estimation strategy and the data are discussed in Section 2.3. The empirical results are presented in Section 2.4. Section 2.5 analyzes the overall revenue consequences of tax competition. The last section concludes the analysis.

2.2 Setting

The goal of this paper is to explain the divergent development of STRs and CTRs in Figure 2.1.1. Following Hines Jr and Summers (2009), globalization leads to both higher public expenditure needs and capital mobility, resulting in an intensification of corporate tax competition. The paper extends this point by arguing that increased tax competition creates revenue losses which governments compensate by substituting to CTRs. For this mechanism to be plausible, some assumptions need to hold which are descriptively tested in this section. First, public good provision remains constant. One reason for this could be short-run budget rigidity. If governments could simply reduce the required budget at short notice, the need for additional public funds never arises. Looking at Figure 2.2.1, we observe that public spending between 2000 and 2020 exhibits a stable horizontal development with the exception of a discrete jump following the global financial crisis in 2008. Following this discrete jump, the spending level stabilized again. However, public spending is only an imperfect proxy for public good provision as it also captures administrative costs. Figure 2.2.3 depicts the development of the expenditures on public goods and services from 2000 to 2019. Most of these expenditures have remained stable throughout the observational period indicating that, on average, countries did not experience a significant reduction/underprovision of public goods and services. The only two exceptions are defense and general public services, which have both decreased by roughly 20 percent relative to the level of 2000. The development of the latter could indicate a reduction in public good provision. However, the development appears to depend on overall business cycles, as expenditures sharply increase following the global financial crisis in 2008 and start to decrease again with the ongoing economic recovery. Looking at governmental expenses in Figure 2.2.4, we observe that almost all types of expenses have remained stable throughout the past two decades. The only two expenses that exhibit substantial changes are interest payments and social benefit expenses. While the decrease of the former is most likely driven by the low central bank discount rates, the latter increased substantially due to economic repercussions from the financial crisis in 2008. Taking these results together, we do not observe underprovision of public goods. In fact, government spending increased as a result of several global economic crises.

Second, governments are not able to debt-finance a public deficit indefinitely. Looking at Figure 2.2.1, public revenues also exhibit a stable trend but have remained below public spending for the majority of the observed sample period implying that, on average, governments run a public deficit. Judging from the development of gross debt, also depicted in Figure 2.2.1, governments on average debt-financed this fiscal deficit, at least in the short-run. If governments were able to debt-finance public deficits for a prolonged period of time, the need for raising additional revenue disappears. Theoretically, some governments might be able to run such a deficit. As long as they can credibly signal their ability and willingness to repay public debt, interest rates will remain reasonably low and government default is very unlikely (see Breen and McMenamin, 2013).[4] However, the majority of countries will eventually need to increase taxes in the future to prevent excessive debt and rising interest rates. Additionally, countries may also wish to increase tax rates and raise additional tax revenue to emphasize a commitment to solvency, thus, keeping interest rates low. All in all, it is impossible to conclusively test whether governments are able to debt-finance public deficits infinitely. However, it appears plausible to assume that most governments will need to repay their debt eventually and subsequently raise taxes.

Third, corporate tax revenues decline. Turning to Figure 2.2.2, we observe that the largest share of the overall tax revenue comes from consumption taxes, while personal income and corporate taxation play a smaller yet relevant role. In line with Hines Jr and Summers (2009), revenue from corporate income has decreased by 1.7 percent over the past two decades, while consumption tax revenues have risen by 4.7 percent. Overall, personal income tax revenue has remained almost constant. The decline in the revenue share of corporate income taxation appears to moderate given the substantial decrease in STRs. However, Fuest et al. (2020) document a substantial increase in pre-tax corporate profits which is only to a small extent driven by increases in operating profits. This precludes the possibility of a self-financing corporate tax cut.[5] Given the increase in public spending and these revenue developments, governments appear to have increasingly relied on revenues from consumption taxation to finance public goods. This argument is supported by the findings of Hines Jr and Summers (2009) and Arezki et al. (2021), who find that increasing trade openness, generally associated with more intense tax competition, results in a shift of the tax mix towards consumption taxation. Additionally, Egger et al. (2019) document that a similar development occurred within personal income tax revenue as the tax burden has been shifted from top income earners to the middle class, explaining the stability in the share of personal income tax revenues.

Fourth, governments do not substitute to other non-consumption tax bases. While the evidence so far illustrates the need to raise additional revenue, governments could also tab into other potential tax bases including personal income, property or capital gains taxes instead of consumption. However, several arguments can be made in favor of taxing consumption. First, consumption is comparatively inelastic allowing for

[4] Lierse and Seelkopf (2016) analyze the fiscal responses of debt-constrained European countries during the 2008 financial crisis. They find that countries facing high bond yields refinance themselves predominantly by increasing taxes on consumption and other less mobile tax bases.

[5] Figure 2.A.1 in the Appendix illustrates that corporate tax revenues follow an inverted U-Shape, technically allowing for the possibility of self-financing corporate tax cuts. However, the average corporate tax rate is well below the revenue-maximizing one, thus, revenue increases must be driven by other non-tax policy related developments.

revenue to be raised more efficiently (see Ramsey, 1927). Furthermore, consumption taxes are less sensitive to business cycles resulting in a more stable revenue flow due to the immobility of thetax base. Second, personal income tax rates (PITs) show the same downward trend as STRs over the past two decades.[6] Using the data of Egger et al. (2019), Figure 2.A.3 illustrates the development of the effective average PITs based on the average country-year-specific wage. STRs and PITs exhibit an almost identical development. Furthermore, the analysis in Appendix 2.A.4 indicates that the PIT development is not self-financing and results in revenue losses.[7] These results are in line with expectations, the taxation of personal income suffers from similar problems as capital gains and corporate taxation. Additionally, personal income taxation generally serves as a backstop to corporate taxation. Large differentials between corporate and personal income taxation would create (dis-)incentives for incorporation and, thus, additional frictions and inefficiencies. Third, consumption taxes are set on the national level and flow predominantly into the national budgets, which allows for an easier adaptation to revenue requirements of the national government.[8] While the property tax base is substantially less elastic compared to consumption, it is generally administered at the sub-national level (see Bird and Slack, 2004). As a result, property taxation is out of reach for national parliaments and, thus, not adequate to consolidate national budgets. Looking at the overall size of the revenue generated (Table 2.3.1), it is apparent that property taxes only make up a small portion of the overall tax revenue raised (see also Hines Jr and Summers, 2009). Therefore, only a disproportionate increase of property tax rates could compensate for falling STRs, which bears the substantial risk of political repercussions by voters. Consequently, consumption taxes are the most feasible instrument to raise additional revenue.

2.3 Empirical Model and Working Hypotheses

2.3.1 Working Hypothesis

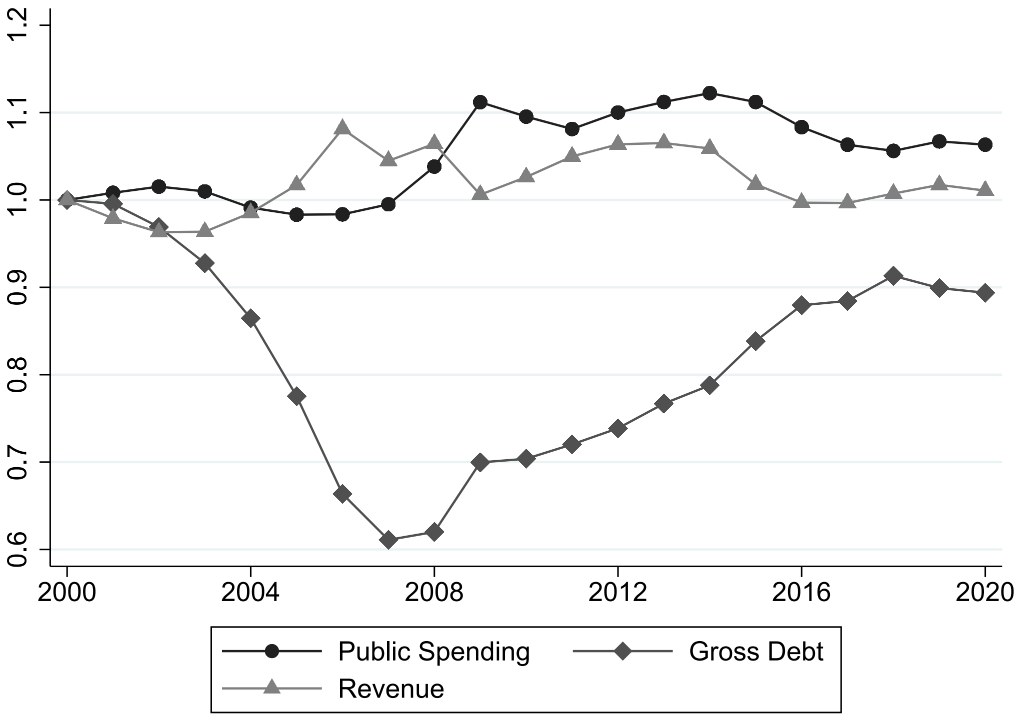
Based on the research question and the descriptive evidence presented in Section 2.2, I derive several testable hypotheses for the empirical analysis. The first hypothesis concerns the relationship between corporate and consumption tax rates. Due to budget

[6] See for example Egger et al. (2019) and Loretz (2008).

[7] See Appendix 2.A.4 for more details.

[8] There are some notable exceptions to this rule, including the United States of America and Brazil.

Figure 2.2.1: *Average Fiscal Development 2000-2020 (Normalized to the Base Year 2000)*



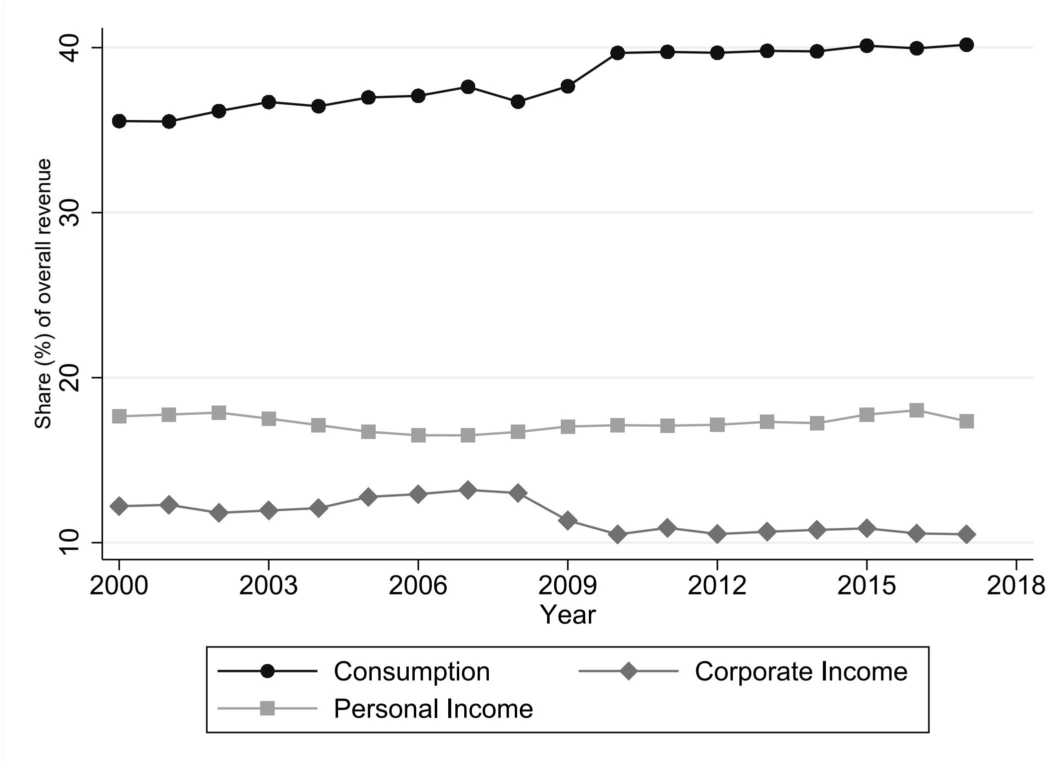
The calculations are based on an unbalanced panel of 113 countries taken from the IMF Fiscal monitor. The values are normalized by the respective value in the year 2000. The variable values are expressed in % of GDP.

rigidity, revenue losses stemming from falling (effective) corporate tax rates are compensated through raising additional revenue from consumption. Accordingly, I derive the following hypothesis:

Hypothesis 1: The corporate and consumption tax rates are substitutes.

The next set of hypotheses is related to the revenue effects caused by changes in the consumption and corporate tax rate. Given the relatively mobile corporate tax base, it is reasonable to expect that the relationship between corporate tax rates and revenue follows an inverted U-shape (Laffer-Curve) pattern. This pattern is produced by the opposing mechanical and behavioral effect. The mechanical effect is linear in the tax rate, as an increase (decrease) in the tax rate leads to more (less) revenue raised from the existing tax base. The behavioral effect is quadratic in the tax rate and captures

Figure 2.2.2: *Average Development of Revenue Shares Relative to Overall Tax Revenue*



The calculations are based on an unbalanced panel of 164 countries taken from the UN Government Revenue Dataset. The variable values are expressed as share of total tax revenue.

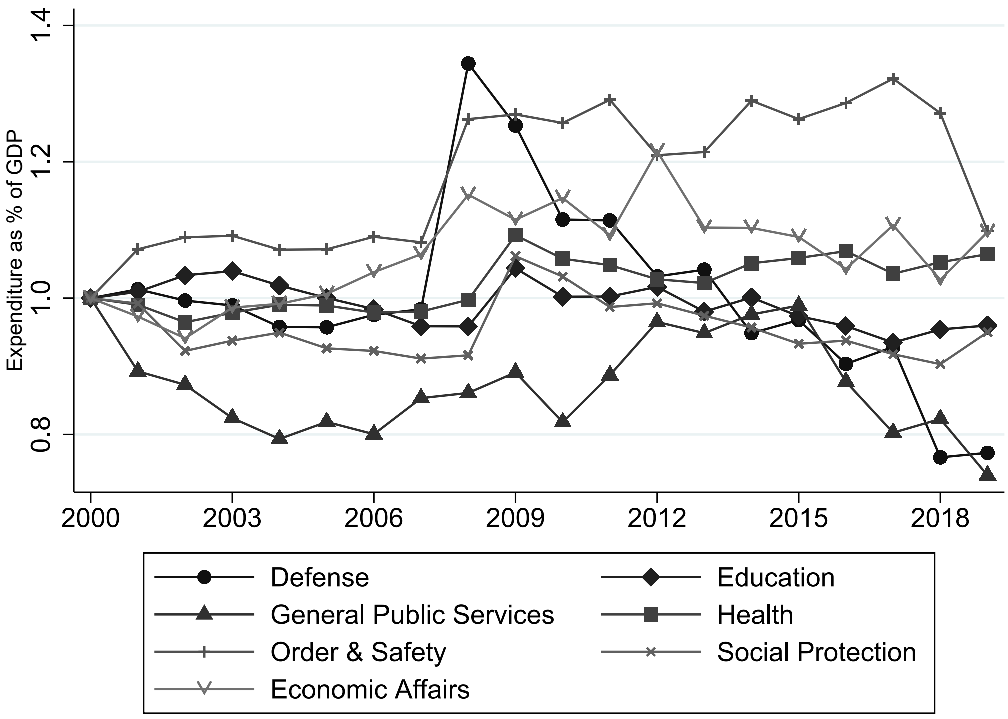
the tax base mobility, thus, an increase (decrease) in the tax rate causes the tax base and, therefore, revenue to decrease (increase) as capital is relocated. Since consumption is a less mobile base compared to corporate profits, one would expect to see a strong mechanical effect but only a weak behavioral effect.[9] Given these differences in base mobility, I derive the following two hypotheses:

Hypothesis 2: The corporate tax rate-revenue relationship exhibits a positive mechanical effect and a negative behavioral effect.

Hypothesis 3: The consumption tax rate-revenue relationship exhibits a positive mechanical effect and a weak negative behavioral effect.

[9]For descriptive evidence on tax base mobility refer to Appendix 2.A.3. Local polynomial regression of tax revenue on tax rates reinforce the presumed differences in tax base mobility.

Figure 2.2.3: *Average Development of Different Expenditures*



The calculations are based on an unbalanced panel of 73 countries taken from the IMF Expenditure by function of Government Database. The values are normalized by the respective value in the year 2000. The variable values are expressed in % of GDP.

Given the argument on budget rigidity, the question remains, whether the revenue effects of consumption taxation are sufficient to match the revenue changes from corporate taxation. In order to investigate this relationship, I test the following hypothesis:

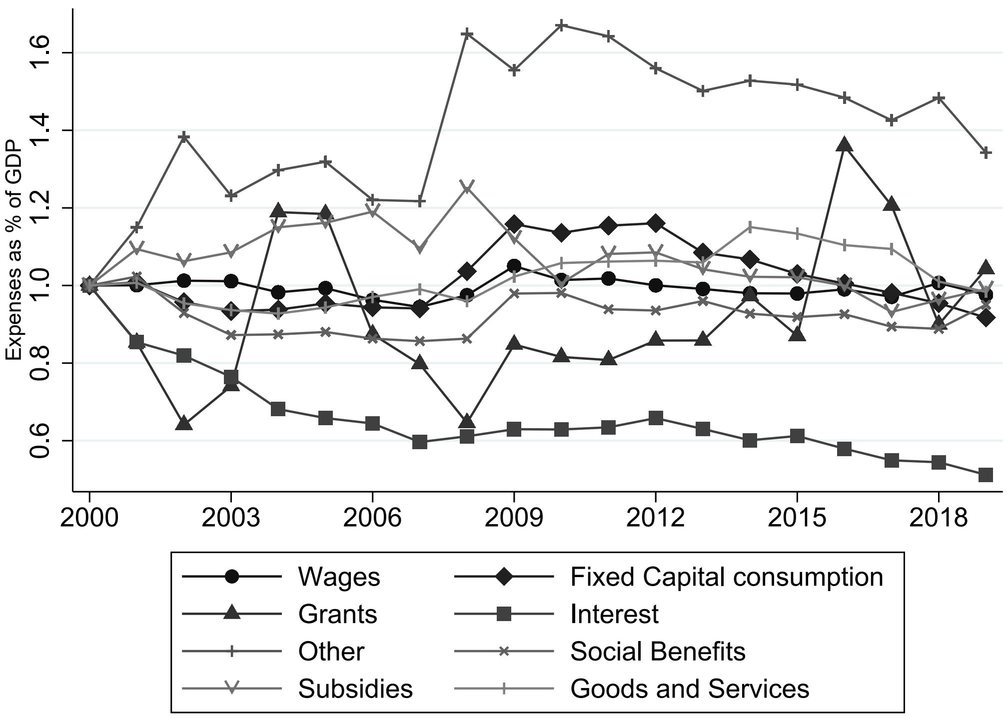
Hypothesis 4: Governments fully compensate revenue losses from STR decreases through substitution to consumption taxation.

2.3.2 Empirical specification

Hypothesis 1 to 3 are examined using a panel data set covering T time periods and N countries. To test hypothesis 1, I estimate the tax reaction function of the CTR with respect to the STR, following:

$$\theta_t = \beta_\theta \tau_t + \mathbf{X}_t \gamma_\theta + \epsilon_t, \tag{2.3.1}$$

Figure 2.2.4: *Development of Normalized Mean Expenses from Different Categories*



The calculations are based on an unbalanced panel of 181 countries taken from the IMF Government Finance Statistics Database. The values are normalized by the respective value in the year 2000. The variable values are expressed in % of GDP.

where θ_t and τ_t are $N \times 1$ vectors of consumption and corporate tax rates in year t. $\mathbf{X}_t$ is a $N \times (3 + N)$ matrix containing control variables for country size, production and trade cost as well as country fixed effects. ϵ_t is the disturbance term of the model. The coefficient of interest is β_θ, returning the type and strength of the interaction between STRs and CTRs. In line with hypothesis 1, substitutability implies that β_θ is expected to be negative.

Hypothesis 2 and 3 are tested separately for consumption and corporate taxation. The revenue consequences of corporate/consumption tax rate changes are estimated according to:

$$\mathbf{REV}_{\tau t} = \alpha_0 + \alpha_\tau \tau_t + \delta_\tau \tau_t^2 + \mathbf{X}_{\tau t} \eta_\tau + \epsilon_{\tau t}, \tag{2.3.2}$$

$$\mathbf{REV}_{\theta t} = \alpha_0 + \alpha_\theta \theta_t + \delta_\theta \theta_t^2 + \mathbf{X}_{\theta t} \eta_\theta + \epsilon_{\theta t}. \tag{2.3.3}$$

$\mathbf{REV}_{\tau t}$ and $\mathbf{REV}_{\theta t}$ are $N \times 1$ vectors denoting the corporate and consumption tax revenues in period t respectively. $\mathbf{X}_t$ is a $N \times (1 + N + T)$ matrix containing control variables for economic growth, country and year fixed effects. $\epsilon_{\tau t}$ and $\epsilon_{\theta t}$ represent the disturbance terms of the respective model. Both equation 2.3.2 and 2.3.3 estimate a Laffer-Curve relationship, with α_τ and α_θ capturing the strength and direction of the mechanical effect and δ_τ and δ_θ picking up the behavioral effect. In line with hypothesis 2, the expected coefficients are $\alpha_\tau > 0$ and $\delta_\tau < 0$. Regarding hypothesis 3, α_θ is expected to be positive. Due to the relative immobility of consumption, I expect δ_θ to be smaller than δ_τ. Hypothesis 4 is addressed in Section 2.5 by combining the estimation results of β_θ, α_τ, α_θ, δ_τ and δ_θ to analyze the effects of a change in the STR on the overall tax revenue.

2.3.3 IV Approach

There are two econometric issues that need to be addressed to obtain consistent and unbiased results for equation 2.3.1. First, naively estimating equation 2.3.1 using OLS will produce biased results, as corporate and consumption tax rates are likely to be jointly determined rendering τ_t endogenous. Second, the estimated standard errors need to be corrected to be heteroskedasticity, spatial and serial autocorrelation-consistent (SHAC) following Driscoll and Kraay (1998).

To obtain an unbiased estimate of the coefficient of interest β_θ, I estimate equation 2.3.1 by using an IV approach instrumenting for τ_t using:

$$\bar{\tau}_t \equiv \mathbf{W}\tau_t. \tag{2.3.4}$$

$\bar{\tau}_t$ is the weighted average corporate tax rate of country i's neighbors (competitors). $\mathbf{W}$ is an exogenous, time-constant $N \times N$ weighting matrix with zero diagonal elements. w_{ij} is the weight assigned to country j from the perspective of country i. For the analysis, I will use two different weighting schemes; inverse distance (geographical neighbors) and 'natural' trade flows (economic neighbors).[10] All elements of $\mathbf{W}$ are row-sum normalized implying that $\sum_{j=1}^{N} w_{ij} = 1$. The identifying assumption behind this IV strategy is that STRs across countries are cross-sectionally interdependent due to tax competition, while CTRs are only indirectly affected. Put differently, the STRs of $i's$ neighbors affect the STR in i, but have no direct effect on the CTR in i. Consequently, the endogeneity is resolved by exploiting the variation in $i's$ STR, caused by changes

[10] For a more detailed description of the different weighting schemes applied see Appendix 2.A.1.

in the corporate tax policy of $i's$ neighbors, which lie beyond the control of i. For the IV strategy to yield unbiased estimates, both relevance and exclusion restriction need to hold. The relevance assumption in this case requires that the STRs of $i's$ neighbors do have an economically and statistically significant impact on the STR in i; countries strategically interact in their tax setting behavior due to corporate tax competition. To test the relevance assumption, I replicate the estimation conducted by Egger and Raff (2015) in Appendix 2.A.2 to test for strategic interaction in corporate tax instruments. I find that STRs are strong strategic complements. These results imply that the chosen instrument is relevant and not weak.[11] These findings are in line with the results derived by Devereux et al. (2008), Overesch and Rincke (2011) and Egger and Raff (2015) who provide strong evidence for corporate tax competition in the OECD/EU context. Apart from the relevance assumption, the results in Appendix 2.A.2 imply that the findings of the empirical tax competition literature are not confined to the OECD/EU context but also generalize to the panel analyzed in this essay. Thus, tax competition appears to be not only an EU/OECD phenomenon but takes place globally.

The exclusion restriction demands that $\mathbb{E}(\epsilon_t|\bar{\tau}_t) = 0$; STRs of $i's$ neighbors have no direct effect on the choice of the CTR in country i. This assumption would be violated if countries were to compete not only in corporate but also consumption tax rates, since this would imply that CTRs in i are simultaneously determined with the corporate and consumption tax rates of $i's$ neighbors. I test for consumption tax competition in Appendix 2.A.3, using a similar empirical approach as for corporate tax competition.[12] Following the results presented in Table 2.A.3, I do not find evidence for consumption tax competition, thus, the exclusion restriction holds. The weighted average of CTRs has no direct statistically significant impact on the CTR in i.[13] This result is intuitive, given that mobility of consumption is limited, countries have little incentive to strategically set CTRs to attract foreign consumption.

2.3.4 Data

The analysis in this paper builds on two self-collected data sets containing information on corporate and consumption tax regimes. The corporate tax data are a substantial

[11]For a more detailed description of the estimation strategy and the results see Appendix 2.A.2.

[12]Note that ideally I would also run a Sargan-Hansen-test to validate the exclusion restriction. Unfortunately, I am unable to so as this as more than one instrument is required.

[13]See Appendix 2.A.2 for a more detailed description.

extension of the data set presented in Steinmüller et al. (2019). It contains information on corporate tax rates, depreciation allowances, and methods for an unbalanced panel of 224 countries for the years 2001-2020.[14] Following Devereux et al. (1991) as well as Devereux and Griffith (1998), I combine STRs and depreciation allowances to calculate forward-looking effective marginal (EMTR) and effective average tax rates (EATR) for a balanced panel of 166 countries. Both the EMTR and EATR are composite measures encompassing rate and base effects of corporate tax policy. They capture the tax incentives a firm faces for marginal (EMTR) and discrete investment projects (EATR) respectively.[15] The consumption tax data set contains variables on standard and reduced consumption tax rates, the type of consumption tax, as well as the number of different consumption tax rates for an unbalanced panel of 203 countries covering the time period from 2003 to 2020. This data were primarily collected using the *EY Worldwide VAT, GST and Sales Tax Guides*, *Deloitte Guides to Fiscal Information*, *PwC Worldwide Tax Summaries* and the *IBFD Tax Research Database*. From these two novel data sets, I construct a balanced corporate and consumption tax rate panel for 173 countries from 2003 to 2020. The number of countries drops to 154 countries when also considering the forward-looking effective tax rates.

For the empirical analysis, I use country size, production and trade cost, as well as GDP growth as control variables. Furthermore, I require revenue data as the dependent variable for the estimation of equations 2.3.2 and 2.3.3. Country size and labor cost are approximated through log GDP and log GDP per capita in constant USD. Both variables as well as annual GDP growth in % are taken from the World Bank's *World Development Indicators Database*. Trade cost is approximated using the log value of cost, insurance and fright (CIF) data from the *CEPII Trade Unit Values database*. The expenditure, debt and revenue data presented in Figure 2.2.1 are taken from the IMF *Fiscal Monitor*. The data on different types of tax revenue illustrated in Figure 2.2.2 and used for testing hypotheses 2-4 were retrieved from the UN *Government Revenue Dataset*. The public expenditure and expenses data represented in Figures 2.2.3 and 2.2.4 were taken from the IMF *Government Finance Statistics Database*. All the variables taken from the IMF are measured in % of GDP. The inverse distance weighting matrix is calculated using geo-spatial information from the CEPII *GeoDist* database. "Natural" Trade flow weights are estimated using structural gravity estimation build-

[14]Note that these also include unincorporated territories with tax autonomy like Puerto Rico, the Kosovo, or South Sudan.

[15]For a thorough discussion of the data set and the calculation of the EMTRs and EATRs see Steinmüller et al. (2019).

ing on the same geo-spatial information as well as bilateral export volume data from the CEPII *BACI* database and data on regional trade agreements from Egger and Larch (2008). After combining the tax regime data with several control variables, I am left with a balanced panel of 133 countries covering the years 2003 to 2018 for the empirical analysis. For the analysis in Appendix 2.A.4 I use data from Egger et al. (2019) on effective average personal income tax rates calculated for the mean income in each country and year. This data was provided to me by the authors and covers 162 countries from 2003 to 2012. Table 2.3.1 contains the summary statistics.

Table 2.3.1: *Summary Statistics*

Variable	Mean	SD	Min	Max	N.Obs
Corporate income tax rate	0.24	0.10	0.00	0.57	2,772
Standard consumption tax rate	0.14	0.07	0.00	0.27	2,772
NPV of depr. allowances	0.52	0.14	0.00	0.88	2,772
Effective marginal tax rate	0.13	0.06	0.00	0.37	2,772
Effective average tax rate	0.21	0.08	0.00	0.49	2,772
Effective Average PIT rate	0.13	0.13	0.00	0.80	1,530
Public expenditure (% of GDP)	32.25	11.63	3.79	65.05	1,742
Gross public debt (% of GDP)	51.70	34.98	0.00	237.69	1,736
Public revenue (% of GDP)	30.69	12.32	1.98	72.34	1,742
Corporate Income Tax Revenue (% of GDP)	3.09	2.12	0.00	20.78	1,831
VAT Revenue (% of GDP)	6.15	2.61	0.00	18.89	1,702
Goods and Services Tax Revenue (% of GDP)	9.06	4.43	0.03	36.04	1,945
Property Tax Revenue (% of GDP)	0.92	1.07	0.00	17.37	1,732
Income Tax Revenue (% of GDP)	7.30	4.56	0.08	31.67	1,923
GDP growth (annual %)	3.77	4.44	-46.08	34.47	2,365
log GDP per capita (constant 2010 US$)	8.83	1.43	5.27	11.86	2,344
log GDP (constant 2010 US$)	24.67	2.17	18.82	30.51	2,344
log mean trade cost (CIF)	11.93697	1.194189	7.824515	18.06337	2,394

2.4 Results

In the following, I will present the estimation results for the tax reaction function of CTRs with respect to STRs and their respective revenue effects. Table 2.4.1 summarizes the estimation results for equation 2.3.1, instrumenting for τ_t using equation 2.3.4. Columns (1)-(3) depict the results based on the inverse distance weighting scheme, while the results in Columns (4)-(6) are based on the ‘natural’ trade flow weighting. The dependent variable in all models is the standard CTR. TAX represents the STR, the EMTR or EATR, as denoted by the column label. The coefficient of interest is negative and statistically significant across all models.[16] This result is in line with hypothesis 1, implying that corporate and consumption tax rates are, in fact, substitutes. A decrease in the EMTR and/or EATR implies that not only statutory rates are decreasing but also the base to which this rate is applied becomes narrower. Thus, it is not surprising that the estimated slope of the tax reaction function is steeper for the EMTR or EATR. Governments respond stronger to changes in the effective tax rates, since they need to compensate for rate and base decreases, requiring a larger increase in the CTR. Employing different weighting schemes only changes the results quantitatively but not qualitatively. Interpreting the results of Column (1) as a baseline, a one percentage point decrease in the STR is on average compensated by a 0.35 percentage point increase in the standard CTR. Quantitatively, this tax reaction function implies that consumption taxes change less than proportionately as a response to changes in the STR. This result captures the fact that the consumption tax base is much larger than the corporate tax base (see Table 2.3.1). To compensate for falling STRs, a less than proportionate increase in consumption taxes is sufficient to balance out the respective revenue effects. Given these results, 91.6% of the average CTR increase between 2003 and 2020 can be attributed to the decrease in average STRs by 5.68 percentage points. Looking at the F-values, I can confidently conclude that the chosen instrument is relevant as also indicated by the analysis in Appendix 2.A.2.

Table 2.4.2 presents the results for the estimation of equations 2.3.2 and 2.3.3. Columns (1)-(3) use the corporate income tax revenue and Column (4) the consumption tax revenue as dependent variable. TAX denotes the different tax rates as described by the column label. Looking at the coefficients of TAX and TAX^2 for Columns (1) to (3), an inverted U-shape pattern emerges for corporate tax revenue. As expected and in line with hypothesis 2, the mechanical effect is positive throughout all three specifications, while the behavioral effects are negative. Similar to the tax reaction function, the revenue responses with respect to changes in the effective tax measures are stronger. This result is intuitive, as jointly decreasing or increasing the STRs and the tax base should trigger a more pronounced revenue response. The rate-revenue patterns for the STRs also emerge even when no functional form is ex-ante assumed as documented by Figure 2.A.1. Turning to Column (4), the rate-revenue relationship of consumption taxation exhibits both a substantial mechanical and behavioral effect. In contrast to hypothesis 3, the consumption tax base appears to be fairly mobile.

[16]Note that this result is robust to using τ_{t-1}^{-} as an instrument.

Table 2.4.1: *Consumption Tax Reaction Function*

Weighting scheme	inverse distance			'natural' trade flow		
	(1) STR	(2) EMTR	(3) EATR	(4) STR	(5) EMTR	(6) EATR
TAX	-0.352***	-0.576***	-0.411***	-0.388***	-0.644***	-0.454***
	(0.041)	(0.070)	(0.048)	(0.045)	(0.074)	(0.052)
Country size (log GDP)	-0.040***	-0.047***	-0.041***	-0.045***	-0.052***	-0.046***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)	(0.010)
Costs (log GDP-per-capita)	0.038***	0.047***	0.039***	0.041***	0.051***	0.042***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)
Trade costs (log CIF)	0.001**	0.001**	0.001**	0.001*	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Country FE	X	X	X	X	X	X
N	2128	2128	2128	2128	2128	2128
F-Value	234.06	198.28	223.83	307.59	282.01	305.31

*The table presents IV estimates. Standard errors are reported in parentheses. Standard errors are heteroskedasticity, spatial and serial autocorrelation-consistent. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

The linear relationship in Figure 2.A.2 in Appendix 2.A.3 is thus mostly driven by country size which is mostly accounted for using country fixed effects in Table 2.4.2; large countries setting higher tax rates and raising higher revenues.

2.5 Revenue Consequences

To test for the overall revenue effects of tax competition (hypothesis 4), I conduct a back-of-the-envelop calculation combining the results from the previous section to analyze the average countries' ability to compensate for falling STRs through increasing CTRs. I will focus primarily on the effects of corporate tax rate changes on the overall budget. So far, the empirical analysis suggests that STR reforms affect both CTRs (Table 2.4.1) and the corporate tax base (Table 2.4.2). Furthermore, the consumption tax base also responds to CTR changes (Table 2.4.2). The relationship between corporate and consumption tax rates is a linear function with the slope of -0.352 which is assumed to be time constant (see Table 2.4.1 Column (1)). Given the inverted U-shape rate-revenue relationship of both corporate and consumption taxation in Table 2.4.2, I am able calculate revenue-maximizing tax rates; the tax rate for which a marginal

Table 2.4.2: *Revenue Effects of Rate Changes*

	(1) STR	(2) EMTR	(3) EATR	(4) CTR
TAX	14.504***	17.747***	17.499***	38.361***
	(2.054)	(3.273)	(2.400)	(3.093)
TAX^2	-22.953***	-41.904***	-32.465***	-95.001***
	(4.413)	(11.680)	(6.007)	(13.660)
GDP growth	0.015**	0.015**	0.014**	0.005
	(0.006)	(0.006)	(0.006)	(0.007)
Constant	0.269	0.800***	0.265	1.902***
	(0.268)	(0.242)	(0.268)	(0.217)
Country FE	X	X	X	X
Year FE	X	X	X	X
N	1919	1845	1845	1901
Within R^2	0.0859	0.0806	0.0835	0.0968

*The table presents OLS estimates. Standard errors are reported in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

increase is just revenue neutral.[17] Using the results of Column (1) of Table 2.4.2, the average revenue-maximizing corporate tax rate (τ^*) is equal to 31.59%. For any $\tau > \tau^*$ the behavioral dominates the mechanical effect and a STR reduction would lead to net revenue gains. For any $\tau < \tau^*$ the opposite holds true. In 2003, 38.6% of the countries in our dataset had a tax rate exceeding τ^*, by 2018 this number dropped to 11.2%. Thus, by 2018, the vast majority of countries was in a position where the mechanical effect dominated the behavioral effect. Given that the average STR between 2003 and 2018 fell from 28.4% to 23.02%, the average country suffered corporate tax revenue losses from decreasing their STR. Similarly, the average revenue-maximizing consumption tax rate (θ^*) is equal to 20.19%. In 2003, 91.5% of countries levied a consumption tax smaller than θ^*. By 2018, this number dropped to 87.2%. Consequently, the overwhelming majority of countries imposed less than revenue-maximizing CTRs. Since the average CTR rose from 12.13% in 2003 to 14.6% in 2018, most countries generated additional consumption tax revenue. The question remains whether these revenue gains outweighed the corporate tax revenue losses.

Based on these results, I test hypothesis 4. First, I calculate the average tax revenue

[17] The calculation follows from the first order derivative of equation 2.3.2 and 2.3.3 with respect to the corporate and consumption tax rate respectively.

from each base by plugging the empirical results from Table 2.4.2 and the average STR and CTR level in 2003 into equations 2.3.2 and 2.3.3.[18] In 2003, governments raised an estimated 2.267% of GDP in corporate tax revenues and 3.255% of GDP in consumption tax revenues. Due to the decline in STRs between 2003 and 2018 by 5.38 percentage points, corporate tax revenues reduced by 6.4% to 2.122% of GDP. Similarly, the decrease in STRs resulted in an average increase of the CTR by 1.894 percentage points to an estimated 14.014%. Thus, the estimated consumption tax revenue in 2018 rose by 7.9% to 3.511% of GDP. Consequently, the revenue gains from substituting from corporate to consumption taxation more than outweighed the revenue losses from falling corporate tax rates. This result is in line with hypothesis 4, illustrating that most countries fully compensated for falling STRs. Thus, the threat of underprovision of public goods appears to be overemphasized as governments are able to maintain a stable overall level of tax revenues. However, tax competition appears to have resulted in an increasing share of the overall tax burden to fall on consumption, raising equity rather than efficiency concerns. The increases in CTRs are likely to be at least partially passed on to consumers, effectively leaving them to pay part of the bill of corporate tax competition.

2.6 Conclusion

This paper empirically investigates the spillovers from international tax competition to consumption taxation deriving three key findings. First, governments increase consumption tax rates as a result of falling (effective) corporate income tax rates. A one percentage point decrease in the STR is on average compensated by a 0.35 percentage point increase of the CTR explaining 91.6% of the average CTR increase between 2003 and 2020 decreasing average STRs. This result is derived by exploiting strategic interdependence in STRs across countries as an instrument for domestic STRs. Second, the corporate and consumption tax rate-revenue relationship follow an inverted U-shape (Laffer-Curve) with governments setting, on average, less than revenue-maximizing corporate and consumption tax rates. Third, the substantial reduction in STRs in the past two decades resulted in net revenue losses, which were more than compensated by substituting to consumption taxation. Thus, the ability to substitute to other tax bases has allowed governments to maintain a stable level of public expenditures and

[18] For simplicity I will disregard the both GDP growth and the regression constant and focus only on α_{TAX} and δ_{TAX}.

public good provision. All in all, these results illustrate that the fiscal repercussion of corporate tax competition on the overall public budget/expenditure are small, as long as governments are able to substitute to consumption taxation. Consequently, tax competition affects the tax mix but not the overall level of public expenditures. Thus, the discussion about corporate tax competition should be less concerned about under-provision of public goods and should focus more on the question who ends up paying for corporate tax competition. Judging from the analysis presented in this paper, consumption bears a substantial part of the cost of corporate tax competition. While this may be economically efficient, it raises concerns about equity, as consumption taxes affect low-income households disproportionately strong.

Given the recent G7's proposal for the introduction of a global minimum corporate tax, governments around the globe appear to be determined to curb corporate tax competition. According to Mathias Cormann, secretary general of the OECD, the introduction of a minimum tax would both "put a limit on the level of tax competition" and ensure that "governments [are] able to raise the necessary revenue to fund [public] services" (Bloomberg, 2021). However, based on the results of this paper, a global minimum corporate tax might have unintended consequences for consumption taxation as it would allow governments to reduce the tax burden born by consumption, due to tax competition. Thus, apart from the beneficial impact on tax revenues, the minimum tax might also offer additional, so far unexpected, benefits to low income households and potentially curb income/wealth inequality.

The paper adds to the existing literature by providing estimates of the slope of the consumption tax reaction function with respect to STRs. To the best of my knowledge, this paper is the first to analyze and quantify the effects of corporate tax competition on consumption taxation. Additionally, it provides estimates of the revenue consequences of both corporate and consumption tax rate changes. I introduce tax competition as an innovative instrument to obtain unbiased reaction functions of simultaneously determined tax policy instruments. Furthermore, the estimations are based on a novel data set covering more than 190 countries around the globe. This allows for the results to be generalized beyond the EU/OECD context.

Building on these results, future research should focus on whether the increasing consumption taxation has contributed to the polarization of wealth and income distributions in the past decades. This analysis would crucially depend on the question whether the supply or demand side has been bearing the majority of the consumption tax burden. More thoroughly analyzing the relationship between STRs, CTRs, and

PITs could also offer another interesting starting point for future research to further illuminate the effects of corporate tax competition on other national policy instruments. A more thorough analysis of the tax rate and revenue data would potentially yield interesting insights into the anatomy and development of public spending and revenues of the past decades. Results from these analyses could allow for a more comprehensive conclusion whether governments are generally moving away from direct taxation due to increasing tax base mobility. This could provide valuable evidence for a long-held debate in economics whether to tax consumption instead of income (see Fisher, 1942; Feldstein, 1978; Bradford, 1980; Kaldor, 2014).

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2.A Appendix

2.A.1 Weighting Scheme

Following Egger and Raff (2015), I am employing two different weighting schemes for the analysis in Section 2.3 and for the estimations in Appendix 2.A.2. The weighting matrix $\mathbf{W}$ is calculated based on inverse distance and on 'natural' trade flows. In the following, I will briefly outline the properties of these weighting schemes, how they are calculated, and what data are used for the calculation. To obtain unbiased and reliable results $\mathbf{W}$ needs to be exogenous, time-constant, exhibit bounded row-sums, and zero-diagonal elements. Exogeneity of $\mathbf{W}$ is necessary to obtain unbiased estimates and implies that $\mathbb{E}(\epsilon|\mathbf{W}) = 0$. In order to estimate the effect of changes in the corporate tax rate on the consumption tax rate, variation must only come from changes in the tax policy and may not stem from changes in the weighting scheme. Thus, $\mathbf{W}$ needs to be time-constant and the panel completely balanced. Bounded row-sums are required as each entry of $\mathbf{W}$ for row i and column j w_{ij} is row-sum normalized such that:

$$\sum_{j=1}^{N} w_{ij} = 1.$$

The zero-diagonal elements ensure that the dependent variable is not included in the weighted average.

