Essays in International Corporate Taxation

Simon Miguel Naitram

Submitted in fulfilment of the requirements for the
Degree of Doctor of Philosophy in Economics

Adam Smith Business School
College of Social Sciences
University of Glasgow

February 2020

Abstract

This thesis is made up of three essays on international corporate taxation. This thesis answers three important questions. First, what is the size of strategic spillovers from international tax competition? Second, what determines the magnitude and direction of corporate tax base spillovers? Third, what is the fundamental reason for taxing firms and what does this imply for the optimal design of the corporate income tax?

The theory of tax competition tells us that when governments compete for mobile capital, tax rates fall below the social optimum, leading to the under-provision of the public good. But magnitudes matter—how big a problem is the under-provision of the public good? That depends on how big strategic tax rate spillovers from corporate tax competition are. In the first essay, I estimate the size of strategic spillovers. To do so, I identify tax competition as being an optimal response to base spillovers. Using the stock of foreign direct investment between countries to approximate bilateral base spillovers, I estimate a spatial autoregressive model of tax competition. I find strategic spillovers to be a third of the magnitude of previous estimates. More specifically, I find that governments respond to a 1 percentage point reduction in the foreign average tax rate with a 0.23 percentage point cut of their own. This implies low revenue loss from tax competition and modest under-provision of the public good—much lower than is commonly implied.

Corporate tax reforms do not occur in a vacuum. In the second essay, I estimate corporate tax base spillovers on a country-by-country basis for European countries. Corporate tax base spillovers are the international externalities that occur when one government's tax rate change affects another country's tax base. We normally assume that tax base spillovers are substitutionary—that a cut in

the tax rate in one country must lower corporate profits in neighbouring countries. I find that spillovers are, on average, substitutionary. However, spillovers vary across country-pairs in size and significance. Some spillovers are even complementary. I isolate theories that help us to understand this heterogeneity in spillover semi-elasticities and try to determine whether variation in the estimated semi-elasticities is explained by the structural features predicted by these theories. This essay seeks to enrich our understanding of corporate tax base spillovers.

In the third essay I derive an optimal benefit-based corporate tax rate formula as a function of the public input elasticity of profits and the (net of) tax elasticity of profits. I argue that the existence of the corporate income tax should be justified by the benefit-based view of taxation: firms should pay tax according to the benefits they receive from the use of the public input. I argue that benefit-based corporate taxation is normatively fair. Since the public input is a location-specific factor, a positive benefit-based corporate tax rate is also feasible even in a small open economy. The benefit-based view gives three clear principles of corporate tax design. First, we should tax corporate profits at source. Second, the optimal tax base is location-specific rents. Third, profit shifting is normatively wrong. An empirical application of the formula suggests the optimal benefit-based corporate tax rate on public corporations in the United States lies in the range of 35 to 59 percent.

Together, these three essays provide a clear perspective of the mechanisms of the international corporate tax system. By combining theory with evidence throughout this thesis, I show that the international corporate tax system is a complex creature. Importantly, I also provide concrete suggestions for the redesign of the corporate tax so that it fulfils a fundamental economic purpose.

Contents

List of Tables

List of Figures

Acknowledgements

The journey through a PhD is a long, lonely, and sometimes dark journey. It only becomes apparent to the PhD student at the end that this is actually a journey of self-discovery thinly overlaid with mathematics, data, coding, and writing. And each individual must find those things that carry them to the end of this journey. For me: people, purpose, and inspiration.

I must first acknowledge the contributions of Dr Céline Azémar, who has been my supervisor throughout this entire journey, and Dr Francesca Flamini, who so generously stepped in to offer her support over the final year and half. I must especially thank Dr Bram Driesen for his hours of tireless assistance and academic advice. I must also thank Professor Jim Malley for his gentle push during my first year. I also acknowledge the support from Dr Mahalia Jackman and Professor Winston Moore, who encouraged me to begin this scary PhD journey.

I wish to acknowledge the constant support—verbal, physical, or silent—of those closest to me. Never have I felt lonely. My flatmate Laura Comincini, who made sure I did not throw away my shot. My favourite legspinner, Mario Miller, who constantly checked to make sure I was keeping my head above water. Dr Kotryna Fraser encouraged me to crawl, to stumble, but to be independent, and to go alone. My parents, Carlisle and Merlene, whose support has been constant, certain, and silent—because they knew this is what I needed. And Sandy, the runt of the litter and my best friend for 16 years who refused to give in to her old age until she knew I was coming home. Without doubt I must acknowledge the immense impact of my friend and fellow PhD student Spyridon Lazarakis. Many friends have supported me through this process, but none has been so integral to the completion of this PhD thesis. He has been a constant source of inspiration, an excellent sounding board, brilliant at catching my silly mistakes,

and always quick to point out how far in the left tail of common sense our ideas fell. And for all the beautiful friends I made along the way in Glasgow, you have made this journey of self-discovery worthwhile.

I wish to acknowledge every other person who has supported me. Over the final year of my PhD, I found out that those rooting for my success counted more than a small village. And if it only takes a village to raise a man, then I think I'm stood in good stead. For your thoughts, your prayers, your well-wishes: they mean the world to me.

Finally, I want to acknowledge that this thesis would have been impossible without the inspiration of God—whom I hold to be the Creator of all things bright and beautiful, and the sole Author and Finisher of my faith. Any remaining mistakes, however, are mine!

Author's Declaration

I declare, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Name: Simon Miguel Naitram

Signature:

Chapter 1

Introduction

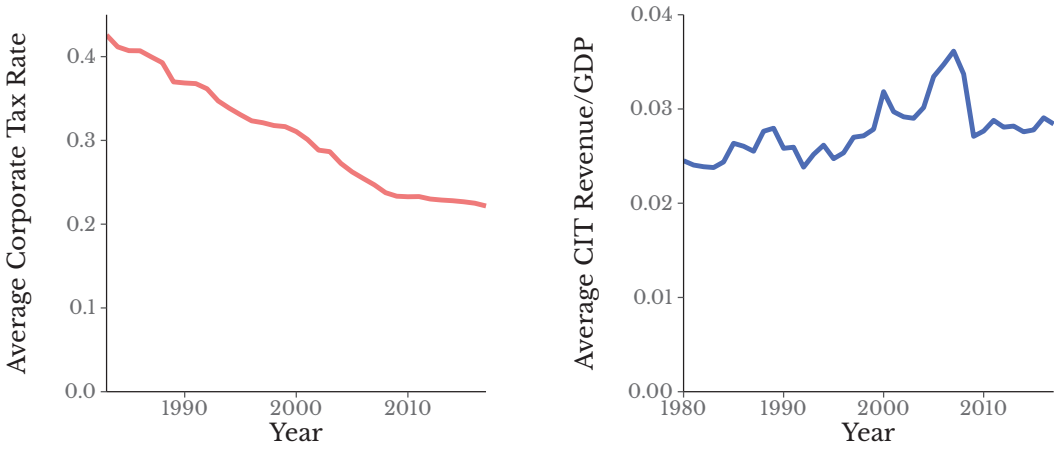
The landscape of international corporate tax is contentious. It is littered with stories of multinational firms who do not pay their fair share of tax, who play one government off against the other, and who use extreme versions of tax planning to minimise their tax liability (Beesley, 2019; Schreuer and Stevis-Gridneff, 2019). The actions of multinational firms create and exploit fault lines in the landscape. Economists, politicians, policy advisers, and tax professionals each have their own strongly-held opinions of what the corporate tax landscape should look like. For the tax economist, the landscape should be shaped by the dual principles of equity and efficiency.