Inverse distance weighting is the first weighting scheme employed in the paper. The argument behind using inverse distance weighting is that countries located in geographic proximity have a bigger influence on country i compared to countries located further away. $\mathbf{W}$ is calculated using bilateral distances between countries.

The second weighting scheme is based on 'natural' trade flows. Employing actual trade flows would bias the results since trade flows are likely affected by tax policy. Thus, following Egger and Raff (2015), I estimate counterfactual trade flows according to:

$$Exports_{ijt} = \alpha_0 + \alpha_1 dist_{ij} + \alpha_2 border_{ij} + \alpha_3 language_{ij} + \alpha_4 FTA_{ijt} + \eta_i + \gamma_j + \epsilon_{ijt}. \tag{2.A.1}$$

Exports represents the bilateral export volume from country i to country j in year t, *dist* is the bilateral distance between i and j. *border* is an indicator variable taking on the value one if i and j share a common border and zero otherwise. $language$ is an indicator variable taking on the value one if i and j share a common official language and zero otherwise. FTA is an indicator variable taking on the value one if i and j are in a free trade agreement and zero otherwise. Equation 2.A.1 is estimated using Pseudo Poisson Maximum Likelihood (PPML) following Silva and Tenreyro (2006). The results of estimating equation 2.A.1 are illustrated in Table 2.A.1. Based on these results counterfactual trade flows between country i and j are calculated.

Table 2.A.1: *PPML Estimation for Natural Trade Weighting*

	(1) Importvolume
log distance	-0.308***
	(0.013)
Contiguity	1.294***
	(0.038)
Common Language	0.380***
	(0.029)
FTA	0.483***
	(0.027)
Constant	20.596***
	(0.116)
Observations	318402
$Pseudo - R^2$	0.8750

*The table presents PPML estimates. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

2.A.2 Tax Competition

The existence of international corporate tax competition is crucial to the argument made in this paper. The descriptive evidence presented in Devereux and Griffith (2003), Loretz (2008), Steinmüller et al. (2019), and Figure 2.1.1 illustrate that corporate tax rates have continuously decreased from the early 1980s to the 2020s. While this development may serve as tentative evidence for tax competition, it could also be the result of other developments unrelated to strategic interaction in corporate tax instruments, stemming from capital mobility. These potential developments could include yardstick competition or overall liberal political tendencies. In the following, I will present empirical evidence illustrating that strategic interaction in corporate tax rates, i.e. tax competition, is the driving force behind the downward trend in corporate tax rates.[19] I will also briefly outline the methodology used to derive this results. Several authors have documented this results for earlier periods in the OECD context including Devereux et al. (2008), Overesch and Rincke (2011) and Egger and Raff (2015). Thus, the following section illustrates that corporate tax competition is still relevant for the time period covered in this paper and that it is not only limited to well developed countries in the OECD context.

In order to investigate whether corporate tax competition is present, I will estimate tax policy reaction functions following Egger and Raff (2015). Tax policy reaction functions are estimated following:

$$\tau_{\mathbf{t}} = \beta_\tau \tilde{\tau_{\mathbf{t}}} + \mathbf{X_t} \gamma_\tau + \epsilon_{\tau,\mathbf{t}}, \tag{2.A.2}$$

where $\tau_{\mathbf{t}}$ $N \times 1$ vector of corporate tax rates in year t. $\tilde{\tau_{\mathbf{t}}}$ is a $N \times 1$ vector of the weighted average corporate tax rates of country $i's$ competitors with $\tilde{\tau_{\mathbf{t}}} \equiv \mathbf{W} \times \tau_{\mathbf{t}}$. $\mathbf{W}$ is a $N \times N$ weighting matrix.[20] $\mathbf{X_t}$ is an $N \times K$ matrix with $K = 3 + N$ containing controls for country size, production cost, trade cost and country fixed effects. $\epsilon_{\tau,\mathbf{t}}$ is the disturbance term. In line with the well-established theoretical literature on tax competition, the empirical model in equation 2.A.2 implies that corporate tax rates are simultaneously determined.[21] Furthermore, we expect corporate tax rates to be strategic complements ($\beta_\tau > 0$). Additionally, since we do not empirically observe a race to the bottom, we expect $\beta_\tau > 0$ to be bounded between zero and 1.[22] Due to the simultaneity in the tax setting behavior of countries, estimating equation 2.A.2 with OLS will return biased results. To resolve this endogeneity problem, the weighted average of foreign tax policy instruments needs to be instrumented. Following Kelejian and Prucha (1999) and Kelejian et al. (2004), $\mathbf{WX_t}$, $\mathbf{W^2X_t}$ and $\mathbf{W^3X_t}$ are used as instruments. Intuitively, this approach exploits spatial interdependence between

[19]Note that I am not explicitly looking at the corporate tax base as a policy instrument as within country variation of depreciation allowances is minimal.

[20]For a more detailed description of $\mathbf{W}$ and how it is calculated see Appendix 2.A.1.

[21]For for a comprehensive summary of the theoretical tax competition literature, see Wilson (1999).

[22]The empirical absence of a race to the bottom is implying that capital is not perfectly mobile or that governments have the ability to tax location specific rents.

country implying that a countries tax setting behavior is influenced by its GDP, labor cost and trade cost, and the effect of its neighbors and the neighbors of its neighbors on these variables. This two-stage least squares approach yields consistent estimates if the instruments are relevant and exogenous to the disturbance term. The disturbance term is heteroskedasticity, spatial and serial autocorrelation-consistent (SHAC) following Driscoll and Kraay (1998).

For the estimation of equation 2.A.2, I use three different tax rate variables to test for strategic complementarity, the STR, foward-looking effective marginal (EMTR), and effective average tax rates (EATR). In contrast to the statutory tax rate, the EMTR and EATR also take depreciation allowances and, therefore, base effects into account. Thus, the statutory corporate tax rate captures competition for corporate profits, while the EMTR (EATR) capture the competition for marginal (discrete) investment projects. For country size, I use log GDP in constant 2010 USD from the World Bank World Development Index (WDI). Log GDP per capita in constant 2010 USD is used as production cost and is also taken from the WDI. Log cost of insurance and freight from the CEPII trade unit value data set. The analysis is based on a balanced panel of 133 countries from 2001 to 2018.

Table 2.A.2 presents the estimation results for equation 2.A.2. Columns (1)-(3) are based on inverse distance weights, while Columns (4)-(6) reflect the results for 'natural' trade weights. Throughout Columns (1)-(6) the coefficients of interest have the desired signs and are statistically significant indicating that countries strategically interact in their corporate and effective tax rates. Tax rates are strategic complements and the tax reaction is substantial. The coefficients imply that a 1 percentage point decrease in the weighted average of the tax rates of country $i's$ competitors results on average in a 0.9 percentage point decrease in country i.[23] Looking at the F-test, we cannot reject the hypothesis that the chosen instruments are relevant. Furthermore, the Hansen J statistic indicates that the exogeneity hypothesis of the chosen instruments cannot be rejected. Taking thse results together, I can confidently conclude that the instrumental variable chosen for the identification in Section 2.3.3 is relevant. I also test the exclusion restriction of the instrument, by ruling out that countries compete in consumption tax rates. I test this by estimating the following model:

$$\theta_{\mathbf{t}} = \gamma_\tau \tilde{\tau}_{\mathbf{t}} + \gamma_\theta \tilde{\theta}_{\mathbf{t}} + \mathbf{X_t} \gamma_\tau + \epsilon_{\theta,\mathbf{t}}. \tag{2.A.3}$$

[23]The reaction of country i to a rate change in a particular country j is equal to $\beta_\tau \times w_{ij}$.

Table 2.A.2: *Strategic Interaction in Corporate Tax Rates*

Weighting scheme	inverse distance			'natural' trade flow		
	(1) STR	(2) EMTR	(3) EATR	(4) STR	(5) EMTR	(6) EATR
TAX	0.869***	0.919***	0.871***	0.905***	0.889***	0.899***
	(.044)	(0.047)	(0.044)	(0.048)	(0.048)	(0.048)
log GDP	-0.0284**	-0.022***	-0.025**	-0.029*	-0.029***	-0.027**
	(0.0140)	(0.008)	(0.012)	(0.015)	(0.009)	(0.013)
log GDP p.c.	0.027	0.026**	0.025	0.029	0.032***	0.026
	(0.018)	(0.011)	(0.015)	(0.019)	(0.012)	(0.017)
log trade cost	0.0001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Country FE	X	X	X	X	X	X
N	2394	2394	2394	2394	2394	2394
Hansen J stat	6.289	6.261	6.286	7.738	7.846	7.721
P-val	0.6149	0.6180	0.6152	0.1713	0.1649	0.1723
F-test	976.18	605.90	857.84	139.49	160.71	140.28

*The table presents IV estimates. Standard errors are reported in parentheses. Standard errors are heteroskedasticity, spatial and serial autocorrelation-consistent. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

Where $\theta_\mathbf{t}$ $N \times 1$ vector of consumption tax rates in year t. $\tilde{\theta_\mathbf{t}}$ is a $N \times 1$ vector of the weighted average consumption tax rates of country $i's$ competitors with $\tilde{\theta_\mathbf{t}} \equiv \mathbf{W} \times \theta_\mathbf{t}$. Due to data availability, the sample period reduces to the years 2003-2018. All other variables and the estimation strategy remain the same. In line with my argument, I expect foreign consumption taxes to have no impact on domestic consumption taxes and thus γ_θ needs to be statistically insignificant. Table 2.A.3 summarizes the estimation results from equation 2.A.3. Columns (1)-(3) are calculated with inverse distance weights. Results in Columns (4)-(6) are based on natural trade flow weights. Throughout all specifications γ_θ is statistically insignificant. Thus, implying that the weighted average of the consumption tax rate of country $i's$ neighbors has no significant impact on the consumption tax rate in i. Consequently, the exclusion restriction is not violated.

Table 2.A.3: *Testing for Consumption Tax Competition*

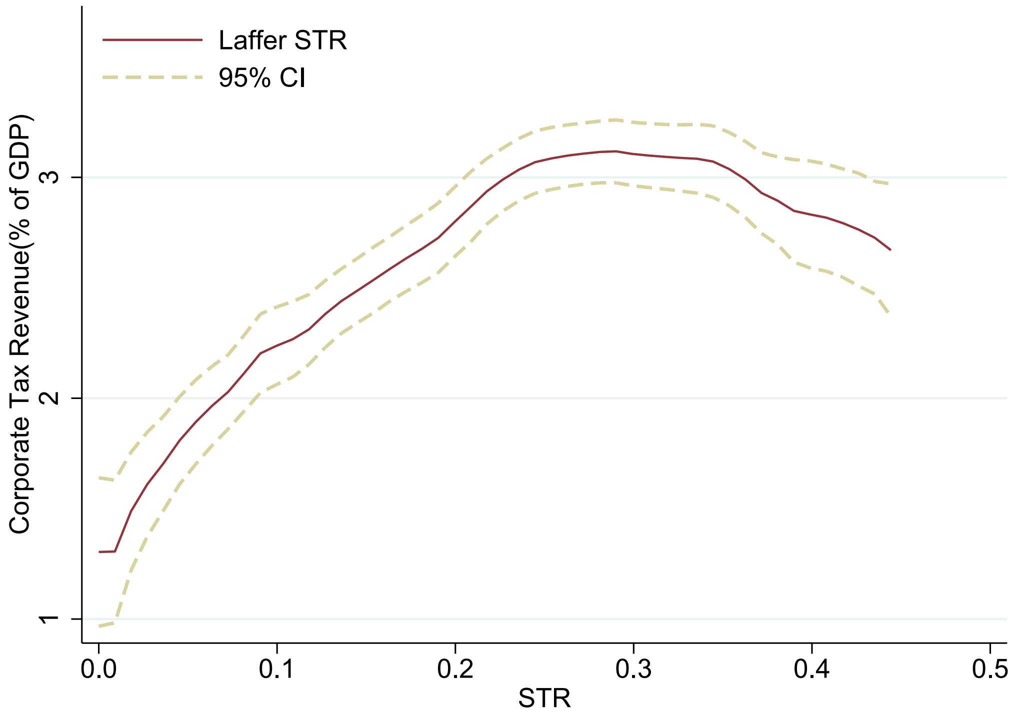
Weighting scheme	inverse distance			'natural' trade flow		
	(1) STR	(2) EMTR	(3) EATR	(4) STR	(5) EMTR	(6) EATR
Weighted θ	0.112	0.212	0.131	-0.111	-1.531	-0.271
	(0.312)	(0.320)	(0.314)	(3.656)	(10.654)	(4.463)
Weighted TAX	-0.350***	-0.550***	-0.403***	-0.416	-1.260	-0.531
	(0.073)	(0.132)	(0.086)	(0.890)	(4.307)	(1.272)
log GDP	-0.031***	-0.034***	-0.031***	-0.030***	-0.030***	-0.030***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)	(0.005)
log GDP p.c.	0.022***	0.024***	0.022***	0.020***	0.019***	0.020***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
log trade cost	0.001	0.001*	0.001	0.001**	0.001**	0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Country FE	X	X	X	X	X	X
N	2128	2128	2128	2128	2128	2128
Hansen J stat	5.686	5.454	5.432	7.265	7.846	7.721
P-val	0.5768	0.7081	0.7106	0.2017	0.1649	0.1723
F-value (θ)	185.51	185.51	185.51	210.06	210.06	210.06
F-value (TAX)	2082.94	493.24	1585.96	66.07	88.96	67.93

*The table presents IV estimates. Standard errors are reported in parentheses. Standard errors are heteroskedasticity, spatial and serial autocorrelation-consistent. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

2.A.3 Descriptive Evidence of the Rate-Revenue Relationship

The choice of the rate-revenue relationship in the context of corporate taxation is motivated by the previous literature that finds strong evidence for an inverted U-shape. However, there is very little evidence on the relationship between consumption tax rates and revenues. While the working hypotheses in Section 2.3.1 are deduced from economic theory, I also took an inductive approach by looking only at the data. Figures 2.A.1 and 2.A.2 illustrate the results for local polynomial regressions of the respective tax revenue on the tax rate. The advantage of this approach is its non-parametric nature. Consequently, I do not superimpose a functional form on the data. The non-linear shape of this relationship is solely determined from the data. Turning to Figure 2.A.1, we observe that the relationship between corporate tax revenue and rates follows approximately an inverted U-shape. While corporate tax revenue initially increases with rising corporate tax rates, the slope gradually decreases and becomes negative when STRs are exceeding the revenue-maximizing tax rate at approximately 30%. Looking at Figure 2.A.2, we do not observe an inverted U-shape. The relationship is almost perfectly linear with very narrow confidence intervals. The evidence from these figures both motivates the hypotheses generated in Section 2.3.1 and supports the results discussed in Section 2.4.

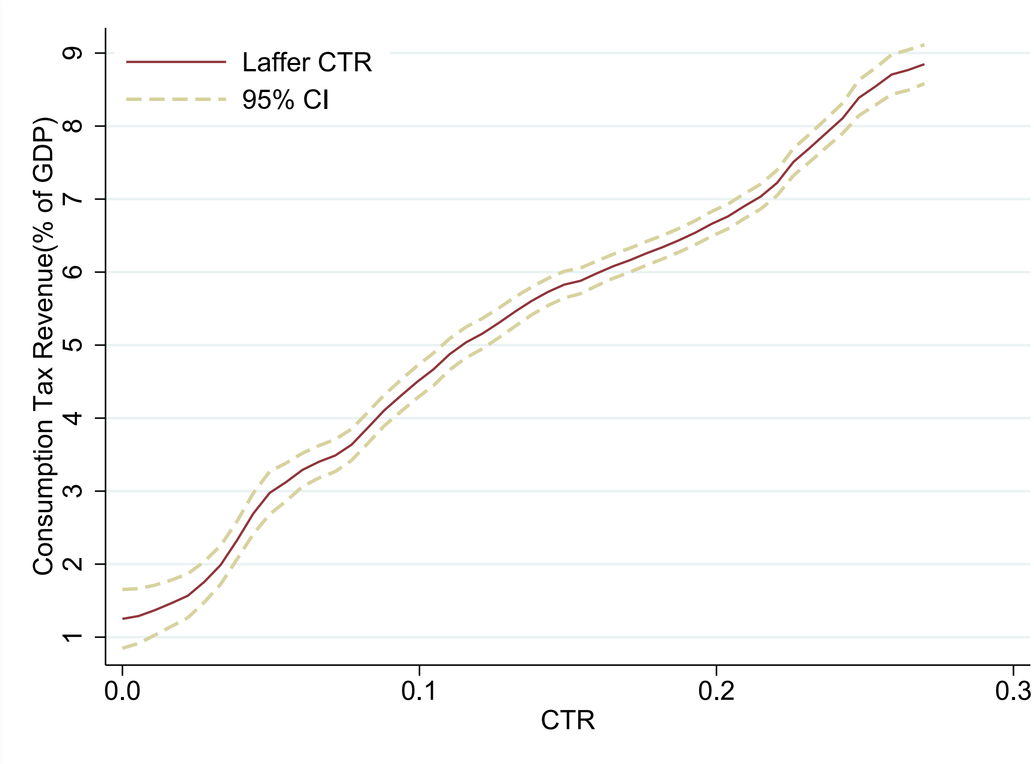
Figure 2.A.1: *Local Polynomial Results for the Corporate Tax Rate-Revenue Relationship*



2.A.4 Evidence on Personal Income Tax Rate

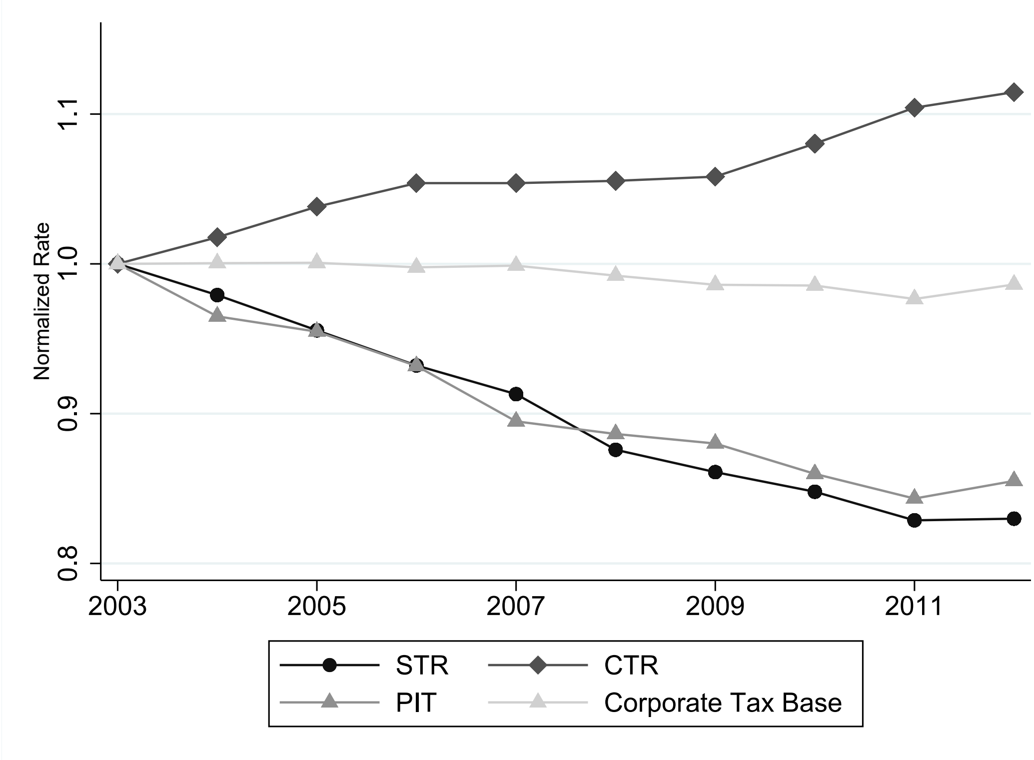
The following section describes the development of personal income tax rates (PIT) and the revenue consequences of PIT changes. I am focusing on effective average tax rates as they are the relevant measure from a revenue perspective. Figure 2.A.3 illustrates the development of the STR, CTR, PIT, and the NPV of depreciation allowances. The PIT exhibits an almost identical development as the STR. This emphasizes the fact that the STR and PIT are closely linked, both due to their legal design (backstop function) and their economic characteristics (mobile tax base). Similar to corporate taxation,

Figure 2.A.2: *Local Polynomial Results for the Consumption Tax Rate-Revenue Relationship*



a mobile tax base allows for the possibility that a rate cut results in a net revenue gain if the behavioral effect dominates the mechanical effect. I replicate the rate-revenue estimation from Section 2.4 for PITs, results are depicted in Table 2.A.4. As expected, the PIT also follows an inverted U-shape pattern with a positive mechanical and a negative behavioral effect. From these estimates we can calculate the revenue-maximizing PIT rate, which is approximately 52 %. The mean PIT rate in 2003 was 14.09 % which dropped by roughly 2 percentage points to 12.05 in 2012. Thus, similar to the STR, the mean PIT rate lay substantially below the revenue-maximizing tax rate and moving further away throughout the observational period. Consequently, the drop in PITs cannot have been self-financing for the vast majority of countries.

Figure 2.A.3: *Development of Average STR, CTR, PIT, and the NPV of Depreciation Allowances 2003-2012*



The figure is based on a balanced panel of 153 countries. All values are normalized to the 2003 value.

Table 2.A.4: *Revenue Effects of PIT Rate Changes*

	(1) Tax Revenue (% of GDP)
PIT	7.773***
	(1.402)
PIT^2	-6.838***
	(2.567)
GDP growth	-0.005
	(0.006)
	3.387***
	(0.139)
Country FE	X
Year FE	X
N	1082

*The table presents OLS estimates. Standard errors are reported in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.*

Chapter 3

The tax elasticity of tangible fixed assets: Evidence from novel corporate tax data

ABSTRACT

This paper develops a new approach to calculate country-year-industry-specific forward-looking effective corporate tax rates (FLETRs) based on a panel of 19 industries, 221 countries, and the years 2001 to 2020. Beside statutory tax rate and tax base information, the FLETRs account for firms' typical (i.e., industry specific) financing structures as well as asset compositions. We show that effective tax rates suffer from significant measurement error when the latter information is neglected, owing primarily to inappropriately assigned asset weights to statutory depreciation allowances. Our empirical analysis exploits the substantial variation in FLETRs over time to provide estimates of the semi-tax-elasticity of corporate investment in tangible fixed assets. Based on more than 24 million firm-entity observations, our results suggest a semi-tax-elasticity of -0.45, which is at the lower end of previous findings. We further show that different sub-groups of firms respond very heterogeneously to tax incentives. For example, when focusing on firm-entities operating in the manufacturing sector, we find a substantially bigger semi-elasticity of -1.29.

3.1 Introduction

One of the main objectives of fundamental tax reforms such as the 2017 US "Tax Cuts and Jobs Act" is to raise corporate investment and thereby economic growth. Whether and to what extent such reforms are successful in this regard depends in large parts on the extent to which firms' real investments respond to changes in tax incentives. To adequately capture investment incentives of the corporate tax system, the literature suggests forward-looking corporate effective tax rates (FLETRs) that characterize the tax burden of a hypothetical investment project (see, e.g., Sørensen, 2004).[1] One goal of this paper is to calculate FLETRs that combine corporate tax code information (i.e., statutory tax rates and depreciation regimes) with firm characteristics (i.e., financing and asset structures) that are typical of a certain country and industry. Accounting for specific firm characteristics plays an important role in determining the magnitude of the FLETRs, as depreciation allowances differ between asset categories and interest payments on debt are usually tax-deductible.

As differences in financial capital structures as well as asset compositions substantially determine firms' effective corporate tax rates, it is essential to account for this heterogeneity when investigating investment behavior. A central measure of the relationship between corporate taxation and investment is the semi-tax-elasticity of corporate investment. The literature suggests very heterogeneous estimates of the semi-tax-elasticity of corporate investment ranging from -9.8 to 1.26 (see Feld and Heckemeyer, 2011). However, these estimates rarely take industry- and firm-specific characteristics into account, often due to a lack of adequate data. Instead, most scientific contributions calculate FLETRs for a representative firm with a constant asset and financing structure across all countries and industries.[2] Disregarding this country-industry-level variation in FLETRs may lead to a systematic measurement problem of the investment incentives of country-industry-specific tax policy. In fact, firms differ substantially along several margins including the industry and/or country context they operate in.

[1]Note that backward-looking measures (calculated as taxes paid relative to pre-tax profit) not only fail to capture current and future investment incentives but are also prone to severe endogeneity concerns as both taxes paid and pre-tax profit may be driven by tax-planning decisions of the firm (Devereux and Griffith, 2002).

[2]See, e.g., Davies et al. (2018), Devereux and Griffith (1998b), Egger et al. (2014), Spengel et al. (2016a), Spengel et al. (2016b), Spengel et al. (2016c), Steinmüller et al. (2019). Note that most contributions use the constant financing and asset structures proposed in the seminal publication *Taxing Profits in a Global Economy: Domestic and International Issues* by the OECD from 1991.

Thus, they likely exhibit heterogeneous responses to tax policy changes. Accounting for these differences is crucial for an informed policy debate about, for example, special depreciation rules as fiscal policy instruments. There is a surprisingly small literature looking at the impact of different firm characteristics on the semi-tax-elasticity of investment using FLETRs for a common global data basis. This paper addresses this research gap by answering the research questions: Do firms exhibit heterogeneous semi-tax-elasticities of investment? Which firm characteristics drive this heterogeneity?

To address these research questions we develop a new approach to calculate country-year-industry-specific FLETRs that explicitly account for differences in the financial capital structures as well as asset compositions both across and within industries. The country-industry-specific asset structures are derived and, if necessary, imputed from the *EUKLEMS & INTANProd* database as well as Bureau van Dijk's *Orbis* database and financing structures from the *Orbis* database.[3] These FLETRs are calculated for 221 countries,[4] 19 industries, and 20 years. Based on these FLETRs we estimate semi-tax-elasticities of firms' tangible fixed assets based on firm-level data of more than 24 million observations. Additionally, we conduct a large number of group-specific semi-tax-elasticity estimations to analyze heterogeneity in investment responses. Our estimates of the tax sensitivity of firms' tangible fixed assets, based on 24 million firm-entity observations and substantial variation of FLETRs (across countries, industries, and time) suggest a semi-tax-elasticity of investment of about -0.45. We demonstrate that our new FLETRs capture tax incentives more adequately and are robust to alternative estimation specifications as well as employing different tax instruments. The results of our heterogeneity analysis indicate that tax responsiveness strongly depends on industry, firm-group, and country-specific characteristics. We find larger semi-tax-elasticities for firms from the manufacturing and transportation sectors, and small or statistically insignificant semi-elasticities for firms in the wholesale business. Firms with positive profits and less profit-shifting opportunities are highly responsive to tax rate changes. Additionally, firms located in countries with substantial GDP growth, less developed capital markets, and/or low GDP per capita exhibit large and statistically significant semi-tax-elasticities of investment.

[3] Note that we impute missing country-industry-specific asset and financing structures based on *Predictive Mean Matching* (PMM), which allows us to calculate FLETRs for almost the entire world and all industries.

[4] Our dataset primarily comprises UN member states but also non-member states, e.g., Taiwan, as well as self-governing territories that formally are part of other states, e.g., Greenland. For the sake of clarity and simplicity, we shall henceforth refer to all included tax-jurisdictions as "countries".

This paper adds to several strands of the literature. First, it contributes to studies analyzing the tax elasticity of corporate investment. A large part of this literature uses international investment data to identify tax effects from country-year specific variation in taxes. De Mooij and Ederveen (2003) perform a meta-analysis of 25 studies estimating the tax elasticity of corporate investment. They find substantial heterogeneity in elasticities across studies with a median value of -3.3. De Mooij and Ederveen (2008) analyze a sample of 427 tax elasticity estimates from from 31 empirical studies. The authors illustrate that corporate taxation has a substantial impact on the choice of the legal form, financing structure, profit shifting, as well as investment decisions on the intensive and extensive margin. Additionally, they demonstrate that the tax elasticities along these different decision margins vary substantially. Similarly, Feld and Heckemeyer (2011) conduct a meta-analysis of 45 empirical studies on the investment effects of corporate taxation. The authors estimate a median tax semi-elasticity of corporate investment of -2.49. They illustrate that employing firm-level data and (country-specific) effective tax measures yields more accurate estimations of the semi-elasticity. We contribute to this literature by providing a large number of semi-tax-elasticities of investment for different-subgroups based on firm-level data and more than 24 million observations. In contrast to the previous literature, our novel FLETRs allow us to adequately capture and exploit variation within and across different industries in a unified estimation and data context. Additionally, we are able to investigate the relevance of a large number of industry, firm-group, and country-specific characteristics on a firm's tax sensitivity.

Second, we contribute to the literature analyzing the impact of industry-specific characteristics on the tax responsiveness of investment. Stöwhase (2005) investigates the effect of effective corporate tax rates on three different economic sectors in Germany, the UK, and the Netherlands. Using Eurostat data on FDI flows, the author finds substantial heterogeneity across the three sectors in their investment response to changing tax incentives. Zwick and Mahon (2017) analyze a large sample of US firms to investigate the impact of temporary bonus depreciation rules on firm investment, distinguishing between eligible and non-eligible capital and industries. They find a substantial increase of investment into eligible equipment. These effects are especially pronounced when firms receive immediate cash flows implying that financial frictions have a strong influence on investment decisions. In contrast to the previous literature, we provide an extensive analysis for a large number of industries and countries that generalizes beyond a policy or country-specific context.

Third, our paper contributes to the literature that develops and analyzes FLETR measures. Quantifying the tax burden using forward-looking measures goes back to the seminal contribution of King and Fullerton (1984) and was substantially advanced by Devereux and Griffith (1998a) as well as Devereux and Griffith (2003). Our approach is most closely related to the pioneering contributions by Egger et al. (2009) as well as Egger and Loretz (2010).[5] Egger et al. (2009) calculate firm-level FLETRs for 38 countries from 2000 to 2005, using firm-specific asset and financing weights computed from the *Orbis* database. Egger and Loretz (2010) use the same methodology to calculate firm-level FLETRs for 77 countries from 1993 to 2008. While both papers calculate FLETRs that account for firm heterogeneity, their approach differs in two key aspects from our paper. First, the asset and financing structures they obtain are directly taken from *Orbis* and, thus, vary at the time- and firm-level. However, the choice of the financing and asset structure may itself depend on corporate tax policies and, thus, cannot adequately capture exogenous tax incentives to which firms respond to. We therefore calculate the FLETRs using country-industry-specific asset and financing structures to measure the tax incentives that apply to a typical firm operating in a given country and industry. Second, the asset structure Egger et al. (2009) and Egger and Loretz (2010) retrieve from *Orbis* only differentiates between tangible and intangible assets as well as inventory. Tangible assets are then further separated into buildings, machinery, and land for which the authors assume industry-specific shares based on McKenzie et al. (1998) that are identical across countries. Using fixed shares to divide the tangible assets may introduce additional bias, as asset structures crucially depend on the specific characteristics of production and technologies used by countries. In this paper, we do not assume fixed relations between asset types but instead allow for each individual country-industry-specific asset structure to be unique.

The remainder of the paper is structured as follows. Section 3.2 theoretically derives the country-year-industry-specific FLETRs. Section 3.3 describes the various data sources that are used for the calculation of the FLETRs and the estimation of the tax elasticities of investment. The calculation of country-industry-specific financing and asset weights is detailed in the Section 3.4. Section 3.5 describes the country-year-industry-specific FLETRs. The different semi-tax-elasticities of investment are estimated in Section 3.6. Finally, Section 3.7 concludes and presents policy implications.

[5]More related studies on FLETRs and the different variations of calculating those are presented in Steinmüller et al. (2019).

3.2 Theoretical Framework

For the analysis of the semi-tax-elasticity of investment, we use two different forward-looking effective tax measures: The effective marginal tax rate (EMTR) and the effective average tax rate (EATR). The EMTR captures incentives of the tax code at the intensive margin, i.e., the tax burden a firm would face on a marginal investment that just breaks even. This property makes it particularly suitable for the calculation of semi-tax-elasticities. EATRs, on the other hand, depict the effective tax burden of all infra-marginal units invested. It is therefore primarily used for the analysis of discrete investment choices, such as location decisions (see Devereux and Griffith, 2003).

The theoretical framework of the EMTR is developed in the seminal contributions by Devereux and Griffith (1998a), Hall and Jorgenson (1967), King (1974), King and Fullerton (1984), and Devereux et al. (1991). A simple formal representation of the EMTR is

$$EMTR = \frac{(\tau - \tau\delta)}{(1 - \tau\delta)}, \tag{3.2.1}$$

where τ and δ denote the statutory tax rate and the net present value (NPV) of depreciation allowances, respectively. A detailed derivation of this formula is provided in 3.A.1. From (3.2.1), it is obvious that the marginal investment is not affected (i.e., $EMTR$=0) if $\delta = 1$, i.e., in the case where the tax law allows a firm to immediately deduct the full purchase price of an asset (e.g., a machine) from income. A feature of the EMTR is that it may easily become negative (the tax system then effectively subsidizes investments) if governments allow for generous investment tax credits and bonus depreciation (Zwick and Mahon, 2017).

Next, we briefly discuss the EATR, which was initially proposed by Devereux and Griffith (2003). Essentially, the EATR is the scaled difference between the pre-tax NPV (R^*) and the post-tax NPV (R) of a hypothetical investment that has a given pre-tax rate of return p.[6] This *tax wedge* reflects the excess return to investment necessary to compensate for taxation. To obtain the EATR, the tax wedge is divided by the discounted rate of return (using market interest rate for equity i for discounting), yielding

$$EATR_{cit} = \frac{R^* - R}{p/(1+i)} = \frac{\tau(p - i\delta)}{p}. \tag{3.2.2}$$

[6]See Steinmüller et al. (2019), for more details on R^* and R.

For the sake of illustration, let us look at a specific example. In 2010, France levied a corporate tax rate of 34.4% and a NPV of depreciation allowance for equity financed machinery of 0.81. Plugging these values into equations (3.2.1) and (3.2.2) yields an EMTR of 9.1% and an EATR of 27.4%.[7] In this paper, however, the goal is not to calculate FLETRs of investments in a single asset type that are purely equity financed. Instead, we depict the tax burden of country-industry-typical investment mixes in different asset categories that are financed using a combination of equity and debt.[8] In total, we distinguish between seven asset categories: *Buildings, Machinery, Office equipment, Vehicles, Computer equipment, Intangible fixed assets,* and *Inventory.* The distinction of different asset categories is important, as different assets are subject to varying depreciation allowances, e.g., buildings depreciate over a substantially longer period than computer equipment. The distinction between equity and debt financing is relevant as interest payments on debt are usually tax deductible, which results in higher NPVs of depreciation allowances for debt financing compared to financing through retained earnings.[9] Let us denote the NPV of depreciation allowances per unit of investment in asset type a in country c in year t by A^E_{act} and A^D_{act}, with the superscripts E and D indicating financing through retained earnings and debt, respectively.[10] It is important to note that the NPVs of depreciation allowances are purely determined by national tax codes, and tax law applies equally to all industries in a country. Hence, the only reason why different industries located in the same country have a different overall NPV of depreciation allowances is that they use different financing and asset compositions when carrying out an investment project. This is reflected in the formal depiction of the country-year-industry-specific NPV:

$$\delta_{cit} = ES_{ci} \sum_{\text{all } a} w_{aci} \cdot A^E_{act} + DS_{ci} \sum_{\text{all } a} w_{aci} \cdot A^D_{act}, \tag{3.2.3}$$

where w_{aci} denotes the share of asset a in a typical investment carried out in industry i in country c.[11] ES_{ci} and DS_{ci} denote the country-industry-specific shares of retained earnings and debt used to finance the investment, respectively, which add up to unity.

[7]Note that for the calculation of EATRs in this paper, we follow the parameterization of Steinmüller et al. (2019), who set $p = 0.2$ and $i = 0.05$.

[8]Note that using time-constant rather than time-varying financing and asset weights for the empirical analysis of investment avoids endogeneity issues that may arise due to changes in the financing and asset structures in response to changes in the tax code.

[9]Note that we disregard the possibility of issuing new equity.

[10]Note that since we disregard inflation, inventories are not depreciable, i.e., $A^E_{invent,ct} = A^D_{invent,ct} = 0 \; \forall \; c, t$ (see Hanappi, 2018).

[11]The sum of the asset weights equals one for each country-industry pair, i.e., $\sum_{\text{all } a} w_{aci} = 1$.

The procedures to obtain w_{aci} as well as ES_{ci} and DS_{ci} are explained in greater detail in Section 3.4.

Finally, using (3.2.3), we obtain country-year-industry-specific EMTRs,

$$EMTR_{cit} = \frac{(\tau_{ct} - \tau_{ct}\delta_{cit})}{(1 - \tau_{ct}\delta_{cit})}, \tag{3.2.4}$$

as well as EATRs,

$$EATR_{cit} = \frac{R^*_{cit} - R_{cit}}{p/(1+i)} = \frac{\tau_{ct}(p - i\delta_{cit})}{p}. \tag{3.2.5}$$

Note that we introduced the subscripts c and t to the statutory tax rate τ_{ct} to indicate country and year, respectively. The formulas (3.2.4) and (3.2.5) are used to calculate the EMTRs and EATRs in Section 3.5.

3.3 Data

Throughout this paper, we use data from a total of five different databases to calculate and impute country-industry-specific financing and asset weights (see Section 3.4), calculate FLETRs (see Section 3.5), and estimate semi-tax-elasticities of investment (see Section 3.6). In the following, we briefly describe the databases, which data they provide, and how we use the data for our purposes.

3.3.1 RSIT International Tax Institutions (ITI) database

The statutory corporate tax regime data that we use to calculate FLETRs is taken from the Research School of International Taxation's (RSIT) *International Tax Institutions (ITI)* database (Merlo et al., 2022). More precisely, we use the data on statutory corporate tax rates (τ_{ct}) as well as NPVs of depreciation allowances for the six asset categories *Buildings, Machinery, Office equipment, Computer equipment, Intangible fixed assets,* and *Vehicles* for both investments financed purely through retained earnings (A^E_{act}) and debt (A^D_{act}). This panel includes 3,954 year-specific data points that span over a total of 221 countries over the years 2001 to 2020.[12] Additionally, we retrieve the count variable of the number of double taxation treaties that a country has in a given year ($NDTT_{ct}$) from the *ITI* database which serves as a control variable in the estimation

[12]For a detailed description of the dataset and data sources, see Merlo et al. (2022).

of the semi-tax-elasticity of investment.

3.3.2 EUKLEMS & INTANProd

The country-industry-specific asset weights that we derive in this paper are – with the exception of the asset type inventory – based on the 2021 release of the *EUKLEMS & INTANProd* database provided by the Luiss Lab of European Economics. For our purpose, we use the net capital stocks at current replacement costs in million units of the respective national currency that the database provides at the NACE Rev. 2 (ISIC Rev. 4) section level.[13] In detail, we retrieve the capital stock variables for *Dwellings, Other buildings and structures, Computer hardware, Research and development, Computer software and databases, Other machinery equipment and weapon systems, Telecommunications equipment*, and *Transport equipment*. Note that these asset categories, which are based on the European System of Accounts (ESA) 2010, do not directly match the ones for which the *ITI* database provides the depreciation allowances which we use for the calculation of the FLETRs. In Section 3.4.2, we therefore regroup the ESA 2010 based variables from *EUKLEMS & INTANProd*. In total, we obtain industry-specific net stock values of all considered asset categories for 18 EU countries, as well as for the UK, Japan, and the US.[14] The data coverage ranges from 1995 to 2019, though 2019 is scarcely covered. With the exception of Japan and the US, data for 19 NACE Rev. 2 (ISIC Rev. 4) sections is provided.[15]

3.3.3 Orbis

For our firm-level analysis of the semi-tax-elasticity of investment in Section 3.6, we use Bureau van Dijk's *Orbis* database. *Orbis* contains yearly balance sheet and income statement information as well as general information on the firm-entities, such as industry affiliation, year of incorporation, and ownership structure. The variable preparation and sample selection for the purpose of the investment elasticity estimation is detailed in Section 3.6.2.

[13]For the descriptions of all sections see Table 3.A.3. Note that since NACE Rev. 2 was created based on ISIC Rev. 4, these two classification systems are identical at the section level.

[14]Note that since we in Section 3.4.2 obtain asset weights by summing up all capital stock variables and then taking shares, we only consider observations for which all variables are non-missing.

[15]Note that the sections T and U are not covered in the *EUKLEMS & INTANProd* database. For Japan, additionally the sections M and N are not covered and for the US the sections D, E, and O. For the descriptions of all sections see Table 3.A.3.

Furthermore, we aggregate *Orbis* information to obtain the financing structure and the weight of the asset type inventory at the country-industry level, both of which we need for the calculation of the FLETRs. More precisely, for the calculation of the financing structure (see Section 3.4.1), we retrieve the variables long-term debt ($LTDB_{jt}$, with j and t denoting firm-entity and year, respectively), other non-current liabilities ($ONCL_{jt}$), and total assets ($TOAS_{jt}$). The calculation of the inventory shares is based on the stocks of current assets (i.e., inventories) (INV_{jt}), tangible fixed assets ($TFAS_{jt}$), and intangible fixed assets ($IFAS_{jt}$),

3.3.4 World Development Indicators and Worldwide Governance Indicators

In our analysis of the semi-tax-elasticity of investment (see Section 3.6), we condition on a number of country-level factors that possibly influence investment behavior. Furthermore, we feed the matching algorithm for the imputation of missing financing and asset weights with country-level variables (Section 3.4.3). Our sources for the country-level controls are the World Bank's *World Development Indicators (WDI)* and *Worldwide Governance Indicators (WGI)* databases.

From the *WDI* database, we retrieve the GDP measures GDP in constant PPP US$ (GDP_{ct}), GDP per capita in constant PPP US$ ($GDP\ p.c._{ct}$), and GDP growth ($GDP\ growth_{ct}$). Additional variables taken from the *WDI* are inflation ($Inflation_{ct}$) and domestic credit to the private sector in percent of a country's GDP ($DCPS_{ct}$).