With each passing year, the corporate tax debate seems to draw closer to a tipping point. There are persistent and loud calls for the urgent redesign of the international corporate tax system (Lagarde, 2019). Yet governments all around the world continue to cut corporate tax rates (see Figure 1.1). And some governments are finding new and clever ways to offer preferential tax treatment (Abbas and Klemm, 2013). Meanwhile other governments enact unilateral action such as taxes on digital companies (Govindarajan et al., 2019). In the midst of this, tax havens of varying nature and intensity continue to operate despite the leaks, blacklists, and crackdowns (Guarascio, 2017). From an objective perspective, the international corporate tax system appears to be in turmoil.

And somehow—despite all of this apparent turmoil—corporate tax revenues have not declined. It sparks wonder to think that the large decline in the average

corporate tax rate over the past few decades has not led to the total decimation of corporate tax revenue. For 48 of the largest countries in the Oxford University Centre for Business Taxation's Tax Database, the average top statutory corporate tax rate has almost halved from 1985 to 2017. This reflects a monumental swing in governments' collective tax ideology. In vivid contrast, corporate tax revenue as a percentage of gross domestic product has actually edged *up* since 1980. This data is plotted in Figure 1.1. The Organisation for Co-operation and Development's (2019) recent Corporate Tax Statistics Database suggests that corporate tax revenue now makes up 13.3 percent of total tax revenue in 88 countries in 2016, up from 12 percent in 2000. And this figure is even higher for developing countries.

Figure 1.1: Trends in Global Corporate Tax Rates and Revenues.



Data on top statutory corporate tax rates comes from the Oxford University Centre for Business Taxation Tax Database. Data on tax revenue comes from UNU-Wider's Government Revenue Dataset. Both tax rate data and revenue are for the same 48 countries.

Bond et al. (2000) ask the important question: is the observed decline in corporate tax rates actually an efficient response to increased corporate income mobility, or is it merely the result of an inefficient process of corporate tax competition between uncoordinated governments? Were it simply uncoordinated tax competition, then our theoretical economic models suggest that we should observe a severe decline in corporate tax revenue around the world.

Various authors have pointed out this complexing trend (Bond et al., 2000; Devereux et al., 2004; Griffith and Klemm, 2004; Sørensen, 2007; Loretz, 2008; Clausing, 2007). For the most part, these authors have attributed this buoyancy of corporate tax revenue to the broadening of the tax base. As documented by Kawano and Slemrod (2016), governments have made up for lower tax rates with

a range of different tax base reforms including thin capitalisation rules, transfer pricing regulations, controlled foreign company legislation, depreciation allowances, and investment credits. The consensus is that governments have enacted a combination of rate-cutting and base-broadening that has supported the corporate income tax base, particularly across the developed world. Other potential explanations might include the increased prevalence of high-profit multinational firms in the world economy, or an increasing share of economic activity being conducted by incorporated firms—either due to corporations growing in size or due to an increased rate of company incorporation. Haufler and Stähler (2013) propose that the observed decline in corporate tax rates with steady tax revenue might actually be an optimal response to the combination of increased profitability and increased firm mobility.

Curiously, academic advice on the design of the corporate income tax rarely seems to be followed. For example, economists are uniform in their belief that the normal returns to capital should not be taxed by the corporate income tax. Instead, to reduce the distortions that the corporate income tax generates, we should exempt the normal returns to capital and tax only economic profits or economic rents (Griffith et al., 2010). This would limit the incidence of the corporate income tax on workers and dampen any negative effects on output. Multiple concrete proposals exist for how to exempt the normal returns to capital. These proposals include the allowance for corporate equity and the cash flow tax. Exempting the normal returns to capital seems like it would generate a Pareto improvement and comes highly recommended in any policy reform package. And yet, few governments in the world have adopted the idea that we should exempt the normal returns to capital. For example, of European countries, only Belgium and Portugal have found it expedient to switch to an allowance for corporate equity tax system. And Italy repealed its own allowance for corporate equity incentive as of January 1, 2019.

Similarly, governments have refused to engage in any substantial degree of coordination on tax competition. Certainly there has been no coordination on tax rates—the main policy proposal of decades worth of corporate tax competition literature. Even within the European Union they cannot agree to coordinate on corporate tax rates or corporate tax bases. And policies to limit spillovers are non-existent. While the European Commission attempts to police its members'

behaviour and how it might affect other member states, no member state has taken any serious interest in how its own tax policy might work beyond its own borders. Even the European Union's attempt to crackdown on tax havens appears flawed, as it ignores the European Parliament's findings that seven countries within its Union act like tax havens—Belgium, Cyprus, Hungary, Ireland, Luxembourg, Malta, and the Netherlands (European Parliament, 2019).

Neither does public opinion appear to hold any real sway. In the United States, survey evidence seems to consistently suggest that individuals would prefer *higher*, not lower taxes on corporations. For example, in 2017, a Pew Research Center (2017a) survey found that Americans' greatest concern about the design of the whole federal tax system was that corporations do not pay their fair share of tax. This almost certainly implies an overwhelming desire for higher tax rates. Yet, in December 2017 the United States passed the Tax Cut and Jobs Act, which involved a reduction in the top corporate tax rate from 35 percent to a flat rate of 21 percent. Unsurprisingly, in 2018 a Gallup (2018) survey found that 62 percent of Americans thought that corporations paid too little tax. Not only is the design of corporate tax policy consistently out of step with what academics think is appropriate, but it also seems to flout the preferences of the population.

This highlights a fundamental problem with the corporate income tax project: there exists no consensus across stakeholders. Each group is pulling in a different direction. In particular, government policy seems to contradict both scholarly advice and public opinion. It is almost as if governments have a different set of information or a different set of preferences. From an academic perspective, the difference in views means we must pause and ask whether the corporate income tax system is truly in crisis, or whether we missed something. The absence of a policy consensus reflects the absence of consensus on the effects and intent of the corporate income tax. Can we forge a new global consensus about the purpose of corporate income taxation? Can we generate convincing evidence of the effects of the corporate tax? This thesis contributes to the body of knowledge on the effects and intent of the international corporate tax system. In this thesis, I seek evidence and ideas that informs the ongoing debate on a consensus design of the corporate income tax.

1.1 The Main Actors

There are two main actors in this thesis: the firm and the government. Throughout this thesis I examine the interplay between these two economic actors. In the real world it is sometimes difficult to distinguish whether the relationship between the firm and the government is antagonistic or symbiotic. At times, governments appear to be trying in vain to tax an evasive firm. At other times, it appears that governments yield substantial favours to firms—particularly large multinational firms. We can only be certain that the relationship between the two is highly complex. This relationship is the focus of this thesis. The first essay focuses on how firm behaviour induces government responses. The second essay focuses on how government policies induce firm responses. The third proposes what a more constructive relationship between the two might look like—an inherently co-operative relationship founded quite literally on mutual benefit.

The multinational firm is an ever-present agent throughout this thesis. In the first two essays I focus mainly on multinational firms. In the second essay, I include domestic firms in my study to generate a counterfactual for the multinational firm. In the third essay I engage a more general definition of the firm, in an attempt to consider a widely-applicable optimal tax system. Implicit in this study is that multinational firms generate large amounts of profits, hold substantial power, and have a vast range of outside options. The OECD estimates that the multinational firm accounted for approximately 12 percent of global output in 2014. The multinational is also highly mobile across countries. Combining this mobility with the significance of their production gives the multinational firm substantial global power to alter countries' economic outcomes and even their economic policies. The multinational firm is of great importance to the government.

The other main character in this thesis is the government. The story of corporate tax design is a story of government decisions. Their decisions define the landscape of international tax. Their preferences over the taxation of firms—particularly multinationals—have shaped the existing corporate tax system into the complex beast that exists today. Whether they choose to cooperate or coordinate determines the level of coherence in the global tax system. Therefore, in spite of government policy often disregarding scholarly advice, it is their policy

choices that matter for final outcomes. Their policy choices help us to understand what issues are truly relevant in the design of the corporate income tax. Government policy is therefore crucial to our ability to inform good economic policy in the future.

1.2 The Approach

Each essay is built on a combination of simple theoretical models and straightforward empirical analysis. Throughout this thesis I emphasise the power of the synthesis between these two approaches to answering economic questions. Complex theoretical models can rarely be taken to the data, and theory critically disciplines the type of empirical analysis we need. In this thesis complexity arises mainly in the conceptual approach to answering questions.

To deal with this conceptual complexity, I take an agnostic approach to answering the questions I ask. In this thesis I ask: what is the size of strategic spillovers, what is the magnitude and direction of tax base spillovers, and what is the fundamental reason for taxing firms? The research questions themselves are important; for this reason I aim to answer them without prejudice. The answers to some of these questions might be surprising in parts. Therefore, defending the veracity of these answers requires that my approach be unbiased, logically coherent, and objective.

I ask a combination of important positive and normative questions. The first two essays are positive. I focus first on the international effects of the corporate tax. I target the two major cross-country concerns that the international debate on corporate taxes identify—strategic spillovers and tax base spillovers. These are the terminologies introduced by the IMF (2014) in their analysis of the spillovers generated by the corporate income tax. In general, they define spillovers as the impact that one country's policies have on another country's outcomes or decisions. A somewhat more economic term is the concept of 'fiscal externalities'. **Strategic spillovers** occur when one government's tax reform alters the optimal tax rate of another government. **Base spillovers** occur when a change in one country's tax rate affects the tax base of another country.

The third essay is normative and therefore presents the greatest challenge. I make the argument for a benefit-based corporate tax on the grounds of fairness and the ability to tax. In particular, I use the familiar economic idea of a public input to show that public inputs give rise to location-specific rents that are captured by firms. Such rents reflect the deserved income of the government who provides the public input. And such rents can be taxed since they are immobile. I combine these normative ideas with the more popular theoretical tools of modern tax theory. I also use data to show the empirical relevance of the public input for corporate profits.

In each essay I challenge consensus knowledge. In the first essay, I challenge the notion that strategic spillovers from corporate taxation are very large. In the second essay, I challenge the idea that all countries are equally and evenly affected by tax base spillovers. In the third essay, I challenge the idea that we should only care about the efficiency of the corporate income tax.

1.3 Three Essays

Essay One The first essay begins from a salient issue in international corporate taxation—that of tax competition. We are told that governments compete among themselves. This is described as the main reason for the decline in corporate tax rates around the world (Overesch and Rincke, 2011). The theory of tax competition predicts that corporate tax competition arises from a government's optimal response to a reduction of its tax base, which itself is the result of a neighbouring country's corporate tax rate cut. This chain of events—from one tax cut to a base spillover to another tax cut—defines corporate tax competition. Without the tax base spillover, we cannot define two tax rate cuts as being tax competition for a mobile tax base. In the first essay of this thesis I estimate tax competition as a response to expected tax base spillovers. In this essay, I revisit an important quantitative question using the lens of economic theory as the means of identification.

The theory of tax competition tells us that when governments compete for mobile capital, tax rates fall below the social optimum, leading to the under-

provision of the public good. But magnitudes matter—how big a problem is the under-provision of the public good? That depends on how big strategic spillovers from corporate tax competition are. This essay seeks to answer this question. I estimate the magnitude of strategic spillovers on corporate tax rates between governments. I extend the standard model of tax competition to a three-country model with three multinational firms. This model implies that the size of the response to a neighbour's tax cut depends on the size of the base spillover implied by that tax cut. I use the stock of foreign direct investment between two countries to measure that bilateral base spillover. I convert these bilateral foreign direct investment ties into a weight matrix using the approach typically applied to trade-weighted exchange rates. Using this weight matrix derived from the theory of tax competition, I estimate a spatial autoregressive model of tax competition. I therefore identify tax competition as being an optimal response to base spillovers.

The results of this estimation suggest that a 1 percentage point reduction in the weighted average foreign tax rate leads to a 0.23 percentage point tax cut by the home country in response. This estimate of strategic spillovers is substantially smaller than previous estimates using ad hoc weighting schemes. The existing consensus estimate using ad hoc weights suggests the home country would respond by 0.6 to 0.7 percentage points. I show that these ad hoc weights do not appropriately identify the structure of tax competition. In fact, only the theoretically-implied bilateral foreign direct investment weights manage to satisfy a simple test of identification: that countries should respond more to a tax cut by near neighbours than to a similar tax cut by far neighbours.