From the *WGI* database, we use the *Rule of Law* indicator (ROL_{ct}), which captures "perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence" and the *Control of Corruption* variable ($Corruption_{ct}$) that measures "the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests" (Kaufmann et al., 2011, p. 223).[16] Note that both measures are varying in an interval of -2.5 to 2.5. The Worldwide Governance indicators are defined such that a higher value corresponds to better governance, i.e., a higher value of $Corruption_{ct}$ indicates less corruption

[16]Note that since the *WGI* database was only updated biennially between 1996 and 2002, we impute the missing 2001 values by taking the mean of the respective variables of the years 2000 and 2002.

(Kaufmann et al., 2011).

3.3.5 Eora Global Supply Chain Database

Finally, we retrieve a set of industry-specific variables from the *Eora26* database, which is part of the *Eora Global Supply Chain* database (Lenzen et al., 2012, 2013). These variables are solely used for imputing financing and asset weights (see Section 3.4.3). Note that the *Eora26* database is depicted using an industry classification system that is different from the NACE Rev. 2 (ISIC Rev. 4) classification that we use throughout this paper. Therefore, in 3.A.2, we provide information on how we convert the *Eora26* classification along with general information on the structure of the database.

The industry-specific variables that we then retrieve from the *Eora26* database are (all variables are provided in basic prices in 1000 current year US$): Gross output ($GO_{cit}$), gross input ($GI_{cit}$), compensation of employees (COE_{cit}), net taxes on production (calculated as difference between taxes on production and subsidies on production) ($net\ TOP_{cit}$), net operating surplus (NOS_{cit}), net mixed income (NMI_{cit}), and consumption of fixed capital ($COFC_{cit}$). Additionally, the *Eora26* database records sector-specific information on greenhouse gas emissions associated with production (Kanemoto et al., 2014, 2016). For our purpose, we retrieve the variable total CO_2 emissions in gigagrams ($CO2_{cit}$). In total, all variables are covered for 189 countries over the time span 1990 to 2016.

3.4 Calculating Country-Industry-Specific Weights

In this section, we detail how we calculate the country-industry-specific financing weights (i.e., the DS_{ci}'s and ES_{ci}'s) and asset weights (i.e., the w_{aci}'s) that are needed to compute the country-year-industry-specific EMTRs and EATRs that we use for the estimation of the semi-tax-elasticity of investment. More precisely, the industry levels we distinguish are the NACE Rev. 2 (ISIC Rev. 4) *sections*.[17]

The derivation of the weights is undertaken in two steps. First, we compute (or impute) country-year-industry-specific weights for years within the time horizon for

[17] Note that we can only calculate weights and therefore FLETRs for 19 of the 21 sections. We cannot calculate weights for the sections *T activities of households as employers; undifferentiated goods- and services-producing activities of households for own use* and *U activities of extraterritorial organisations and bodies* due to lack of data.

which we want to calculate the FLETRs.[18] Second, we obtain the final time-constant weights by taking averages over all year-specific weights belonging to a certain country-industry-combination.

Depending on the respective data availability, a certain country-industry-specific weight may either be obtained (i) directly from data, (ii) by imputation using a matching algorithm, or (iii) by imputation using weights from countries in geographical proximity. The preferred approach is (i). Approach (ii) is only implemented in the case where (i) does not yield a single year-specific weight. Approach (iii) is used only when also approach (ii) does not yield a single year-specific weight due to lack of data for matching. Note that by requiring an approach to only yield a minimum of one year-specific data point, we obtain final time-constant weights that are averages over varying numbers of years. We think that more year-specific data points are generally helpful to capture the typical financing or asset composition of a country-industry-combination in the considered time span. However, our reason for not combining the different approaches to maximize the number of year-specific observations is that we perceive having possibly few but very precise yearly weights preferable to having a larger number of yearly weights out of which some are imputed with less precision.

3.4.1 Financing Structure

For the derivation of the country-industry-specific financing structures, we start by calculating debt ratios at the firm-entity level using data from *Orbis*. Following Steinmüller et al. (2019), we define the debt ratio of firm-entity j in year t, DS_{jt}, as long-term debt over total assets.[19] More specifically, we calculate long-term debt as the sum of the variables long-term debt ($LTDB_{jt}$) and other non-current liabilities ($ONCL_{jt}$).[20] Formally, we get

$$DS_{jt} = \frac{LTDB_{jt} + ONCL_{jt}}{TOAS_{jt}}. \tag{3.4.1}$$

[18]Note that we generally only consider data for the years 2001 to 2018 for the calculation of the weights. The year 2001 is chosen as first year as it is also the first year for which we calculate FLETRs. The year 2018 is the latest year for which capital stock information from the *EUKLEMS & INTANProd* is available on a broad basis.

[19]Steinmüller et al. (2019) argue that only long-term debt can be harnessed to finance investment projects and is therefore the relevant measure to be considered when assessing an entity's investment opportunities, even if it underestimates its actual (total) debt ratio.

[20]Note that we exclude observations with non-positive total assets and set ratios that are negative due to negative long-term debt equal to zero. As we do not allow weights to exceed unity, we set debt ratios exceeding unity to unity.

We proceed by aggregating the entity-level data points from (3.4.1) to the final country-industry-specific debt shares in two steps. First, we create year-specific debt shares for country c and industry i, DS_{cit}, by taking unweighted means over all firm-entities belonging to a given country-year-industry bin. Note that to obtain meaningful values, we set the minimum number of firm-entities per bin to five. Second, we obtain the final time-constant debt shares, DS_{ci}, by taking unweighted means over all available year-specific debt shares, DS_{cit}, corresponding to the given country-industry pair. Respective equity shares are then obtained by subtracting these debt shares from unity, i.e., $ES_{ci} = 1 - DS_{ci}$.

3.4.2 Asset Structure

For the calculation of the country-industry-specific asset weights, we use data from two different sources. For the asset categories *Buildings, Machinery, Office equipment, Computer equipment, Intangible fixed assets,* and *Vehicles*, we use data from the *EUKLEMS & INTANProd* database. Information on the asset category *Inventory* is retrieved from *Orbis*. Since the coverage of these two data sources differs, we first calculate time-constant asset weights using only the *EUKLEMS & INTANProd* data without taking inventory into account, i.e., the weights for *Buildings, Machinery, Office equipment, Computer equipment, Intangible fixed assets,* and *Vehicles* initially sum up to unity without inventory. Then, we determine time-constant inventory weights and rescale the weights of the other asset types such that the weights of all assets – including inventory – add up to unity. The advantage of separating the calculations this way is that we are not limiting the data usage to years that are covered by both sources, but instead are able to use all available information.

As noted in the data section above, we need to regroup the capital stock variables that we retrieve from *EUKLEMS & INTANProd* to match the ones that we distinguish for the calculation of the FLETRs. This regrouping is detailed in Table 3.A.1. Next, for each country-year-industry combination, we sum up the six asset stock figures and take shares for the individual asset types. We denote these weights by w^*_{acit}, with a, c, i, and t denoting asset type, country, industry, and year respectively. The superscript asterisk indicates that the weights are not yet re-scaled with the inventory share. We then obtain the respective time-constant, country-industry-specific weights, w^*_{aci}, by taking unweighted means over all available year-specific weights w^*_{acit}.

For the calculation of the inventory shares we follow Egger et al. (2009) and Egger and Loretz (2010) who define the firm-entity j-specific inventory share in year t as

$$w_{\text{invent},jt} = \frac{INV_{jt}}{TFAS_{jt} + IFAS_{jt} + INV_{jt}}, \tag{3.4.2}$$

where $TFAS_{jt}$, $IFAS_{jt}$, and INV_{jt} denote tangible fixed assets, intangible fixed assets, and stocks of current assets (i.e., inventories), respectively. The aggregation to country-year-industry-specific inventory weights, $w_{\text{invent},cit}$, and then the final time-constant weights, $w_{\text{invent},ci}$, is identical to the one used for the debt shares in Section 3.4.1.

Finally, we re-scale the time-constant asset weights obtained from *EUKLEMS & INTANProd* by multiplying each of them with the factor $(1-w_{\text{invent},ci})$. So, for instance, the final weights for the asset type *Buildings*, $w_{\text{build},ci}$, are obtained as $w_{\text{build},ci} = w^*_{\text{build},ci} \cdot (1 - w_{\text{invent},ci})$. This ensures that the sum over all seven asset types equals unity.

3.4.3 Imputation

Unfortunately, using the *Orbis* and *EUKLEMS & INTANProd* databases does not yield financing and asset structures for all country-industry combinations for which we intend to calculate FLETRs. Therefore, we implement an imputation strategy that matches observed weights from country-industry pairs that are covered in the data to those that are missing.

The matching algorithm that we use for the imputation is *Predictive Mean Matching* (PMM) (Little, 1988; Rubin, 1986). The PMM-based imputation of a single missing weight corresponding to country k, industry l, and year m, denoted by $y^{miss}_{c=k,i=l,t=m}$, is carried out as follows.[21] In a first step, we estimate a linear model, using all observations corresponding to the same industry l. Formally, this model can be written as

$$\boldsymbol{y}^{obs}_{c,i=l,t} = \boldsymbol{\beta}_{i=l}\boldsymbol{X}^{obs}_{c,i=l,t} + \boldsymbol{\varepsilon}^{obs}_{c,i=l,t}. \tag{3.4.3}$$

$\boldsymbol{y}^{obs}_{c,i=l,t}$ denotes the vector of all observed weights for industry l. $\boldsymbol{X}^{obs}_{c,i=l,t}$ denotes a matrix of covariates that are used for the matching (including a vector of ones, i.e., a constant is always included) and $\boldsymbol{\beta}_{i=l}$ denotes the corresponding coefficient vector. The model errors are collected in the vector $\boldsymbol{\varepsilon}^{obs}_{c,i=l,t}$. Estimating (3.4.3) yields the coefficient estimate vector $\widehat{\boldsymbol{\beta}}_{i=l}$ that is then used to form predictions for all complete cases that

[21] We follow the notation of Van Burren (2018).

were used to estimate (3.4.3), i.e.,

$$\widehat{\boldsymbol{y}}^{obs}_{c,i=l,t} = \widehat{\boldsymbol{\beta}}_{i=l}\boldsymbol{X}^{obs}_{c,i=l,t}. \tag{3.4.4}$$

Furthermore, $\widehat{\boldsymbol{\beta}}_{i=l}$ is used to calculate an estimate for the case we want to impute, i.e.,

$$\widehat{y}^{miss}_{c=k,i=l,t=m} = \widehat{\boldsymbol{\beta}}_{i=l}\boldsymbol{X}^{miss}_{c=k,i=l,t=m}, \tag{3.4.5}$$

with $\boldsymbol{X}^{miss}_{c=k,i=l,t=m}$ denoting the covariates for the missing observation. The missing weight $y^{miss}_{c=k,i=l,t=m}$ is imputed with the observed weight (the so-called donor), $y^{obs}_{c=o,i=l,t=p}$, for which

$$|\widehat{y}^{miss}_{c=k,i=l,t=m} - \widehat{y}^{obs}_{c=o,i=l,t=p}| \tag{3.4.6}$$

is minimal. We require the donor to be from the same industry that we are looking to impute (here industry l). However, the donor must not necessarily stem from the same year of the data point we are looking to impute, i.e., m and p in (3.4.6) may be different.[22]

An advantage that PMM holds over other so-called "hot deck" imputation methods, i.e., methods that use values observed elsewhere for imputation, is that the covariates are summarized into one matching metric using a weighting scheme, i.e., the $\widehat{\boldsymbol{\beta}}_i$, that reflects the importance of the different covariates for predicting financing and asset weights.[23] Another advantage of PMM is that it is implicit (Little and Rubin, 2019), i.e., there is no need to define an explicit model for the distribution of the missings. Instead, the only assumption that has to be invoked is that the distribution of a missing entry is identical to the observed data of the donor (Van Burren, 2018).

We first impute the financing weights. The dependent variable is the observed yearly debt share, which we get from Orbis, DS_{cit} (see Section 3.4.1). The country-level covariates used for the matching largely follow the ones used by Goldbach et al. (2021), and broadly aim at capturing the condition of a country's financial market, the

[22] Alternatively, instead of using just the donor for which the corresponding prediction is closest to the prediction of the missing data point, the mean of the d closest matches can be considered for imputation. As robustness check, we graphically provide imputation results for $d = 5, 10$, and 15 in 3.A.3.

[23] In contrast, for instance with the widely used k-Nearest Neighbor (k-NN) matching, all included covariates are assigned the same importance for finding a match (Hastie et al., 2009). In 3.A.3, we provide graphical evidence, using k-NN for imputation and compare the results to the ones obtained using PMM.

strength of its institutions, as well as its overall economic development. More specifically, we control for the *Rule of Law* indicator (ROL_{ct}), the *Control of Corruption* indicator ($Corruption_{ct}$), the logarithm of the variable measuring domestic credit provided to the private sector relative to a country's GDP ($log\ DCPS_{ct}$), annual inflation ($Inflation_{ct}$), as well as GDP growth ($GDP\ growth_{ct}$). Furthermore, we include the statutory tax rate τ_{ct} as a proxy for the generosity of a country's corporate tax code. Additionally, we condition on a set of country-industry-level variables to account for the size and characteristics of industries. These variables are the logarithm of gross output ($log\ GO_{cit}$), gross input ($log\ GI_{cit}$), compensation of employees ($log\ COE_{cit}$), net operating surplus ($log\ NOS_{cit}$), net mixed income ($log\ NMI_{cit}$), paid net taxes on production ($log\ net\ TOP_{cit}$), and consumption of fixed capital ($log\ COFC_{cit}$). Finally, we include year indicators to control for year-specific effects that are common to all countries. Descriptive statistics of the matching covariates are presented in Table 3.A.4, Panel A. Note that we can only impute yearly financing weights for the years 2001 to 2016, as 2016 is the last year for which the industry-specific matching covariates are available.

Once we have imputed the yearly debt ratios, DS_{cit}, for country-industry combinations that are not covered in *Orbis*, we proceed to compute time-constant debt and retained earnings shares as described in Section 3.4.1.

Next, we proceed to impute the asset weights. As discussed above in Section 3.4.2, we calculate the asset weights for inventory and the six other asset types separately using two different databases with different coverage. As a result, in many cases, we only need to impute the inventory share or the composition of the other asset types, but not both. To optimally use all available data and to be able to sensibly combine imputed and observed asset weights into one structure, we disregard inventory when imputing the asset categories *Buildings*, *Machinery*, *Office equipment*, *Computer equipment*, *Intangible fixed assets*, and *Vehicles*. That is, we use the yearly weights derived from the *EUKLEMS & INTANProd* database that have not yet been rescaled with the inventory share (denoted by w^*_{acit} in Section 3.4.2). By construction, these w^*_{acit}'s add up to unity in each year for a given country-industry combination. For the imputed equivalents, however, this is not necessarily the case, as different donors may be drawn for each asset type. We therefore rescale the imputed w^*_{acit}'s such that they add up to unity at the year level for each country-industry combination. Thereafter, the derivation of the final time-constant asset structures is identical to the procedure described in Section 3.4.2.

For the imputation of the asset weights, we again use a combination of country-specific and country-industry-specific covariates to control for market size and conditions, economic development, as well as the industry-specific structure of primary inputs and production.[24] At the country level, we control for the logarithm of GDP ($log\ GDP_{ct}$) and GDP per capita ($log\ GDP\ p.c._{ct}$). At the industry level, we control for the logarithm of the compensation of employees ($log\ COE_{cit}$), the net operating surplus ($log\ NOS_{cit}$), the net mixed income ($log\ NMI_{cit}$), the consumption of fixed labour ($log\ COFC_{cit}$), as well as the logarithm of CO_2 emissions ($log\ CO2_{cit}$). Finally, we control for year-specific effects by including time dummies. Descriptive statistics of the covariates used for the matching of asset weights are presented in Table 3.A.4, Panel B. Again, note that we can only impute yearly weights for the years 2001 to 2016 due to covariate coverage.

Due to a lack of data on covariates, missing financing structures in 54 countries and asset structures in 56 countries cannot be imputed using the PMM procedure. In order to calculate FLETRs for these countries, they are assigned the time-constant observed and/or PMM-imputed weights of their geographical neighbors. For instance, San Marino is assigned the weights from Italy and Andorra is assigned the mean of the weights of France and Spain. More than half of the countries that we are missing are small islands in the Caribbean region or Oceania. In these cases, missing asset and/or financing weights are replaced by the region-specific mean of all non-missing weights. The exact imputation using geographically close countries is detailed in Table 3.A.5.

3.4.4 Descriptive Statistics of Asset and Financing Weights

Table 3.4.1 presents summary statistics of the time-constant, country-industry-specific financing and asset structures that we use for the calculation of the FLETRs. The summary statistics are grouped by the approaches that were used to obtain the weights. Panel A only depicts information on weights that are directly derived from the primary data sources. The Panels B and C describe weights that were imputed using the PMM procedure or values from geographically proximate countries, respectively.

A key result that holds for each panel is that there is substantial variation between the mean values of the debt ratios and in particular the asset weights of the different industries. Intuitively, this heterogeneity seems plausible. For instance, the section *C manufacturing* exhibits a noticeably higher share of *machinery* in its mean asset com-

[24]Note that we use the same covariates for the imputation of each asset type.

Table 3.4.1: *Descriptives on Imputed Country-Industry-Specific Financing and Asset Weights*

Panel A: Weights derived directly from data sources

	DS_{ci}	$w_{\text{build},ci}$	$w_{\text{comp},ci}$	$w_{\text{ifas},ci}$	$w_{\text{mach},ci}$	$w_{\text{office},ci}$	$w_{\text{vehic},ci}$	$w_{\text{invent},ci}$
A	22.2 (0.123)	51.6 (0.116)	0.2 (0.002)	0.5 (0.007)	18.7 (0.088)	0.3 (0.007)	5.0 (0.030)	26.4 (0.096)
B	21.9 (0.113)	47.7 (0.148)	0.3 (0.003)	1.9 (0.020)	28.3 (0.135)	0.5 (0.009)	2.9 (0.025)	21.0 (0.089)
C	18.3 (0.105)	24.4 (0.102)	0.5 (0.003)	10.9 (0.086)	25.5 (0.057)	0.6 (0.008)	1.4 (0.007)	37.4 (0.102)
D	29.5 (0.151)	64.9 (0.166)	0.3 (0.002)	1.7 (0.022)	23.9 (0.135)	0.9 (0.015)	0.8 (0.011)	11.6 (0.107)
E	22.3 (0.137)	73.0 (0.100)	0.2 (0.002)	0.9 (0.008)	9.8 (0.075)	0.4 (0.007)	1.9 (0.010)	16.5 (0.102)
F	18.5 (0.128)	35.6 (0.115)	0.7 (0.006)	1.8 (0.021)	18.8 (0.096)	0.5 (0.005)	9.7 (0.048)	33.2 (0.145)
G	16.1 (0.111)	29.1 (0.066)	0.9 (0.006)	2.6 (0.021)	10.2 (0.031)	0.6 (0.006)	4.5 (0.024)	54.3 (0.129)
H	22.7 (0.125)	56.3 (0.140)	0.4 (0.002)	1.3 (0.015)	7.4 (0.042)	0.9 (0.010)	26.8 (0.143)	9.8 (0.077)
I	26.6 (0.153)	59.9 (0.096)	0.7 (0.006)	1.3 (0.023)	15.4 (0.073)	1.1 (0.011)	2.5 (0.024)	18.8 (0.142)
J	18.3 (0.121)	40.9 (0.136)	3.1 (0.022)	15.1 (0.103)	10.1 (0.065)	11.1 (0.093)	3.3 (0.082)	18.2 (0.099)
K	21.3 (0.128)	54.4 (0.188)	3.9 (0.025)	15.4 (0.114)	8.0 (0.063)	1.7 (0.027)	4.4 (0.047)	11.8 (0.096)
L	29.0 (0.164)	85.9 (0.080)	0.0 (0.001)	0.1 (0.001)	0.4 (0.005)	0.0 (0.001)	0.1 (0.002)	18.1 (0.144)
M	17.6 (0.117)	36.8 (0.128)	3.1 (0.026)	27.9 (0.152)	11.4 (0.041)	1.7 (0.024)	4.4 (0.017)	16.9 (0.091)
N	19.8 (0.116)	28.5 (0.144)	2.1 (0.014)	4.5 (0.061)	19.1 (0.082)	2.3 (0.029)	30.7 (0.131)	15.7 (0.087)
O	19.7 (0.155)	76.0 (0.087)	0.5 (0.003)	1.9 (0.012)	8.0 (0.066)	0.3 (0.003)	1.7 (0.021)	14.9 (0.107)
P	19.7 (0.142)	68.1 (0.136)	0.8 (0.005)	14.3 (0.104)	5.4 (0.032)	0.5 (0.006)	0.8 (0.007)	10.1 (0.080)
Q	21.6 (0.135)	66.1 (0.139)	1.1 (0.009)	4.1 (0.040)	17.7 (0.103)	1.0 (0.018)	1.7 (0.007)	11.7 (0.077)
R	24.5 (0.162)	68.7 (0.143)	1.1 (0.010)	3.0 (0.038)	12.6 (0.119)	1.5 (0.018)	1.7 (0.016)	12.4 (0.079)
S	22.2 (0.164)	50.7 (0.100)	1.5 (0.016)	4.9 (0.069)	12.1 (0.075)	1.2 (0.017)	3.8 (0.028)	25.6 (0.127)
Obs	1,278	394	394	394	394	394	394	1,261

Panel B: Weights imputed using PMM

	DS_{ci}	$w_{\text{build},ci}$	$w_{\text{comp},ci}$	$w_{\text{ifas},ci}$	$w_{\text{mach},ci}$	$w_{\text{office},ci}$	$w_{\text{vehic},ci}$	$w_{\text{invent},ci}$
A	13.6 (0.065)	33.7 (0.108)	0.2 (0.001)	2.3 (0.013)	30.4 (0.080)	2.5 (0.013)	4.4 (0.025)	26.1 (0.050)
B	14.8 (0.059)	57.9 (0.085)	0.3 (0.003)	1.3 (0.011)	13.6 (0.082)	0.5 (0.010)	2.3 (0.016)	25.0 (0.045)
C	13.1 (0.039)	33.0 (0.057)	0.6 (0.004)	1.7 (0.034)	24.3 (0.041)	0.9 (0.009)	2.4 (0.005)	36.5 (0.026)
D	15.6 (0.067)	64.0 (0.071)	0.2 (0.002)	1.3 (0.007)	19.5 (0.053)	0.3 (0.010)	0.5 (0.006)	14.6 (0.037)
E	7.3 (0.063)	65.9 (0.106)	0.4 (0.003)	0.8 (0.007)	12.6 (0.081)	0.4 (0.008)	3.1 (0.010)	16.8 (0.059)
F	11.2 (0.062)	40.7 (0.092)	0.7 (0.003)	1.1 (0.009)	17.9 (0.052)	0.3 (0.004)	7.2 (0.048)	31.9 (0.037)
G	11.1 (0.044)	27.3 (0.060)	0.4 (0.006)	1.2 (0.015)	8.7 (0.037)	0.8 (0.003)	4.4 (0.015)	58.7 (0.046)
H	14.0 (0.066)	52.4 (0.121)	0.4 (0.001)	0.4 (0.004)	4.7 (0.024)	0.6 (0.005)	27.1 (0.142)	16.1 (0.065)
I	12.4 (0.084)	56.4 (0.092)	0.4 (0.004)	1.0 (0.013)	14.7 (0.060)	2.4 (0.010)	1.8 (0.010)	25.0 (0.052)
J	7.7 (0.039)	42.4 (0.104)	1.5 (0.017)	8.4 (0.049)	9.5 (0.054)	8.4 (0.049)	3.6 (0.074)	29.5 (0.096)
K	12.0 (0.054)	29.2 (0.202)	6.8 (0.046)	28.0 (0.162)	9.7 (0.034)	5.2 (0.067)	8.8 (0.064)	12.6 (0.071)
L	13.2 (0.099)	72.5 (0.145)	0.0 (0.001)	0.2 (0.003)	1.2 (0.008)	0.1 (0.001)	0.2 (0.001)	28.7 (0.129)
M	6.7 (0.052)	48.9 (0.113)	1.4 (0.023)	12.4 (0.117)	13.5 (0.041)	2.2 (0.031)	3.3 (0.017)	18.7 (0.054)
N	9.2 (0.054)	44.4 (0.119)	2.1 (0.010)	1.8 (0.013)	16.5 (0.064)	2.7 (0.029)	14.1 (0.113)	19.1 (0.078)
O	7.4 (0.074)	68.6 (0.089)	0.7 (0.003)	0.7 (0.008)	11.6 (0.079)	0.3 (0.005)	1.8 (0.028)	16.0 (0.050)
P	9.8 (0.064)	70.9 (0.091)	1.7 (0.006)	9.9 (0.091)	6.4 (0.027)	0.7 (0.004)	0.8 (0.004)	9.4 (0.040)
Q	9.2 (0.048)	39.8 (0.179)	1.7 (0.008)	4.5 (0.032)	37.2 (0.177)	2.9 (0.018)	2.3 (0.007)	11.0 (0.070)
R	7.4 (0.072)	52.2 (0.141)	1.5 (0.009)	2.0 (0.014)	24.0 (0.120)	1.9 (0.024)	6.7 (0.040)	11.4 (0.053)
S	10.1 (0.088)	41.3 (0.113)	0.9 (0.007)	1.7 (0.029)	12.0 (0.073)	1.0 (0.006)	7.6 (0.033)	38.7 (0.112)
Obs	1,961	2,741	2,741	2,741	2,741	2,741	2,741	1,930

Panel C: Weights imputed using values of geographically proximate countries

	DS_{ci}	$w_{\text{build},ci}$	$w_{\text{comp},ci}$	$w_{\text{ifas},ci}$	$w_{\text{mach},ci}$	$w_{\text{office},ci}$	$w_{\text{vehic},ci}$	$w_{\text{invent},ci}$
A	18.0 (0.067)	39.7 (0.096)	0.1 (0.001)	2.1 (0.008)	26.8 (0.055)	2.2 (0.010)	4.6 (0.013)	24.3 (0.058)
B	19.6 (0.060)	58.4 (0.060)	0.3 (0.001)	1.2 (0.012)	15.9 (0.055)	0.3 (0.001)	1.4 (0.010)	22.5 (0.047)
C	15.7 (0.060)	30.3 (0.061)	0.6 (0.002)	4.0 (0.060)	24.3 (0.031)	0.7 (0.004)	2.2 (0.005)	37.8 (0.043)
D	24.0 (0.096)	62.1 (0.078)	0.3 (0.001)	1.6 (0.017)	21.1 (0.070)	0.5 (0.009)	0.7 (0.008)	13.8 (0.039)
E	15.1 (0.081)	70.8 (0.080)	0.3 (0.002)	0.7 (0.005)	10.0 (0.055)	0.2 (0.003)	2.2 (0.007)	15.0 (0.057)
F	16.3 (0.068)	42.6 (0.076)	0.6 (0.002)	1.0 (0.008)	15.3 (0.028)	0.4 (0.002)	7.5 (0.029)	31.9 (0.053)
G	14.9 (0.060)	25.9 (0.034)	0.5 (0.003)	1.5 (0.011)	8.7 (0.020)	0.7 (0.002)	4.4 (0.008)	58.3 (0.060)
H	18.2 (0.071)	46.7 (0.088)	0.4 (0.001)	0.7 (0.006)	6.2 (0.026)	0.6 (0.004)	34.0 (0.102)	11.4 (0.049)
I	18.0 (0.097)	57.3 (0.060)	0.5 (0.002)	0.9 (0.010)	16.2 (0.035)	1.9 (0.006)	2.0 (0.006)	21.2 (0.068)
J	12.4 (0.067)	42.2 (0.073)	3.0 (0.016)	10.3 (0.078)	9.4 (0.028)	9.6 (0.043)	3.1 (0.020)	22.4 (0.067)
K	18.6 (0.065)	28.4 (0.162)	9.4 (0.037)	32.7 (0.128)	10.4 (0.037)	3.4 (0.024)	6.0 (0.040)	9.6 (0.053)
L	22.9 (0.096)	76.7 (0.103)	0.1 (0.000)	0.2 (0.001)	1.2 (0.005)	0.0 (0.001)	0.2 (0.001)	21.2 (0.083)
M	12.7 (0.068)	44.9 (0.076)	1.6 (0.014)	19.4 (0.114)	13.7 (0.034)	1.5 (0.011)	3.2 (0.007)	15.5 (0.049)
N	15.2 (0.064)	41.1 (0.092)	2.2 (0.005)	2.3 (0.019)	18.9 (0.052)	2.4 (0.012)	17.5 (0.096)	15.5 (0.058)
O	11.4 (0.057)	68.6 (0.050)	0.6 (0.002)	1.4 (0.008)	11.2 (0.042)	0.2 (0.003)	1.8 (0.015)	16.2 (0.049)
P	13.2 (0.074)	68.8 (0.052)	1.5 (0.004)	13.9 (0.057)	6.1 (0.014)	0.7 (0.003)	0.9 (0.003)	8.3 (0.034)
Q	14.7 (0.080)	42.8 (0.133)	1.8 (0.006)	4.5 (0.015)	36.9 (0.104)	2.3 (0.009)	2.4 (0.005)	9.1 (0.049)
R	14.2 (0.095)	54.1 (0.109)	1.5 (0.005)	2.0 (0.009)	23.8 (0.085)	1.7 (0.010)	6.0 (0.025)	10.7 (0.038)
S	15.0 (0.086)	43.4 (0.066)	1.3 (0.007)	3.0 (0.045)	12.9 (0.034)	1.0 (0.008)	6.1 (0.021)	32.2 (0.084)
Obs	960	1,064	1,064	1,064	1,064	1,064	1,064	1,008

The table depicts means (expressed in %) and standard deviations (in brackets) of the financing and asset weights by NACE Rev. 2 (ISIC Rev. 4) sections. Panel A depicts weights that are derived directly from data sources (see Sections 3.4.1 and 3.4.2). Panels B and C depict weights that are imputed using PMM with $d = 1$ donor and weight values of geographically proximate countries, respectively (see Section 3.4.3). The last row of each panel gives the number of the country-industry-specific weights across all industries. Descriptions for the different NACE Rev. 2 (ISIC Rev. 4) sections are provided in Table 3.A.3.

position than the service industries, e.g., *P education*. Additionally, there is substantial variation in every weight within each industry, irrespective of the method that was used to derive it, as indicated by the standard deviations. The fact that the variation is strong not only for the weights derived directly from the data but also for the PMM imputed weights (Panel B) indicates that for the latter approach a wide range of observed values was drawn for the matching.[25] Overall, the strong variation both between and within industries corroborates our approach of estimating country-industry-specific financing and asset compositions for the calculation of FLETRs. Conversely, assuming symmetric asset and financing structures across all countries and industries, as done by most of the previous literature, most likely leads to imprecise tax measures and introduces additional measurement error. We finally provide a number of plausibility checks, looking at single data points, in 3.A.3.

3.5 Country-Year-Industry-Specific FLETRs

In this section, we calculate and describe the new country-year-industry-specific EMTRs, using the time-constant, country-industry-specific asset and financing weights we have calculated and estimated in the previous section. In a first step, we compute the NPV of depreciation allowances, δ_{cit}, by plugging the asset shares, w_{aci}, as well as the financing shares, ES_{ci} and DS_{ci}, into (3.2.3). Then, we use δ_{cit} as well as the statutory tax rate τ_{ct} in (3.2.4) and (3.2.5) to obtain country-year-industry-specific EMTRs and EATRs.

For the sake of comparison, we additionally calculate EMTRs that are based on symmetric asset and financing weights for all countries and industries as commonly done in the existing literature. More precisely, we use the asset composition that is used by Steinmüller et al. (2019) to match the asset types that are also used in the paper at hand.[26] We denote the EMTRs and NPVs of depreciations allowances based on these symmetric weights as $EMTR_{ct}$ and δ_{ct}, respectively.

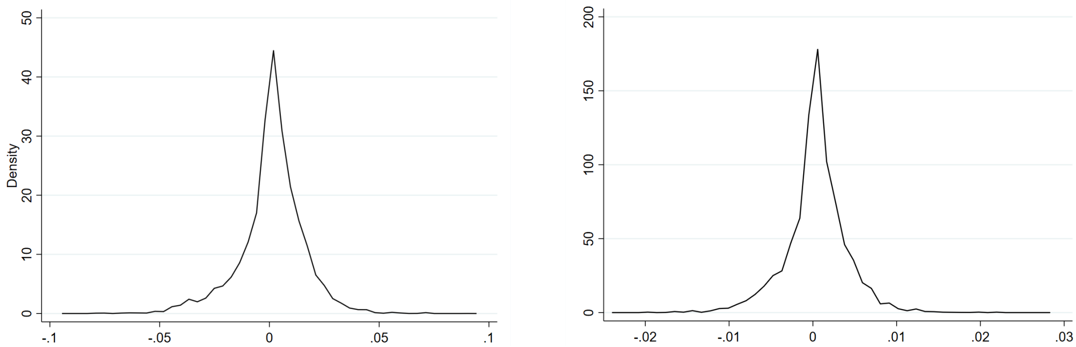
Figure 3.5.2 suggests that the country-year-industry-specific FLETRs follow, on average, the same downward trend as their country-year-specific counterparts. How-

[25] In 3.A.3, we illustrate graphically that this result is robust to increasing the number of donors considered for the imputation of a single year-specific data point.

[26] In detail, the asset structure is composed as follows: *buildings* 38%, *computer equipment* 2%, *intangible fixed assets* 11%, *inventory* 26%, *machinery* 2%, *office equipment* 1%, *vehicles* 2%. The debt-financing share and the equity-financing share are assumed to amount to 1/3 and 2/3, respectively (Steinmüller et al., 2019).

Figure 3.5.1: *Distribution of Deviations from the Country-Year FLETRs*

(a) *EMTR* (b) *EATR*



The figure depicts the distribution of the differences between county-year-industry-specific and country-year-specific FLETRs. The distribution is calculated using a triangle kernel with a bandwidth 0.0007.

ever, there is substantial variation in the average FLETRs across industries implying that the country-year-specific average FLETRs significantly over-/underestimate the tax burden for certain industries. For example firms operating in construction, wholesale and retail, as well as manufacturing face the highest average FLETRs due to their relatively large asset shares of inventories and buildings. On the other hand, firms engaged in arts and entertainment, financial and insurance activities, as well as health and social work face the lowest effective tax burden due to their comparatively low inventory share.[27]

Figures 3.5.3 and 3.5.4 illustrate that the country-year-industry-specific FLETRs generally exhibit a similar distribution as the country-year-specific FLETRs. Nevertheless, the right panel of both figures indicates that the distribution of country-year-industry-specific FLETRs includes more high-tax observations and positive outliers. In contrast to the the left panel of both figures, the positive outliers never disappear, indicating that industry-specific asset and financing weights have a substantial impact on the FLETR level a firm faces.

To further explore the heterogeneity from using country-year-industry-specific FLETRs, we take the difference between the two levels of the FLETR measures ($FLETR_{ict} - FLETR_{ct}$) and plot the distribution of this difference in Figure 3.5.1. Looking at the EMTR in the left panel, we observe that the distribution is centered around zero implying that the country-year-industry-specific EMTRs are similar in magnitude to their country-year counterparts. However, we also find substantial deviations of more than 10 percentage points in both directions indicating that for some observations the country-year specification vastly under or overestimates the forward-looking tax bur-

[27]Note that inventories are not subject to depreciation as we disregard inflation.

Figure 3.5.2: *Development of Mean Country-Year and Country-Year-Industry-Specific FLETRs*

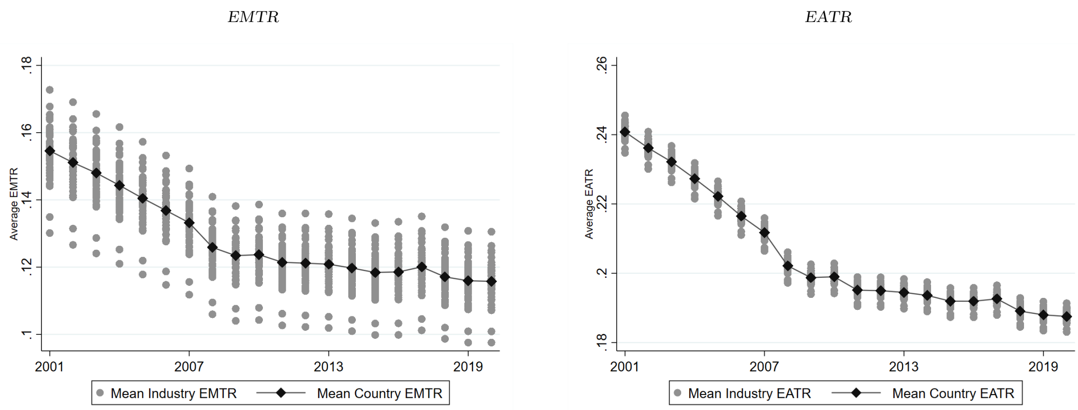
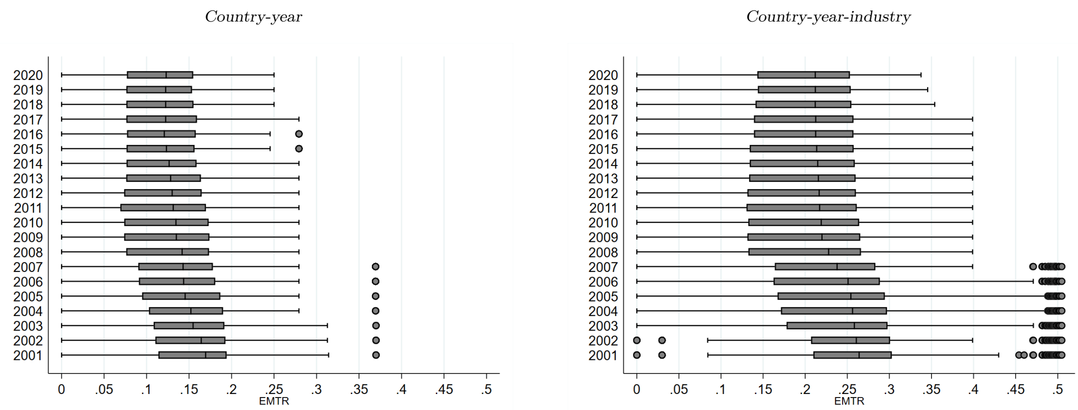
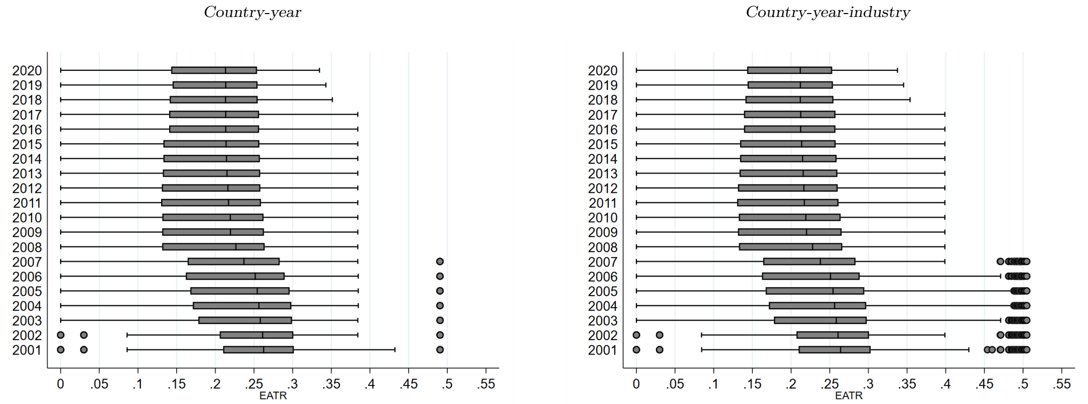


Figure 3.5.3: *Variation of Country-Year and Country-Year-Industry-Specific EMTRs*



den. Turning to the EATRs in the right panel of Figure 3.5.1, we find a similar pattern and distribution. The only difference between the EMTRs and EATRs is that the deviations for the latter are substantially smaller ranging between 3 percentage points below or above the country-year specification. This is due to mechanical differences in the calculation of the EATR in which the NPVs of depreciation allowances have a significantly smaller impact. Given the substantial differences between the country-year and country-year-industry FLETRs, disregarding country-industry-specific differences may lead to significant mismeasurement of the corporate tax incentives firms face. Additionally, calculating FLETRs on the country-year-industry level offers substantial heterogeneity that can be empirically exploited to identify the impact of corporate taxation on firm behavior.

Figure 3.5.4: *Variation of Country-Year and Country-Year-Industry-Specific EATRs*



3.6 Semi-Tax-Elasticity of Firms' Tangible Fixed Assets

3.6.1 Empirical Approach

In this section, we calculate the semi-tax-elasticity of investment, using the EMTRs calculated in Section 3.5. Following Steinmüller et al. (2019), we use the logarithm of firm-entity j's tangible fixed assets ($log\ TFAS_{jt}$) as dependent variable to capture real investment behavior. This outcome has been used regularly in the literature and is also common in studies examining the effect of (corporate) taxation on foreign investments. Note that we provide more discussion on measurement and empirical specification below. We implement the following linear estimation equation

$$log\ TFAS_{jt} = \gamma EMTR_{cit} + \boldsymbol{\psi X_{jt-1}} + \boldsymbol{\zeta X_{ct}} + \theta_t + c_j + \varepsilon_{jt}. \tag{3.6.1}$$

The subscripts j, c, i, and t denote the firm-entity, country, industry, and year of an observation, respectively. The coefficient γ measures the semi-elasticity of investment[28] with respect to the marginal tax rate, $EMTR_{cit}$. We control for a set of lagged affiliate-specific variables, denoted by $\boldsymbol{X_{jt-1}}$, and a set of country-specific variables, denoted by $\boldsymbol{X_{ct}}$, both of which are described in more detail below. The corresponding parameter estimates are contained in the vectors $\boldsymbol{\psi}$ and $\boldsymbol{\zeta}$, respectively. Furthermore, we control

[28]Note that we use "investment" in our micro-level panel data approach interchangeably for "investment in tangible fixed assets".

for year- and firm-entity-specific effects, which we denote by θ_t and c_j, respectively.[29] Finally, ε_{jt} denotes the error component.