I use a back-of-the-envelope calculation to measure the difference in the public good under-provision implied by the various weighting schemes. The ad hoc weights—uniform, GDP, aggregate foreign direct investment, and distance—all suggest public good under-provision between 10 and 14 percent of annual revenue. The bilateral foreign direct investment weights suggest that the level of public good under-provision is approximately 4 percent of revenue. This study finds that strategic spillovers on corporate tax rates between national governments do exist, but the magnitude of these spillovers is around three times smaller than existing estimates suggest. The implication is that tax competition appears to result in modest under-provision of the public good.

Essay Two The results of the first essay highlight the importance of the tax base spillover in defining the process of tax competition. In the first essay, I rely on bilateral foreign direct investment weights to approximate the expected tax base spillover between the two countries. This assumes that governments perceive the cross-tax elasticity to be constant for all pairs of countries. It is a reasonable assumption since even the academic literature has not investigated the heterogeneity of tax base spillover elasticities. We know nothing about the heterogeneity of tax base spillovers.

In this essay, I examine the heterogeneity of corporate tax base spillovers. Corporate tax base spillovers occur when one government's tax rate reform affects the tax base of a neighbouring country. These spillovers are typically assumed to be substitutionary—a tax cut in one country must surely steal profits away from neighbouring countries. Using micro-data for European firms from 2007 to 2016, I estimate the average spillover generated by each country changing its tax rate over the period and the specific country-by-country spillovers these tax changes generated.

I find that, on average, corporate tax base spillovers are substitutionary. However, they are not uniformly substitutionary, and average effects mask substantial heterogeneity. Spillovers between a pair of countries can be either complementary or substitutionary. More surprisingly, many country-pair spillover effects are very small and statistically insignificant. Corporate tax base spillovers appear to operate on a continuum between complementary and substitutionary.

Why is it that not all country-pair spillovers are substitutionary? Theory gives us a few suggestions. The dominant tax competition theories of the multinational firm are of a horizontal multinational and of artificial profit shifting. These typically give unambiguous answers that tax base spillovers will be substitutionary. However, vertical multinational firms may generate more complementary spillovers, as might also happen if firms rely on internal rather than external capital for investment.

I examine this question further empirically. Using the cross-sectional variation in the estimated country-pair elasticities, I attempt to see whether there are any clear patterns across elasticities. I find that countries which are more

similar in purchasing power tend to have more substitutionary spillovers, while countries with larger economic size and public capital intensity tend to limit substitutionary spillovers—likely due to location-specific rents. Surprisingly, I find that countries with larger wage differential also generate more substitutionary spillovers. These results provide a first clear step towards understanding how country-pair tax base spillovers are determined.

Essay Three In the previous essays I find that tax competition is not very intense, and tax base spillovers are quite limited. Having examined the mechanisms of corporate tax competition, I take a step back to investigate the bigger picture: *even if corporate tax competition is leading to the decline of corporate tax rates, is it actually a bad thing that corporate tax rates are falling?* The corporate income tax is known to be highly distorting given the mobility of multinational firms and the profit shifting options available to them. Falling corporate tax rates limit the distortions of the corporate tax. Then by what yardstick are we measuring the decline in corporate tax rates as 'bad'?

If we are only concerned about efficiency, then the optimal corporate tax rate is zero. What justifies our concern that the corporate tax rate is too low? If there is only a revenue-raising justification, then the corporate tax should be eliminated in favour of a less distorting tax instrument, of which there are many. The distorting effects of corporate taxation can only be accepted if there is some offsetting benefit from taxing companies. That is, the relevance of the entire corporate tax system depends on there being some fundamental economic justification for the existence of the corporate income tax. There is no consensus on what that reason might be, and economists have not bothered to take this question seriously over the past two decades.

Then what is the fundamental purpose for the corporate income tax? The third essay of this thesis makes an ambitious attempt to answer this question. In providing a reason for the existence of the corporate income tax, I provide a reason why we might not want corporate tax rates to fall to zero. As Weisbach (2015) proposes, finding a purpose for the corporate income tax gives us advice on the design of the optimal corporate income tax and on the design of the international corporate tax system. By depicting the corporate income tax as a

balance between a fundamental purpose and traditional economic efficiency, I try to bring it in line with the methods of public economics that see taxation as some balance between equity and efficiency. In particular, I explore the idea of inter-nation equity, a concept that has been low on the list of priorities in the academic debate on corporate income tax.

In the third essay, I argue that the existence of the corporate income tax should be justified by the benefit-based view of taxation: firms should pay tax according to the benefits they receive from the use of the public input. A benefit-based corporate tax satisfies both public and policy perceptions of fairness. It also satisfies within-country and inter-nation notions of equity. I model the benefit tax by considering a model with a public input. The returns to the public input appear as profits to the firm, but are actually the deserved income of the government. And since the public input is a location-specific factor, a positive benefit-based corporate tax rate is also feasible, even in a small open economy.

Using the Lindahl (1919) approach to benefit taxation, I propose an optimal benefit-based corporate income tax rate. I modify the Lindahl thought experiment to incorporate the distortionary effects of corporate taxation. I derive an optimal benefit-based corporate tax rate formula that is a function of two estimable elasticities: the elasticity of profit with respect to the public input, and the elasticity of profit with respect to the net-of-tax rate. This gives us a clear and simple understanding of how a benefit-based corporate tax should work: firms with higher public input elasticities (higher marginal valuations of the public input) should pay more; firms with higher tax elasticities will pay less because their responses are more distortionary.

I show that the public input is an empirically relevant mechanism. Using data on public corporations in the United States, I find that the public input elasticity of profits is quite high and economically significant. I also estimate the tax elasticity of profits using the same data. Combining these results using the optimal tax formula suggests that a benefit-based tax on public corporations should be at a rate between 35 to 59 percent. This is substantially higher than the new corporate tax of 21 percent in the United States.

The benefit principle also provides three clear principles of corporate tax sys-

tem design. First, any government should have taxing rights over profits that are generated using its public input. That is—as was the original intent of the international tax system—corporate tax should be levied at source. Second, since the aim of the benefit-based tax is to transfer the returns on the public input from firm to government, then the government should narrow its base as close as possible to these returns. Practically, this implies the government should tax only economic rents—improving both fairness and efficiency in the process. Third, the benefit principle suggests a reason why we can define profit shifting as unfair. Even if profit shifting is efficiency-enhancing, it allows firms to avoid contributing to the provision of public inputs.

The aim of this thesis is to push us to think clearly about the corporate income tax. Is corporate tax competition as harmful as we thought? Are corporate tax base spillovers as uniformly substitutionary as we thought? And do we have a reason for protecting the corporate income tax? Each essay attempts to challenge our widely-held perspectives on the corporate income tax. In its totality, the purpose of this thesis is to provide a fresh perspective on how we think about the corporate income tax.

1.4 This Thesis in Current Context

How does this thesis relate to, and align with current events and issues? One event has dominated the corporate tax landscape in the past few years: the United States' Tax Cut and Jobs Act. This tax reform included a number of alterations to the corporate tax system, but the headline feature was the reduction in the top corporate tax rate from a tax rate of 35 percent to a tax rate of 21 percent. This is a massive reduction in the corporate tax rate for any country. For the world's most systematically important economy, this is potentially seismic.

Much of the debate outside the United States centred around the potential effects of the reform. Beer et al. (2018) attempt to estimate the likely impact of both strategic and base spillovers. My thesis contributes to our future attempts to understand these types of salient and globally important tax reforms. In particular, my work shows that tax base spillovers are likely to be relatively localised,

but will depend on the nature of a country's relationship with the United States. Combining the idea that only a few countries likely experience significant base spillovers with the finding that strategic responses are actually quite small, the evidence from this thesis suggests that there will likely not be a mad global race to the bottom resulting from the Tax Cut and Jobs Act. The estimated spillovers in Beer et al. (2018) rely on average tax base spillovers and large estimates of strategic spillovers from previous literature. My thesis contributes to our understanding of corporate tax rate events by providing a richer set of facts from which we can draw policy predictions.

The Tax Cut and Jobs Act also drew substantial conceptual discussion about the international tax system. In particular, the United States flirted with the idea of a destination-based cash flow tax. In the end, it moved its residence-based corporate tax system in the direction of a source-based corporate tax system. The benefit principle I put forward in this thesis implies that source-based taxation is a fairer means of taxing corporations. This reform brings the United States in line with most of the world. It seems that we are slowly reaching a consensus that source-based taxation represents a fairer distribution of corporate taxing rights.

The clearest contribution of this thesis to the discussion on the Tax Cut and Jobs Act, however, comes in the form of estimating the optimal benefit-based corporate tax for public corporations in the United States. My estimates suggest that the previous top tax rate of 35 percent represents a lower bound on what would be an optimal benefit-based corporate tax rate. This suggests, interestingly, that the American public's opinion that firms pay too little tax is justified (Gallup, 2018).

Globally, the OECD, the G-20, the International Monetary Fund, and the European Union continue to seek a consensus on the design of the corporate income tax system. No consensus is forthcoming. There are very few topics on which policymakers and governments agree. Stepping back from the minute detail of policy design, one might notice that the consideration of fairness is almost non-existent in the international corporate income tax debate. For example, the words 'fair', 'fairness', or 'equity' (in the context of fairness) appear only six times in the International Monetary Fund's (2019) 91-page treatise on *Corporate Taxation in the Global Economy*. This is striking since the fundamental

public economics approach to tax is wholly centred on the trade-off between fairness and efficiency. Almost every other tax is evaluated on how it manages this trade-off.

As Weisbach (2015) indicates, there is unlikely to be any forthcoming consensus on the design of the corporate income tax until we decide what exactly we are trying to achieve through the corporate income tax. In the third essay of this thesis I address this fundamental question that seems to be at the root of the global disagreement on taxation. To answer this question requires a normative approach. I build on the book by Pogge and Mehta (2016a), *Global Tax Fairness*, and the review of their work by Weinzierl (2018a) to identify a fundamental purpose for the existence of the corporate income tax. In the context of the current policy debate, the third essay in this thesis does not serve as a full menu of policy proposals such as is done in works by Auerbach et al. (2017) and Auerbach and Devereux (2018). Instead, it forms an important normative foundation for a corporate income tax project that finds itself running out of steam. The proposal that the corporate income tax should exist as a benefit-based tax provides governments with an appropriate reason to levy the tax, and provides governments with a common understanding of what they should be trying to achieve in designing their domestic tax systems and in cooperating to design the international corporate tax system.

This thesis therefore addresses issues that are both current and important. The aim of this thesis is to provide evidence and insight that is relevant for the design of good economic policy. Each of the three essays that follow is inspired by currents events, and is intended to address specific policy issues.

Chapter 2

How Big Are Strategic Spillovers from Corporate Tax Competition?

The central prediction of the theory of tax competition is that imposing distorting taxes on mobile capital will lead to the under-provision of public goods (Zodrow and Mieszkowski, 1986). This happens because each government has an incentive to lower their tax rate to attract more capital. And every other government has an incentive to respond competitively by lowering their own tax rate to recapture lost capital. Lowering the corporate tax rate as a strategic response to another government's tax cut is what we define as tax competition. This process of tax competition is predicted to lead to a Nash equilibrium where tax rates are collectively below their social optimum (Keen and Konrad, 2014). And if tax rates are below the social optimum, then governments receive less revenue and are unable to provide the socially optimal level of public goods. The potential for severe under-provision of public goods is why tax competition worries both economists and policymakers alike.

But magnitudes matter. How big a problem is the under-provision of public goods due to tax competition? This depends on how far below the social optimum tax rates fall due to tax competition. The difference between actual tax rates and the counterfactual social optimum can be identified by how large the strategic response to a tax cut is. These strategic responses are defined as **strategic spillovers**: the strategic best response to a neighbouring country's tax rate

change. Crucially, a tax cut can only be identified as a strategic spillover when it is an optimal response to the tax competition game.

The magnitude of the under-provision of public goods is therefore identified by the magnitude of strategic spillovers: *on average, how much does a government change its tax rate in response to a collective one percentage point change in its neighbours' tax rates?* Existing evidence suggests that a 1 percentage point reduction in the average foreign corporate tax rate induces the home country to lower its own corporate tax rate by 0.6 to 0.7 percentage points. These are large spillover effects that imply economically substantial under-provision of public goods due to tax competition. Using this estimate, Beer et al. (2018) find that strategic spillovers can more than triple the total spillover effects[1] from a single country's tax rate reform.

In this essay, I revisit this important question: how big are strategic spillovers from corporate tax competition? To identify a strategic spillover, it must be a tax response to an expected or an actual tax base spillover. A **tax base spillover** (or base spillover) is the direct effect one country's tax rate change has on a neighbouring country's tax base. We cannot discern between tax competition, yardstick competition, or common intellectual trends if we do not identify a tax cut as being competition over the allocation of a mobile tax base (Wilson and Wildasin, 2004).

To identify the base spillover mechanism driving strategic spillovers, I sketch a model of tax competition with three countries and three multinational firms. A tax rate change in country C causes multinational firms to optimally reallocate their capital across all three countries. This reallocation is the tax base spillover which then induces an optimal change in country A's tax rate. Importantly, the relative response country A to countries B and C depends on the relative size of the tax base spillovers from B to A and from C to A respectively. If there is no tax base spillover, there is no strategic spillover.