3.6.2 Sample

The control variables that we use largely follow Steinmüller et al. (2019). At the firm-entity level (indicated by index j), we include the one-period lag of the logarithm of sales ($log\ SALES_{jt-1}$) and cost of employees ($log\ STAF_{jt-1}$). Additionally, we include three entity-level ratios proposed by Liu (2020) the cash flow rate ($CF\ rate_{jt}$), defined as the cash flow in year t divided by the sum of tangible and intangible fixed assets in $t-1$; the one period lag of the sales growth rate ($SALES\ growth_{jt-1}$), i.e., the sales growth rate from $t-2$ to $t-1$; and the one period lag of the profit margin ($Profit\ margin_{jt-1}$), with the profit margin in t being defined as $EBIT_{jt}/SALES_{jt}$. To minimize the influence of outliers, we winsorize all three ratio variables at the top and bottom 1 percentiles.[30]

At the country level, we control for host country c's GDP ($log\ GDP_{ct}$), GDP per capita ($log\ GDP\ p.c._{ct}$), and the GDP growth rate ($GDP\ growth_{ct}$) as proxies for market size, the state of a country's economic development, and the general economic situation, respectively. Additionally, we control for inflation ($Inflation_{ct}$) to capture investment risk. In particular, following the arguments in Aggarwal and Kyaw (2008), as well as Huizinga et al. (2008), countries with higher inflation usually exhibit a higher risk premium and higher general business risk. The variable domestic credit to private sector relative to a country's GDP ($log\ DCPS_{ct}$) is included as a measure for capital market depth. The corruption ($Corruption_{ct}$) and rule of law (ROL_{ct}) indicators capture the strength of institutions such as creditor rights. We finally control for the number of double taxation treaties ($NDTT_{ct}$) that a country has.

For our sample, we consider *Orbis* observations for the time span 2001, i.e., the first year for which we calculate FLETRs, to 2018, which is the last year for which all control variables are available. Following the literature (e.g., Steinmüller et al., 2019; Liu, 2020), we exclude a number of industries from our analysis.[31] We finally impose the requirement that a firm-entity must be observed at least twice in the sample period.

[29] Note also that we provide an extensive discussion on different types of fixed effects we might include in the estimations (see Section 3.6.4).

[30] The estimates on the $EMTR$ are not affected by this.

[31] In detail, these industries are denoted by the section codes A, B, K, O, P, Q, T, and U. For a description on these sections, see Table 3.A.3.

Descriptive statistics for our final sample of over 24 million observations as well as a correlation matrix for selected variables are provided in Table 3.6.1.

3.6.3 Basic Results

Table 3.6.2 presents the basic estimation results of the semi-tax elasticity of investment.[32] The results presented in columns (1) to (4) are based on the largest possible sample of more than 24 million observations with 4,787,866 individual firm entities in 70 countries.

Our benchmark specification in column (1) suggests an EMTR semi-elasticity of about -0.45, i.e., a 1 percentage point higher EMTR results in 0.45% less investment in tangible fixed assets. The corresponding elasticity equals -0.072 which is a moderate effect compared to the previous literature. Column (5) provides an interesting variation by taking the first difference of the EMTR as tax incentive variable. The estimate on $\Delta EMTR_{cit}$ suggests a semi-elasticity of about the same size compared to specification (1). Consequently, the effect of corporate taxation on investment appears to be independent of the EMTR level.

Column (2) illustrates that the effect of the EATR is not only smaller but also slightly less statistically significant. This result is in line with expectations as discrete investment decision are less responsive to changes in tax incentives in the short-run. Column (3) employs the statutory tax rate (τ_{ci}) as the respective tax measure, which neither accounts for tax base effects nor for appropriate asset and financing weights. While the coefficient is still negative and statistically significant, it is substantially smaller compared to the EMTR as base effects are neglected. Column (4) distinguishes between τ and the weighted δ – to distinguish between tax rate and tax base effects. The coefficients are both statistically significant and have the expected signs. An interesting finding here is that the corresponding elasticity for δ is relatively high (0.13).[33] Given these results, the newly calculated EMTRs capture tax incentives in the most appropriate way by incorporating both statutory tax policy changes and

[32] Note that we report robust standard errors that are clustered at the country-year-industry level, i.e., the level at which we merge the tax measures to the firm-entity-level data (Moulton, 1990).

[33] When including the EMTR and the statutory tax rate (or the EATR) at the same time, then the EMTR becomes slightly insignificant, but is still negative, while the other coefficients on the two tax measures are insignificant, positive and close to zero. Since the variation – especially the variation over time – in all tax measures is mainly driven by changes in statutory rules (which is, however, what we are mainly interested in), there is not sufficient distinct variation that allows us to properly identify the respective effects jointly.

Table 3.6.1: *Descriptives on Data Set Used for the Estimation of the Tax Elasticity of Corporate Investment*

Panel A: Tax measures

	Observations	Mean	(sd)
$EMTR_{cit}$	24,144,916	0.159	(0.063)
$EATR_{cit}$	24,144,916	0.234	(0.068)
τ_{ct}	24,144,916	0.266	(0.076)
δ_{cit}	24,144,916	0.475	(0.149)
$\Delta EMTR_{cit}$	17,922,758	-0.002	(0.014)

Panel B: Firm-entity level variables

	Observations	Mean	(sd)
$log\ TFAS_{jt}$	24,144,916	10.780	(2.462)
$log\ SALES_{jt-1}$	24,144,916	13.192	(1.889)
$log\ STAF_{jt-1}$	24,144,916	11.514	(1.938)
$CF\ rate_{jt}$	24,144,916	1.808	(11.006)
$SALES\ growth_{jt-1}$	24,144,916	0.278	(1.507)
$Profit\ margin_{jt-1}$	24,144,916	-0.025	(0.541)

Panel C: Country level variables

	Observations	Mean	(sd)
$log\ GDPct$	24,144,916	27.605	(1.146)
$log\ GDP\ p.c._{ct}$	24,144,916	10.475	(0.333)
$GDP\ growth_{ct}$	24,144,916	1.471	(2.408)
$Inflation_{ct}$	24,144,916	1.700	(2.338)
$log\ DCPS_{ct}$	24,144,916	4.450	(0.462)
$Corruption_{ct}$	24,144,916	0.779	(0.726)
ROL_{ct}	24,144,916	0.934	(0.591)
$NDTT_{ct}$	24,144,916	90.172	(22.611)

Panel D: Correlation matrix (24,144,916 observations)

	$log\ TFAS_{jt}$	$EMTR_{cit}$	$EATR_{cit}$	τ_{ct}	δ_{cit}
$log\ TFAS_{jt}$	1.000				
$EMTR_{cit}$	0.052	1.000			
$EATR_{cit}$	0.054	0.872	1.000		
τ_{ct}	0.051	0.792	0.989	1.000	
δ_{cit}	0.001	-0.496	-0.040	0.097	1.000

The table depicts descriptive statistics on all the variables used for the estimation of the tax elasticity of investment. Panel A reports descriptives on the different tax measures applied. Panel B reports descriptives on the firm-entitiy level variables. Panel C depicts Pearson correlation coefficients for key variables. Definitions of the variables are provided in Section 3.6.2.

Table 3.6.2: *Benchmark Estimates*

	(1)	(2)	(3)	(4)	(5)
$EMTR_{cit}$	-0.452***				
	(0.170)				
$EATR_{cit}$		-0.337**			
		(0.141)			
τ_{ct}			-0.282**	-0.289**	
			(0.124)	(0.124)	
δ_{cit}				0.270**	
				(0.115)	
$\Delta EMTR_{cit}$					-0.450***
					(0.114)
$log\ SALES_{jt-1}$	0.266***	0.266***	0.266***	0.266***	0.267***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$log\ STAF_{jt-1}$	0.087***	0.087***	0.087***	0.087***	0.095***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$CF\ rate_{jt}$	-0.004***	-0.004***	-0.004***	-0.004***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$SALES\ growth_{jt-1}$	-0.010***	-0.010***	-0.010***	-0.010***	-0.027***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
$Profit\ margin_{jt-1}$	-0.068***	-0.068***	-0.068***	-0.068***	-0.058***
	(0.003)	(0.0028)	(0.003)	(0.003)	(0.003)
$log\ GDP_{ct}$	1.566***	1.568***	1.567***	1.570***	1.165***
	(0.285)	(0.285)	(0.285)	(0.286)	(0.343)
$log\ GDP\ p.c._{ct}$	-0.402	-0.406	-0.405	-0.409	-0.298
	(0.257)	(0.257)	(0.257)	(0.257)	(0.313)
$GDP\ growth_{ct}$	-0.006***	-0.007***	-0.007***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Inflation_{ct}$	-0.006***	-0.007***	-0.007***	-0.006***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$log\ DCPS_{ct}$	0.093***	0.092***	0.091***	0.091***	0.093**
	(0.030)	(0.030)	(0.030)	(0.030)	(0.038)
$Corruption_{ct}$	-0.055**	-0.055**	-0.055**	-0.055**	-0.075***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.026)
ROL_{ct}	-0.079*	-0.080**	-0.080**	-0.078*	-0.001
	(0.040)	(0.040)	(0.041)	(0.041)	(0.035)
$NDTT_{ct}$	0.008***	0.008***	0.008***	0.008***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Entity fixed effects	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
Adjusted R^2	0.898	0.898	0.898	0.898	0.910
Observations	24,144,916	24,144,916	24,144,916	24,144,916	17,922,758
Elasticities					
$EMTR_{cit}$	-0.072				
	(0.027)				
$EATR_{cit}$		-0.079			
		(0.033)			
τ_{ct}			-0.075	-0.077	
			(0.033)	(0.033)	
δ_{cit}				0.128	
				(0.054)	

*The table presents OLS estimates. The dependent variable is the logarithm of firm-entity j's tangible fixed assets, log $TFAS_{jt}$. Robust standard errors are reported in parentheses (clustered at the county-year-industry level). *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. The last rows report elasticities corresponding to the tax measure used in the respective model. Corresponding standard errors are obtained using the Delta method. Definitions and descriptive statistics on the explanatory variables are provided in Section 3.6.2.*

country-industry-specific firm characteristics.

Let us briefly discuss the findings for the other control variables. We may distinguish between different groups of variables. First, $log\ SALES$ and $log\ STAF$ are positively related to investments in fixed assets. These two variables, thus, seem to capture size effects. Second, $CF\ ratio$, $SALES\ growth$, and $Profit\ margin$ are all negatively associated with the outcome variable. All three variables may be interpreted as proxies for investment opportunities. In fact, all three variables may be positively correlated with firm age, as well as firm and industry maturity, which explains the negative effect on investment in fixed assets. Third, of the different GDP indicators, it is mainly $log\ GDP$ that has a positive and economically significant impact on investment. Fourth, the negative coefficient on $Inflation$ is in line with the investment risk argument presented above. Fifth, $logDCPS$, a measure of capital market depth, facilitates investment, which is what we expect. We may finally highlight the positive impact of $NDTT$, which confirms earlier findings.[34]

To test for robustness, we also also run (i) dynamic regressions, (2) regressions using the investment rate as an alternative outcome (see Liu, 2020), as well as (3) specifications that are based on a balanced panel. This does not substantially change the EMTR effects.[35]

3.6.4 Alternative Fixed Effects Specifications

We now estimate equation (12) for different fixed effects structures to test the robustness and sensitivity of the benchmark results. Table 3.6.3 demonstrates that we find a negative and highly significant tax effect, irrespective of the choice of alternative fixed effects.

The estimates closest to our benchmark result in Table 3.6.2 are those that condition on entity (group) as well as industry-year effects, see Columns (1) and (2).[36] The largest coefficient is found in specification (4), which is conditional on a country-year specific fixed effect. Note that country-year specific EMTRs would not be identified in this specification, but the country-year-industry specific ones are.

[34] As a general remark, let us add that the estimates are not biased through time-constant country- or industry-specific effects per se, as these are captured by the entity-j-specific fixed effects.

[35] Note that the respective results are available upon request.

[36] Note that we identify groups using the information on the global ultimate owner (GUO) of a firm-entity that is provided by *Orbis* for a subset of our sample. In the case where no information on the GUO is available, we treat the entity as if it were a stand-alone firm.

Table 3.6.3: *Fixed Effects Specifications*

	(1)	(2)	(3)	(4)	(5)	(6)
$EMTR_{cit}$	-0.441***	-0.471***	-1.482***	-4.701***	-1.734***	-1.411***
	(0.155)	(0.144)	(0.293)	(0.490)	(0.382)	(0.294)
Elasticities						
$EMTR_{cit}$	-0.070	-0.075	-0.236	-0.748	-0.276	-0.225
	(0.025)	(0.023)	(0.047)	(0.078)	(0.061)	(0.047)

*The table presents OLS estimates. The dependent variable is the logarithm of firm-entity j's tangible fixed assets, log $TFAS_{jt}$. Other than the specified fixed effects, the setup of the models is identical to the one of Table 3.6.2, Column 1. The columns present the following fixed effects specifications: (1) entity and industry-year fixed effects; (2) group and industry-year fixed effects; (3) group and year fixed effects; (4) country-year fixed effects; (5) country and industry-year fixed effects; (6) group, country and year fixed effects. Robust standard errors are reported in parentheses (clustered at the county-year-industry level). *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level. The last rows report elasticities corresponding to the EMTR. Corresponding standard errors are obtained using the Delta method.*

A last, but very powerful test (not shown in Table 3.6.3), relates to an estimate including entity-specific as well as country-year-industry-specific fixed effects. The effect of the $EMTR$ is then only identified when using an interaction term between a time-varying entity-specific variable and the EMTR. The ideal candidate for the former (time-varying j-specific variable) is a binary indicator on whether entity j suffers a loss or not ($NOLOSS_{jt} = 1$ if a positive value for $EBIT$ is observed, 0 otherwise). The logic behind this approach is that the EMTR should only have an effect when profits are positive, so that an interaction allows us to identify the EMTR effect. The estimate on $EMTR_{cit} \times NOLOSS_{jt}$ equals -0.32 (std. err.: 0.037), which is relatively close to our benchmark estimate and highly statistically significant.

Altogether, the alternative fixed effects specifications suggest the following: It is important to condition on entity-specific heterogeneity; the country-industry specific EMTRs offer substantial value-added compared to country-year-specific measures; the findings are very robust to various fixed effects specifications.

3.6.5 Heterogeneous Tax Responses

Finally, we exploit the substantial cross-country and industry variation of our new EMTRs to analyze the heterogeneous impact of statutory tax policy changes on the investment behavior of different subgroups of firms. These groups are defined according to industry-, country- or firm-characteristics. For the purpose of this heterogeneity analysis, we introduce indicator variables for a specific subgroup and then, based on our large sample, report only the results from the interaction terms for the specific group we are interested in.[37]

Figure 3.6.1 depicts the results for the different subgroups. The estimated semi-tax-elasticities are sorted from smallest to largest for illustrative purposes. The dotted line corresponds to our benchmark estimate of the EMTR semi-elasticity of investment. On the left hand side of the illustration, we have the 'transportation and storage' entities (group a). This is the group that is most responsive, with a statistically significant EMTR semi-elasticity of about -2.7. The 'manufacturing'-industry entities (group g) are about half as sensitive but also statistically significant with an EMTR semi-elasticity of about -1.3. Tax incentives matter less for entities in 'wholesale and retail trade' (group i) with a coefficient of -0.21, which is statistically insignificant.

The estimates for the subgroups are by and large in line with expectations. For example, younger as well as stand-alone entities - entities that are not part of a corporate group - are more responsive to tax policy changes (groups e and f). The former group is most likely credit constraint and, therefore, unable to avoid part of the tax burden through additional debt. Stand-alone entities are possibly credit constraint as well, and cannot make use of an internal capital market to avoid taxation. Apart from these entity-specific characteristics, country-level characteristics also play an important role for the tax sensitivity of firms. Entities operating in high growth countries (group b) exhibit a semi-tax-elasticity of -2.1. Entities in low GDP per capita as well as low domestic credit to the private sector countries (groups c and d) have a statistically significant semi-tax-elasticity of -1.7. In line with economic intuition, these results imply that firms respond strongly to corporate taxation when they are in a more volatile economic environment.

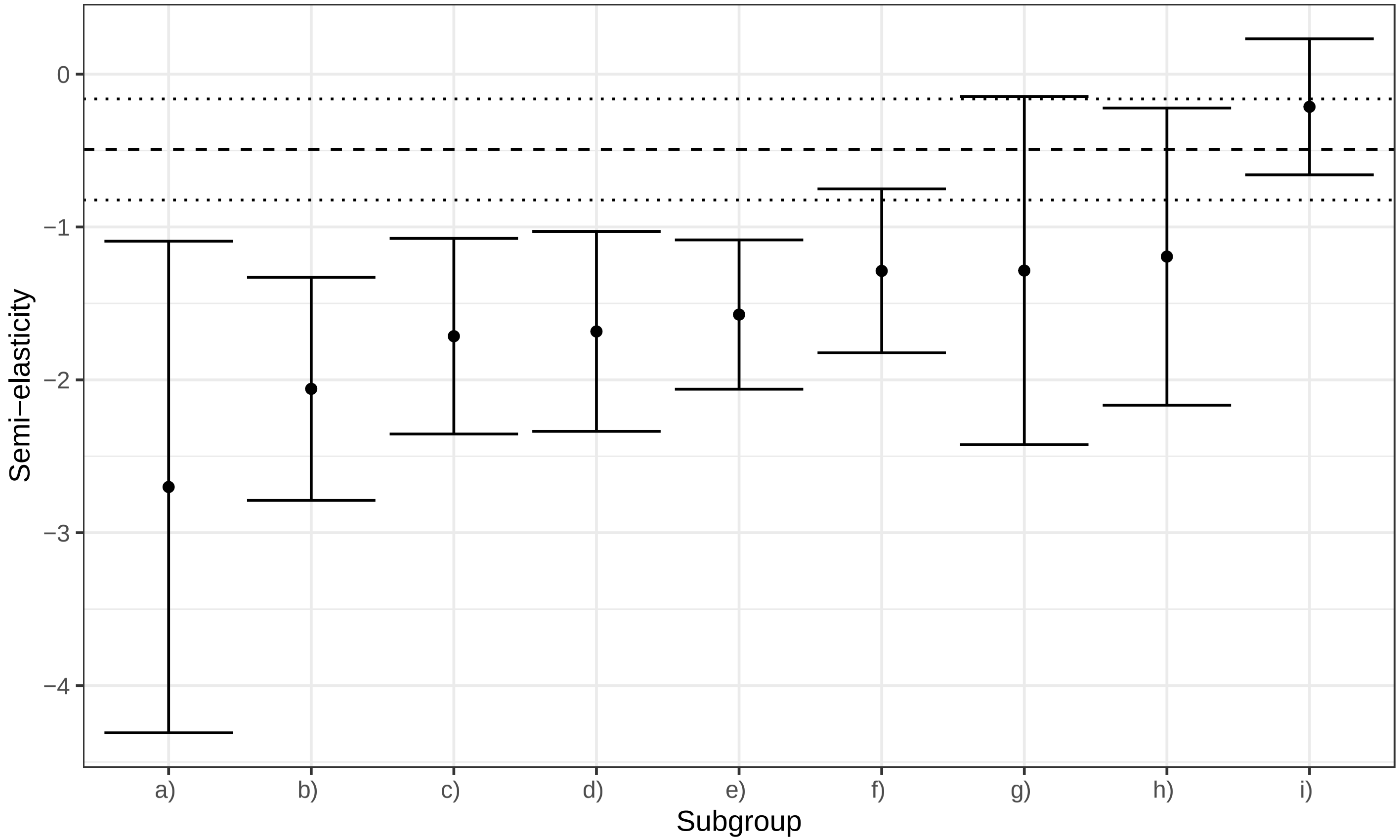
Let us finally focus on a specific type of heterogeneity which we find particularly interesting. It relates to a large literature showing that some firms can avoid taxes by relocating profits to low-tax countries.[38] The idea is now, to examine how firm-entities respond to changes in the EMTR given the group-wide (or multinational-firm-wide) minimum statutory corporate tax rate ($Minimum\ tax_j$).[39] For stand-alone entities and national groups, this minimum tax rate equals the statutory rate of the country

[37]Complete estimation results are available upon request.

[38]In our basic analysis above, note that we include stand-alone entities, entities that belong to a domestic firm group, and entities that belong to a multinational firm group. We have exploited this information above to estimate a coefficient on those that are not part of a firm group (f).

[39]Note that we do this for the whole firm group over all years in our sample.

Figure 3.6.1: *Tax Responsiveness for Different Subgroups*



The figure presents OLS estimates on $EMTR_{cit}$ and the corresponding 95% confidence intervals. The dependent variable is the logarithm of firm-entity j's tangible fixed assets, log $TFAS_{jt}$. The point estimates correspond to firm-entity j-specific subgroups and are estimated using the approach described in Section 3.6.5. The confidence intervals are based on robust standard errors (clustered at the county-year-industry level). In terms of control variables and fixed effects the setup is identical to Table 3.6.2, Column 1. The sample excludes firm-entities with a non-positive EBIT in more than 25% of the appearances (14,480,340 observations). The dashed line gives the semi-elasticity of the benchmark model without interaction and the dotted lines the corresponding confidence bounds. The subgroup are defined as follows. a) Firm-entity j operates in the section H Transportation and storage. b) j is located in a country where half or more than half of the country-specific entity-year observations exhibit a GDP growth rate that is equal to or higher than the 75 percentile of the GDP growth rate of the overall sample. c) j is located in a country where more than half of of the country-specific entity-year observations exhibit a logarithm of the domestic credit to the private sector as share of the GDP that is lower than the 25 percentile of this variable of the overall sample. d) j is located in a country where more than half of of the country-specific entity-year observations exhibit a GDP per capita that is lower than the 25 percentile of this variable of the overall sample. e) j's age (age is calculated as difference between current year and the year of incorporation) is lower than the 25 percentile of the age variable of the overall sample in half or more than half of the appearances. f) j is not part of a group (note that only firm-entities with information on the global ultimate owner are considered for this regression, which reduces the sample to 7,227,746 observations). g) j operates in the section C Manufacturing. h) j operates in the section F Construction. i) j operates in the section G Wholesale and retail trade; repair of motor vehicles and motorcycles.

that they are located in.[40]

The $Minimum\ tax_j$ for an entity that is part of a multinational group is calculated by taking the lowest tax rate among all countries that the multinational is operating in according to *Orbis*. The reasoning behind this approach is that multinationals are generally able to shift profits to entities located in low-tax countries to avoid taxes. Therefore, we expect that those entities facing a very high "minimum" tax should be more responsive, compared to others where $Minimum\ tax_j$ is relatively low. The latter suggests that these firms have access to a low-tax country and may shift profits towards related entities in this low-tax country. Alternatively, if the entity is itself the low-tax affiliate, then it faces a very low corporate tax rate. Figure 3.6.2 plots semi-elasticities for various values of $Minimum\ tax_j$.

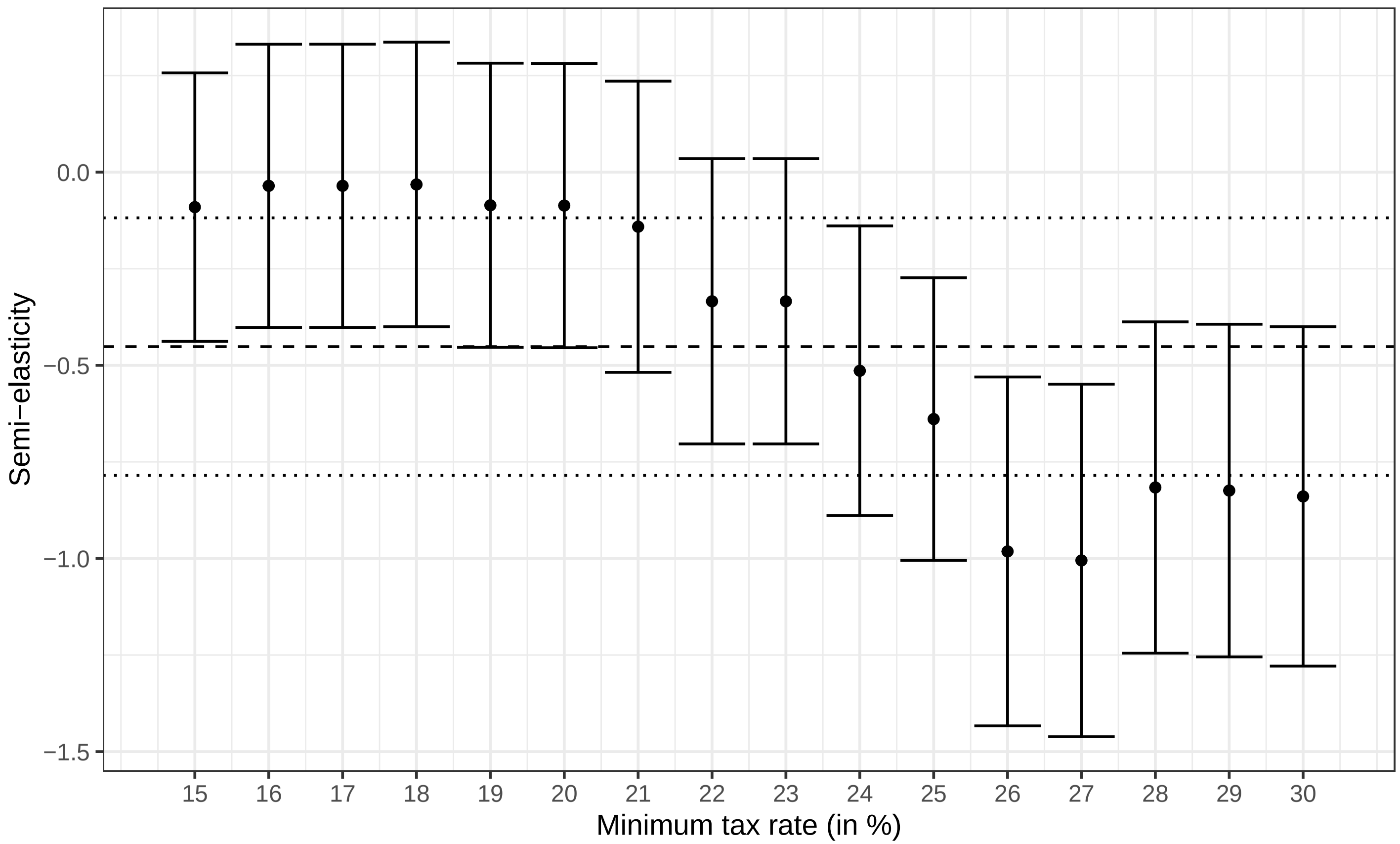
The pattern we find is highly consistent with the profit shifting argument. It seems that the negative tax effect only kicks in when the minimum tax rate is above 20%. For estimates where the minimum tax is lower, the estimated coefficients are close to zero and statistically insignificant. The increase in tax-responsiveness then increases in the minimum tax (in a not fully monotonic way). Note that we cannot estimate the EMTR responses for groups where the minimum tax is below 15% or above 30%. The reason is simply that the group sizes then get very small and the variation over time in EMTRs is too limited, which introduces too much noise.

3.7 Conclusions

This paper suggests a new approach to calculate country-year-industry-specific forward-looking effective tax rates (FLETRs) for 19 industries, 221 countries and the years 2001 to 2020. Besides statutory tax rate and tax base information, the FLETRs account for firms' typical (i.e., industry-specific) financing structures as well as asset compositions. We show that effective tax rates suffer from significant measurement error when the latter information is neglected, owing primarily to inappropriately assigned weights to statutory depreciation allowances. Our empirical analysis exploits the substantial variation in FLETRs over time to provide estimates of the semi-tax-elasticity of investment. Based on more than 24 million firm-entity observations, our results suggest a semi-tax-elasticity of about -0.45, which is at the lower end of previous findings. We further show that different sub-groups of firms respond very heterogeneously to tax

[40] For firm-entities for which we do not have any information on the global ultimate owner, we set the minimum tax rate as if they were stand-alone entities.

Figure 3.6.2: *Tax Responsiveness and Minimum Tax Rates*



The figure presents OLS estimates on $EMTR_{cit}$ and the corresponding 95% confidence intervals. The dependent variable is the logarithm of firm-entity j's tangible fixed assets, log $TFAS_{jt}$. The point estimates correspond to subgroups of firm-entities that are exposed to a statutory tax rate that is equal to or higher than the tax rate depicted on the horizontal axis. For the definition of the minimum tax rate, see Section 3.6.5. The confidence intervals are based on robust standard errors (clustered at the county-year-industry level). In terms of control variables and fixed effects the setup is identical to Table 3.6.2, Column 1. The dashed line gives the semi-elasticity of the benchmark model without interaction and the dotted lines the corresponding confidence bounds.

incentives. For example, when focusing on firm-entities operating in the manufacturing sector, we find a substantially bigger semi-elasticity of -1.29. Country-specific economic circumstances as well as profit shifting opportunities also have a significant impact on the semi-tax-elasticity. All in all, the estimated semi-elasticities range from values close to zero up to -2.7.

The results suggest that policymakers should be careful when designing tax reforms or when using incentives such as bonus depreciation programs to stimulate corporate investment. The extent to which this leads to more real firm activity depends significantly on the type of business and many other firm- and/or country-specific conditions.

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3.A Appendix

3.A.1 Derivation of the EMTR

Suppose a firm produces output following the convex production function $f(K)$ ($f'(K) > 0, f''(K) < 0$) using capital K as the only input. Output is strictly increasing in K, for example investment in machinery, with $\partial f(K)/\partial K > 0$ denoting the marginal product of K. A profit-maximizing firm in a perfectly competitive environment compares marginal benefit of additional investment to marginal cost and increases or decreases K until the two equalize. Let us denote the marginal cost by $u = \sigma + i$, where σ is the economic depreciation rate of K, and i is the cost of equity.[41] We may interpret i as the after-tax return of a risk-free investment and, thus, as opportunity cost.[42] By assuming decreasing returns (a diminishing marginal product) to investment, the profit maximizing investment K is determined by setting marginal benefit equal to marginal cost, i.e., $f'(K) = u$. Thus, in the absence of taxes, optimal investment is given by K^* (see Figure 3.A.1).

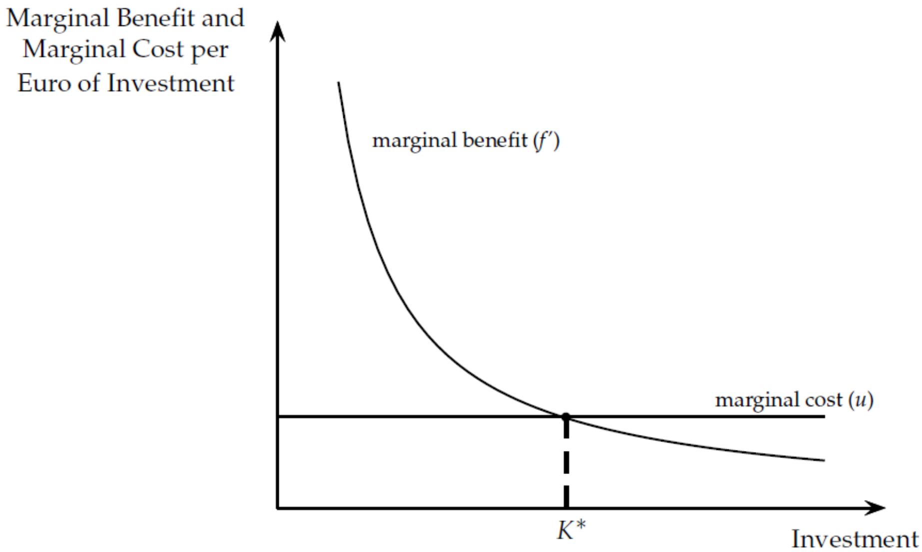
Introducing a tax τ in this simple model implies that some output is taxed away and the marginal earnings per unit of investment reduce to $f'(K)(1-\tau)$. This suggests a parallel downward shift in the marginal benefit curve and a new equilibrium where investment falls to K^τ, as illustrated in Figure 3.A.2. Solving for $f'(K)$, we obtain $f'(K) = \frac{1}{(1-\tau)}(\sigma + i) \equiv u^\tau$. Note that the expression on the right-hand side of the equation is the *user cost of capital* (u^τ). With $\tau \in [0, 1]$ the tax increases the required rate of return such that $u^\tau > u$. In order for the new optimality condition to hold, the firm invests less ($K^\tau < K$), leading to an increase of $f'(K)$ by a sufficient amount to just break even. The reduction in K and the convexity of the production function ensure that the pre-tax return with taxation is higher so that the firm is not making a loss.

We can now account for the fact that governments typically grant tax deductions for the cost of financing and depreciation by introducing *depreciation allowances* into this model. While we only consider the period of the investment, investments generate future returns, and machines or other investments depreciate over time. Accordingly,

[41] For now, we assume that K is equity financed and that financing cost are fully taxed (not tax-deductibility); prices are kept constant.

[42] We may think of i also as a dividend payout. Note, however, that we are interested in calculating the effective tax burden at the corporate level. Thus, we are abstracting from taxes on dividends.

Figure 3.A.1: *Optimal Investment*

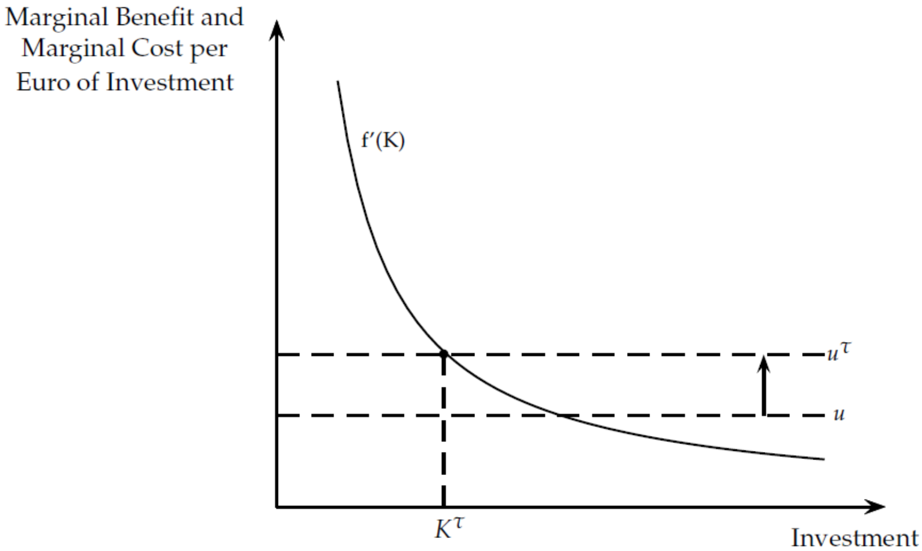


we need to account for the future stream of depreciation allowances by considering the net present value (NPV) of depreciation allowances, which we denote by δ. Depreciation allowances reduce a firm's tax base, suggesting that for each unit of depreciation allowance subtracted from the tax base, the tax payment equals zero. Thus, there is a tax saving of $\tau \cdot \delta$ per Euro of investment. Consequently, the depreciation allowance reduces the user cost of capital: $\widehat{u}^{\tau} = \frac{1}{(1-\tau)}(\sigma + i) \cdot (1 - \tau\delta)$. Note that in a graphical illustration, this would shift the horizontal line of the user cost down.

As Figure 3.A.2 illustrates, a corporate tax τ drives a wedge between marginal benefit and marginal cost. The effective marginal tax rate ($EMTR$) is a measure of the relative size of this tax wedge between user cost of capital with and without taxation. Formally, we get

$$EMTR = \frac{\widehat{u}^{\tau} - u}{\widehat{u}^{\tau}} = \frac{\frac{1}{(1-\tau)}(\sigma + i) \cdot (1 - \tau\delta) - (\sigma + i)}{\frac{1}{(1-\tau)}(\sigma + i) \cdot (1 - \tau\delta)} = \frac{(\tau - \tau\delta)}{(1 - \tau\delta)}. \tag{3.A.1}$$

Figure 3.A.2: *Optimal Investment with Taxation*



3.A.2 Structure and Preparation of the Eora26 database

To provide a deeper understanding of the structure of the *Eora26* database, we start out by describing the *Eora Global Supply Chain* database (Lenzen et al., 2012, 2013), from which *Eora26* is derived. At the centre of the *Eora Global Supply Chain* database are the yearly multi-region input-output tables (MRIOs). For the countries in the MRIOs generally either commodities or industries are included, but not both. This results in a mix of different input-output (IO) tables. In detail, three different types of IO tables are distinguished: Industry-by-Industry IO tables, Commodity-by-Commodity IO tables, and Supply-Use tables (SUTs). The latter category includes Commodity-to-Industry as well as Industry-to-Commodity transactions.[43] Furthermore, the industry and commodity classification systems that are used differ strongly between countries. To facilitate between-country analyses, a simplified version of the *Eora* MRIOs is provided, the so-called *Eora26* MRIOs. In this version, all industries and commodities are aggregated to a common 26-sector classification and the SUTs from the full resolution *Eora* MRIOs are converted to symmetric sector-by-sector IO tables using the *Eurostat manual of supply, use and input-output tables* (2008).[44] We proceed by translating this 26-sector classification of the *Eora26* database to the NACE Rev. 2 (ISIC Rev. 4) sections that we use throughout this paper. In doing this, we rely on the concor-

[43]For a graphical illustration of the MRIO layout, see Lenzen et al. (2013, p. 25).
[44]For more detailes, see the webpage of Eora26, *https://worldmrio.com/eora26/*.

dance table provided on the webpage of the *Eora26* database that documents how the different industries and commodity categories from the full resolution *Eora* were transformed to the 26-sector system of *Eora26*.[45] More precisely, we string-search the industry descriptions of the full resolution *Eora* database for the closest matches to the different NACE Rev. 2 (ISIC Rev. 4) section descriptions. Then, we look at how a chosen industry from the full *Eora* was converted to the 26-sector system and reverse this transformation for all countries. The precise assignment is depicted in Table 3.A.2.

Table 3.A.1: *Assignment of EUKLEMS & INTANProd Release 2021 Asset Types to the Asset Types Used for Calculations of FLETRs*

Asset type	Assigned EU Klems 2019 asset types
Buildings	N111 Dwellings
	N112 Other buildings and structures
Computer equipment	N11321 Computer hardware
Intangible fixed assets	N1171 Research and development
	N1173 Computer software and databases
Machinery	N11O Other machinery equipment and weapons systems
Office equipment	N11322 Telecommunications equipment
Vehicles	N1131 Transport equipment

The table depicts the assignment of the asset categories from the EUKLEMS & INTANProd release 2021 to the asset categories used for the calculations of FLETRs in this paper (excluding the asset type Inventory).

[45] See *https://worldmrio.com/eora26/*.

Table 3.A.2: *Concordance of EORA26 Sectors to NACE REV. 2 (ISIC REV. 4) Sections*

NACE/ISIC	Eora26 sector(s)
A	0.873377 · Agriculture +
	0.126623 · Fishing
B	Mining and Quarrying
C	0.089343 · Food & Beverages +
	0.181663 · Textiles and Wearing Apparel +
	0.045522 · Wood and Paper +
	0.246543 · Petroleum, Chemical and Non-Metallic Mineral Products +
	0.122740 · Metal Products +
	0.229526 · Electrical and Machinery +
	0.025101 · Transport Equipment +
	0.043395 · Other Manufacturing +
	0.016167 · Recycling
D	Electricity, Gas and Water
E	0.181818 · Electricity, Gas and Water +
	0.818182 · Education, Health and Other Services
F	Construction
G	0.023499 · Maintenance and Repair +
	0.302872 · Wholesale Trade +
	0.673629 · Retail Trade
H	Transport
I	Hotels and Restaurants
J	Post and Telecommunications
K	Finacial Intermediation and Business Activities
L	Finacial Intermediation and Business Activities
M	Finacial Intermediation and Business Activities
N	Finacial Intermediation and Business Activities
O	Public Administration
P	Education, Health and Other Services
Q	Education, Health and Other Services
R	Education, Health and Other Services
S	0.071197 · Education, Health and Other Services +
	0.928803 · Others
T	Private Households
U	Others

The table depicts the assignment that is used to translate the 26-sector classification of the Eora26 database to the NACE Rev. 2 (ISIC Rev. 4) sections that we use throughout this paper. The aggregation is based on the concordance table that translates the different industry and commodity categories of the full Eora to the 26 sectors used in Eora26 which can be found on the website of the Eora26 database (https://worldmrio.com/eora26/). Descriptions for the different NACE Rev. 2 (ISIC Rev. 4) sections are provided in Table 3.A.3.

Table 3.A.3: *NACE REV. 2 (ISIC REV.4) Section Descriptions*

Section code	section description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organizations and bodies

The table depicts the descriptions of the sections of the Statistical classification of economic activities in the European Community (NACE) Rev. 2 and the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4 that are used throughout this paper. Note that since NACE Rev. 2 was created based on ISIC Rev. 4, the classification systems are equal at the section level.