Empirically, we can only identify strategic spillovers if there is some variation in the tax base spillovers that country B and country C would generate for country A's tax base. I measure the magnitude of the expected base spillover

[1] Total spillovers are tax base spillovers plus strategic spillovers.

using the size of the stock of bilateral foreign direct investment between countries. The theoretical framework predicts that three capital stocks are important for measuring base spillovers between two countries: first, the stock of capital from country A invested in country B; second, the stock of capital from country B invested in country A; and third, competition between countries A and B for capital from country C. I implement this measure of expected base spillovers using the weighting scheme used by the Federal Reserve of the United States and the European Central Bank to produce trade-weighted exchange rates (Loretan, 2005; Buldorini et al., 2002).

I argue that tax rates are not 'sluggish'. Rather, governments make discrete decisions to change the tax rates when the benefits of doing so outweigh the costs. The choice of tax rate in any period can therefore be modelled as a dynamic game with an adjustment cost. The standard model of tax competition then acts as the underlying stage game. When governments choose to change their tax rates, they play their best response. Only then can we be sure that we are observing the best response to the change in the foreign tax rate. To empirically implement this, I employ a two-stage Heckman selection model that treats only periods where the tax rate was changed as being a best response to the tax competition game.

I find that a 1 percentage point reduction in the weighted average foreign tax rate results in a 0.23 percentage point tax rate cut in response by the home country. This is a third of the size of existing estimates. Importantly, it implies substantially lower under-provision of the public good than previous estimates. Using a back-of-the-envelope calculation, I find that this estimate implies under-provision in 2012 that is merely 3.7 percent of total tax revenue. In comparison, alternative weighting methods such as distance, GDP or aggregate foreign direct investment imply under-provision between 10 and 14 percent of total tax revenue.

I show that this strategy is more convincing than previous studies using ad hoc weight matrices such as distance, gross domestic product, population size, or the size of aggregate foreign direct investment. I examine whether identification is convincing through the theoretical model's main prediction: a country should respond more to a tax cut by a 'close' neighbour compared to a similar tax

cut by a 'far' neighbour. For any choice of weight matrix, we are implying that these weights are an appropriate empirical measure of closeness. Using graphical evidence I show that this prediction is only true for the bilateral foreign direct investment weights I propose. In contrast, this simple test of identification is not met by any of the alternative ad hoc weighting schemes. Further, a uniform weight matrix cannot undergo any such identification test since it assumes that all countries generate the same base spillovers.

The central contribution of this essay is in combining the theory and empirics of tax competition to more accurately identify and estimate the size of strategic spillovers. This contribution is most clearly manifest is the derivation and application of the theoretically-implied weight matrix to the estimation of strategic spillovers. Achieving this central contribution relies on a number of smaller contributions to knowledge. First, I derive the weight matrix using a model of tax competition with three countries and three firms. Second, I recast tax competition as a dynamic two-stage game with an adjustment cost and implement it using a Heckman two-stage correction model. Third, in contrast to traditional literature on tax competition, I use the maximum likelihood method of estimation which requires the correct specification of the weight matrix. Previous works rely on the spatial instrumental variable strategy, which has been found to inflate estimates of strategic spillovers. Fourth, to eliminate potential endogeneity of the weight matrix, I use a gravity model to instrument for stocks of foreign direct investment. Finally, I am able to provide graphical evidence of convincing identification of spillovers.

This paper is related to an interesting line of literature that interrogates how governments set their corporate tax rates, particularly in relation to their neighbours. This paper follows very closely the research question posed by Devereux et al. (2008): how much do governments respond to a tax rate change in neighbouring countries? It is also related to the following works of Overesch and Rincke (2011), Redoano (2014), Davies and Voget (2008), and Exbrayat (2017) who ask very a similar question, but answer with different methods. This paper also draws on important points made by: Heinemann et al. (2010), that tax cuts are a discrete decision; Lyytikäinen (2012), that the standard spatial instrumental variable method gives inflated answers to the main research question of how much governments respond to their neighbours; by Davies and Voget

(2008), that we should measure relative responses rather than absolute responses to achieve identification; and by Becker and Davies (2017), that governments do not always correctly perceive tax elasticities. More detailed examination of the empirical literature on corporate tax rate setting can be found in surveys by Leibrecht and Hochgatterer (2012) and Devereux and Loretz (2013).

The central finding of this essay is that strategic spillovers are much smaller than we think. The implication of this finding is that tax competition results in very modest under-provision of the public good. This essay seeks to bring clarity to the public debate on international corporate tax competition and public good provision. In the following section, I sketch the theoretical framework of tax competition. In Section 2.2 I describe my empirical strategy for identifying strategic spillovers based on the theoretical model. I present the results of this integration of theory and empirics in Section 2.3. Finally, in Section 2.4 I use simple back-of-the-envelope calculations to show the implications of these new results for public good under-provision.

2.1 A Model of Corporate Tax Competition

Tax competition is defined as "the uncooperative setting of source-based taxes on corporate income where the country is constrained by the tax setting behaviour of other countries" (Devereux and Loretz, 2013). Theoretical descriptions of tax competition begin from the seminal framework based on Zodrow and Mieszkowski (1986) and Wilson (1986). This framework envisages tax competition as governments engaging in Cournot competition as a result of fiscal externalities.

The series of tax competition models originating with Zodrow and Mieszkowski (1986) and Wilson (1986) describe governments setting taxes on capital to influence the after-tax return on capital in a bid to attract mobile capital. Were we to consider a tax on the economic profits of *immobile firms* in such a context, we would conclude it induces no behavioural response. In the same vein, Haufler and Schjelderup (2000) explain that a profit tax on domestic firms would only affect cross-border capital allocation to the extent that the profit tax is indirectly

incident on capital due to imperfect tax deductibility of the costs of capital.

But firms are themselves internationally mobile. These are *multinational firms*. Foreign direct investment, mainly conducted by multinational firms, reached 34.6 percent of world GDP in 2016. The value added of multinational firm affiliates was 11 percent of world GDP in 2016. And the foreign affiliates of multinational firms accounted for 33 percent of world exports in 1998 (UNCTAD, 2017). Firm mobility is an important feature of the global economy.

The mobility of multinational firms implies that even when taxes are levied only on economic profits, the profit tax still distorts the allocation of capital. Multinational firms have the ability to shift capital from one country to another in their search for maximum after-tax profits. By inducing reallocation of capital, the statutory corporate tax rate is an important instrument in the corporate tax competition game. This holds even when all capital costs are deductible and the corporate tax is not directly or indirectly incident on capital.

In this essay, I model tax competition as a simple game over multinational firm activity using the statutory corporate tax rate as the policy instrument. The aim is to derive a model that allows us to empirically identify the size of strategic spillovers. I begin with a two-country model of tax competition for the economic activity of a single multinational firm. The two-country model highlights the main mechanism driving tax competition: tax base spillovers. I then extend this to a three-country three-firm model to consider the relative importance of different neighbours. This extension captures the importance of heterogeneity in tax competition—not all neighbours are equally important.

This model follows the traditional approach to corporate tax competition. The traditional approach is based on the workhorse model derived from Zodrow and Mieszkowski (1986) and Wilson (1986). This approach focuses on the intensive margin of the firm's investment decision; relying on a continuous rather than discrete investment decision. As in Haufler and Schjelderup (2000) and Devereux et al. (2008) I consider multinational firms.

2.1.1 Setup

There are two countries which are similar in all respects. A single multinational firm has existing production capacity in both Country A and Country B. The multinational firm owns a fixed amount of capital K. Capital, along with an unobserved fixed location-specific factor, is used to produce a homogeneous good at a price normalised to 1.

In the first stage of the game, the governments choose their tax rate, taking the other country's tax rate as given. In the second stage, the multinational firm chooses its optimal allocation of capital across the two countries—k_A and k_B. As is standard practice, I solve the model using backward induction.

2.1.2 Firm

A single multinational firm has production located in each of two countries: country A and country B. The firm makes profits $\pi(k_A)$ in country A and $\pi(k_B)$ in country B. Capital can be costlessly reallocated across countries. I make standard assumptions about the nature of the profit function: $\pi'(k) > 0$, $\pi''(k) < 0$ and $\pi'''(k) = 0$. Reflecting the majority of corporate tax systems, I assume that taxation is on a source basis, with profits derived in country A being taxed in country A. The tax is an ad valorem tax rate given as τ_A in country A and τ_B in country B. The firm seeks to maximise the sum of its profits across these two operations subject to the capital constraint. The firm's objective function is:

$$\begin{aligned} \max_{k_A, k_B} \quad & (1-\tau_A)\pi(k_A) + (1-\tau_B)\pi(k_B) \\ s.t. \quad & K = k_A + k_B. \end{aligned} \tag{2.1}$$

Taking first derivatives with respect to k_A and k_B, I combine the firm's first-order conditions. The firm's optimal allocation of capital across countries A and B is defined by the condition:

$$(1-\tau_A)\pi'(k_A) = (1-\tau_B)\pi'(k_B) \tag{2.2}$$

The firm optimises global profits where the marginal after-tax profits are equalised across jurisdictions. A change in the tax rate of either country induces a change in the optimal capital allocation. Implicitly differentiating k_A with respect to τ_A and τ_B, we get:

$$\frac{\partial k_A}{\partial \tau_A} = \frac{\pi'(k_A)}{(1-\tau_A)\pi''(k_A)+(1-\tau_B)\pi''(k_B)}, \tag{2.3}$$

$$\frac{\partial k_A}{\partial \tau_B} = \frac{-\pi'(k_B)}{(1-\tau_A)\pi''(k_A)+(1-\tau_B)\pi''(k_B)}. \tag{2.4}$$

The denominators of both these implicit derivatives are negative since $\pi''(k) < 0$ by assumption. Further, both $\pi'(k_A)$ and $\pi'(k_B)$ are positive by assumption. This means that an increase in country A's tax rate leads to a *decrease* in capital in country A. An increase in country B's tax rate leads to an *increase* in capital in country A.

How does this work? An increase in country A's tax rate leads to a reduction in the marginal after-tax profit in country A. The firm can now make a greater marginal after-tax profit in country B than in country A. The firm moves capital from country A to country B until there is no additional gain from reallocating capital from country A to B. Since marginal profit is decreasing in capital by assumption, then reducing capital in country A will increase marginal profit in A, while increasing capital in B will reduce marginal profit in B. According to Equation 2.2, this reallocation will occur until marginal after-tax profits are once again equalised across the two countries. The multinational firm responds in the opposite manner when country B increases its tax rate, reallocating capital from country B to country A until the optimality conditions are satisfied again.

These implicit differentials capture the main mechanism driving tax competition. When a change in country B's tax rate affects the multinational firm's choice of capital in country A, this is a **base spillover**. Base spillovers drive tax competition.

2.1.3 Government

The government in country A sets the corporate tax rate of profits to maximise tax revenue R_A. Revenue maximisation is a simplifying assumption made in a number of preceding works. This assumption is typically justified by the fact that corporate tax revenue tends to be a small portion of total tax revenue, therefore having little influence on the overall marginal cost of public funds. The government of country A takes the tax rate of country B as given, and also takes the firm's optimality conditions as given. The government knows that a change in the tax rate induces a reallocation of capital. Country A's objective is:

$$\max_{\tau_A} \quad R_A = \tau_A \pi(k_A) \tag{2.5}$$

Differentiating with respect to τ_A gives the revenue-maximising condition:

$$\frac{\partial R_A}{\partial \tau_A} = \pi(k_A) + \tau_A \pi'(k_A) \frac{\partial k_A}{\partial \tau_A} = 0 \tag{2.6}$$

The government faces the standard tax trade-off. An increase in the tax rate induces a mechanical effect, increasing the amount of revenue per dollar of a fixed tax base. However, increasing the tax rate also induces a behavioural effect through the firm's optimal behavioural response to the tax rate change. Define the tax semi-elasticity of capital as $e = -(\partial k_A / \partial \tau_A)/k_A$. The semi-elasticity indicates the percentage change in capital located in Country A in response to a 1 percentage point change in Country A's own tax rate. This is akin to the elasticity used in empirical work to measure the responsiveness of foreign direct investment to tax rates. The first-order condition of the government can be rearranged to describe the revenue-maximising tax rate as:

$$\tau_A^* = \frac{\pi(k_A)}{\pi'(k_A) e k_A} \tag{2.7}$$

Note that the greater the responsiveness of capital to tax rates (e), the lower the optimal tax rate will be. More importantly, this can be considered to be government A's best response function to τ_B since the firm's optimal choice of k_A is an implicit function of τ_B.

2.1.4 Strategic Spillovers

Country A's best response to a change in country B's tax rate is defined as a **strategic spillover**. Strategic spillovers can be formalised by linearising the government's best response function around a symmetric equilibrium where $\tau_A = \tau_B$. A strategic spillover is defined as the total derivative,

$$\frac{d\tau_A^*}{d\tau_B} = -\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} \Big/ \frac{\partial^2 R_A}{\partial \tau_A^2}. \tag{2.8}$$

Proposition 2.1. Strategic Complements. Tax rates in Country A and Country B are strategic complements. Country A's best response to a tax increase in Country B is to increase its tax rate such that

$$\frac{d\tau_A^*}{d\tau_B} > 0 \tag{2.9}$$

Proof.