3.A.3 Imputation

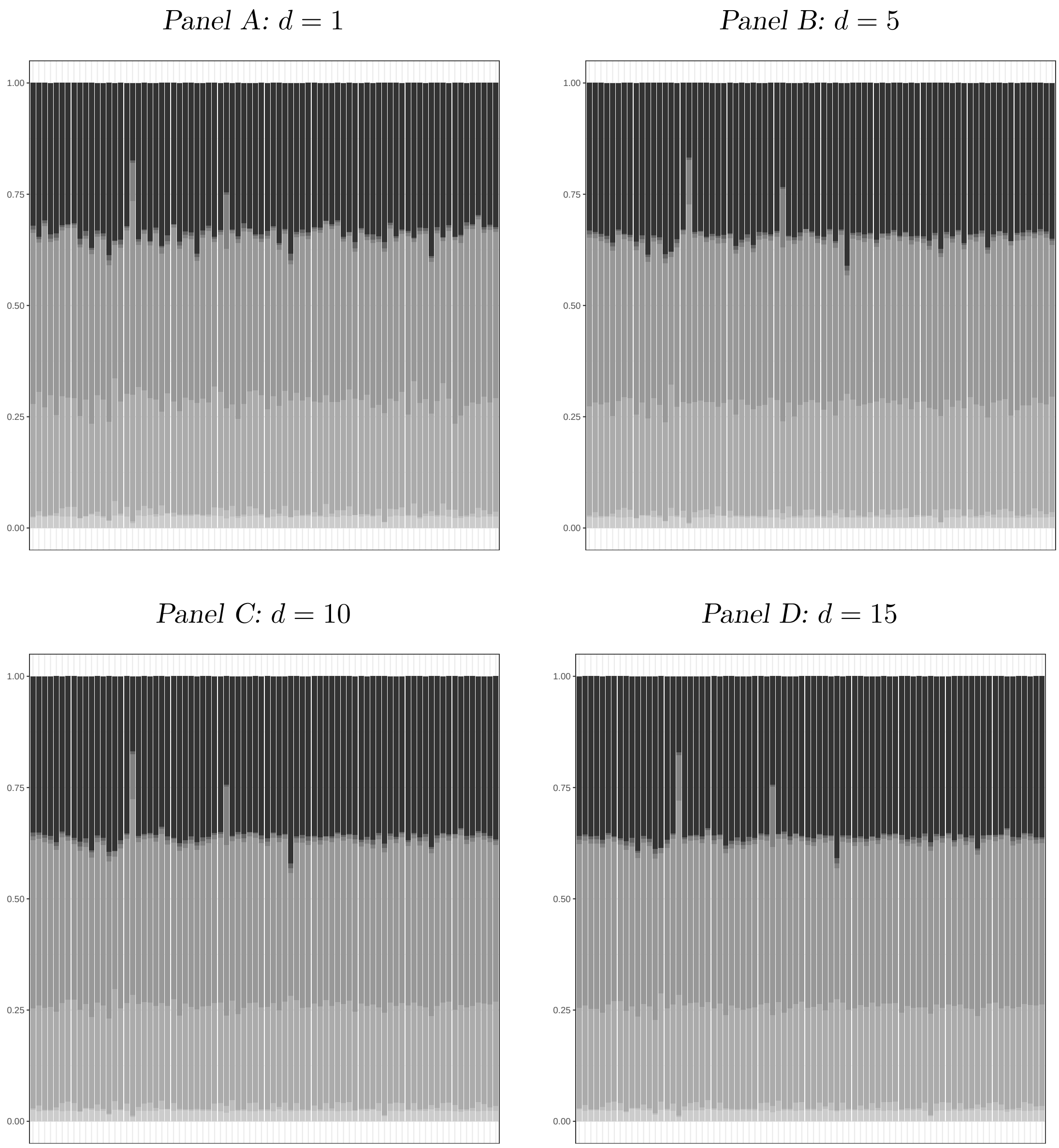
For the PMM imputation in Section 3.4.3, we impute a missing year-specific weight using the observed value corresponding to the data point (the so-called donor) for which the predicted value is closest to the predicted value of the missing data point that we were looking to impute. Alternatively, instead of using just one donor, the mean of the $d > 1$ donors that are closest may be chosen (Van Burren, 2018). In the extreme case of setting d to the number of available complete cases, one would obtain identical imputed values for all missing data points, that is, the mean over all donor candidates. To not lose variation among the imputed values, typically small d's are chosen.[46] In Figure 3.A.3, we depict asset weight structures for the section *C Manufacturing* that are imputed as described in Section 3.4.3 but with a varying number of donors d.[47]

It can be seen that the imputed asset structures look similar for $d = 1, 5, 10$, and 15. In particular, the reduction in variation between countries when increasing d is small. We therefore conclude that our imputation results are robust to other commonly used

[46] See Van Burren (2018) for a thorough literature review on the optimal choice of donors.

[47] Note that the same countries are depicted in the same order as in Figure 3.A.6.

Figure 3.A.3: *Country-Specific Asset Structures of Section C Manufacturing Imputed Using PMM with Different Number of Donors*



The figure depicts asset structures for the NACE Rev. 2 (ISIC Rev. 4) section C Manufacturing by country. The structures of the depicted countries are fully imputed using PMM (see Section 3.4.3). The panels correspond to imputation using a different number of donors d. Each bar corresponds to the asset structure of a different country. The order of the countries is the same in all panels and identical to the one in Figure 3.A.6. The asset types are indicated by the different shadings of the bars. The asset types are – from dark to bright shading – as follows: buildings, computer equipment, intangible fixed assets, inventory, machinery, office equipment, and vehicles.

choices for the number of donors d.

An algorithm that is heavily used in the literature for matching purposes is k-Nearest Neighbor (k-NN) matching. With k-NN matching, each covariate used for the matching is standardized to have an overall mean of zero and variance of one. A missing data point is then imputed with the mean of the k observed data points for which the Euclidean distance of the covariates to those of the missing is minimal. The key difference between PMM and k-NN matching is that PMM takes into account the importance of each covariate for predicting the dependent variable whereas k-NN matching assigns each covariate the same weight. For the sake of completeness, we carry out the imputation of asset structures for the sector *C Manufacturing* with k-NN matching using the same covariates that we used with PMM.[48] The results are depicted in Figure 3.A.4.

It can be seen that, irrespective of k, the imputed asset structures are often identical or extremely similar between countries. Furthermore, it shows that the imputed asset structures seem to be highly dependent on the chosen k, as the amount of variation between countries decreases strongly as k is increased.

Finally, let us also provide some more in-depth plausibility checks of the country-industry-specific asset structures of section *C Manufacturing*. Figure 3.A.5 depicts the asset structures of countries that are fully covered by the primary data sources.

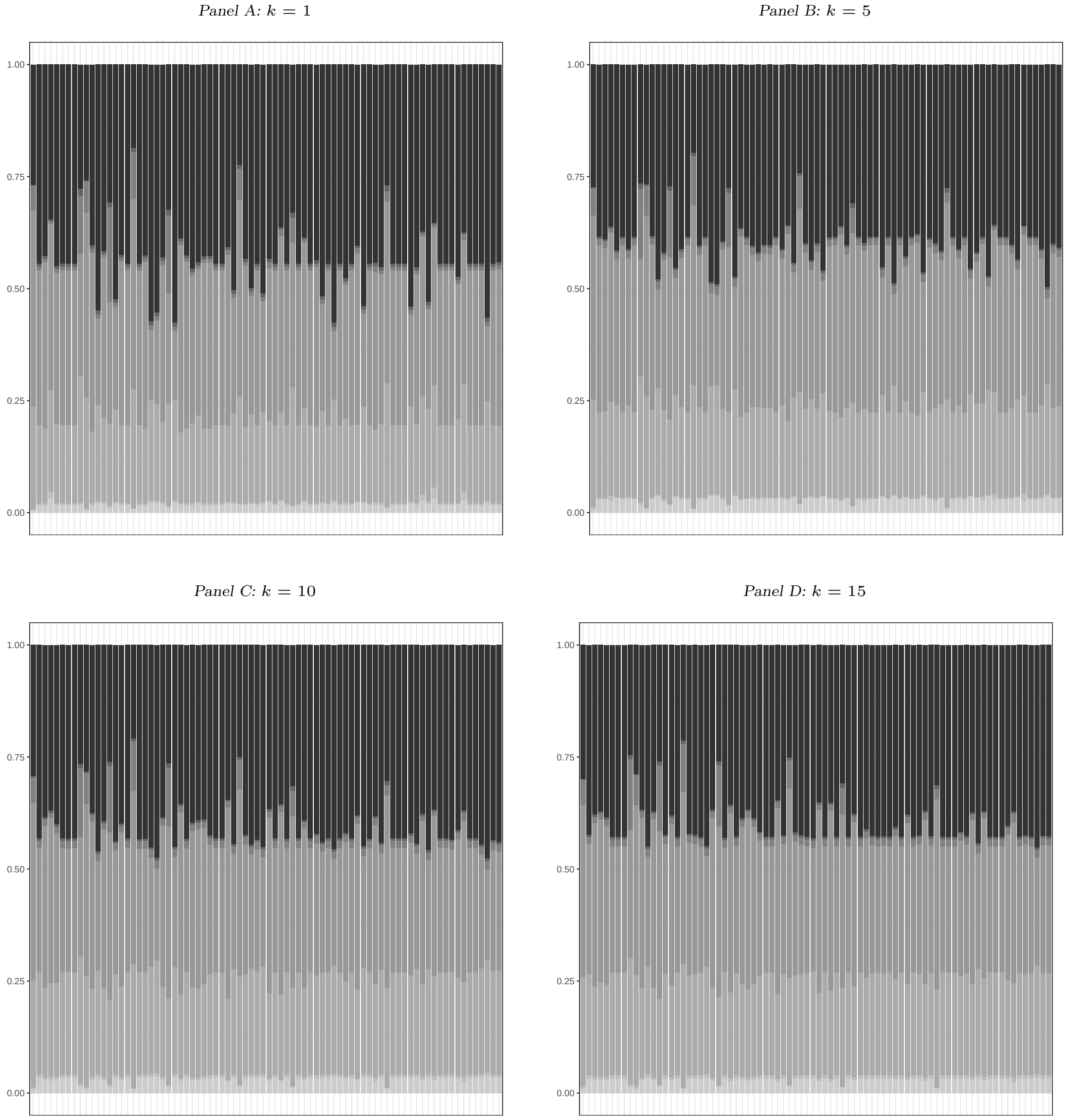
Figure 3.A.6 shows the asset structures of countries that were entirely imputed using the PMM procedure.

Comparing these two figures, it can be seen that the imputed results exhibit somewhat less variation. However, as shown in Table 3.4.1, this is not a result that is representative of the imputation of all weights in all industries. In fact, there are several sections where there is more variation among the group of PMM imputed countries than in the one with observed data. One country that stands out in Figure 3.A.6 is Canada that exhibits the lowest share of buildings among the depicted imputed countries. Taking a look at Figure 3.A.5, it can be seen that the imputed asset structure of Canada is similar to the asset structures of other highly developed nations such as Germany, France, Japan, the Netherlands, Sweden, or the USA. Conversely, the imputed less developed countries in Figure 3.A.6 exhibit similarities to the less developed countries that were used for the matching, such as Lithuania or Slovakia.

Another interesting observation that can be made when looking at Figure 3.A.6 is

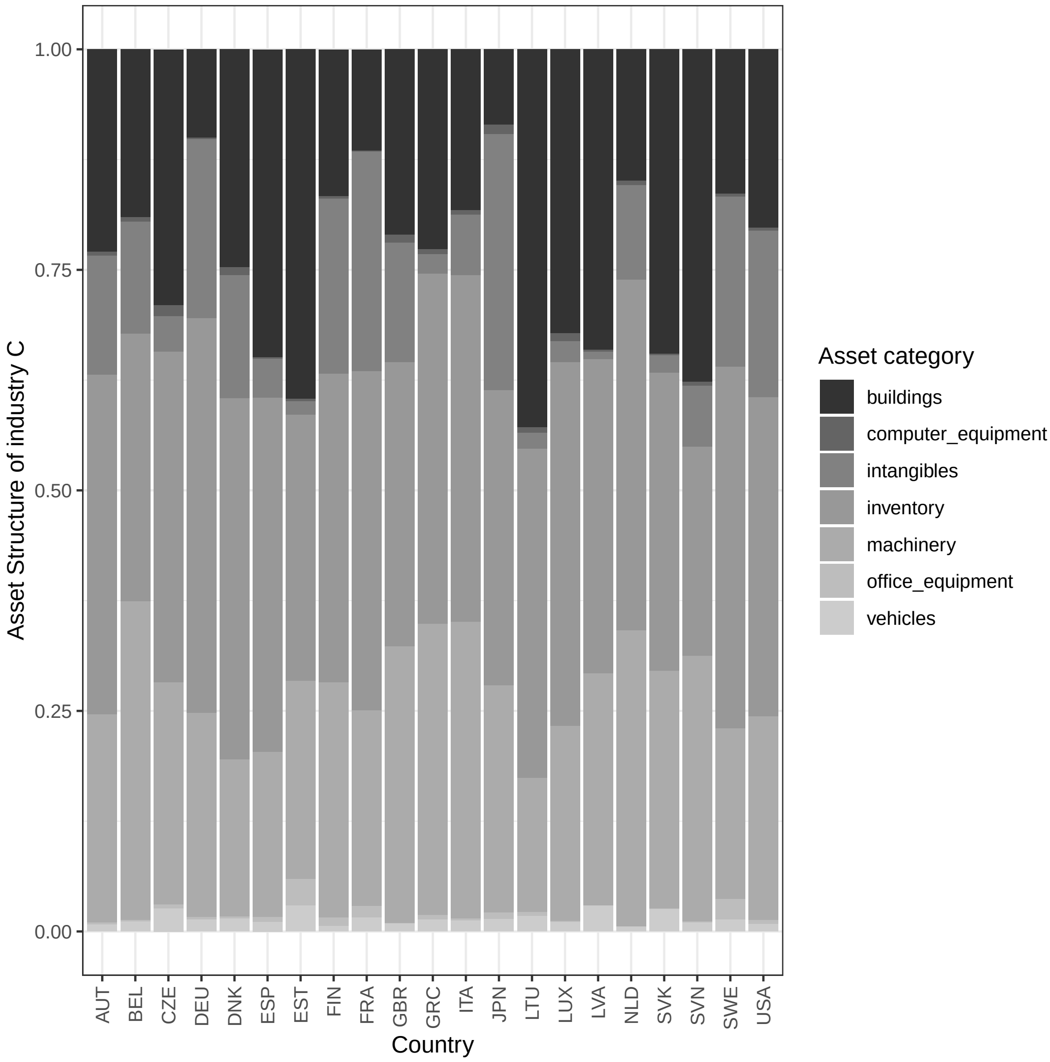
[48] Note that we, however, we do not include time dummies, as k-NN matching does not allow for categorical variables. Further note that no logs of the variables are taken.

Figure 3.A.4: *Country-Specific Asset Structures of Section C Manufacturing Imputed Using k-NN with Different Number of k*



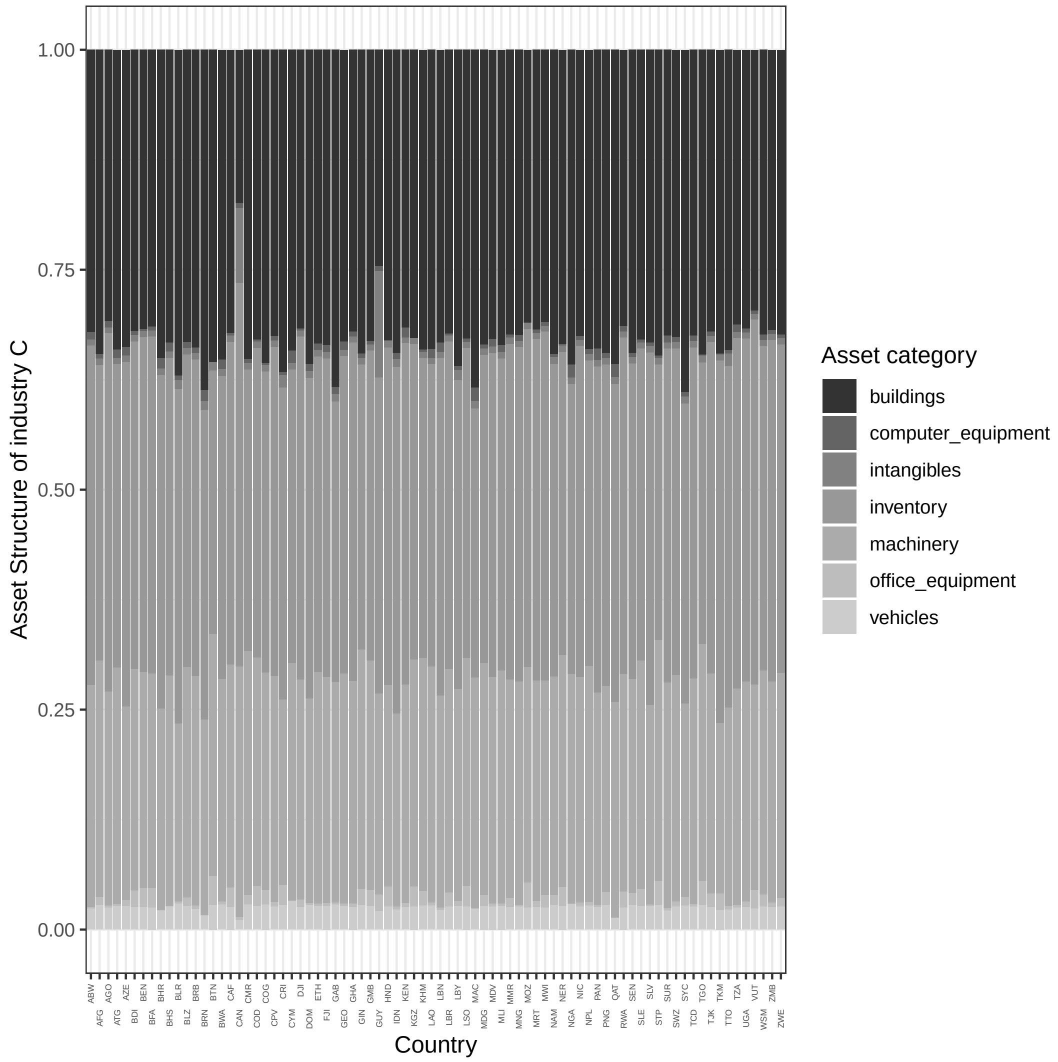
The figure depicts asset structures for the NACE Rev. 2 (ISIC Rev. 4) section C Manufacturing by country. The structures of the depicted countries are fully imputed using k-NN (see Hastie et al., 2009, ch. 13.3). The panels correspond to imputation using a different number of neighbors k. Each bar corresponds to the asset structure of a different country. The order of the countries is the same in all panels and identical to the one in Figure 3.A.6. The asset types are indicated by the different shadings of the bars. The asset types are – from dark to bright shading – as follows: buildings, computer equipment, intangible fixed assets, inventory, machinery, office equipment, and vehicles.

Figure 3.A.5: *Country-Specific Asset Structures from Primary Data Sources of Section C Manufacturing*



The figure depicts asset structures for the NACE Rev. 2 (ISIC Rev. 4) section C Manufacturing by country. The structures of the depicted countries are fully derived from the primary data sources EUKLEMS & INTANProd release 2021 and Orbis (see Section 3.4.2).

Figure 3.A.6: *Country-Specific Asset Structures Imputed Using PMM of Section C Manufacturing*



The figure depicts asset structures for the NACE Rev. 2 (ISIC Rev. 4) section C Manufacturing by country. The structures of the depicted countries are fully imputed using PMM with $d = 1$ donor (see Section 3.4.3).

the fact that the different PMM imputed asset structures appear to not be identical. This indicates that the unique weighting of the covariates for the matching of each asset type yielded a mix of different donors matched for the imputation of a single asset structure.

Table 3.A.4: *Descriptives on Covariates Used for Imputation*

Panel A: Covariates for financing structure imputation (35,980 observations)		
	mean	(sd)
τ_{ct}	0.252	(0.094)
ROL_{ct}	0.065	(0.992)
$Corruption_{ct}$	0.083	(1.017)
$log\ DCPS_{ct}$	3.602	(0.978)
$Inflation_{ct}$	5.429	(10.607)
$GDP\ growth_{ct}$	3.643	(4.418)
$log\ GO_{cit}$	15.200	(2.415)
$log\ GI_{cit}$	15.146	(2.434)
$log\ COE_{cit}$	13.489	(2.810)
$log\ NOS_{cit}$	13.028	(3.100)
$log\ NMI_{cit}$	9.401	(4.911)
$log\ net\ TOP_{cit}$	10.188	(3.285)
$log\ COFC_{cit}$	11.912	(3.189)
Panel B: Covariates for asset structure imputation (49,811 observations)		
	mean	(sd)
$log\ GDP_{ct}$	25.152	(2.006)
$log\ GDP\ p.c._{ct}$	9.288	(1.218)
$log\ COE_{cit}$	13.355	(2.689)
$log\ NOS_{cit}$	12.902	(2.991)
$log\ NMI_{cit}$	9.514	(4.834)
$log\ COFC_{cit}$	11.849	(3.017)
$log\ CO2_{cit}$	6.423	(2.527)

The table depicts descriptive statistics on all the covariates used for the imputation of financing (Panel A) and asset structures (Panel B). The time span that is covered in the sample is 2001 to 2016. Definitions of all variables are provided in Section 3.3.

Table 3.A.5: *Imputation of Countries Without Covariate Data*

Panel A: Financing structure (54 countries with missing weights)	
Countries with missing weights	Countries used for imputation
AIA;ANT;BES;CUW;CYM;DMA;GLP;GRD;KNA;LCA;MSR;MTQ;PRI;SXM; TCA;VCT;VGB;VIR	ABW;ATG;BHS;BRB;DOM;JAM;TTO
ASM;COK;FSM;KIR;MHL;MNP;NCL;NIU;NRU;PLW;PYF;SLB; TLS;TON	AUS;FJI;NZL;PNG;VUT;WSM
AND	ESP; FRA
ARG	BOL; BRA; CHL; PRY; URY
BLZ	GTM; MEX
BMU	ABW;ATG;BHS;BRB;DOM;JAM;TTO;USA
COM	MDG; MDV; MUS; SYC
ERI	DJI; ETH; SDN
GGY	FRA; GBR
GIB	ESP
GNB	SEN; GIN
GNQ	GAB; CMR
GRL	CAN; ISL
IMN	GBR
JEY	FRA; GBR
LIE	CHE; AUT
MCO	FRA
PRK	CHN; KOR
SMR	ITA
TKM	AFG; IRN; KAZ
TWN	CHN; JPN; KOR; PHL
UZB	AFG; KAZ; KGZ; TJK
XKX	SRB
YUG	MNE; SRB

Panel B: Asset structure (56 countries with missing weights)	
Countries with missing weights	Countries used for imputation
AIA;ANT;BES;CUW;DMA;GLP;GRD;KNA;LCA;MSR;MTQ;PRI;SXM; TCA;VCT;VGB;VIR	ABW;ATG;BHS;BRB;CYM;DOM;JAM;TTO
ASM;COK;FSM;KIR;MHL;MNP;NCL;NIU;NRU;PLW;PYF;SLB; TLS;TON	AUS;FJI;NZL;PNG;VUT;WSM
AND	ESP; FRA
COM	MDG; MDV; MUS; SYC
ERI	DJI; ETH
GGY	FRA; GBR
GIB	ESP
GNB	SEN; GIN
GNQ	GAB; CMR
GRL	CAN; ISL
IMN	GBR
JEY	FRA; GBR
LIE	CHE; AUT
MCO	FRA
MKD	ALB; BGR; GRC; SRB
MNE	ALB; BIH; HRV; SRB
PRK	CHN; KOR
PSE	EGY; ISR; JOR
SDN	CAF; EGY; ETH; LBY; TCD
SMR	ITA
SSD	CAF; COD; ETH; KEN; UGA
SYR	IRQ; ISR; JOR; LBN; TUR
TWN	CHN; JPN; KOR; PHL
VEN	BRA; COL; GUY
XKX	SRB
YEM	OMN; SAU
YUG	SRB

The table depicts the assignment of countries for which we obtain weights (either directly through data sources or through the imputation algorithm) to countries for which we do not obtain weights. If two more countries are assigned, then the unweighted average of these countries' weights are used for imputation.

Chapter 4

Race to the top? The (un-)intended policy spillovers of state debt reduction programs.

ABSTRACT

This paper studies tax policy interaction for both mobile and immobile tax bases using a large panel of German municipalities. We exploit quasi-exogenous increases in local tax instruments from state debt reduction programs in *Hesse* and *Northrhine-Westfalia* to identify if governments engage in tax or yardstick competition. Additionally, we also analyze the spatial persistence of any spillovers. We find evidence that municipalities located in the same state but not directly affected by the debt reduction program show strong and significant tax policy responses both in corporate and property tax rates. Furthermore, the policy spillovers from property tax rates are highly localized indicating that municipalities engage in yardstick competition.

4.1 Introduction

Recent political events like Brexit, the US Tax Cuts and Jobs Act, and the OECD's proposal for the introduction of a global minimum corporate tax rate have all sparked controversial debates about the interdependence of tax policy instruments, both between and within countries. While the existence and consequences of these interdependencies are well studied, their origins are often unclear and could be driven by economic and/or political motives. Governments could, for example, engage in tax competition by strategically interacting in tax policy to attract additional mobile tax bases (see Wilson, 1986). However, they could also engage in yardstick competition which is defined as an informational policy spillover allowing the electorate of neighboring jurisdictions to learn about the efficiency and quality of the policy enacted in their jurisdiction and potentially request a change (see Revelli and Tovmo, 2007). Tax policy interaction is particularly problematic in federal states like the US, Canada, Switzerland, Italy, or Germany where local governments enjoy substantial fiscal autonomy with regard to spending and tax policy setting. To avoid ruinous tax competition, excessive public debt, and bailouts, federal states often have elaborate fiscal transfer schemes and other restrictions in place. However, in order to address these issues it is essential to know if and how sub-national units interact in their tax policy setting.

While several studies have investigated tax policy interaction among local governments, findings have been contradictory and appear to often suffer from severe endogeneity concerns due to two problems. First, tax policy changes are generally non-random and depend on economic and political factors which also affect outcomes. Second, outcomes of the control group are also often affected by treatment due to policy spillovers. In the case of tax reforms, spillovers influence both the tax base and, as a result of base spillovers, the choice of tax policy instruments. While the first problem is widely acknowledged in the literature and addressed through exploiting quasi-exogenous policy interventions, the second problem is often neglected. In fact, neighboring jurisdictions are often purposefully chosen to ensure comparability and common trends in outcomes prior to the policy intervention. The response of neighboring jurisdictions likely depends on a number of factors including distance to the policy shock and the size of the shocked municipality.[1] However, if spatial spillovers are present, neighboring jurisdictions are a poor control group as exogeneity of treatment is violated, resulting

[1] Janeba and Osterloh (2013) provide a comprehensive theoretical framework outlining the different sets of competitors large and small entities face.

in biased results. There is a surprisingly small literature looking explicitly at the spatial dimension of tax policy spillovers. Identifying the scope of the policy spillover to seemingly unaffected jurisdictions is essential for the correct choice of a control group and, thus, unbiased identification.

To overcome these endogeneity problems, we exploit quasi-exogenous policy interventions in the German states of *Hesse* and *Northrhine-Westfalia* (NRW). After the financial crisis in 2008, many German municipalities suffered from excessive debt and were running the risk of default.[2] To avoid federal bailouts, several German states introduced debt reduction programs (DRPs) which allowed municipalities to restructure their debt. Generally, the state would take on a significant portion of the municipal debt in return for consolidation efforts that would also involve substantial municipal tax increases. The assignment of municipalities to these DRPs generally led to large jumps in the local business and property tax rates. The DRPs in Hesse and NRW are particularly interesting since eligibility/participation was quasi-exogenously assigned. Exploiting this quasi-exogenous selection into DRPs enables us to determine the size and nature of tax policy interaction among German municipalities. Studying these spillovers is especially interesting in this setting for three reasons. First, all municipalities are subject to the same policy environment (e.g., state laws and fiscal transfer regulation) with the DRPs affecting only a portion of these municipalities. Second, exogenous tax changes in DRP municipalities enable us to study tax policy spillovers to non-DRP municipalities in the same state. Third, German municipalities can levy taxes both on mobile and immobile tax bases, thus, allowing for a separation of tax and yardstick competition. Policy interaction in taxes on immobile bases cannot be attributed to tax competition and, thus, is evidence for yardstick competition.

This paper answers two research questions. First, are local governments engaging in tax or yardstick competition? Second, how are tax policy responses distributed in space? In order to investigate if and how German municipalities compete in local tax instruments, we exploit the quasi-exogenous assignment of municipalities into the DRPs in Hesse and NRW. The analysis is conducted in three steps. First, we establish how corporate and property tax rates of the *Treated* municipalities have changed; the municipalities participating in the DRP in Hesse and NRW. In a second step, we analyze the average policy change of municipalities in the the same state that are not directly subject to these DRP. These municipalities are called the *Nottreated*. Lastly,

[2]In Germany states and municipalities held approximately 779 billion Euro in debt which amounts to 34% of the overall public debt.

we determine the spatial dimension of these policy responses. For all three steps of the analysis we will construct an adequate control group, which we call the *Untreated*, from a pool of municipalities in states without a DRP using Propensity Score Matching (PSM). Using (generalized) Difference-in-Differences (DiD), we find that both the Treated and Nonttreated substantially increased business and property taxes after the respective DRP came into effect. Property taxes exhibit a particularly pronounced increase for both Treated and Nottreated in Hesse and NRW ranging from 3.4 to 9 percentage points. Given the immobility of the property tax base, these findings imply that German municipalities engage in yardstick competition. Furthermore, we find that the policy reaction decreases in the distance to the nearest treated municipality underlining the significance of spatial aspects in policy spillovers. The response in property tax rates decreases the fastest in distance emphasizing that municipalities engage in yardstick competition. Furthermore, we find that the tax policy response is highly localized and quickly subsides in space. These results on the spatial dynamics imply that the Nottreated are a poor control group for the Treated due to policy spillovers.

This paper contributes to several strands of the literature. First, it adds to the literature analyzing local tax competition for mobile tax bases. Büttner (2001) examines determinants of local business tax rates and their interdependence for a large panel of jurisdictions in Germany. Using an IV approach, the author finds evidence for tax competition among jurisdictions. Feld and Kirchgässner (2001) analyze personal income tax competition among Swiss cantons and larger cities. For identification, the authors employ and IV strategy using cantonal tax rates, various public expenditures, infrastructure spending, and average salaries as instruments for municipal tax rates. The authors find that Swiss cantons and cities engage in personal income tax competition to attract high income earners. Both these findings are in line with the theoretical model developed by Janeba and Osterloh (2013). According to this model, urban centers compete with their rural surrounding areas as well as other urban centers for mobile tax bases. Rural areas, however, only compete with rural and urban areas in their direct vicinity. Parchet (2019) analyzes the policy response of Swiss jurisdictions in personal income tax rates across cantonal borders. For identification the author employs an IV approach using changes in state-level personal income tax as an instrument for jurisdiction-level personal income taxes. The results imply that tax rates are strategic substitutes. In contrast to the previous literature, this paper exploits exogenous variation in both property and business taxes without relying on an IV approach or state border discontinuities. Previous findings show substantial heterogeneity across different policy settings, tax instruments, and estimation methods. Exploiting exogenous municipality-specific variation in local tax rates allows for an unbiased identification of policy interaction and the spatial persistence of these spillover effects.

This paper is most closely related to the recent contribution by Fremerey et al. (2022). The authors evaluate the effects of the NRW DRP using a generalized DiD design. They find that municipalities participating in the DRP consolidated their budgets. Additionally, small municipalities consolidated by cutting spending, while larger municipalities raised taxes. As a control group, the authors choose other financially distressed municipalities in NRW. To ensure pre-treatment comparability, the authors emphasize that treatment and control municipalities are in geographical proximity to one another and economically linked. In contrast to Fremerey et al. (2022), we use PSM to construct a control group from a pool of municipalities located in non-DRP states. Our results indicate that municipalities that are located in NRW but not subject to the DRP exhibit substantial tax policy responses due to spillovers. Additionally, we do not explicitly evaluate the DRP in NRW but use it as a quasi-exogenous intervention to identify the size and spatial extend of policy spillovers.

Second, this paper contributes to the literature analyzing yardstick-style tax policy reactions on immobile tax bases. Baskaran (2014) studies tax mimicking of municipalities in NRW and Lower Saxony by exploiting an exogenous reform in local fiscal equalization schemes in NRW. Using border discontinuities and an IV approach as well as DiD, the author finds that municipalities do not interact in business or property tax rates. Lyytikäinen (2012) exploits the exogenous variation in the lower limits of property taxation in Finland to study policy interaction among local governments. He finds no evidence for competition in property tax rates in Finland. Allers and Elhorst (2005) analyze property tax rate interactions among Dutch municipalities. The authors' findings imply that property tax rates are complements to their neighbors tax policy choice. Similarly, Bordignon et al. (2003) find evidence for yardstick competition in property tax rates among Italian municipalities. Yardstick competition appears to be particularly pronounced when mayors' reelection bid is uncertain. This paper adds to this literature by exploiting quasi-exogenous heterogeneous tax policy changes in both corporate and property tax rates. Additionally, these changes are not driven by uniform changes to state-legislation but by municipality-specific interventions of the state that do not directly apply to other municipalities in the same state.

The remainder of the paper is structured as follows. Section 4.2 outlines the institutional background of the debt reduction programs in Hesse and NRW. The data used for the analysis is presented in Section 4.3. Section 4.4 outlines the identification strategy, while Section 4.5 presents the estimation results. Section 4.6 concludes the analysis.

4.2 Institutional Background

4.2.1 German Federal System

Germany is a federal republic governed by the principle of subsidiarity granting substantial autonomy to sub-national entities on the state and municipal level. The federal structure of Germany consists of sixteen states which are further subdivided into 294 administrative districts (*Landkreise*) and 11,056 municipalities (*Gemeinden*).[3] Under the German constitution, municipalities are granted financial sovereignty allowing them to raise revenues and manage expenditures. German municipalities raise approximately 15% of overall tax revenue in Germany. Revenue from municipal tax instruments make up roughly 52% of municipal tax revenue.[4] Vertical transfers from the personal income and consumption taxes set at the federal level comprise 46 % of overall municipal revenues. The total revenue of municipalities is completed by allocations of the state and federal government, along with fees and contributions payed by citizens.

German municipalities have three different tax instruments at their disposal to raise revenue. The local business tax (*Gewerbesteuer*) which is levied on profits of local businesses, a property tax on agrarian land including forestry *(Grundsteuer A)*, and a property tax levied on developed/constructible land including commercial and residential properties *(Grundsteuer B)*.[5] As part of the vertical transfer schemes, municipalities pass about one sixth of the gross local business tax revenue on to the federal government and respective state. In return, municipalities receive 15 percent of the income tax revenue and 2.2 percent of the value-added-tax revenue that is generated in their jurisdiction. The mentioned transfers are not horizontal ones equalizing across municipalities, but vertical ones, as they shift fiscal revenue between the respective municipality, state, and the federal government.[6]

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[3] The amount of municipalities reflects the territorial boundaries in January 2021.

[4] For more information see https://www.destatis.de.

[5] Note that some commercial activities are exempt from the local business tax including farmers and freelancers.

[6] Except for the difference due to the *Länderfinanzausgleich*.

4.2.2 Local tax instruments and fiscal tansfers

Following a major tax reform in 2008, the tax liability for the local business tax (LBT), *Grundsteuer A* (PropA), and *Grundsteuer B* (PropB) are calculated by multiplying the tax base with a basic rate (*Steuermesszahl*) and a municipal multiplier (*Hebesatz*), following:

$$\text{tax liability} = \text{tax base} \times \text{basic rate} \times \text{municipal multiplier}. \qquad (4.2.1)$$

The basic rate is determined by the federal government and applies to all states equally. For the LBT, the basic rate is 3.5 percentage points. For example, a LBT multiplier of 400 equals a statutory tax rate of 14 percent (400 x 0.035).[7] For the PropA and PropB the basic rates vary between 2.6 and 10 percentage points depending on the kind of land, the type, age and size of buildings on the property, and whether it is located in the former German Democratic Republic. The tax base of the property tax is determined by the fiscal authorities which determine the standard value of a property.[8] The LBT is levied on firm profits of both partnerships (*Personengesellschaften*) and legal entities (*Kapitalgesellschaften*). Under federal tax law, profits from partnerships are indirectly taxed by the income tax *(Einkommensteuer)*, as owners must indicate gains in their tax declaration, while legal entities (*Kapitalgesellschaften*) are obliged to pay corporate taxes *(Körperschaftssteuer)* on their profits. Under the LBT, profits of partnerships of up to 24,500 Euro are exempt. Furthermore, to avoid excessive double taxation of partnerships, LBT payments are fully tax deductible for income tax purposes up to a municipal multiplier of 380.[9] The multipliers for the LBT, PropA, and PropB are set independently on a yearly basis on the municipal level. By law, municipal multiplier increases must be passed until the 30th of June of a given year.

Due to their substantial tax setting autonomy, German municipalities may strategically set local business tax rates to attract relatively mobile corporate profits. To avoid a race-to-the-bottom and limit fiscal externalities, the autonomy of municipalities to freely set the LBT is limited by a number of regulations and incentives from fiscal

[7]In the following, the terms "tax rate" and "multiplier" will be used synonymously, as they are perfectly proportional to each other.

[8]Standard property values were last ascertained on 01.01.1964 in the West and 01.01.1935 in the East and have not changed since. These values will be reevaluated by 2025 following a property tax reform in 2019.

[9]Several papers explore this particularity. von Schwerin (2015) find considerable bunching of multipliers at the 380 threshold. Büttner et al. (2014) find that municipalities with a high ratio of partnerships have more frequently raised their LBT multiplier.

equalization schemes. In 2004, the federal government introduced a legal minimum multiplier of 200. This effectively put an end to tax haven municipalities setting excessively low tax rates.[10] Tax competition among municipalities is further disincentivized through horizontal fiscal equalization schemes (*kommunaler Finanzausgleich*) within all German states.[11] The transfer is provided by the state and funded through tax revenues from joint taxes (*Gemeinschaftssteuern*) raised in the respective state.[12] The size of their transfers crucially depends on a municipalities' fiscal need (*Finanzbedarf*) and its fiscal capacity in terms of raising revenue (*Steuerkraftmesszahl*). Intuitively, a municipality with a high (low) fiscal need and low (high) fiscal capacity receives more (less or none) of the funds. The calculation of fiscal needs varies by state, but generally large municipalities in terms of area and/or population are assigned disproportionately larger fiscal needs. However, the calculation of the fiscal capacity depends on the municipalities' tax policy decisions. Fiscal capacity is calculated for the LBT, PropA and PropB following:

$$\text{fiscal capacity} = \frac{\text{tax revenue}_{its}}{\text{multiplier}_{its}} \times \text{reference rate}_{is}, \tag{4.2.2}$$

where i denotes the municipality, t the year, and s the respective state. The state-specific reference rate (*Nivellierungshebesatz* or *Fiktiver Hebesatz*) generally reflects the average multiplier level in the state.[13] The size of the horizontal transfer is based on the difference between fiscal need and fiscal capacity and, thus, only indirectly depends on the actual amount of tax revenue. Municipalities setting a multiplier below the state reference rate will have a fiscal capacity exceeding their actual tax revenue and will, therefore, be implicitly punished for setting a "too low" tax rate.[14] Generally, municipalities with fiscal capacity greater than their fiscal need are not charged and, thus, receive zero transfers. Through fiscal equalization schemes, municipalities are encouraged to set a multiplier at least equal to the states' reference rate.

[10] Previously some small (<100 inhabitants) municipalities successfully attracted firms by setting LBT rates of zero (see Büttner and von Schwerin, 2016).

[11] The moderating impact of fiscal externalities is well-established (see e.g. Büttner and Holm-Hadulla, 2008; Egger et al., 2010; Köthenbuerger, 2002).

[12] Joint tax rates and bases are set on the federal level and include the personal and corporate income tax, the VAT and the capital gains tax.

[13] Calculations differ by state. Some states prescribe a reference rate by law (e.g. NRW) others use some form of a state average (e.g. BW).

[14] Baskaran (2014) finds that municipalities' tax setting strongly depends on the reference rate.

4.2.3 Municipal Debt Reduction Programs

In response to rising debt levels which further deteriorated during the global economic crisis in 2009, nine German states launched municipal debt reduction programs (Arnold et al., 2015).[15] These programs provided state funding to indebted municipalities to reduce the debt level and ensure that social security and public good obligations can be met in the future. A common feature across all states was the obligation for participating municipalities to sign a consolidation contract (*Konsolidierungsvertrag*), declaring a clear plan on how to reduce debts. These contracts did not mandate tax increases or expenditure cuts but left it to municipalities to outline feasible consolidation measures. Depending on the program, states had to deem these measures appropriate. In return, states either (partially) bailed out the respective municipalities or took over portions of their public debt. These measures were usually executed over a longer time period to ensure municipalities' compliance with the signed contracts, while not overburdening the state's public budgets. States also provided financial assistance with interest payments. Each of the nine states independently designed their respective program, leading to substantial heterogeneity across states regarding eligibility for participation, the scope and size of the program and/or the efforts demanded from municipalities. In the following, we will discuss the debt reduction programs in the states of Hesse and NRW in greater detail, as we focus on these two programs in our empirical analysis.

The state of Hesse passed its debt reduction program (*Kommunaler Schutzschirm*) with a volume of 3.2 billion Euro into law in May 2012. Under this program, the state takes on 46% of the debt of participating municipalities (2.8 billion Euro) and part of their interest payments (400 million Euro). In order to be eligible to participate in the Hesse DRP, municipalities had to meet at least one of three criteria.[16] First, the average debt (*Kassenkredit*) amounted to more than 1000 Euro per capita between 2009 and 2010. Second, an average deficit of more than 200 Euro per capita was reported between 2005 and 2009. Third, municipalities reported, on average, a deficit between 2005 and 2009 and an average debt of more than 470 Euro per capita between 2009 and 2010. For eligible municipalities, actual participation is voluntary and conditional on a contract between the municipality and the state. The program was first announced in 2010, a basic agreement between the state and the umbrella organizations of the

[15] The nine states wit a DRP are Bavaria, Hesse, Lower Saxony, Mecklenburg-Western Pomerania, North Rhine-Westphalia, Rhineland-Palatinate, Saarland, Saxony-Anhalt and Schleswig-Holstein.

[16] See Hessisches Ministerium der Finanzen (2014) for more details.

municipalities in Hesse *(Kommunale Spitzenverbände)* was reached in January 2012. The first contract was signed in November 2012 and the last contract was signed in February 2013. Given that all three eligibility criteria are based on budget figures in or prior to 2010, municipalities were unable to manipulated their budget figures preventing them from self-selecting into the program. Additionally, anticipation effects from ex-ante diffusion of information can be credibly ruled out as the program was first announced in 2010 by the newly appointed prime minister Volker Bouffier, following the unexpected resignation of Roland Koch.[17] The state argues that the thresholds were set in an objective manner. Furthermore, participation was not based on outcomes, as the multipliers were irrelevant for the selection process. Thus, the status of eligibility can be regarded as quasi-exogenous, allowing for an unbiased estimation of the effects of the Hesse debt reduction program. The assignment of eligibility does not change over time, which provides a stable treatment group.[18] Ultimately, 92 municipalities were eligible out of which 86 participated and 6 declined.[19] Since municipal governments can only increase tax multipliers until the 30th of June, the treatment year for the Hesse DRP is 2013.

The NRW debt reduction program (*Stärkungspakt*) was passed into law in December 2011 with a volume of 5.85 billion Euro. The program was conducted in two waves. In the first wave, municipalities were forced to participate in the program and sign a consolidation contract with the state if they were expected to run into excessive debt between 2011 and 2013 based on their 2010 budget figures. In return, these municipalities receive a yearly aid of 25,89 Euro per inhabitant and additional aid based on the specific budget situation and interest payments. In total, these payments amount to 350 million Euro per year. 34 municipalities were obligated to participate in the first wave. In the second wave, municipalities that were expect to run into excessive debt in the years 2014 to 2016 based on their 2010 budget figures could opt into the program. Municipalities had to decide by March 2012 whether they wanted to participate in the second wave. Starting in 2012, second wave participants received the same payments as first wave participants and also had to sign a consolidation contract with the state. 27 municipalities opted into voluntary participation. Unfortunately, we

[17]The change of the prime minister was not the result of an election nor of a change in the government coalition.

[18]Note that treatment in this case is the intent to treat. Including municipalities that did not actually participate in the Hesse DRP would, if anything downwardly bias our results.

[19]In our sample we have only 85 treated municipalities as Hesseneck has been part of a municipal merger in 2018 and subsequently dropped.

do not observe which municipalities have declined second wave participation. Thus, our analysis focuses predominantly on first wave participants. The NRW government has not considered the opinions of municipal umbrella organizations in their decision which municipalities were mandated to participate.[20] Given the state mandate and the non-participation of municipal umbrella organizations in the program design, NRW municipalities could not self-select into treatment. Additionally, anticipation effects are also unlikely under these circumstances. Thus, first wave participation was quasi-exogenous.

In the following, we will primarily focus on the effect the DRPs in Hesse and NRW had on municipal multipliers. While both state programs included individual contracts with participating municipalities, it is important to highlight that an adjustment of multipliers was one of many options to consolidate, yet no obligation. However, the programs prevented LBT reductions, as multipliers should be maintained. Nevertheless, the state governments did not prescribe standard increases in multipliers, but left the size of the increase to the municipalities. Given the differing abilities to reduce expenditures, the size and timing of multiplier changes across treated municipalities varies substantially.

4.3 Data

For the analysis we use a panel of 10,118 German municipalities from 2004 to 2018 which is taken from the German *Regionaldatenbank*. This data contains information on local public finance, demographics, economic and geographic indicators.[21] Most relevant for our analysis are data on the multiplier levels of the three local tax instruments, their bases, and revenues. Additionally, the *Regionaldatenbank* also contains detailed information about the consumption and personal income tax shares municipalities have received and the share of the local business tax paid in return. All variables are reported annually. For our analysis, we balance the panel by dropping all municipalities for which we have missing information of either of the three tax instruments for one or more years.

The number of German municipalities has steadily decreased from 12,629 in 2004 to 11,012 in 2018. This drop is due to municipal mergers and other territorial reforms

[20] Source: Landtag Nordrhein-Westfalen, Gesetzesdokumentation, Archiv-Signatur: LTNRW 19 A 0303/15/44, Gesetz zur Unterstützung der kommunalen Haushaltskonsolidierung im Rahmen des Stärkungspakts Stadtfinanzen (Stärkungspaktgesetz), vom 09.Dezember 2011.

[21] Unfortunately, the data only contains information about debt levels on the county-level.

especially in the states of the former German Democratic Republic. We account for this fact by harmonizing the data to the territorial boundaries of 2018. This is done by artificially combining all data of all municipalities that would eventually be merged into one. For example, A and B merged in 2009 to the new municipality C. For all years prior to 2009 we combine the data of A and B to recreate C for years prior to 2009 to obtain observations for C throughout the entire observational period. Count data like the tax bases or revenues are simply added up, while we take a simple average of the three tax instrument multiplier levels.[22] As there is evidence that territorial reforms change economic outcomes (Egger et al., 2022), we also rerun our analysis excluding all municipalities that were part of a reform. The results change only quantitatively, therefore, all observations are kept for the analysis. Importantly, the two states considered in the empirical analysis are almost totally unaffected by these irregularities. There is only one reform in Hesse and none in North Rhine-Westphalia.

The summary statistics of the final panel used for the analysis are depicted in Table 4.3.1. The Treated and Nottreated in NRW and Hesse are depicted separately. Column (5) contains all other municipalities not located in Hesse or NRW. A general pattern that emerges is that Treated and Nottreated municipalities in Hesse and NRW are much more similar to each other than to the average municipality in Column(5). However, compared to Hesse, municipalities in NRW that fall into a DRP are substantially larger in terms of population and density compared to their Nottreated counterparts. Looking at the local multipliers, we observe that NRW municipalities generally set a substantially higher multiplier than other German municipalities. Furthermore, LBT multipliers show a substantially smaller variation compared to either property tax rate. The smaller variance of the LBT is likely driven by the fiscal equalization schemes and legal framework outlined in Section 4.2. All in all, the substantial differences between the different states indicates that a naive comparison of Treated and Nonttreated municipalities with all control states would produce misleading results.

Data on state debt reduction programs was collected from public documents outlining the participation criteria as well as the list of participants. Figure 4.3.1 depicts the changes of LBT, PropA and PropB multipliers after the DRP came into effect. Municipalities participating in the debt reduction program are colored yellow. In the case of NRW, treatment is very centralized in the *Ruhrgebiet*, where many municipalities with excessive economic debt and limited economic opportunities are located. In

[22]We rerun the analysis using population weighted means and the results do not change.

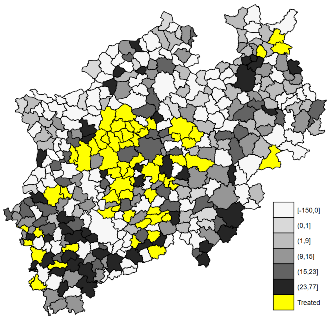
Table 4.3.1: *Summary Statistics*

	Hesse		NRW		
	Treated	Nottreated	Treated	Nottreated	Control
Population Density (inhabitants/sqkm)					
mean	371.86	327.50	829.00	428.78	169.86
sd	497.51	354.74	603.96	444.43	248.85
min	43.17	37.88	139.45	43.23	1.11
max	2,868.63	3,032.73	2,846.69	2,848.51	4,736.11
N	1,365	4,905	510	4,890	139,650
Area (in sqkm)					
mean	52.86	48.14	84.72	86.67	24.90
sd	31.05	31.67	55.22	50.10	30.92
min	4.40	4.05	20.49	22.36	0.39
max	129.71	248.31	232.83	405.17	891.82
N	1,365	4,905	510	4,890	139,650
Total Population					
mean	17,103.04	13,655.46	78,526.50	37,764.13	5,380.73
sd	29,793.44	41,497.41	101,392.48	81,954.86	45,951.01
min	981	1,066	6,508	4,116	5
max	201,585	753,056	504,403	1,085,664	3,644,826
N	1,365	4,905	510	4,890	139,650
Population share age 18 and younger					
mean	0.17	0.17	0.17	0.19	0.18
sd	0.02	0.02	0.02	0.02	0.03
min	0.12	0.12	0.14	0.14	0.00
max	0.21	0.25	0.23	0.28	0.60
N	1,365	4,905	510	4,890	138,457
Population share older than 65					
mean	0.22	0.21	0.21	0.20	0.20
sd	0.03	0.03	0.02	0.02	0.04
min	0.14	0.13	0.16	0.13	0.00
max	0.32	0.31	0.25	0.32	0.80
N	1,365	4,905	510	4,890	139,232
Local Business Tax Multiplier					
mean	356.84	342.27	456.10	422.74	342.03
sd	40.97	34.69	31.81	28.04	33.48
min	270	250	380	250	100
max	480	490	580	575	900
N	1,365	4,905	510	4,890	139,650
Property Tax A Multiplier					
mean	352.09	298.30	289.85	240.75	313.14
sd	105.43	70.57	103.82	55.39	68.67
min	200	0	170	130	0
max	785	720	710	825	1900
N	1,365	4,905	510	4,890	139,650
Property Tax B Multiplier					
mean	369.49	304.87	534.76	424.70	338.19
sd	130.50	79.68	152.00	70.38	50.16
min	210	140	330	230	0
max	1,050	790	959	950	900
N	1,365	4,905	510	4,890	139,650

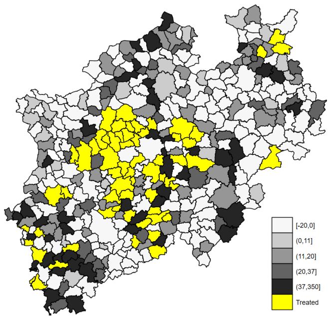
Summary Statistics Continued

	Hesse		NRW		
	Treated	Nottreated	Treated	Nottreated	Control
Property Tax A Base (in 1000 Euro)					
mean	14.78	15.01	31.26	44.83	8.55
sd	11.39	15.13	25.57	31.00	11.78
min	-7.00	-99.00	3.00	-2.30	-47.00
max	57.00	724.00	138.98	328.75	386.00
N	1,365	4,905	510	4,890	139,183
Property Tax B Base (in 1000 Euro)					
mean	598.62	506.17	2,424.38	1,329.99	177.75
sd	1,164.25	2,230.18	3,158.16	3,308.81	1,520.52
min	18.00	19.00	149.00	30.00	-89.00
max	7,621.95	42,819.00	15,586.65	45,196.26	100,817.11
N	1,365	4,905	510	4,890	139,615
Local Business Tax Base (in 1000 Euro)					
mean	2,007.38	2,503.43	7,021.50	5,221.33	693.92
sd	5,323.22	18,623.82	9,604.53	17,666.69	7,581.42
min	-2,146.76	-2,973.61	100.00	-560.00	-6,448.00
max	44,903.27	418,565.82	59,956.80	274,381.96	551,921.33
N	1,365	4,905	510	4,890	139,269
Personal Income Tax Transfer (in 1000 Euro)					
mean	6,989.68	6,140.29	26,036.96	14,025.47	1,965.45
sd	12,040.74	20,213.24	32,391.44	33,044.86	18,829.81
min	226.00	238.00	1,987.00	848.00	0.00
max	94,670.14	453,685.94	189,762.79	581,566.97	1,664,591.43
N	1,365	4,905	510	4,890	139,649
Value-Added Tax Transfer (in 1000 Euro)					
mean	931.55	869.46	3,833.55	2,138.65	257.88
sd	2,519.13	7,400.04	5,833.10	7,394.91	3,242.55
min	5.00	4.00	64.00	36.00	-343.00
max	27,287.57	191,859.55	46,069.65	158,841.79	286,621.39
N	1,365	4,905	510	4,890	139,294
Local Business Tax Transfer (in 1000 Euro)					
mean	1,422.97	1,770.72	5,098.94	3,777.22	452.67
sd	3,755.18	13,064.80	7,014.39	12,808.44	4,780.25
min	-1,466.24	-2,036.92	66.00	-386.00	-4,427.00
max	30,983.26	285,880.28	43,772.86	203,042.65	409,860.19
N	1,365	4,905	510	4,890	139,159
Total Tax Revenue (in 1000 Euro)					
mean	17,229.57	17,253.77	71,836.97	41,320.88	6,242.76
sd	39,078.35	110,409.81	96,669.12	121,936.28	129,392.57
min	296.33	-6,040.35	3,453.00	1,854.70	-10,619.00
max	304,150.30	2,492,955.72	578,396.11	2,042,050.63	13,150,000.00
N	1,365	4,905	510	4,890	139,049

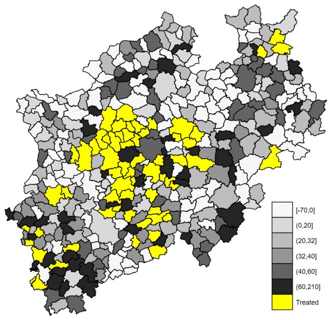
Figure 4.3.1: *Tax Multiplier Changes of the Nottreated in Hesse and NRW*



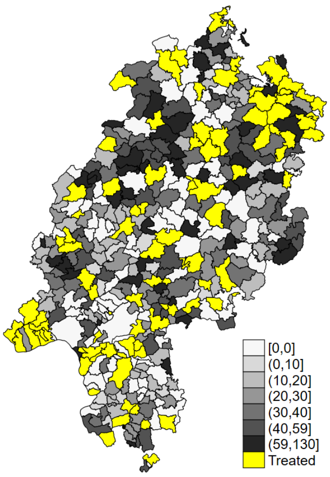
(a) *LBT NRW*



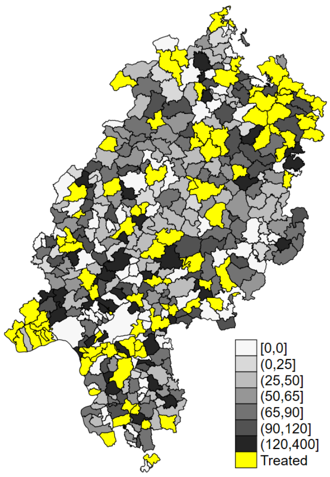
(b) *Prop A NRW*



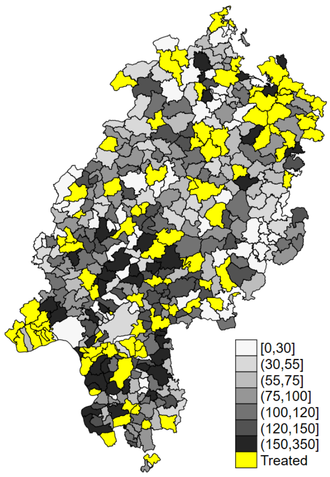
(c) *Prop B NRW*



(d) *LBT Hesse*



(e) *Prop A Hesse*



(f) *Prop B Hesse*

Hesse, on the other hand, treatment is distributed across the entire state. For both states we observe substantial responses by municipalities located close to a treated municipality illustrating the importance of spatial aspects in the diffusion of tax shocks. This pattern appears to be particularly prominent in Hesse.

4.4 Methodology

The analysis will be conducted in two steps and aims to identify municipal tax policy spillovers from state debt reduction program participation. First, we focus on the Treated municipalities in Hesse and NRW which are subject to state debt reduction programs. Second, we focus on the tax policy response of the Nottreated municipalities located in Hesse or NRW which are not directly affected by the respective DRP. In order to identify the average causal effect of treatment on the treated, we employ a

Difference-in-Differences estimator following:

$$TAX_{i,t} = \alpha + \beta(Post_t \times Treat_i) + \delta_i + \zeta_t + \epsilon_{i,t} \tag{4.4.1}$$

$TAX_{i,t}$ denotes the LBT, PropA or PropB multiplier of municipality i at year t. δ_i and ζ_t represent municipality and year fixed effects respectively. $\epsilon_{i,t}$ captures the disturbance term. $Post_t$ is a dummy taking on the value one in the year of treatment and afterwards. $Treat_i$ is a dummy indicating whether a municipality participated in a state DRP. The coefficient of interest β yields the average change in the municipal tax rate in treated municipalities. As state debt reduction programs require municipalities to consolidate their public budgets, we expect β to be positive and statistically significant for all three tax instruments.

In order to further explore the timing and persistence of the effect of treatment on municipal tax policy, we also estimate the treatment effect using a generalized DiD following:

$$TAX_{it} = \alpha_0 + \sum_{t=2004}^{2018} \alpha_t Treat_i \times year_t + \delta_i + \zeta_t + \epsilon_{it}. \tag{4.4.2}$$

Thus, we obtain T coefficients of interest α, which yield the level difference of local tax multipliers of the Treated relative to the control group. Ideally, all α_t for $t < t_{treat}$ are statistically insignificant and close to zero, while all α_t for $t \geq t_{treat}$ are positive and statistically significant. As municipalities participate over longer time periods in the state debt reduction programs, we would expect the treatment effect to be persistent over time. The goal of this first step of the analysis is to establish that treated municipalities indeed exhibit a strong tax policy reaction to the quasi-exogenous assignment to a state debt reduction program.

In the second step, we turn to the Nottreated municipalities located in the geographical proximity of treated municipalities, but not directly participating in the respective state's DRP. To focus on these Nottreated municipalities, we estimate equations (4.4.1) and (4.4.2) replacing $Treat_i$ with $Nottreat_i$. For this analysis the German setting is particularly intriguing as municipalities can chose to tax both mobile corporate profits and immobile property values through the LBT and PropA/B respectively. If German municipalities engage in corporate tax competition, we would expect that the LBT multipliers are strategic complements, implying that a rise in the LBT of a neighboring municipality should lead to an increase in my own LBT. This response should be less than proportionate, however, as we should otherwise observe a race to the top. Regarding the expected results for PropA and PropB, the intuition is less straight forward, especially given the mixed results of the previous literature. As properties are immobile, governments should have little to no strategic incentive to react to changes in their neighbors' tax policy. However, if municipalities were to engage in yardstick competition, then property tax rates should also be complements. In this case, spillovers in the property tax rates would be driven by tax mimicking and/or learning from neighboring municipalities.

Lastly, we explore the spatial dynamics of this tax/yardstick competition. If neighboring municipalities are also affected by state DRPs even though they are not directly treated, the question remains how quickly this effect disappears with distance to a treated unit and, whether the spatial dynamics are heterogeneous across tax instruments. In order to investigate these questions, we augment equation (4.4.1) following

$$TAX_{i,t} = \alpha + \beta(Post_t \times Treat_i \times Dist_{ij}) + \delta_i + \zeta_t + \epsilon_{i,t}, \tag{4.4.3}$$

where $Dist_{ij}$ denotes the minimum distance between an untreated municipality i and the nearest treated municipality j.[23]

For an unbiased identification using the (generalized) DiD estimator, we require a control group that meets two assumptions. First, the common trends assumption which ensures that the true effect of treatment is not confounded by general time trends or structural time-constant differences between the treatment and control group. Intuitively, it ensures that the treatment and control municipalities are actually comparable, i.e., would have exhibited the same development of municipal multipliers in the absence of DRPs. Second, the exogeneity of treatment assumption must be met ensuring that treatment is exogenously assigned independent of unobserved municipality characteristics. Furthermore, treatment may not affect control municipalities. Given the institutional set up of the debt reduction programs in Hesse and NRW the assignment of treatment is quasi-exogenous and unaffected by unobserved firm characteristics. In NRW, however, some municipalities could select into treatment for later periods. Consequently, these municipalities are disregarded for the analysis, as they are not initially treated, but may show policy responses not based on proximity but receiving treatment at a later point in time.

Regarding the choice of the control group, we need to ensure that both assump-

[23]Distance is defined as the linear distance between the two municipalities' centroids.

tions are met to identify the impact of state debt reduction programs both on the participating and non-participating municipalities in Hesse and NRW. To ensure that both assumptions hold, we construct the control group using Propensity Score Matching (PSM). Ideally, matching on observables using PSM ensures that treatment and control municipalities only differ by their treatment status. For the construction of the control group, we use k-nearest neighbor matching without replacement. Matching is based on the unweighted mean of observable control variables for the periods $t_{PostTreat-3}$ to $t_{PostTreat-7}$. The donor pool of potential control municipalities consists of all municipalities located in a state without a debt reduction program, these are the states of Baden-Württemberg, Bavaria, Brandenburg, Saxony, and Thuringia.[24] The match is based on a number of municipality characteristics including demographics, tax base, development of tax instruments, and fiscal transfers. More specifically, we use the area of a municipality, the population density, as well as the population share of young ($<= 18$) and old($>= 65$) inhabitants to adequately represent a municipalities' demographics. To capture the fiscal capacity of a municipality, we use the tax bases of the LBT, PropA and PropB. Additionally, we match on the average change in the LBT, PropA and PropB rate to capture common trends in tax policy development. Lastly, fiscal transfers include the share of the VAT and personal income tax a municipality receives as well as the LBT transfer the municipality pays to the state and federal budget.

4.5 Results

We will first focus on the results for the treated municipalities. Table 4.5.1 depicts the results for the baseline specification in equation (4.4.1). The results for the treated municipalities in Hesse and NRW are given in Panel A. Looking at Columns (1)-(3), we observe that forced participation in the NRW DRP led to a substantial increase in the municipal multipliers of all three tax instruments. The increase was most pronounced for the property tax rate B which increased on average by approximately 188 basis points or 6.5 percentage points. The increase in the local business tax is less pronounced with only 29 basis points or approximately 1 percentage point, but still economically sizable and statistically significant. A similar picture emerges when looking at the

[24]Bavaria had a small debt reduction program as part of the states' fiscal equalization scheme. The program only had a volume of 140 million Euros per year nd was primarily aimed at the development of rural municipalities rather than fiscal consolidation.

results for Hesse in Columns (4)-(6). Again, eligibility for the Hesse debt reduction programs led to substantial increases in all three municipal tax instruments with the most pronounced increase in the property tax rate B. Municipalities in Hesse exhibit a more pronounced increase in the local business tax and the property tax rate A compared to the municipalities in NRW.

Figure 4.5.1 plots the dynamic DiD estimation results of equation (4.4.2). Unsurprisingly, we observe a substantial increase in all three tax instruments in both Hesse and NRW after treatment occurs, as already documented in Table 4.5.1. Looking at the results for NRW in greater detail, treated municipalities depict significant pre-trends for the LBT and PropA in the four years prior to treatment. The pre-trend is most pronounced for the LBT and appears to be driven by fiscal consolidation efforts during the economic crisis in 2008. The treatment group in NRW consistently mostly of *Ruhrgebiet* municipalities which are very populous and economically underdeveloped, making it difficult to construct an adequate control group. Property tax rate A multipliers show a statistically significant difference for several pre-treatment years. However, these differences are economically close to zero.[25] This absence of a pre-trend suggests that the common trends assumption holds only for the PropB and that treated and matched control municipalities exhibit different developments in their multipliers. Given the existence of a pre-trend in the two periods prior to treatment, which are not considered in constructing the control group, further implies that there were anticipation effects of the debt reduction program. Thus, the results for Treated municipalities in NRW should be interpreted cautiously. Nevertheless, we observe a significant increase in multipliers after treated municipalities were forced to participate in the NRW debt reduction program in December 2011. Local multipliers continuously increased between 2012 and 2016 with a distinct jump in property tax rates A and B between 2012 and 2013. Thus, treated municipalities exhibit a staggered response leading to a large and persistent increase in all three tax instruments. Due to this dynamic adjustment to treatment the average treatment effects reported in Table 4.5.1 understate the true and persistent increase in municipal multipliers by 28% to 37%. This is particularly pronounced for the property tax rate B which exhibits an average increase in its multiplier of 253 basis points in 2017 compared to the average increase of 188 across all periods. Lastly, we observe some variation around the point estimates, implying that treated municipalities in NRW exhibit heterogeneous responses to their

[25]For detailed estimation results depicted in Figure 4.5.1 and Figure 4.5.2 see Table 4.A.1 and Table 4.A.2 respectively.

Table 4.5.1: *Difference-in-Differences Results*

Panel A: DiD Treated

	NRW			Hesse		
	(1) LBT	(2) Prop A	(3) Prop B	(4) LBT	(5) Prop A	(6) Prop B
Treat × Post	28.636***	90.882***	188.236***	40.015***	120.943***	171.377***
	(1.247)	(4.156)	(5.150)	(3.721)	(7.070)	(7.241)
Constant	399.319***	292.528***	417.710***	344.481***	324.780***	327.443***
	(0.291)	(0.970)	(1.202)	(0.744)	(1.414)	(1.448)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Observations	1020	1020	1020	2730	2730	2730

Panel B: Nottreated

	NRW			Hesse		
	(1) LBT	(2) Prop A	(3) Prop B	(4) LBT	(5) Prop A	(6) Prop B
Nottreat × Post	12.873***	26.116***	59.902***	28.122***	58.273***	85.095***
	(1.264)	(3.564)	(4.993)	((3.356)	(3.218)	(4.405)
Constant	381.606***	283.821***	374.146***	337.212***	302.614***	308.949***
	(0.295)	(0.832)	(1.165)	(0.671)	(0.644)	(0.881)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Observations	9780	9780	9780	9810	9810	9810

Panel C: Spatial

	NRW			Hesse		
	(1) LBT	(2) Prop A	(3) Prop B	(4) LBT	(5) Prop A	(6) Prop B
Post × Dist	-0.026	-0.068*	-0.072**	-0.045	-0.021	-0.035
	(0.012)	(0.026)	(0.025)	(0.031)	(0.022)	(0.038)
Nottreat × Post	9.558	12.651	60.104***	18.114*	64.690***	100.530***
	(4.590)	(10.205)	(11.037)	(7.948)	(5.912)	(10.036)
Nottreat × Post × Dist	-0.157***	-0.251***	-0.765***	0.387***	-1.000***	-2.155***
	(0.012)	(0.026)	(0.025)	(0.031)	(0.022)	(0.038)
Constant	385.485***	294.309***	385.096***	337.969***	304.042***	307.459***
	(2.043)	(4.444)	(4.551)	(2.651)	(1.909)	(3.300)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Observations	9750	9750	9750	9375	9375	9375

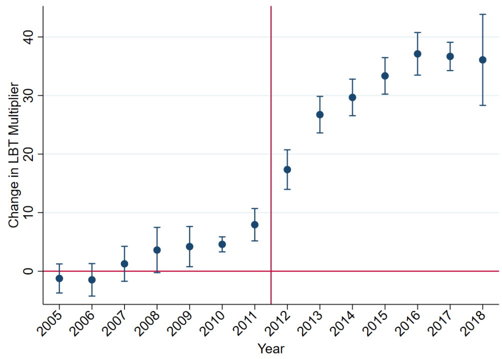
*The table depicts the results of the DiD estimation. Standard errors are reported in parentheses and are clustered on the state level. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.*

forced participation in the state debt reduction program.

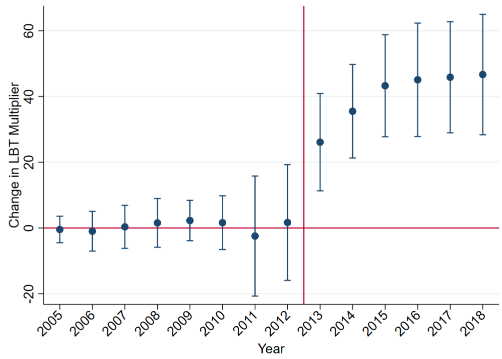
Looking at the results for Hesse in Figure 4.5.1, a similar picture emerges. Prior to treatment, treated municipalities exhibit no pre-trends compared to their respective control municipalities again implying that the common trends assumption holds and that there are no anticipatory effects of eligible municipalities. Generally, the staggered response of Hessian municipalities is quicker compared to NRW causing the average treatment effect and the overall final increase in local multipliers to differ only by 15% to 28%. All in all, Table 4.5.1 and Figure 4.5.1 illustrate that the debt reduction programs in Hesse and NRW can be regarded as quasi-exogenous and that the control group was adequately chosen. Furthermore, these programs had a substantial impact on all three municipal tax instruments in both states. Overall, these results are in line with expectations as municipalities are forced/agree to consolidate their public budgets, they increase tax rates and subsequently tax revenues.

The question remains how municipalities not being directly treated under these debt reduction programs are affected. Looking at Panel B of Table 4.5.1, we observe that Nottreated municipalities in the same state also increase their municipal tax rates. In the case of NRW, local business tax multipliers increase by approximately 13 basis points or 0.46% which is less than half the increase of the municipalities forced to participate in the debt reduction program. Turning to the results in Column (4), we observe a similar response for Nottreated municipalities in Hesse. LBT multipliers increase substantially but less than proportional. These results suggest that local business tax multipliers in Hesse and NRW are strategic complements. Given that the corporate tax base is mobile, this finding implies that municipalities in both states engage in tax competition. Looking at the results in Column (2) and (3), we observe that also Nottreated municipalities in NRW substantially raised both their property tax rates. PropA multipliers increased by approximately 43 basis points (1.5 percentage points), while PorpB multipliers rose by 96 basis points (3.4 percentage points). The increase in property tax multipliers is again less than proportionate compared to municipalities participating in the DRP, but economically and statistically significant. A similar picture emerges when looking at the results for Hesse in Columns (5) and (6). The increase in both property tax multipliers in Nottreated municipalities in Hesse is particularly pronounced and amounts for the property tax rate B to a 3 percentage point increase. Again property tax rates across different municipalities appear to be complements. However, since the property tax base is almost immobile, this finding cannot be rationalized by strategic interdependence. It seems that Nottreated munic-

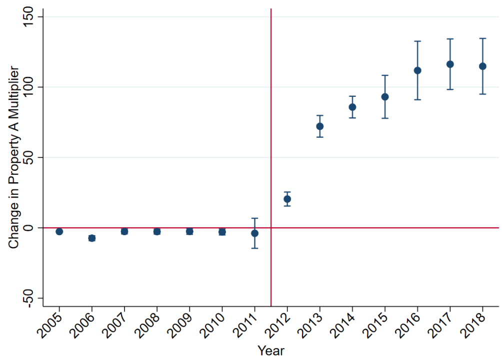
Figure 4.5.1: *Effect of Debt Reduction Programs on the Treated*



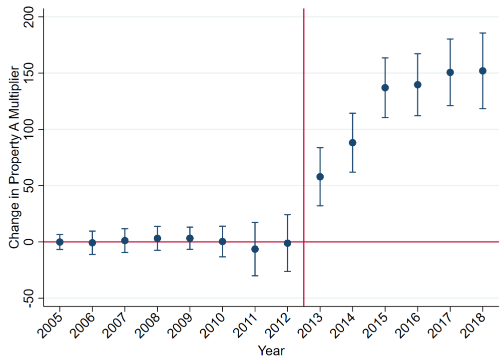
(a) *LBT NRW*



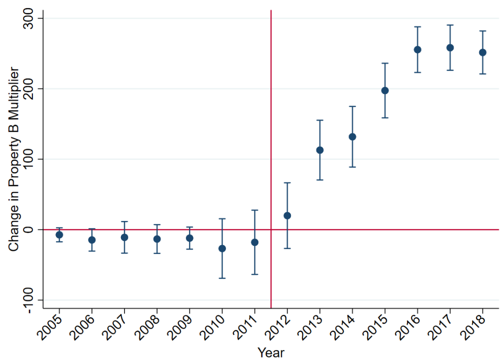
(b) *LBT Hesse*



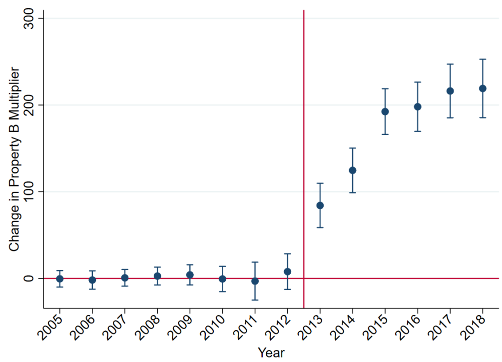
(c) *PropA NRW*



(d) *PropA Hesse*



(e) *PropB NRW*



(f) *PropB Hesse*

ipalities in both states observe, learn from, and imitate the policy changes of their treated neighbors. Consequently, these results imply that municipalities in Hesse and NRW engage in yardstick competition.

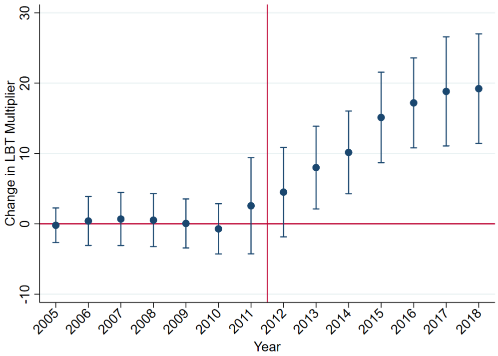
Looking at the dynamic DiD results depicted in Figure 4.5.2, we see that these findings are further reinforced. Regarding the response of Nottreated municipalities in NRW in panel (a), (c), and (e), we observe no statistically significant pre-trend for either tax instrument. Thus, PSM provides an adequated control group exhibiting a common time trend and no anticipatory effects. The policy response of Nottreated municipalities materializes with a one year delay as all three tax instrument coefficients for 2012 are statistically insignificant at the 5% level. Similar to the Treated, tax multipliers have gradually increased over time until 2017 where the effect appears to stabilize. Again, this implies that multiplier levels have increased substantially and that this change is persistent over time. Due to this staggered response, the persistent post-reform level of all three multipliers is significantly larger than the implied average increase in Panel B of Table 4.5.1. However, confidence intervals for Nottreated municipalities in NRW are substantially larger indicating that these municipalities exhibit substantial heterogeneity in their responses to debt reduction programs. Panels (b), (d), and (f) in Figure 4.5.2 illustrate an absence of statistically significant pre-trends in Hesse, indicating again that the control group is adequately chosen as the common trends assumption holds and no anticipatory effects are observed. Similar to NRW, Hessian municipalities exhibit a one year delay in their property tax response. However, they display a change in their LBT multiplier in the first year after treatment. Again, multiplier levels gradually rise over time before stabilizing around 2017 depicting a large, persistent, and statistically significant increase in all three multiplier levels. The instantaneous response of Nottreated municipalities in Hesse supports the impression that municipalities engage in corporate tax competition. Additionally, the delayed response in property tax rates substantiates the hypothesis that municipalities also engage in yardstick competition. It is plausible that yardstick competition takes place with a time lag as a Nottreated municipality requires a certain time period to observe the policy actions and outcomes of their neighbors and learn from them.

Finally, we are interested in the spatial dimension of the effect of state debt reduction programs on the Nottreated municipalities. Based on Figure 4.3.1, it appears as if there are pronounced spatial patterns in Hesse and less pronounced patterns in NRW. This relationship is captured by equation (4.4.3) for which we report results in Panel C of Table 4.5.1. When considering the minimum distance to the nearest treated unit in NRW, the average treatment effect for the LBT and PropA disappear. However, we find that on average the LBT (PropA) is 0.15 (0.25) points lower per kilometer between a non-participating municipalities and the closest treated municipality after treatment. Thus, the treatment effects seem to be driven by the municipalities located close to a treated municipality. The absence of the overall treatment effect, however, confirms that this spatial pattern is rather weak. Turning to Column (3), the average treatment effect for the property tax rate B does not vanish. Additionally, it decreases with an increasing distance to the nearest treated unit at an average rate of 0.765 points per kilometer. Consequently, the effect vanishes, on average, for a municipality located 79 or more kilometers away from the nearest treated municipality. The fact that the effect on the property tax rate B declines the fastest indicates that geographical proximity is particularly relevant for this tax instrument and that municipalities, consequently, engage in yardstick competition. Turning to the results for Hesse in Columns (4)-(6), we observe that the average treatment effect remains statistically significant. For the LBT, however, this efffect is now only significant at the 10% level. Interestingly, the spatial interaction coefficient for the LBT is positive implying that municipalities located in Hesse, but further away, show larger increases in their LBT. This finding indicates that for the LBT not only the spatial but also other factors play a role as indicated by Janeba and Osterloh (2013). Looking at both property tax rates in Hesse, we observe a substantial increase in the average multiplier of the Nottreated which quickly diminishes with increasing distance to the nearest treated. In the case of the PropA, the effect vanishes, on average, 65km away from the nearest treated while for the PropB it is only 47km. Given these results, the effect on the property tax multipliers of the Nttreated in Hesse is highly localized and appears to be driven by yardstick competition. Not only do these municipalities react strongly, their response is also highly dependent on being located closely to a municipality participating in the DRP.

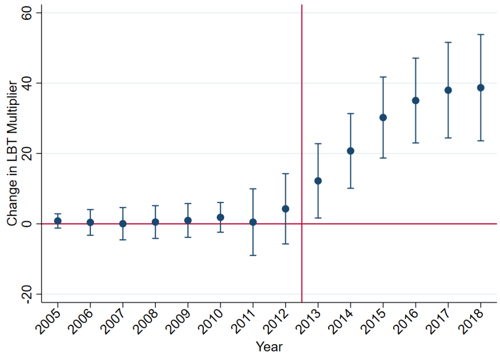
4.6 Conclusion

In this paper we analyze if and how sub-national entities compete over local tax instruments for both mobile and immobile tax bases. Exploiting tax increases in municipalities that were participating in quasi-exogenous state debt reduction programs, we find that not only the directly affected municipalities but also their geographical neighbors in the same state exhibit substantial increases in both corporate and property tax

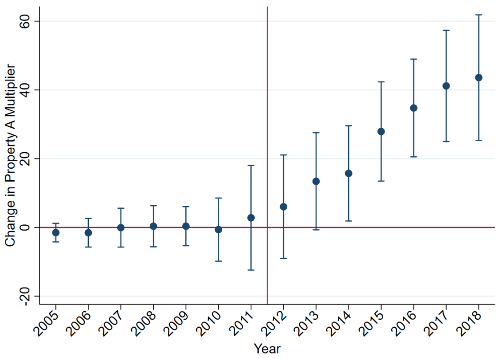
Figure 4.5.2: *Effect of Debt Reduction Programs on the Nottreated*



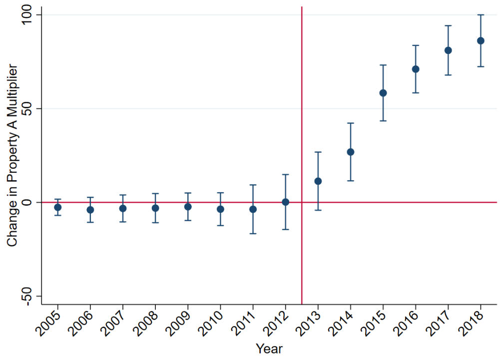
(a) *LBT NRW*



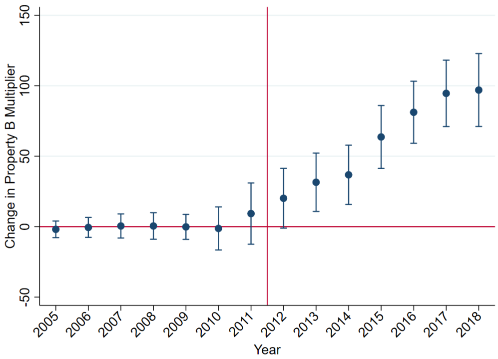
(b) *LBT Hesse*



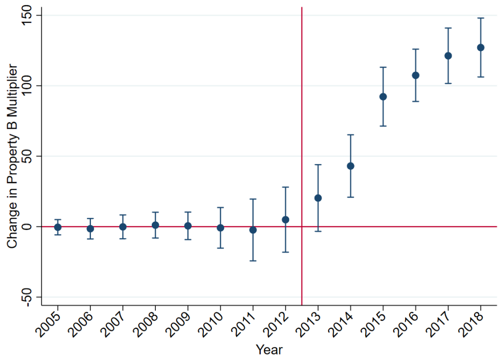
(c) *PropA NRW*



(d) *PropA Hesse*



(e) *PropB NRW*



(f) *PropB Hesse*

rates. The effect is particularly pronounced for the property tax rates on developed land which increased, on average, by 7.7 percentage points in DRP municipalities in Hesse and 9 in NRW. Nottreated municipalities in Hesse and NRW also exhibit a pronounced increase in corporate and property tax rates with the property tax rate on developed land rising by 3.4 and 4.5 percentage points in NRW and Hesse, respectively. Furthermore, the effects on property tax instruments are highly localized and quickly diminish with distance to the nearest treated municipality. The fact that municipalities property tax instruments appear to be highly localized complements indicates that German municipalities are engaging in substantial yardstick competition. Additionally, we also find evidence for corporate tax competition.

This study adds to the literature by analyzing tax and yardstick competition within a common legal framework, while simultaneously exploiting quasi-exogenous heterogeneous variation in local tax instruments. The literature has so far found mixed evidence for tax competition in several European countries. Additionally, the importance of spatial factors has been largely disregarded. If anything, the choice of control groups in the literature has largely been driven by geographical proximity, potentially resulting in endogeneity problems and biased results. We address this research gap by explicitly looking at these spatial factors and illustrating their importance. Furthermore, we demonstrate that yardstick competition is highly localized in a narrow geographical area around the shock.

The question remains whether this pattern is confined to Germany or if it also generalizes to other European countries. Recent evidence by Blesse et al. (2019) suggests that German municipalities generally choose too low property tax rates due to imprecise expectations and political concerns. This might explain the sizable effects we find for both property tax rates in Germany as some local governments are strongly encouraged to increase their tax rates, giving neighbors the chance to correct their beliefs. Consequently, exogenous state mandated shocks might also be a valuable policy tool to provide learning opportunities and prevent too low revenue streams and subsequent default.

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4.A Appendix

Table 4.A.1: *Generalized Difference-in-Differences Treated*

	NRW			Hesse		
	(1) LBT	(2) Prop A	(3) Prop B	(4) LBT	(5) Prop A	(6) Prop B
Treat × 2005	-1.235	-2.676***	-7.324	-0.451	-0.121	-0.440
	(0.780)	(0.160)	(3.126)	(1.567)	(2.574)	(3.697)
Treat × 2006	-1.471	-7.353***	-14.618*	-0.978	-0.780	-1.846
	(0.872)	(0.551)	(4.980)	(2.350)	(4.050)	(4.113)
Treat × 2007	1.265	-2.618**	-10.941	0.341	1.143	0.703
	(0.938)	(0.551)	(7.051)	(2.546)	(4.107)	(3.734)
Treat × 2008	3.618*	-2.706**	-13.324	1.549	3.165	2.747
	(1.214)	(0.558)	(6.414)	(2.882)	(4.138)	(4.010)
Treat × 2009	4.206**	-2.559**	-12.029*	2.264	3.275	4.121
	(1.079)	(0.653)	(4.930)	(2.387)	(3.848)	(4.525)
Treat × 2010	4.588***	-2.941**	-26.794	1.615	0.330	-0.626
	(0.403)	(0.666)	(13.281)	(3.176)	(5.291)	(5.669)
Treat × 2011	7.941***	-3.882	-17.971	-2.451	-6.407	-3.088
	(0.869)	(3.355)	(14.333)	(7.102)	(9.225)	(8.513)
Treat × 2012	17.353***	20.471***	19.882	1.670	-1.099	7.846
	(1.061)	(1.565)	(14.651)	(6.848)	(9.818)	(8.007)
Treat × 2013	26.735***	72.147***	112.912***	26.099***	57.879***	84.176***
	(0.980)	(2.419)	(13.326)	(5.756)	(10.054)	(9.948)
Treat × 2014	29.676***	85.824***	131.853***	35.505***	88.154***	124.626***
	(0.980)	(2.419)	(13.532)	(5.533)	(10.185)	(10.004)
Treat × 2015	33.353***	93.118***	197.471***	43.264***	137.011***	192.418***
	(0.980)	(4.789)	(12.177)	(6.036)	(10.298)	(10.269)
Treat × 2016	37.118***	111.853***	255.529***	45.077***	139.659***	198.022***
	(1.143)	(6.534)	(10.191)	(6.708)	(10.710)	(11.052)
Treat × 2017	36.676***	116.294***	258.324***	45.846***	150.637***	216.198***
	(0.759)	(5.644)	(10.090)	(6.575)	(11.507)	(12.047)
Treat × 2018	36.088***	114.824***	251.559***	46.670***	151.989***	219.099***
	(2.443)	(6.219)	(9.582)	(7.124)	(13.072)	(13.119)
Constant	98.137***	294.074***	424.147***	344.283***	324.808***	326.919***
	(0.183)	(0.851)	(4.582)	(2.113)	(3.478)	(3.486)
Observations	1020	1020	1020	2730	2730	2730
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X

*The table depicts the results of the generalized DiD estimation. Standard errors are reported in parentheses and are clustered on the state level. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.*

Table 4.A.2: *Generalized Difference-in-Differences Nottreated*

	NRW			Hesse		
	(1) LBT	(2) Prop A	(3) Prop B	(4) LBT	(5) Prop A	(6) Prop B
Nottreat× 2005	-0.206	-1.506	-1.908	0.817	-2.627	-0.410
	(0.959)	(1.051)	(2.296)	(0.789)	(1.682)	(2.106)
Nottreat × 2006	0.405	-1.549	-0.564	0.401	-3.972	-1.477
	(1.355)	(1.619)	(2.755)	(1.423)	(2.594)	(2.826)
Nottreat × 2007	0.684	-0.061	0.479	0.040	-3.226	-0.144
	(1.468)	(2.201)	(3.329)	(1.786)	(2.793)	(3.289)
Nottreat × 2008	0.525	0.347	0.482	0.505	-3.055	1.067
	(1.468)	(2.326)	(3.664)	(1.810)	(3.023)	(3.562)
Nottreat × 2009	0.055	0.365	-0.166	0.963	-2.321	0.575
	(1.355)	(2.211)	(3.446)	(1.870)	(2.853)	(3.793)
Nottreat × 2010	-0.712	-0.629	-1.273	1.841	-3.615	-0.850
	(1.389)	(3.570)	(5.948)	(1.643)	(3.404)	(5.611)
Nottreat × 2011	2.564	2.813	9.270	0.477	-3.685	-2.352
	(2.659)	(5.918)	(8.457)	(3.685)	(5.055)	(8.532)
Nottreat × 2012	4.503	6.021	20.147*	4.269	0.193	4.945
	(2.473)	(5.858)	(8.252)	(3.882)	(5.699)	(8.982)
Nottreat × 2013	7.997**	13.423*	31.500**	12.220**	11.312	20.306*
	(2.289)	(5.496)	(8.055)	(4.113)	(6.032)	(9.209)
Nottreat × 2014	10.153***	15.733**	36.782***	20.731***	26.869***	43.046***
	(2.288)	(5.390)	(8.190)	(4.133)	(5.980)	(8.621)
Nottreat × 2015	15.123***	27.917***	63.653***	30.226***	58.330***	92.260***
	(2.504)	(5.614)	(8.687)	(4.483)	(5.789)	(8.123)
Nottreat × 2016	17.196***	34.748***	81.199***	35.055***	71.034***	107.422***
	(2.487)	(5.530)	(8.568)	(4.690)	(4.918)	(7.220)
Nottreat × 2017	18.825***	41.172***	94.598***	38.000***	81.046***	121.303***
	(3.018)	(6.294)	(9.172)	(5.285)	(5.123)	(7.653)
Nottreat × 2018	19.218***	43.601***	96.963***	38.706***	86.174***	127.138***
	(3.030)	(7.104)	(10.066)	(5.878)	(5.372)	(8.138)
Constant	381.399***	283.835***	373.751***	336.694***	303.854***	308.874***
	(0.956)	(2.002)	(3.027)	(1.430)	(1.923)	(2.852)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Observations	9780	9780	9780	9810	9810	9810

*The table depicts the results of the generalized DiD estimation. Standard errors are reported in parentheses and are clustered on the state level. * denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.*

Appendix A

Corporate Tax Data Documentation

General Assumptions:

If not indicated differently, the data is based on information provided in the EY *Worldwide Corporate Tax Guide*. Other sources include the International Bureau of Fiscal Documentation (IBFD) tax research platform, the PWC *Worldwide Tax Summaries*, KPMG *Corporate Tax Rate Tables*, the OECD, and national tax codes and are explicitly stated. The representative firm is assumed to be operating in the manufacturing sector. Depreciation allowances for some asset categories are frequently missing. In order to obtain a balanced panel and maximum data coverage, we assume that the depreciation schemes of missing asset categories are equal to the closest most similar asset type. If the rates for Office Equipment are missing, we assume the these rates are equal to the rates of Plant and Machinery. Computers are assumed to depreciate like Office Equipment, if not specified differently. Similarly, we assume that Vehicles depreciate like Plant and Machinery, if depreciation rates for Vehicles are missing. Additionally, several countries do not report specific depreciation allowances, but allow for the depreciation of an asset over its "useful life". In this case, we follow the useful lives reported in *Taxing profits in a global economy : Domestic and international issues* published by the OECD in 1991.

Afghanistan:

Statutory corporate income tax rates (STR) and depreciations rates for 2015-2020 are taken from IBFD. STRs from 2010 to 2014 are taken from KPMG. Buildings are assumed to be "Brick or stone structures" and, thus, depreciate over 50 years. Plant and Machinery is "not otherwise specified below" and, thus, depreciates over 10 years. The depreciation allowances for Intangible fixed assets (IFAS) are assumed to be 10% under the straight-line (SL) method. Vehicles are assumed to be "Cars" and, thus, depreciate over 4 years.

Albania:

Plant and Machinery, Vehicles and Office Equipment depreciate like "Other fixed assets".

Algeria:

Firms are assumed to be in the production sector and, therefore, subject to a 19% STR as opposed to 25%/23%. Depreciation rates for Buildings, Office Equipment and Vehicles are taken from PWC for the years 2014 to 2018. Computers are assumed to depreciate like "Office items". STRs for the years 2009 to 2013 are taken from IBFD. The depreciation rates for Plant and Machinery are assumed to be based on their useful life. Following OECD (1991), Plant and Machinery have a useful life of 7 years. They are depreciable accordingly under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Depreciation allowances for years prior to 2014 are assumed to be equal to the respective rates in 2014. The depreciation allowances for 2019 are assumed to be equal to the respective allowances in 2018 (Both assumptions are supported by EY and IBFD).

American Samoa:

STR and depreciation rates for the years 2000 to 2020 are taken from IBFD. Firms are assumed to generate taxable income equal to or exceeding 650,000 US Dollars (USD) in years prior to 2018. Starting 2018, firms are assumed to generate taxable income equal to or exceeding 75,000 USD. Depreciation allowances are equal to the respective allowances in the United States of America.

Andorra:

STRs for the years 2000 to 2020 are taken from the OECD. STRs prior to 2000 are taken from the Andorran tax code. A corporate tax rate entered into force in 2012 (LA LLEI 95/2010). Depreciation rates are taken from the national tax code and are in line with information provided by IBFD. Office Equipment is assumed to depreciate like “Furniture”. Vehicles are assumed to depreciate like “Transport elements”. An additional deduction of 5% is available if the asset is kept in place for at least 5 years, this applies to all assets in our data except for Office Equipment and Computers.

Angola:

The depreciation rates for Plant and Machinery are assumed to be equal to the rates for “Electric Motors and Mechanical Engines” for the years 2004 to 2014. Office Equipment is assumed to depreciate like “Furniture”. The rates for Computer are assumed to be equal to the rates of Office Equipment for the years 2004 to 2014 and equal to the rates of “Devices” starting in 2015. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Anguilla:

STRs for the years 2000 to 2009 are taken from the OECD. STRs for the year 2010 to 2020 are taken from IBFD. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Antigua and Barbuda:

STRs and depreciation allowances for the years 2009 to 2020 are taken from IBFD. As no provisions for intangible assets exist, these assets are assumed to be non-depreciable. STRs are taken from the “The Income Tax Act” from the Laws of Antigua and Barbuda. The tax code sets forth that wear and tear allowance is allowed. As no rates are specified the rates applying in 2009 are also assumed to apply in the previous years.

Argentina:

Depreciation allowances are granted based on the useful life of the asset. For the years 2009 to 2020 depreciation rates are taken from IBFD. Office Equipment depreciates like “office furniture”. Computers depreciate like “equipment”. In line with OECD (1991), buildings are assumed to have a useful life of 40 years and, thus, less than 50 allowing for a larger depreciation rate. Starting 2020, intangible assets are assumed to have a limited life of 10 years. Thus, the depreciation allowances for IFAS are assumed to be 10% under the SL method. In line with EY depreciation rates prior to 2009 are assumed to be equal to the respective rates in 2009.

Armenia:

Buildings are assumed to belong to “Category A” and depreciate over a useful life of 20 years. Vehicles and Office Equipment are assumed to be subject to the same depreciation rules as “Other Fixed Assets”. From 2014 to 2017, Plant and Machinery depreciates like “Robot equipment and assembly lines”. STR and depreciation rates for 2009 are taken from IBFD. Depreciation rates for years prior to 2009 are assumed to be equal to the respective rates in 2009. STR and depreciation rates prior to 2009 are taken from “The Law of the Republic of Armenia on Profit Tax”.

Aruba:

EY and the IBFD do not provide specific depreciation rates for Aruba, but state that depreciation is allowed based on “sound business practices”. PWC provides specific rates for the years 2013 to 2017. These rates are assumed to be also applicable for the years 2001 to 2012 and from 2017 onward. In the years 2001 to 2003, firms are assumed to make 1 million Aruban Florin in profits qualifying for the 39% corporate tax rate. Office Equipment is assumed to depreciate like “Machinery and installations”. Buildings may qualify for accelerated depreciation if their cost exceeds 43 million EUR.

Australia:

STRs and depreciation allowances for buildings and IFAS are taken from EY and IBFD. The rates for Plant and Machinery, Office Equipment, Computers and Vehicles are taken from the “Tax Rulings” of the Australian government. Firms may also choose the declining-balance (DB) method for depreciation. The allowances under this method are from 2004 to 2006 1.5 times the SL depreciation rate and from 2007 onward double the SL rate. Firms are assume to have a turnover greater than 50 million Australian Dollars (AUD) in 2019 to 2020 and are, therefore, subject to a 30% STR. IFAS held by the company is assumed to be mainly patents. Office Equipment is assumed to depreciate like “Multi function machines” and, thus, have a useful life of 5 years. Vehicles are assumed to depreciate like “Cars“ in the “Generally” category and, thus, have a useful life of 8 years. Computers are assumed to depreciate like “Computers and computer equipment” and, thus, have a useful life of 4 years. Starting in 2014, Plant and Machinery is assumed to depreciate like “Machine tools” in the category “CNC and NC based machines” and, thus, have a useful life of 10 years. Prior to 2014, Plant and Machinery is assumed to depreciate like “Lathe” of the category “computer controlled” and, thus, have a useful life of 10 years.

Austria:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment.

Azerbaijan:

STR and depreciation rates for the years 2001 to 2020 are taken from IBFD. Based on the proposition of the Azerbaijanian tax authorities documented by PwC (2010-2018) the depreciation rates set forth by IBFD are also applied to the period between 2001-2009 (in line with EY, which allows for useful life depreciation).

Bahamas:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. STRs for 2000 are taken from the OECD.

Bahrain:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. STRs for 2000 are taken from the OECD.

Bangladesh:

The STRs for the years 2009 to 2018 are taken from IBFD. Companies are assumed to be publicly traded. Depreciation rates are taken from IBFD and EY. The depreciation rates for the years 2009 to 2019 for Computers and IFAS are taken from IBFD. Depreciation allowances for Computers and IFAS prior to 2009 are assumed to be equal to the respective rates in 2009 (supported by EY as no reform has taken place). Depreciation allowances for Buildings, Plant and Machinery, Office Equipment and Vehicles are taken from EY. Buildings are assumed to be factories and, thus, depreciate at 20% instead of 10% ("General Buildings"). In 2019, Vehicles are assumed to depreciate like Plant and Machinery. The depreciation allowances of Buildings, Plant and Machinery, Office Equipment and Vehicles between 2007 and 2019 are assumed to be equal to the respective rates in 2019. This is in line with the IBFD as no reform appears to have taken place.

Barbados:

The depreciation allowances for IFAS are assumed to be 10% SL method from 2001 to 2003. From 2009 to 2018, companies are assumed to be manufacturing and, thus, subject to a 15% STR (instead of 25%). STR and depreciation rates for 2019 and 2020 are taken from IBFD. Starting in 2019, firms are assumed to generate more than 30 million Barbadian Dollars. In accordance with the IBFD, depreciation rates are taken from the national tax code. Plant and Machinery is assumed to depreciate like "Electrical equipment".

Belarus:

All depreciation rates are taken from PWC. STR and depreciation rates for the years 2001 to 2010 are assumed to be equal to the values of 2011 (supported by EY and IBFD which state useful life prior to 2011). The depreciation allowances for IFAS are assumed to be 10% SL method in 2018. The depreciation rates for 2019 and 2020 are assumed to be equal to the respective rates in 2018. For 2019, the initial allowances are taken from EY.

Belgium:

The surtax on corporate profits of 3% until 2017 and 2% starting 2018 is included.

Belize:

STR and depreciation rates for the years 2010 to 2019 are taken from IBFD. Buildings, Plant and Machinery, Office Equipment, Computers, and Vehicles are assumed to be "Qualifying Expenditures". The depreciation allowances for IFAS are assumed to be 10% SL method. It is assumed that depreciation rates in 2014 and 2015 are equal to the respective rates in 2016, since no difference in either tax rate nor depreciation allowances exist from 2013 to 2016. Firms are assumed to be subject to the regular tax rate and are, thus, not international business companies (IBCs). STRs for the years 2000 to 2009 and 2020 are taken from the OECD. In line with the national tax code, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over their useful life. Following OECD (1991), Plant and Machinery, Office Equipment, Computers and Vehicles have a useful life of 7 years. All of these assets depreciate under the SL method.

Benin:

STR and depreciation rates for the years 2008 to 2020 are taken from IBFD. The depreciation allowances for IFAS are assumed to be 10% SL method. Starting in 2009, firms are assumed to be industrial and, thus, subject to a 25% STR. Based on the "Circular Note No.85/MFE/DC/SGM/DGID" from the 13th of April 2004, Plant and Machinery are assumed to be "Engines and generators" and depreciate at a rate of 15%. Office Equipment and Vehicles are assumed to be "Mobile equipment and tools" and depreciate at a rate of 15%.

Bermuda:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. The STR for the year 2000 is taken from the OECD.

BES – Islands:

Firms are assumed to be subject to the BES tax legislation rather than Dutch corporate income tax. STR and depreciation rates prior to 2011 are assumed to be equal to the rates of the Netherland Antilles as the predecessor country. Due to the zero STRs starting in 2011, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Bhutan:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Buildings are assumed to be permanent. Office Equipment is assumed to depreciate like Furniture. Computers are assumed to depreciate like "miscellaneous equipment". The depreciation allowances for IFAS are assumed to be 10% SL method. STR and depreciation rates prior to 2009 are taken from the national tax code.

Bolivia:

The depreciation allowances for IFAS before 2010 are assumed to be equal to the ones in 2010. Depreciation allowances in 2001 are assumed to be equal to the rates in 2002.

Bosnia and Herzegovina:

The STR and depreciation rates reflect the rates of the Federation of Bosnia and Herzegovina, thus, disregarding the Republic of Srpska and the Brčko District. STRs and depreciation rates for IFAS for the years 2009 to 2020 are taken from IBFD. Depreciation rates for the years 2011 to 2020 are taken from PWC. Plant and Machinery and Office Equipment are assumed to depreciate like "Equipment". In line with IBFD and PwC (but not further specified therein), depreciation rates from 2009 to 2010 are assumed to be equal to the respective rates in 2011. STRs prior to 2009 are taken from OECD. Depreciation rates prior to 2009 are taken from the national tax code.

Botswana:

Computers are assumed to depreciate like Office Equipment. The depreciation allowances for IFAS are assumed to be 10% SL method. Firms are assumed to be approved manufacturing firms and, therefore, only subject to a 15% STR.

Brazil:

Office Equipment is assumed to be subject to the same depreciation rules as Plant and Machinery. The depreciation allowances for IFAS are assumed to be 10% SL method. The STR includes the surtax and the "Social Contribution Tax".

British Virgin Islands:

Starting in 2006, the STR drops to zero. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Prior to 2006, the depreciation allowances for IFAS are assumed to be 10% under the SL method. Prior to 2006, Computers are assumed to depreciate like Office Equipment.

Brunei Darussalam:

Office Equipment and Vehicles are assumed to depreciate like Plant and Machinery. The depreciation rates for the years 2009 to 2019 for Computers are taken from IBFD. Depreciation rates for Computers prior to 2009 are assumed to equal the rate in 2009.

Depreciation allowances for IFAS are taken from the national tax code. STRs for the years 2000 to 2020 are taken from the OECD.

Bulgaria:

Plant and Machinery is assumed to be new and, thus, subject to a 50% depreciation rate. Office Equipment depreciates like “Other Equipment”. Vehicles are assumed to depreciate like “transportation equipment and other types of transportation”.

Burkina Faso:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Plant and Machinery is assumed to be “fixed”. Office Equipment and Computers are assumed to be “non fixed”. The depreciation allowances for IFAS are assumed to be 10% SL method. Depreciation allowances past 2015 are assumed to be equal to the respective rates in 2015. This is in line with the information provided by the IBFD in these years. According to “LOI No 008-2010/AN - PORTANT CREATION D’UN IMPOT SUR LES SOCIETES” no changes of the tax law occurred between 1965 and 2010. Thus, the depreciation and STR set out by the IBFD in 2009 are assumed to also apply to prior years. Depreciation rates for 2010 are taken directly from the tax code. Plant and Machinery is assumed to depreciate like “Factory equipment including machine tools (Matériels d’usines y compris machines outils)” over 5 years. Vehicles are assumed to depreciate like “Light commercial motor vehicles (Véhicules automobiles utilitaires légers)” over 3 years. Buildings are assumed to be built out of “durable materials”.

Burundi:

Depreciation rates are taken from the General Tax Code of Burundi and are in line with the IBFD. STRs for the years 2004 to 2019 are taken from IBFD. Plant and Machinery is assumed to depreciate like “Machines et Matériels avec moteur”. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Cameroon:

Depreciation rates from 2009 to 2019 are taken from IBFD. Plant and Machinery is assumed to be “factory machinery”. Office Equipment is assumed to depreciate like “Furniture”. Vehicles are assumed to depreciate like “Containers” or “light vehicles”. Depreciation allowances prior to 2009 are taken from the national tax law (supported by EY).

Cambodia:

Plant and Machinery is assumed to depreciate like “Other tangible property”.

Canada:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 09.10.2019). Depreciation rates for IFAS are taken from IBFD. Depreciation rates of IFAS prior to 2010 are assumed to be equal to the respective rates in 2010. Plant and Machinery is assumed to be used in manufacturing. From 2001 to 2011 Computers are assumed to depreciate like Office Equipment.

Cabo Verde:

STR and depreciation rates for the years 2008 to 2020 are taken from IBFD. Taxable income is assumed to be subject to the fire brigade surcharge. Depreciation allowances for years prior to 2008 are taken from the "Ministerial Decree" of 28 January 1984. The rates for the years 2015 to 2017 are assumed to be the same as in 2018, based on the "Ministerial Decree 42/2015". STRs prior to 2008 are taken from the national tax law. Computers are assumed to depreciate like Office Equipment. Prior to 2015, Plant and Machinery is assumed to depreciate like "machines". Office Equipment is assumed to depreciate like "non-metallic furniture". Computers are assumed to depreciate like "calculator, typewriter". IFAS are assumed to depreciate like "patents, trademarks, licences, concessions and other rights". Vehicles are assumed to depreciate like "lightweight motor vehicles".

Cayman Islands:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Central African Republic:

STR and depreciation allowances for the years 2009 to 2020 are taken from IBFD. Buildings are assumed to be "made of durable materials" and, thus, depreciate at a rate of 5%. Vehicles are assumed to be "light". Firms are assumed to generate turnover exceeding 30 million CFA Francs. STR and depreciation rates for the years 2001-2009 are taken from the national tax code (Directive relative à l'impôt sur les sociétés Annexe à la directive no02/01/UEAC-050-CM-06 du 3 août 2001). Plant and machinery are assumed to depreciate like factory equipment ("Matériel d'usines"). The depreciation rate for Office Equipment and Computers is taken from the national tax code for all years. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Chad:

The STR for the years 2011 to 2020 are taken from IBFD. Depreciation rates for the years 1997 to 2020 are also taken from IBFD. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Chile:

Buildings are assumed to depreciate like "solid structures". The depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment is assumed to depreciate like "peripherals". Prior to 2004, Office Equipment and Computers are assumed to depreciate like "General installations".

China:

Computers are assumed to depreciate like "Electronic Equipment". Office Equipment is assumed to depreciate like "Furniture and other assets related to production and business operations".

Colombia:

Colombian firms are assumed to make sufficient profits to be subject to the income tax surcharge which faded out in 2019. Depreciation allowances for IFAS prior to 2007 are assumed to be equal to the depreciation rates in 2007. Office Equipment is assumed to depreciate like Plant and Machinery. Depreciation rates for the years 2017 and 2018 are taken from PWC. STR and depreciation rates for 2019 and 2020 are taken from IBFD. The income tax surcharge is equal to:

Year	Threshold	Surtax
2003	-	5%
2004-2006	-	10%
2007-2016	-	-
2017	800 million Colombian Pesos	6%
2018	800 million Colombian Peso	4%
2019 -	-	-

Comoros Islands:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Buildings are assumed to be built with "with durable materials". Plant and Machinery is assumed to depreciate like "heavy industrial and commercial equipment". In 2008, computers are assumed to depreciate like Office Equipment. Starting in 2013, Office Equipment depreciates like "Furniture". Vehicles are assumed to depreciate like "heavy vehicles". The depreciation allowances for IFAS are assumed to be 10% under the SL method. STR and depreciation rates for years prior to 2012 are taken from the national tax code "Law 85/018/AF of 24 December 1985". IBFD does not provide STR and depreciation rates for 2017, however, they do not differ from the rates in 2016 and 2018 and are, thus, assumed to be identical.

Congo, Democratic Republic of:

The depreciation rates for Computers for the years 2009 to 2020 are taken from IBFD. The DB depreciation rates for all assets from 2009 to 2020 are taken from IBFD. Land and intangibles are non-depreciable. As IBFD states, the tax law does not specify applicable depreciation rates. Thus, depreciation rates for years prior to 2009 are assumed to be equal to the respective rates in 2009. STRs for the years 2000 to 2008 are taken from the OECD.

Congo, Republic of:

Computers are assumed to depreciate like Office Equipment. Land and intangible assets such as goodwill are non-depreciable.

Cook Islands:

STR and depreciation rates for the years 2008 to 2020 are taken from IBFD. The depreciation allowances for IFAS are assumed to be 10% under the SL method. (in line with information provided by IBFD). The useful life assumption of OECD (1991) applies to depreciation rates for Buildings, Plant and Machinery, Office Equipment, Computers and Vehicles on the Cook Islands (in line with IBFD). Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. STR and depreciation rates for the years 1997 to 2008 are taken from the national tax law. For the years 1997 to 2010 Buildings and Plant and Machinery are eligible for a 100% depreciation rate.

Costa Rica:

Costa Rican firms are assumed to make sufficient profits to exceed the relevant threshold to qualify for the maximum STR (30%). Computers are assumed to depreciate like Office Equipment. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Cote d'Ivoire:

Plant and Machinery is assumed to be stationary. IFAS are non-depreciable.

Croatia:

Firms are assumed to realize a revenue greater or equal to 3 million Croatian Kuna resulting in a STR of 18%. Vehicles are assumed to depreciate like non-personal cars. Prior to 2010, Office Equipment and Computers are assumed to depreciate like "Equipment". Past 2010, only Office Equipment is assumed to depreciate like "Equipment".

Cuba:

STRs are taken from IBFD for the years 2010, 2013, 2016, 2019, and 2020. Depreciation rates were not available. Firms are assumed to be resident. STRs between 2010 and 2013 are identical, thus, rates for 2011 and 2012 are assumed to be the same.

Curaçao:

STR and depreciation rates for the years 2017 to 2020 are taken from IBFD. Office Equipment is assumed to depreciate like Plant and Machinery. In line with EY and IBFD, depreciation rates for 2011, 2013 and 2015 to 2016 are assumed to be equal to the respective rates in 2017. Prior to 2016, firms are assumed to qualify for accelerated depreciation but not for the reduced profit tax rate for manufacturing firms. STR and Depreciation rates prior to 2011 are equal to the respective rates of the Netherland Antilles (predecessor country).

Cyprus:

Firms are assumed to generate sufficient profits to qualify for the maximum tax rate. In line with EY and IBFD, the useful life of IFAS is assumed to be 10 years for the years 2001-2020.

Czech Republic:

The depreciation rates for IFAS equal the rates specified for "Other intangible assets". Prior to 2004, the depreciation rates for IFAS are assumed to be equal to the respective rates in 2004 (EY states that IFAS is depreciable in accordance with the accounting depreciation). Machinery is assumed to be "light machinery" and, thus, depreciates over three years. Computers depreciate like "Office machines". Firms are assumed to elect the accelerated depreciation method. Vehicles are assumed to depreciate like "passenger cars".

Denmark:

Vehicles are assumed to depreciate like "Operating Equipment". Prior to 2008, Office Equipment and Computers are assumed to depreciate like "Equipment".

Djibouti:

STR and depreciation rates for the years 2012 to 2020 are taken from IBFD. Office Equipment is assumed to depreciate like "Furniture". Vehicles are assumed to depreciate like "Tractors". The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Dominica:

The years 2010 to 2020 are taken from IBFD. Plant and Machinery and Vehicles are assumed to be "7-year plant and machinery". Office Equipment and Computers are assumed to be "5-year plant and machinery". The depreciation allowances for IFAS are assumed to be 10% under the SL method. The STR and depreciation rates in 2013 are assumed to be equal to the respective rates in 2012 and 2014. STR and depreciation rates in 2019 are assumed to be equal to the rates in 2020.

Dominican Republic:

Plant and Machinery is assumed to depreciate like "Other assets". The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Ecuador:

The depreciation rate for IFAS in 2001 is assumed to equal the rate in 2002. Firms are assumed to not reinvest their profits in Ecuador

Egypt:

Office Equipment is assumed to depreciate like “Furniture”. Plant and Machinery is assumed to depreciate like “Small machinery and equipment”. The depreciation rates for IFAS prior to 2006 are assumed to be equal to the respective rate in 2006.

El Salvador:

Starting in 2012, firms are assumed to have sales exceeding 150.000 USD. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers and Office Equipment are assumed to depreciate like “Other movable property”. Depreciation allowances prior to 2003 are equal to the respective rates in 2003. From 2003 to 2005, Vehicles are assumed to depreciate like “Other movable property”.

Equatorial Guinea:

Computers are assumed to depreciate like Office Equipment. Land and intangible assets, such as goodwill, are non-depreciable.

Eritrea:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Office Equipment is assumed to depreciate like “furniture”. Starting 2017, Computers are assumed to depreciate following the same rate as in 2016.

Estonia:

Companies are assumed to be either resident companies or permanent establishments of non-resident companies and are, therefore, exempt from corporate taxation. This implies that firms do not distribute profits to shareholders. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Eswatini:

Depreciation allowances for Buildings, Plant and Machinery, Office Equipment, Computers, and Vehicles for the years 2010 to 2018 are taken from PWC. The depreciation allowances for IFAS are assumed to be 10% under the SL method. STR and depreciation rates for 2008, 2009 and 2019 to 2020 are taken from IBFD. Depreciation rates prior to 2008 are assumed to be equal to the respective rates in 2008 (in line with EY). Plant and Machinery is assumed to work only one shift per day.

Ethiopia:

Depreciation rates given in EY are assumed to be Straight Line. Office Equipment is assumed to depreciate like “Furniture” prior to 2004. Prior to 2004, Computers are assumed to depreciate like Office Equipment. Depreciation rates of IFAS prior to 2004 are assumed to equal the respective rate in 2004. Past 2004, Plant and Machinery, Office Equipment, and Vehicles are assumed to be “Other Business Assets”. The STR and depreciation rates for 2018 to 2020 are taken from IBFD. Starting 2018, buildings are assumed to depreciate like “Structural improvement other than greenhouse”.

Fiji:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Prior to 2016, Plant and Machinery is assumed to have an effective life of 10 to 20 years. For the years 2016 to 2018, Computers are assumed to depreciate like Office Equipment. Past 2016, Vehicles are assumed to fall into the category of “Heavy Commercial motor vehicles”.

Finland:

Office Equipment and Vehicles are assumed to depreciates like machinery. Computers are assumed to have a useful life of less than three years and cost 850 Euros or less and are, thus, fully expensed in the year of acquisition.

France:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 09.10.2019). The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment.

French Polynesia:

STR and depreciation rates for the years 2013 to 2019 are taken from IBFD. Firms are assumed to be subject to the maximum tax rate. Depreciation allowances for the year 2013 are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. Intangible assets are assumed to have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method. Starting in 2014, Computers are assumed to depreciate like Office Equipment. Starting in 2015, Computers are assumed to be worth less than 5 million CFP Francs (XPF). Starting in 2016, firms are assumed to generate more than 400,000,001 XPF in taxable income and are, thus, subject to a 15% STR surcharge.

Gabon:

Computers are assumed to depreciate like Office Equipment. Land and intangible assets, such as goodwill, are non-depreciable.

Gambia:

STR and depreciation rates for the years 2010 to 2019 are taken from IBFD. Firms are assumed to be audited. Depreciation allowances for IFAS are assumed to be following the SL method.

Georgia:

Starting in 2017, companies are assumed to be either resident companies or permanent establishments of non-resident companies and are, therefore, exempt from corporate taxation. This implies that firms do not distribute profits to shareholders. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Depreciation rates prior to 2006 are assumed to equal the respective rates in 2006.

Germany:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 09.10.2019). Depreciation rates for all tangible asset types, except buildings, are taken from the "AfA-Table" (national tax law). IFAS is assumed to depreciate over 15 years, following Section 7(1) of the national tax law (EstG). Vehicles are assumed to depreciate like "Personenkraftwagen". Plant and Machinery is assumed to depreciate like "Sonstige Be- und Verarbeitungsmaschinen". Office Equipment is assumed to depreciate like "Foto-, Film-, Video- und Audiogeräte".

Ghana:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. For 2001, Vehicles are assumed to depreciate like Plant and Machinery and Computers like Office Equipment. Plant and Machinery is assumed to be used in manufacturing.

Gibraltar:

STR and depreciation rates for the years 2009 to 2019 are taken from IBFD. According to PwC, Goodwill is non-depreciable. STR and depreciation rates for 2007 and 2008 are taken from the IBFD European Tax Handbooks. Office Equipment is assumed to depreciate like "Furniture". Computers are assumed to depreciate like Office Equipment.

Greece:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. from 2001 to 2013. The depreciation rate of Plant in Machinery between 2002 and 2013 is assumed to be equal to the rate in 2001. Starting in 2014, Office Equipment is assumed to depreciate like "Other fixed assets". Starting in 2014 Vehicles are assumed to depreciate like "Means of transportation of goods".

Greenland:

Depreciation rates from 2014 to 2018 are taken from PWC. Plant and Machinery, Office Equipment, Computers and Vehicles are assumed to depreciate like "Operating Assets". The depreciation allowances for IFAS are assumed to be the same prior to 2019 as in 2019. STR and depreciation rates for 2019 and 2020 are taken from IBFD.

Grenada:

STR and depreciation rates for the years 2016 to 2019 are taken from IBFD. Plant and Machinery is assumed to be “heavy”. Buildings are assumed to depreciate over their useful life (7 years). Following OECD (1991), buildings have a useful life of 40 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Guadeloupe:

STR and depreciation rates for 2010 and 2019 are taken from IBFD. Firms turnover is assumed to exceed the threshold to qualify for the maximum tax rate. For 2010 depreciation rates are based on the useful life of the assets. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Guatemala:

Office Equipment is assumed to depreciate like “Furniture”.

Guernsey:

Starting in 2008, the statutory tax rate drops to 0%. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Prior to 2008, Office Equipment, Vehicles, and Computers are assumed to depreciate like Plant and Machinery. The depreciation allowances for IFAS are assumed to be 10% under the SL method. prior to 2008.

Guinea:

Land and intangible assets, such as goodwill, are non-depreciable based on information provided in EY. STR and depreciation rates for the years 2010 to 2019 are taken from IBFD. Office Equipment is assumed to depreciate like “Furniture”. STR and depreciation allowances for 2015 are assumed to be equal to the respective allowances in 2014 and 2016. Starting in 2018, firms are assumed to belong to the group of “other legal entities”. Firms are assumed to qualify for the DB depreciation method. STRs prior to 2010 are taken from EY. The depreciation rates prior to 2010 are assumed to be equal to 2010 the respective rates in 2010 (supported by EY).

Guinea-Bissau:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Buildings are assumed to be “with concrete structures”. Plant and Machinery depreciates like “Other machines”. Office Equipment is assumed to depreciate like “furnishings and decorative items, metallic packing for transport, ordinary furniture and other tools”. Computers are assumed to depreciate like “Electronic equipment”. Vehicles are assumed to depreciate like “passenger cars”. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Guyana:

Depreciation rates for all years after 1992 are taken from EY 2019. Companies in Guyana are assumed to be commercial. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Goodwill is non-depreciable.

Honduras:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment. Firms net income is assumed to exceed 1 million Honduran Lempira so that the 5% Social Contribution Tax applies.

Hong Kong:

Plant and Machinery is assumed to satisfy the conditions for the 100% immediate write-off. Depreciation rates of IFAS prior to 2013 are assumed to equal the rates in 2013.

Hungary:

Office Equipment is assumed to depreciate like “other specified items”. The depreciation allowances for IFAS prior to 2005 is equal to the rate in 2005. The STR in 2007 includes the 4% solidarity surcharge.

Iceland:

Computers are assumed to depreciate like “Other movable property”. Plant and Machinery is assumed to depreciate like “Industrial machinery and equipment”.

India:

STRs for the years 2001 to 2019 include the varying surcharge and starting in 2005 an additional surcharge in the form of an education cess. From 2014 onward, firms are assumed to be domestic and generate net income exceeding 100 million Indian Rupees. Starting in 2002, Office Equipment is assumed to depreciate like “Furniture”. For the year 2002 vehicles are assumed to be newly acquired and, thus, depreciate at a rate of 50%. From 2006 onward, Plant and Machinery are assumed to qualify for the initial allowance. The following is the table for the STR, surcharge and education cess:

Year	CIT	Surcharge	Education Cess
2001	35	10	-
2002	35	2	-
2003	35	5	-
2004	35	2.5	-
2005	35	2.5	2
2006,2007	30	10	2
2008-2010	30	10	3
2011	30	7.5	3
2012,2013	30	5	3
2014,2015	30	10	3
2016-2018	30	12	3
2019	30	12	4
2020	30	12	4

Indonesia:

Plant and Machinery and IFAS are assumed to be a Class 2 asset. Office Equipment, Computers and Vehicles are assumed to be Class 2 assets.

Iran:

STR and depreciation allowances for the years 2010 to 2019 are taken from IBFD. Plant and Machinery is assumed to depreciate like “Machines for the production of a variety of materials”. Buildings are assumed to depreciate like “Steel structure buildings”. Vehicles are assumed to depreciate like Plant and Machinery. IBFD is unspecific on depreciation allowances prior to 2017, therefor, applicable rates prior to 2017 are assumed to be equal to the rates in 2017. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment is assumed to depreciate like “Poly copy machines, photocopiers, reproduction machines and cash desks”.

Iraq:

Depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. Intangible assets are assumed to have a limited life and that the depreciation allowances are 10% SL method.

Isle of Man:

Starting in 2006, the statutory tax rate drops to 0%. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. For the year 2001 firms’ profits are assumed to exceed 125.000 British Pounds (GBP). For the years 2002 and 2003 firms’ profits are assumed to exceed 500.000 GBP. From 2004 to 2006 firms are assumed to not make more than 100 million GBP. For years with a positive STR, the depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment and Computers depreciate like Plant and Machinery.

Israel:

Office Equipment is assumed to depreciate like “Peripheral Equipment”. The depreciation rates of Plant and Machinery and Vehicles are assumed to be equal to the rates for “Mechanical Equipment.

Italy:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 15.10.2019). Office Equipment, Computers and Vehicles are assumed to depreciate like Plant and Machinery. The depreciation rates for buildings prior to 2009 are assumed to be equal to the respective depreciation rates in 2009.

Jamaica:

Past 2013, Computers are assumed to depreciate like Office Equipment. Starting in 2014, firms are assumed to be unregulated. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Japan:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 15.10.2019). Office Equipment and Computers are assumed to depreciate like “equipment”.

Jersey:

Starting in 2009, the statutory tax rate drops to 0%. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Prior to 2009, Office Equipment, Computers, and Vehicles are assumed to depreciate like Plant and Machinery. Prior to 2009 buildings depreciate over their useful life. Following OECD (1991), buildings have a useful life of 40 years and, thus, depreciate following the SL method. Prior to 2009 The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Jordan:

Firms are assumed to belong to the category “Others” and are taxed accordingly. Plant and Machinery is assumed to depreciate like “Other machinery and equipment”. Office Equipment is assumed to depreciate like “Other furniture”. Starting in 2016, IFAS is assumed to belong to the category “Other intangible assets”. Prior to 2016, The depreciation allowances for IFAS are assumed to be 10% under the SL method. Prior to 2011, Computers are assumed to depreciate like Office Equipment. Firms are assumed to use the initial depreciation allowance in 2006.

Kazakhstan:

Office Equipment and Vehicles are assumed to depreciate like "Other fixed assets". The depreciation allowances for IFAS are assumed to be 10% under the SL method. From 2001 to 2008 firms make use of the initial allowance. Prior to 2007, Office Equipment and Computers are assumed to depreciate like Plant and Machinery.

Kenya:

Plant and Machinery is assumed to depreciate like "All other machinery". The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Kiribati:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Firms are assumed to generate profits in excess of 50,000 AUD. Office Equipment is assumed to depreciate like "furniture and fittings".

Korea, Democratic Peoples Republic of:

STR and depreciation rates for the years 2008 to 2020 are taken from IBFD. Plant and Machinery, Office Equipment and Computers are assumed to depreciate like "other apparatus". Vehicles are assumed to depreciate like "other vehicles". The depreciation allowances for IFAS are assumed to be 10% under the SL method. The information for 2009 is missing, however, the rates for 2010 are identical to the ones in 2008 and are, thus, assumed to be the same for 2009.

Korea, Republic of:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 15.10.2019). Computers are assumed to depreciate like Office Equipment. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Kosovo:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Plant and Machinery is assumed to depreciate like "other tangible assets". IFAS depreciates over its useful life which is assumed to be 10 years. Firms are assumed to generate annual gross income exceeding EUR 50,000.

Kuwait:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Depreciation rates for Computers are assumed to be equal to the depreciation rates of Office Equipment. For years prior to 2008, firms are assumed to generate taxable profits exceeding 500,000 Kuwaiti Dinars and are, thus, subject to a 57% CIT.

Kyrgystan:

STR and depreciation rates for the years 2008 to 2011 and 2016 to 2020 are taken from IBFD. STR and depreciation rates for the years 2012 to 2015 are taken from PWC. Office Equipment is assumed to depreciate like “Office Furniture”.

Laos:

Computers are assumed to depreciate like Office Equipment. The depreciation allowance for IFAS in 2014 is assumed to equal the respective depreciation allowance in 2015.

Latvia:

The depreciation allowances for IFAS prior to 2008 are assumed to be equal to the respective rates in 2008. IFAS are assumed to be patents. The depreciation allowances are taken from PwC (consistent with EY). Plant and Machinery and Office Equipment are assumed to depreciate like “Other fixed assets”. For the years 2017 to 2019, the nominal STR is 20% of distributed taxable profits, however, the distributed profits are multiplied by the factor 1.25, effectively resulting in an effective STR of 25%, which we use in our data. The information for 2017 to 2019 are taken from IBFD. There is no depreciation on the distributed profits. Firms are implicitly assumed to distribute all profits.

Lebanon:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Prior to 2008, Computers are assumed to depreciate like Office Equipment.

Lesotho:

Firms are assumed to be manufacturing firms and, thus, subject to a decreased STR. Computers are assumed to depreciate like “Office machines”. Office Equipment is assumed to depreciate like “Furniture”. IFAS is assumed to depreciate like “Other assets”.

Liberia:

STR and depreciation rates are taken from IBFD. Prior to 2001, firms are assumed to generate an income exceeding 100,000 Liberian Dollars. Plant and Machinery is assumed to be “Heavy Machinery”. Office Equipment, Computers and Vehicles are assumed to be “Light Equipment”. Buildings depreciate like “Tangible Fixed Property”.

Libya:

The STR includes 4% Jihad Tax of profits. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Plant and Machinery is assumed to depreciate like “tools”. Office Equipment is assumed to depreciate like “Furniture”.

Liechtenstein:

Vehicles are assumed to depreciate like automobiles. The depreciation allowance rate for IFAS is taken from IBFD. The depreciation allowance for IFAS prior to 2010 is assumed to be equal to the rate in 2010.

Lithuania:

Office Equipment is assumed to depreciate like "Other Assets". For the years 2001 and 2002, Office Equipment is assumed to depreciate like Plant and Machinery. The depreciation allowance of IFAS prior to 2003 is assumed to be equal to the respective allowance in 2003.

Luxembourg:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 15.10.2019). The depreciation allowances for IFAS are assumed to be 10% under the SL method., this is in line with information provided by IBFD. Computers are assumed to depreciate like Office Equipment.

Macau:

Firms are assumed to generate profits in excess of 600.000 Macau Patacas. Vehicles are assumed to be "Light vehicles". Plant and Machinery is assumed to depreciate like "Electronic equipment and machinery". In 2020, firms net profits are assumed to exceed 100 million Macau Patacas.

Madagascar:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment. Firms are assumed to have a turnover exceeding the relevant threshold to qualify for the 20% STR which are as follows:

Year	Threshold
2018	100.000.000 Malagasy Ariary
2019, 2020	200.000.000 Malagasy Ariary

Malawi:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Buildings and Plant and Machinery are assumed to be newly acquired. The STR and depreciation rates prior to 2005 are assumed to be equal to the rates specified for 2005. Office Equipment, Computers, and Vehicles are assumed to be allowed to depreciate at the maximum rate by the commissioner general.

Maldives:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Mali:

STR and depreciation rates for the years 2008 to 2020 are taken from IBFD. For all years depreciation rates are based on the useful life of the assets. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Malta:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Plant and Machinery is assumed to depreciate like “Other machinery”. Office Equipment is assumed to depreciate like “Furniture”.

Malaysia:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. From 2019 onward, firms are assumed to generate sufficient taxable income to qualify for the standard tax rate.

Marshall Islands:

STR and depreciation rates are taken from IBFD. A gross revenue tax of 3% is imposed. Thus, effectively there is a corporate tax rate and no depreciation allowances.

Martinique:

STR and depreciation rates for 2009, 2010 and 2019 are taken from IBFD. Firms are assumed to be sufficiently large to qualify for the “Social Surcharge”. Business assets are allowed to be depreciated over their useful life. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. IFAS are assumed to depreciate at 10% following the SL method.

Mauritania:

Computers are assumed to depreciate like Office Equipment. Land and intangible assets, such as goodwill, are not depreciable for tax purposes.

Mauritius:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment is assumed to depreciate like Plant and Machinery. Depreciation rates prior to 2005 are assumed to be equal to the respective rates in 2005.

Mexico:

The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Micronesia:

Data for the years 2010 to 2020 is taken from IBFD. Firms are assumed to generate gross revenue exceeding 10.000 USD and are, thus, subject to a 3% STR. IBFD outlines that starting in 2011 the STR is 21%. Starting in 2019, depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. Intangible assets are assumed to have a limited life and that the depreciation allowances for IFAS are 10% SL method. Starting in 2020, the financial years of major corporations is assumed to end on or after the 31 of March 2020. Firms are assumed to generate a taxable income above 500,000 USD and, thus, a 30% STR applies.

Moldova:

Buildings are assumed to be part of Category I. Plant and Machinery are assumed to be part of Category IV. Office Equipment is assumed to depreciate like “Furniture”. Office Equipment, Computers and Vehicles are assumed to be part of Category V. The categorization is in line with PwC. From 2008 to 2011, the STR was set to zero. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Starting in 2019, assets depreciate according to their useful life. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. IFAS are assumed to depreciate at 10% following the SL method.

Monaco:

Depreciation allowances prior to 2017 are assumed to be equivalent to the rates prescribed in the French tax code (this is mostly in line with the depreciation rates provided in EY starting in 2017, also in line with IBFD prescribing useful life). The STRs between 2007 and 2016 are taken from IBFD. Starting in 2017, the depreciation allowances for IFAS are assumed to be 10% under the SL method. Starting in 2017, Computers are assumed to depreciate like Office Equipment.

Mongolia:

Office Equipment and Vehicles are assumed to depreciate like "Other non-current assets". Firms are assumed to exhibit taxable income exceeding 3 billion Mongolian Tughrik. As of 2020, this amount increases to 6 billion. STR and depreciation rates for 2009 to 2011 are taken from IBFD.

Montenegro, Republic of:

STR and depreciation rates for 2003 and previous years equal the rates of the Federal Republic of Yugoslavia. STR and depreciation rates for 2004 to 2006 are equal to the rates of the Union of Serbia and Montenegro. STR and depreciation rates from 2007 to 2010 are assumed to equal the respective rates in 2011 (in line with IBFD). Assets are assigned to the following categories:

Asset Category	Asset Class 2005/06	Asset Class Post 2006
Buildings	I	I
Plant and Machinery	IV	III
Office Equipment	III	II
Computers	V	V
IFAS	III	II
Vehicles	III	II

Montserrat:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Office Equipment, Computers, and Vehicles are assumed to depreciate like Plant and Machinery. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Morocco:

Starting in 2016, firms are assumed to generate more than 5,000,000 Moroccan Dirhams in taxable income. Computers are assumed to depreciate like Office Equipment. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Mozambique:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. (Consistent with PWC). Office Equipment and Computers are assumed to depreciate like Plant and Machinery (Consistent with PWC).

Myanmar:

STR and depreciation rates for 2009 to 2014 are taken from IBFD. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment. Starting in 2017, Office Equipment is assumed to depreciate like "Miscellaneous". Buildings are assumed to be factory buildings for the years 2001 to 2005. Additionally, Buildings and Plant and Machinery are assumed to qualify for the initial allowance granted until 2009. Buildings are assumed to be “First Class”. STR and depreciation rates from 2006 to 2008 are assumed to be equal to the respective rates in 2005 and 2009.

Namibia:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment and Computers are assumed to depreciate like “Utensils” and “Articles”.

Nauru:

STR and depreciation allowances for the years 2009 to 2020 are taken from IBFD. Until 2016, the STR is equal to zero. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden. Starting in 2016, the depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. Intangible assets are assumed to have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method. Starting in 2019, firms are assumed to be resident and generate an annual gross revenue exceeding 15 million AUD.

Nepal:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Firms are assumed to be subject to the STR of “other entities”. Plant and Machinery is assumed to depreciate like “any depreciable asset not included in another class”. The depreciation allowances for IFAS are assumed to be 10% over the useful life (covered by IBFD).

Netherlands:

Prior to 2007, Computers are assumed to depreciate like Office Equipment. Prior to 2007, the depreciation allowances for IFAS are assumed to be 10% under the SL method. Between 2007 and 2018 Plant and Machinery, Office Equipment, Computers, and Vehicles depreciate like “ others”.

Netherlands Antilles:

The country was dissolved in 2010. Prior to 2010 The depreciation allowances for IFAS are assumed to be 10% under the SL method.

New Caledonia:

Depreciation allowances are granted based on the useful life of the asset (in line with EY and IBFD). Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. Intangible assets are assumed to have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method.

New Zealand:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. (in line with IBFD). Other depreciation allowances are taken from the website of the Inland Revenue Department: https://www.ird.govt.nz/?id=globalnav. Assets are generally assumed to depreciate like their default category. Thus, Buildings depreciate like “Buildings with reinforced concrete framing (default class)”, Plant and Machinery like “Factory and other sundries”, Office Equipment like “Office Equipment (default class)”, Computers like “Computer Equipment (default class)”, and Vehicles like “Transportation (default class)”

Nicaragua:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Between 2001 and 2012, Vehicles are assumed to depreciate like “Freight and mass transportation equipment”. STR and depreciation rates for 2013 to 2020 are taken from IBFD. Starting in 2013, Plant and Machinery are assumed to depreciate like “other”. Starting in 2013, Vehicles are assumed to depreciate like “collective or freight transport”. Starting in 2013, Office Equipment is assumed to depreciate like “other”. Starting in 2013, firms are assumed to have net income exceeding 500,000 Nicaraguan Cordoba.

Niger:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Office Equipment is assumed to depreciate like “furniture”. The depreciation allowances for IFAS are assumed to be 10% under the SL method. No information was available for the years 2012 to 2016 by IBFD, however, as the STR and depreciation rates for the prior and past years do not differ, the respective rates for the years 2012 to 2016 are assumed to be identical. Starting in 2013 Plant and Machinery is assumed to depreciate like “Industrial machinery and equipment”.

Nigeria:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. (in line with PWC). Office Equipment is assumed to belong to the category “Furniture”. Computers are assumed to depreciate like Office Equipment. Starting 2020 are assumed to have turnover greater than 100 million Nigerian Naira.

Niue:

STR and depreciation rates for the years 1996 to 2020 are taken from the Niue Income Tax Act passed in 1961.

North Macedonia:

Prior to 2004, Office Equipment and Computers are assumed to depreciate like Plant and Machinery. The depreciation allowances for years prior to 2004 are assumed to be equal to the respective rates in 2004. STRs and depreciation allowances for the years 2009 to 2020 are taken from IBFD. The rates specified in 2020 are assumed to apply for all periods from 2009 to 2020. For prior years IBFD is vague on the specific rates but in line with the rates set forth in 2020. Buildings are assumed to be “low structure buildings”. Office Equipment depreciates like “Furniture”. Vehicles depreciate like “other equipment”.

Northern Mariana Islands:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. US legislation applies, therefore, corporate tax rates and depreciation allowances are equal to the respective rates in the US.

Norway:

Computers are assumed to depreciate like Office Equipment. Starting in 2012, Industrial buildings are assumed to have a useful life of more than 20 years (in line with OECD (1991)).

Oman:

The depreciation allowances for IFAS are determined by the “Secretary General of Taxation” and are assumed to be 10% SL method. Prior to 2010 firms are assumed to be registered in Oman and, thus, subject to 12% STR. Until 2009 Computers are assumed to depreciate like “Other Equipment”. Buildings are assumed to be “Permanent buildings”. Plant and Machinery is assumed to depreciate like “Other machinery and equipment”. Office Equipment is assumed to depreciate like “Furniture and fixtures”.

Palau:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Firms are subject to 4% tax on gross revenue.

Pakistan:

Office Equipment is assumed to depreciate like “Furniture and fixtures”. Prior to 2003, Computers are assumed to depreciate like Plant and Machinery and depreciation allowances for IFAS are assumed to be 10% SL method.

Panama:

Machinery, Computers, Office Equipment, and Vehicles are assumed to be “movable assets‘” and, thus, depreciate over three years. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Papua New Guinea:

Buildings are assumed to be “steel framed”. Machinery, Office Equipment, and Computers are assumed to depreciate like Manufacturing items at 10% under the SL method or 15% under the DB method.

Paraguay:

STRs and depreciation allowances for the years 2009 to 2020 are taken from IBFD. Buildings are assumed to be in urban areas. Office Equipment depreciates like Machinery. Intangible assets prior to 2020 are assumed to depreciate at the same rate as in 2020. Depreciation allowances prior to 2009 are assumed to be equal to these allowances in 2009.

Peru:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. (in line with PWC). Computers are assumed to depreciate like “Data processing equipment”. Office Equipment is assumed to depreciate like “Other fixed assets”.

Philippines:

Depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. We assume that intangible assets have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method.

Poland:

IFAS is assumed to depreciate like goodwill (60 months). Depreciation rates of IFAS prior to 2011 are assumed to be equal to the IFAS rate in 2011. Firms are assumed to make revenues exceeding 1.2 million EUR.

Portugal:

Prior to 2014,the depreciation allowances for IFAS are assumed to be 10% under the SL method. Computers are assumed to depreciate like Office Equipment.

Puerto Rico:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. All other depreciation allowances from 2010 to 2020 are taken from IBFD. Depreciation allowances prior to 2010 are assumed to equal the rates in 2010, since EY states that assets are depreciable based on their useful life. Office Equipment is assumed to depreciate like “Certain Furniture and fixtures”. Buildings are assumed to depreciate like "Other real property". Companies are assumed to generate a net income of more than 275,000 USD and are, thus, subject to the maximum surtax rate.

Qatar:

The depreciation allowances for IFAS prior to 2011 are assumed to equal the respective rate in 2011. Office Equipment is assumed to depreciate like "Furniture".

Romania:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Office Equipment is assumed to depreciate like "Furniture". Computers are assumed to depreciate like Office Equipment.

Russian Federation:

Federal and regional governments are assumed to impose the maximum tax. The different asset types are sorted into the following asset groups prescribed by the Russian Tax Code, IBFD and PWC and depreciate following the SL method.: Asset Type Group Useful Life (years):

Asset Catergory	Group	Useful Life (years)
Buildings	VIII	20 to 25
Plant and Machinery	V	7 to 10
Office Equipment	III	3 to 5
Computers	II	2 to 3
IFAS	VI	10 to 15
Vehicles	III	3 to 5

Rwanda:

Plant and Machinery, Office Equipment and Vehicles are assumed to depreciate like "All other business assets" for the years 2007 to 2020.

Samoa:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method. The Useful life assumption is expanded to the years prior to 2009. STRs prior to 2009 are also taken from IBFD.

San Marino:

STRs for the years 2010 to 2020 are taken from IBFD. Depreciation allowances are taken from Ministry of Finance, "Legge 16 Dicembre 2013 No.166".

Sao Tome and Principe:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. According to IBFD, depreciation is possible over the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. We assume that intangible assets have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method.

Saudi Arabia:

Prior to 2005, Computers are assumed to depreciate like Office Equipment. The depreciation allowances prior to 2005 are assumed to be equal to the respective allowance in 2005. Past 2005, Office Equipment is assumed to depreciate like "all other tangible assets".

Senegal:

Land and intangible assets, such as goodwill, are non-depreciable. Computers are assumed to depreciate like Office Equipment.

Serbia:

STR and depreciation rates for 2003 and previous years equal the rates of the Federal Republic of Yugoslavia. STR and depreciation rates for 2004 to 2006 are equal to the rates of the Union of Serbia and Montenegro. Starting in 2019, IFAS depreciate over their useful life (10 years). The different assets are assumed to be attributed to the following groups:

Asset Category	Asset Class 2005/06	Asset Class Post 2006
Buildings	I	I
Plant and Machinery	IV	IV
Office Equipment	III	III
Computers	V	V
IFAS	III	III
Vehicles	III	III

Seychelles:

Companies are assumed to make more than 1,000,000 Seychellois Rupees. The depreciation allowances for IFAS are assumed to be 10% under the SL method. STR and depreciation rates for 2018 to 2020 are taken from IBFD.

Sierra Leone:

STR and depreciation rates for the years from 2010 and 2019 are taken from IBFD. Office Equipment and Computers are assumed to depreciate like "all other depreciable tangible and intangible assets". STRs for 2001 to 2009 are also taken from IBFD. Depreciation allowances prior to 2010 are assumed to be equal to the respective rates in 2010.

Singapore:

Starting in 2010, Buildings are assumed to qualify for the initial allowance. Office Equipment is assumed to depreciate like Plant and Machinery. Depreciation allowances for IFAS prior to 2002 are assumed to equal the respective allowance in 2002.

Sint Maarten:

STR and depreciation rates prior to 2011 are equivalent to the ones of the Netherland Antilles.

Slovak Republic:

The depreciation allowances for Buildings, Plant and Machinery, Office Equipment, Computers, and Vehicles for the years 2010 to 2019 are taken from IBFD. Depreciation allowances for IFAS are taken from EY. Depreciation allowances between 2006 and 2010 are assumed to be equal to the respective rates in 2005 and 2010. Office Equipment and Vehicles are assumed to be part of "Category 2". Depreciation categories are taken from IBFD and EY. Firm revenues are assumed to exceed 100,000 Euros.

Slovenia:

Office Equipment is assumed to depreciate like "Equipment". IFAS is assumed to depreciate like "Other investments".

Solomon Islands:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Plant and Machinery, Office Equipment, and Computers are assumed to depreciate like "all plant not otherwise specified". The depreciation allowances for IFAS are assumed to be 10% under the SL method.

South Africa:

Office Equipment is assumed to depreciate like "Furniture". Computers are assumed to be "personal computers". Plant and Machinery is assumed to be new and used in manufacturing, thus, qualifying for an initial depreciation allowance of 20%.

South Sudan:

STR and depreciation rates prior to 2012 are equal to the respective rates of Sudan. STR and depreciation rates for the years 2012 to 2020 are taken from IBFD. Starting in 2012, firms are assumed to be "large enterprises" and, thus, subject to 20% CIT.

Depreciation rates prior to 2014 are assumed to be equal to the respective rates in 2014. Firms are assumed to be located in “relatively developed areas”.

Spain:

Goodwill is amortizable at an annual rate of 5%.

Sri Lanka:

Office Equipment is assumed to depreciate like Furniture. In 2001, the depreciation rate of Computers is equal to the rate for Office Equipment.

St. Kitts and Nevis:

The Income Tax Act specifies STR and depreciation rates for all the years from 2002 and onward. No depreciation allowances are specified, but assets are generally allowed to depreciate. According to PwC and IBFD, depreciation is allowed using the DB method. Depreciation rates are assumed to be following the useful life assumption of OECD (1991). Depreciation rates for buildings are taken from PwC. Buildings are assumed to be concrete buildings.

St. Lucia:

Depreciation rates for the years 2010 to 2018 are taken from IBFD. Plant and Machinery is assumed to be “electrically operated”. STRs for the years 2003 to 2018 are taken from IBFD. Firms are assumed to be “in good standing” with the Inland Revenue Department and, therefore, only subject to a 30% STR.

St. Vincent:

STR and depreciation rates for the years 2010 to 2020 are taken from IBFD. Plant and Machinery is assumed to be “heavy”. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Manufacturing firms are assumed to derive chargeable income from “the local market and from exports to the Organisation of Eastern Caribbean States (OECS) market”. Lower rates apply if goods are exported to other markets.

Sudan:

STR and depreciation rates for 2010 to 2020 are taken from IBFD. STRs prior to 2010 are taken from KPMG. Firms are assumed to be industrial and, thus, subject to 10% tax rate. Depreciation rates prior to 2010 are assumed to be equal to the respective rates in 2010 (in line with EY).

Suriname:

Depreciation rules are allowed that are based on “sound business practices”. Therefore, depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Sweden:

Buildings are assumed to depreciate like “Factories”. Office Equipment and Vehicles are assumed to depreciate like Plant and Machinery. Computers are assumed to have a useful life of three years or less.

Switzerland:

STRs are taken from the OECD database to account for state and municipal taxes (last visited 09.10.2019). Computers depreciate like “Office machines”.

Taiwan:

Computers are assumed to depreciate like Office Equipment. Firms are assumed to generate an income of more than 500,000 New Taiwan Dollars.

Tajikistan:

STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Firms are assumed to exhibit a Taxable income-to-gross income ratio of 20 %. Plant and Machinery is assumed to depreciate like “industrial equipment”. Office Equipment is assumed to depreciate like “furniture”. Information for 2010, 2012 and 2014 not available by IBFD are taken from PWC.

Tanzania:

Prior to 2005, Plant and Machinery, Computers, and Vehicles are assumed to be “Medium heavy”. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Thailand:

Office Equipment is assumed to depreciate like “Furniture”. Depreciation allowances for Computers prior to 2003 are assumed to be equal to the respective rates in 2003.

Timor-Leste:

STRs for the years 2007 to 2020 are taken from IBFD. Depreciation rates for the years 2001 to 2020 are taken from IBFD. Prior to 2008, useful lives of assets are assumed to be in line with OECD (1991) implying that, buildings have a useful life of 40 years, Plant and Machinery, Office Equipment, Computers, and Vehicles of 7 years. All assets depreciate under the SL method.

Togo:

Firms are assumed to be industrial companies. STR and depreciation rates for the years 2009 to 2020 are taken from IBFD. Buildings are assumed to depreciate like "factories". The depreciation allowances for IFAS are assumed to be 10% under the SL method. Plant and Machinery is assumed to qualify for accelerated depreciation. Computers are assumed to depreciate like "movable equipment". No depreciation rates for 2010, 2015 and 2017 were available by IBFD, however, as the depreciation allowances for the prior and past years do not differ, the respective allowances for 2010, 2015, and 2017 are assumed to be identical.

Tonga:

STRs for the years 2008 to 2020 are taken from IBFD. Depreciation rates for the years 2009 to 2020 are taken from IBFD.

Trinidad and Tobago:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Plant and Machinery is assumed to be in the category "Heavy". Starting in 2017, firms are assumed to make more than 127,000 EUR in profits.

Tunesia:

Prior to 2009, the depreciation allowances for Buildings and IFAS are assumed to be equal to the respective rates in 2009. Prior to 2009, Plant and Machinery is assumed to depreciate like "Movable Equipment".

Turkey:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Plant and Machinery is assumed to depreciate over its useful life. Following OECD (1991), Plant and Machinery has a useful life of 7 years and depreciates following the SL method. Depreciation allowances for Office Equipment, Computers, and Plant and Machinery prior to 2005 are assumed to be equal to the respective allowances in 2005.

Turkmenistan:

STR and depreciation rates for the years 2009 and 2015 to 2020 are taken from IBFD. Firms are assumed to be taxed as "all other resident companies". STR and depreciation rates for the years 2010 to 2015 are taken from PWC. According to IBFD and PWC depreciation is possible but no rates are specified. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. We assume that intangible assets have a limited life and that the depreciation allowances for IFAS are assumed to be 10% under the SL method.

Turks and Caicos Islands:

STRs for the years 2010 to 2020 are taken from IBFD. The STR in 2013 is assumed to be equal to the respective rate in 2012 and 2014. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Uganda:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Vehicles are assumed to belong to the depreciation class III.

Ukraine:

Office Equipment is assumed to depreciate like “Tools, appliances and equipment”.

United Arab Emirates:

Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

United Kingdom:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Vehicles are assumed to emit between 50g/km and 110g/km and are, thus, subject to 18% allowance rate. Office Equipment and Computers are assumed to depreciate like Plant and Machinery.

United States:

STRs include federal and states taxes and are taken from the OECD Tax Database. According to the Internal Revenue Code (IRC), assets depreciate over their useful life. The useful life of an asset is determined by the IRC §168. Vehicles are assumed to be “any automobile or light general-purpose truck” and, thus, a 5-year property. Computers are “qualified technological equipment” and, thus, 5-year property. Plant and Machinery as well as Office Equipment are assumed to be 7-year property as they do not explicitly fall into another asset category. Buildings are “Nonresidential real property” and, thus, depreciate over 39 years. IFAS depreciate over 15 years in accordance with IRC §197. For the depreciation rates under the DB method firms are assumed to elect the 200% rate.

Uruguay:

Computers are assumed to depreciate like Office Equipment. The depreciation allowances for IFAS are assumed to be 10% under the SL method. The depreciation rate for buildings is assumed to be the average between the rural and urban rate.

US Virgin Islands:

Depreciation rates are equal to the rates of the United States of America.

Uzbekistan:

Depreciation allowances from 2000 to 2003 are assumed to be equal to the rates in 2004.

Vanuatu:

STRs for all years are taken from IBFD. Due to the zero STRs, depreciation allowances are set to zero since they cannot be offset against any tax burden.

Venezuela:

Firms are assumed to make sufficient profits to be subject to the maximum tax rate. Depreciation rules are allowed that are based on "sound business practices". Therefore, depreciation allowances are granted based on the useful life of the asset. Following OECD (1991), buildings are assumed to depreciate over a useful life of 40 years, Plant and Machinery, Office Equipment, Computers and Vehicles depreciate over a useful life of 7 years. All of these assets depreciate under the SL method. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Vietnam:

Depreciation rates for the years 2010 to 2020 are taken from IBFD and are in line with EY. If not specified differently, depreciation rates from 2001 to 2010 are assumed to be equal to the ones in 2010 in line with EY. Buildings are assumed to be "Substantial buildings" over 25 years. Plant and Machinery is assumed to depreciate like "Other motor machinery/equipment" over 6 years. Depreciation rates for Office Equipment prior to 2005 are taken from EY. Computers are assumed to depreciate like Office Equipment. Depreciation rates for IFAS post 2004 are equal to the rate in 2004 (in line with subsequent EY reports).

West Bank and Gaza:

The depreciation allowances for IFAS are assumed to be 10% under the SL method. Depreciation allowances of Plant and Machinery and Vehicles prior to 2008 are assumed to depreciate like Plant and Machinery in 2008. Depreciation rates prior to 2002 are assumed to be equal to the respective rate in 2002.

Yemen:

STR and depreciation rates for the years 2012 to 2020 are taken from IBFD. Prior to 2006, Computers are assumed to depreciate like Office Equipment. Prior to 2006, the depreciation allowances for IFAS are assumed to be 10% under the SL method.

Yugoslavia:

The data for Yugoslavia is only available until 2002 when the remains of the former Republic of Yugoslavia dissolved in independent countries. Office Equipment and Computers are assumed to depreciate like Plant and Machinery. The depreciation allowances for IFAS are assumed to be 10% under the SL method.

Zambia:

Firms are assumed to be manufacturing and, thus, subject to a 35% STR. The depreciation allowances for IFAS are assumed to be 10% under the SL method. Buildings depreciate like "Others" in the category of industrial buildings. Office Equipment and Computers are assumed to depreciate like "Other implements and plant and machinery".

Zimbabwe:

Firms are assumed to elect the special wear-and-tear allowance for buildings (allowed assets are documented in IBFD and in line with this assumption). The depreciation allowances for IFAS are assumed to be 10% under the SL method. An AIDS levy of 3% is imposed on income tax payable (excluding tax on income subject to special rates). Depreciation rates for Plant and Machinery, Vehicles and Office Equipment are taken from EY. The depreciation allowances for Computers from 2010 to 2020 are taken from IBFD. Depreciation allowances of Computers from 2001 to 2009 are assumed to be equal to the respective rate in 2010.

Appendix B

Consumption Tax Data Documentation

General Assumptions:

If not indicated differently, the data is based on information provided by the EY *Worldwide VAT, GST and Sales Tax Guide*, the IBFD tax research platform, and the European Commission. Other sources are indicated in the documentation. The count of tax rates variable includes the normal, reduced, increased and zero-rated rates, but not the exemption. If no reduced rate but a zero-rate is specified, the latter is classified as the reduced rate. When a country only has one reduced rate, that rate is shown in the data set. If there are multiple reduced rates, the one chosen is the one that applies to staple food. If there is no reduced rate applying to staple foods, the reduced rate that is applied to the broadest range of products is chosen. The rationale for the rate chosen is reflected in the comments.

Afghanistan:

Afghanistan currently employs a Business Receipt Tax. It is to be replaced by a flat VAT rate from 2021 on.

Andorra:

Andorra's general indirect tax (IGI) is broadly similar to EU value added tax. The reduced rates range from 0% to 2.5%. The rate of 1% applies among other things to foodstuffs. An increased rate applies to banking and financial services. It entered into force 2013 and was amended 2016.

Anguilla:

A GST is expected to be implemented in 2021.

Antigua and Barbuda:

Multiple reduced rates exist and apply to basic foodstuffs and hotel accommodation.

Argentina:

An increased rate applies to non-dwelling tel-com, utilities and sewage disposal services. The reduced rate applies among other things to newspaper sales, while books qualify for exemption.

Aruba:

The Revenue Tax is comprised of a turnover tax ("Belasting over bedrijfsomzetten") and a surcharge for PPP-Projects ("Belasting additionele voorziening PPS-projecten").

Austria:

The regions of Jungholz and Mittelberg apply different standard rates. The reduced rates are applied to most foodstuffs, books and hotel accommodations. The standard rate represented in the data set is the federal rate.

Azerbaijan:

Importation of goods, supply of goods, and performance of works and provision of services to recipients under grants, with the proceeds of grants received from abroad are taxable at 0%.

Bahamas:

There are multiple reduced rates. Breadbasket items are taxable a 0%. Businesses that make goods and services at the standard rate of VAT may instead pay a flat tax on net sales. Businesses are assumed to opt for the flat tax.

Bangladesh:

Besides the standard rate, basic foodstuffs are exempt. Further, there are a variety of different reduced and increased rates, based on considerations of social desirability. Due to insufficient detail in the sources, these cannot be represented in the data.

Barbados:

The reduced rate applies to accommodations, while mobile services carry an increased rate since 2016.

Belarus:

The reduced rate applies, among other things, to basic foodstuffs. Other increased and decreased rates were briefly applied at different times in Belarus.

Belgium:

The reduced rate applies to books and magazines, accommodation among other things, which is reflected in the data set. There is also a reduced rate that applies to restaurant services and public housing.

Belize:

The information in the data set are retrieved from the Central Bank of Belize.

Benin:

The information in the data set are retrieved from the Belgian policy research group on Financing for Development.

BES Islands:

The consumption tax rates differ across the different islands Bonaire, Sint Eustatius, and Saba and between goods and services. The rates for Bonaire and goods are chosen for the data set.

Bolivia:

Though the VAT applies at a rate of 13%, the effective rate is 14.94% (This rate applies to the taxable amount inclusive of the VAT).

Bosnia and Herzegovina:

The information in the data set are retrieved from the following source: https://www.researchgate.net/publication/277612674_Characteristics_of_Value_Added_Tax_in_Bosnia_and_Herzegovina.

Brazil:

In Brazil there are VATs at the State, Federal, Municipal level as well as additional gross receipt contributions. All vary across states and across goods and services. State level rates vary between 0% and 35%, while federal VAT rates range from 0% to 300%, based on 9,728 classification codes. The municipal service tax does not exceed 5%. The Gross receipt contributions range from 0.65% to 9.65% for some imported goods. The standard and reduced rates reflected in the data are the general state level rates of the Tax on the Circulation of Products and Services ("ICMS"; "Imposto sobre Operações relativas à Circulação de Mercadorias e Prestação de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação"). The reduced rate applies to supplies of locally produced goods

Canada:

A General Sales Tax applies in much of Canada since 2008, with a zero-rate applicable to e.g. basic foodstuffs. These rates are represented in the data set. A Harmonized Sale Tax (HST) applies to Nova Scotia, New Brunswick, Newfoundland, Labrador as well as on Prince Edward Island. In Quebec a combined Quebec Sales Tax/GST currently applies.

Chile:

In Chile, a standard rate of 19% applies. Additional taxes ranging from 10% to 50% may be applied to jewelry, soft drinks or pyrotechnics. Goods qualifying for exemptions include used motorized vehicles, and certain real estate transactions. There exist no reduced rates in Chile.

China:

In China, multiple reduced rates ranging from 0% t 9 % are applied. Special rates apply to small-scale VAT taxpayers. The reduced rate represented in the data set applies to foodstuffs, books and magazines, and agricultural products.

Colombia:

In Colombia prior to 2013, reduced rates of 1,6% to 10%, as well as the increased rates of 20% to 35% are applied. Basic necessities, however, were exempt, so the reduced rate displayed in the data set is 0%.

Comoros:

The consumption tax applies at varying rates to imports, production and manufacturing, utilities, restaurants, intl. travel tickets, and casinos. Pior to 2009, rates were 0%, 3%, 5% and 15%, without information available what each applies to. Therefore 15% is reflected as standard rate and 5% is reflected as reduced rate.

Congo, Democratic Republic of:

In the Democratic Republic of the Congo prior to 2012, a turnover tax was applied. There also was a large number of reduced and increased rates, of which the 3% represented in the data set applied to equipment and agricultural and veterinary input products.

Cook Islands:

The information in the data set are retrieved from the Ministry of Finance and Economic Management of the Cook Islands.

Costa Rica:

The reduced rate chosen for Costa Rica applies to a "basic consumption basket". Books are exempt. Prior to 2018, the basic consumption basket incurred a zero-rate. Other reduced rates were applied to wood and residential electricity respectively.

Croatia:

Reduced rates for Croatia apply to basic foodstuffs, books and authorized drugs. Accommodations and periodicals are taxed at a different reduced rate.

Curaçao:

The standard rate is 6%, higher rates apply to insurance and hotel accommodations, and to, e.g., soft drinks, alcoholic beverages and tobacco products. Basic foodstuffs are exempt, leading to the zero-rate in the data set.

Cyprus:

The reduced rate applies to, e.g., newspapers and books. A different rate applies to restaurant services and accommodation.

Czech Republic:

The reduced rates for the Czech Republic applies to books, magazines as well as to restaurant services. A different reduced rate applies to foodstuffs, medical care and non-alcoholic beverages.

Djibouti:

Prior to the VAT, a consumption tax applied rates between 8% to 33%. The rates of 8% and 15% are reflected as reduced and standard rate respectively in the data.

Dominica:

The information in the data set are retrieved from the following source: http://ird.gov.dm/tax-laws/value-added-tax.

Dominican Republic:

The reduced rate applies to yoghurt, coffee, butter, cacao, and sugar, whereas other non-processed foods as well as certain books and magazines qualify for exemption.

Eritrea:

Sales Taxes range from 5% to 12% according to schedules. Most consumer goods are taxed at 5%. The last major reform took place 1994.

Faroe:

The information in the data set are retrieved from the following source: https://dge0o259pa1fu.cloudfront.net/media/1045/tax-facts-2016.pdf,https://www.taks.fo/fo/log/logir/meirvirdisgjaldslogin/.

Fiji:

The information in the data set are retrieved from the following source: https://www.frcs.org.fj/our-services/taxation/business/value-added-tax-vat/.

Finland:

The reduced rates for Finland applies to, e.g., books and accommodation. Most foodstuffs including restaurants (with rate changes as shown in the data set) are subject to a different reduced rate.

France:

In France, different reduced rates apply to pharmaceuticals, foodstuffs and accommodation (the latter being introduced in 2012).

French Polynesia:

Additionally, to the standard goods and reduced rate an intermediate rate of 13% is applied to services.

Georgia:

In Georgia, a reduced rate applies to temporary imports for each calendar month located in Georgia (max 18%). Numerous items (such as supply of books and newspapers) are zero-rated, which is represented as reduced rate in the data set.

Ghana:

In Ghana, a flat rate scheme at 3% without deduction is available for retailers and wholesalers (at least since 2011). Basic agricultural products qualify for exemption, giving rise to the reduced rate of 0% in the data set. Before 2019, the rate shown includes a 2,5% "National Health Insurance Levy" at 2,5%.

Greece:

In Greece, since 2015 a reduced rate applies to books and newspapers, while a higher rate applies to accommodation, restaurants, and various food preparation.

Guatemala:

The standard rate is 12%. A lower rate on gross sales applies to small tax payers.

Honduras:

An increased rate applies to alcoholic beverages as well as cigarettes and some digital services. The basic consumption basket is exempt, leading to the zero-rate in the data set.

Hungary:

Different reduced rates apply to books, hotel services, and basic foodstuffs. The latter was not applied between 2006 and 2009.

India:

There is no clear standard rate. The chosen standard rate of 18% applies to electrical apparatus, construction services, and accommodation. Between 2005 and 2017, a VAT was applied with multiple rates, varying over time. Basic food items were exempt, leading to the zero-rate in the data set. Prior to 2005, the "Central Sales Tax" is displayed, as one of various other regionally varying instrument being applied at that time.

Iran:

The VAT rate is comprised of a basic VAT rate of 6% and an additional levy of 3%. Tobacco and petrol are subject to higher effective VAT rates.

Ireland:

Different reduced rates apply to most foodstuffs, books, newspapers, magazines, and to restaurants and holiday accommodation.

Italy:

A rate of of 0% applies to intra-EU supplies and export supplies. The reduced rate applies to books and newspapers, to certain foodstuffs and to restaurant services. Other rates include 5% for social service provisions (since 2016) and 10%, applicable e.g. for restaurant and hotel services (since 1995).

Jordan:

Different reduced rates apply to oil, school supplies, corn, live animals, dairy products, and gasoline. Beer, tobacco, and vehicles are subject to Special Tax. The reduced rate represented in the data set applies to live animals, dairy products, and gasoline.

Kenya:

Currently, reduced rate applies to fuel and oil. Between 2010 and 2013, a reduced rate applied to diesel and electricity. Prior to 2007, a reduced rate applied to hotel services. These rates represent the reduced rate in the data set for the respective tme period.

Korea, Democratic Peoples Republic of:

A turnover tax ranging from 0% to 15% are applied. The standard rate is taken from the Deloitte *Global Indirect Tax Rates* table.

Kosovo:

The information in the data set are retrieved from the following source: http://www.atk-ks.org/wp-content/uploads/2017/10/Regulation_2001_11.pdf.

Kuwait:

A VAT is expected to be implemented 2021.

Laos:

Prior to the VAT, a turnover tax was applied at rates ranging from 3% to 15%. Since no indication was found on which could be the standard and which the reduced rate, these data are omitted from the data set.

Lesotho:

Different reduced rates apply to utilities and to telecommunications. Foodstuff is exempt, leading to the zero-rate in the data set.

Liechtenstein:

Liechtenstein adopted the VAT regulation of Switzerland in 1995. As such, it applies different reduced rates to food, drinks and hotel accommodation.

Lithuania:

Different reduced rates apply to medical equipment and medicines, books, newspapers, and accommodation services. The rate for books, newspapers, and accommodation services is represented in the data set.

Luxemburg:

The reduced rate applies to food, books, and newspapers. Other reduced rates for various goods and services exist ranging from 6% to 14%.

Malaysia:

The rates in the data set refer to Sales Tax of goods.

Maldives:

An increased rate applies as a “Tourism General Sales Tax” for companies registered with the tourism minstry.

Mali:

A reduced rate applies to computer hardware and solar energy equipment.

Malta:

A reduced rate of 0% applies to food. Different reduced rates of apply to books, other printed material, and to tourist accommodations.

Marshall Islands:

The Marshall Islands’ local governments apply sales taxes at rates between 2% and 4%. Since there is federal sales tax, the local rates are not reflected in the data set.

Mauritania:

An increased rate applies to telecommunication services.

Micronesia:

In Micronesia, each local government applies sales tax at a different rate. Since there is no federal sales tax the local rates are not reflected in the data set.

Moldova:

Prior to 2013, a reduced rate of applied to natural gas among other things.

Morocco:

The reduced rate represented in the data set applies to hotel and restaurant operations. Other reduced rates apply to the sales of water and for transport services.

Monaco:

Monaco adopted the french VAT regime. Reduced rates range from 2.1% to 10%. The reduced rate represented in the data set applies to essential items.

Montserrat:

There is no VAT in Montserrat in the traditional sense, but an international trade tax is levied. However, the trade tax is not considered in the data set.

Myanmar:

Food and health-related merchandise are exempt from the CT, leading to the zero-rate in the data set. Other reduced rates apply to gold jewelry, buildings, and electricity exports ranging from 1% to 8%. Prior to 2017, the rate on goods ranged from 5% to over 100%.

Netherlands Antilles:

In the Netherlands Antilles, different rates apply over the islands of Bonaire, Curacao, St. Marten and others. The rates also vary across goods and services, while available sources are inconsistent regarding the type of tax. Therefore, no rate is presented for the Netherlands Antilles in this data set. The Netherlands Antilles were dissolved in 2010.

New Caledonia:

Additionally, to the standard and reduced rates there are special rates ranging from 6% to 22%.

Niger:

The reduced rate applies to basic food items.

Northern Macedonia:

The information in the data set are retrieved from the following source: https://www.libertas-institut.com/de/MK/nationallaws/VAT.pdf.

Northern Mariana Islands:

In the Northern Mariana Islands, a “Business Gross Revenue Tax” applies at varying rates between 1.5% and 5%. Since no information was available how rates vary according to activity, the tax is not included in the data set.

Norway:

Different reduced rates are applied to food, hotel accommodation, and domestic transportation services ranging from 12% to 15%.

Oman:

Oman is implementing a VAT starting 2021.

Pakistan:

Pakistan has different standard rates as well as a number of reduced reduced rates for goods and services. There is also regional variation in taxation rates. The standard rate represented in the data is applied to goods. Foodstuffs are exempt from the CT, leading to the zero-rate in the data set.

Panama:

Groceries are exempt. Special rates of apply to hotel accommodations and to tobacco products.

Poland:

In Poland, the reduced rate applies to some basic foodstuffs and books, which is represented in the data set. Additionally, a different reduced rate applies to other foodstuffs, books as well as hotel services among other things.

Portugal:

Mainland Portugal has a reduced rate, which includes foodstuff, books, and accommodations. The autonomous regions of Madeira and of Azores have different standard and reduced rates apply (these differ since 2013). The rates of mainland Portugal are represented in the data set.

Puerto Rico:

Puerto Rico uses a Sales and Use Tax, a municipal rate, a business-to-business service rate, and a special rate on prepared foods. Certain foods, as well as books and prescription medicine among other things are exempt.

Qatar:

Qatar has ratified the Gulf Cooperation Council VAT Agreement but not announced an implementation schedule yet.

Romania:

Reduced rates apply among other things to books, newspapers, hotel accommodation, restaurants, foodstuffs, and medicines. The reduced rate represented in the data set applies to some foodstuffs and medicines among other things.

Russian Federation:

The reduced rate of 10% applies to basic foodstuffs and medical goods among other things. A special rate applies to electronically supplied services.

Rwanda:

The information in the data set are retrieved from the following source: http://admin.theiguides.org/Media/Documents/Law%20on%20Code%20of%20Value%20Added%20Tax%202001.pdf.

Saint Lucia:

Prior to the introduction of the VAT, a consumption tax at rates between 5% and 40% was applied. However, due to lack of information on the tax structure prior to 2012 the period cannot be represented in the data set.

Sao Tome and Principe:

A consumption tax of 5% applies to services. Rates ranging from 0% to 150% apply to goods. Prior to 2011, rates from 6% to 10% applied to goods and services.

Senegal:

The reduced rate applies to hotel services.

South Sudan:

Exemptions are given on a case-by-case basis.

Spain:

The reduced rate applies to basic foodstuffs as well as books. A special rate applies to food and drink as well as hotel accommodation. The rate for basic foodstuffs is represented in the data.

Suriname:

Different standard rates apply to goods and services. The rate for goods is represented in the data set. Basic foodstuffs is exempt. An increased rate applies to some vehicles and weapons among other things.

Sweden:

Different reduced rates apply to books, transport, cultural services, foodstuffs, hotel accommodations, and restaurant services. The reduced rate applying to foodstuffs, hotel accommodations, and restaurant services is represented in the data.

Syria:

In Syria, there is no general turnover tax, however the introduction of a VAT was anticipated in the past. A sales tax ranging from 1.5% to 40% is applied to services and certain imported goods, but is not reflected in this data set.

Tajikistan:

Different reduced rates apply to education and public catering services. Foodstuff is exempt, leading to the zero-rate in the data set.

Timor-Leste:

The quoted standard rate applies to sales. Services are taxed at a different rate.

Tunesia:

Different reduced rates apply to transport, tourism, medical supplies and activities, as well as professional services. Foodstuff is exempt, leading to the zero-rate in the data set.

Turkey:

Different reduced rates apply to basic foodstuffs, used passenger cars, newspapers, magazines, other basic foodstuffs, books, medical products and medicines, and other things. The reduced rate for basic foodstuffs, used passenger cars, newspapers, and magazines is represented in the data set.

United States:

In the United States, there is considerable state- and local-level variation in the imposition of sales taxes. The highest applied rate is 10.25% in Chicago, IL. The rate of 7.25% is being applied in California, the largest state by output within the United States, which is the rate represented in the data set.

Vatican:

Vatican City is exempt from duties and taxes and the small amount of goods exported from Vatican City are exempt from duty.

Venezuela:

VAT law indicates a minimum rate at 8% and a maximum rate as shown in the data set. Food items are exempt from VAT. Luxury goods incur an additional 10%.

Yemen:

Reduced rates range from 2% to 10%. Foodstuff is exempt, leading to the zero-rate in the data set.