The second derivative of the revenue function is

$$\frac{\partial^2 R_A}{\partial \tau_A^2} = \pi'(k_A)\left[\tau_A \frac{\partial^2 k_A}{\partial \tau_A^2} + 2\frac{\partial k_A}{\partial \tau_A}\right] + \tau_A \pi''(k_A)\left(\frac{\partial k_A}{\partial \tau_A}\right)^2. \tag{2.10}$$

The term outside the parentheses is negative given that $\pi''(k_A) < 0$. The second term inside the square brackets is negative given that $\partial k_A/\partial \tau_A < 0$. Using the assumption $\pi'''(k) = 0$, I obtain an expression for the second implicit derivative of k_A with respect to τ_A:

$$\frac{\partial^2 k_A}{\partial \tau_A^2} = \frac{\pi''(k_A)\frac{\partial k_A}{\partial \tau_A}\left[(1-\tau_A)\pi''(k_A) + (1-\tau_B)\pi''(k_B)\right] + \pi'(k_A)\pi''(k_A)}{\left((1-\tau_A)\pi''(k_A) + (1-\tau_B)\pi''(k_B)\right)^2} \tag{2.11}$$

Replacing $\partial k_A/\partial \tau_A$ with Equation 2.3 then gives

$$\frac{\partial^2 k_A}{\partial \tau_A^2} = \frac{2\pi'(k_A)\pi''(k_A)}{\left[(1-\tau_A)\pi''(k_A) + (1-\tau_B)\pi''(k_B)\right]^2} \tag{2.12}$$

which is negative. The overall second derivative of the revenue function with respect to the home tax rate is therefore negative. From Equation 2.8, this implies that the sign of the total strategic spillover will take the same sign as the

cross-partial derivative of the government's objective function with respect to τ_B. This cross-partial derivative is given by:

$$\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} = \frac{\partial k_A}{\partial \tau_B}\left[\pi'(k_A) + \tau_A \pi''(k_A)\frac{\partial k_A}{\partial \tau_A}\right] + \tau_A \pi'(k_A)\frac{\partial^2 k_A}{\partial \tau_B \partial \tau_A} \tag{2.13}$$

The first term in this expression is positive. The second term in this expression needs to be signed. Differentiating the implicit derivative of k_A with respect to τ_A again by τ_B gives:

$$\frac{\partial^2 k_A}{\partial \tau_B \partial \tau_A} = \frac{\pi'(k_A)\pi''(k_B) - \pi'(k_B)\pi''(k_A)}{((1-\tau_A)\pi''(k_A) + (1-\tau_B)\pi''(k_B))^2}. \tag{2.14}$$

Beginning at a symmetric equilibrium where $\tau_A = \tau_B$, and where $(1-\tau_A)\pi'(k_A) = (1-\tau_B)\pi'(k_B)$, then $\pi'(k_A) = \pi'(k_B)$. By symmetry of the countries themselves, we assume that $\pi''(k_A) = \pi''(k_B)$. This means that the above expression is equal to zero. For simplicity, we can then rewrite the cross-partial derivative as:

$$\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} = \frac{\partial k_A}{\partial \tau_B}\left[\pi'(k_A) + \tau_A \pi''(k_A)\frac{\partial k_A}{\partial \tau_A}\right], \tag{2.15}$$

which is unambiguously positive. Therefore, given an increase in the corporate tax rate in country B, country A's best response is to increase its own corporate tax rate.

How does this work? The effect of an increase in τ_B is to reduce the marginal after-tax profitability of the firm in that country, leading the multinational firm to reallocate capital from country B to country A. This rebalancing means that country A now has a larger tax base and will maximise revenue at a higher tax rate. The usual testable prediction that emerges from a standard model of tax competition is that tax rates are strategic complements in the competition for mobile capital.

Notice that two main mechanisms form the basis of the theory of tax competition. Firstly, multinational firms respond to higher corporate tax rates by reducing economic activity in higher tax countries and reallocating capital across borders. Secondly, governments respond to changes in their tax bases due to capital movement (base spillovers) by changing their optimal tax rate. Combining these two mechanisms provides us with a theory of international corporate

tax competition.

2.1.5 Three Countries

I now extend the model from a two-country one-firm model to a three-country model. There are three countries A, B, and C. Each country competes for the mobile capital of a single multinational firm. The firm's optimal allocation of capital now depends on the tax rates in each of these three countries. However, the bilateral reaction functions depend only on partial derivatives (holding all else constant), and therefore remain the same.

I take the approach of Davies and Voget (2008), which is to identify the relative responsiveness of country A to countries B and C. That is, why does country A respond more to a tax cut in country B compared to a similar tax rate change in country C? I express the reaction functions $d\tau_A/d\tau_B$ and $d\tau_A/d\tau_C$ as a ratio, and consider what determines country A's relative responsiveness to countries B and C.

Proposition 2.2. Relative Responses. The size of the response of country A to country B relative to the size of the response of country A to country C is an increasing function of the size of base spillovers from country B to country A and a decreasing function of the size of base spillovers from C to country A.

Proof. The ratio of country A's strategic best responses to countries B and C is:

$$\frac{d\tau_A}{d\tau_B}\Big/\frac{d\tau_A}{d\tau_C} = \frac{-\dfrac{\partial^2 R_A}{\partial\tau_B\partial\tau_A}\Big/\dfrac{\partial^2 R_A}{\partial\tau_A^2}}{-\dfrac{\partial^2 R_A}{\partial\tau_C\partial\tau_A}\Big/\dfrac{\partial^2 R_A}{\partial\tau_A^2}} = \frac{\dfrac{\partial^2 R_A}{\partial\tau_B\partial\tau_A}}{\dfrac{\partial^2 R_A}{\partial\tau_C\partial\tau_A}}. \tag{2.16}$$

Substituting in for Equation 2.15, I get:

$$\begin{aligned}\frac{d\tau_A}{d\tau_B}\Big/\frac{d\tau_A}{d\tau_C} &= \frac{\dfrac{\partial k_A}{\partial\tau_B}\left[\pi'(k_A)+\tau_A\pi''(k_A)\dfrac{\partial k_A}{\partial\tau_A}\right]}{\dfrac{\partial k_A}{\partial\tau_C}\left[\pi'(k_A)+\tau_A\pi''(k_A)\dfrac{\partial k_A}{\partial\tau_A}\right]} \\ &= \frac{\partial k_A}{\partial\tau_B}\Big/\frac{\partial k_A}{\partial\tau_C}\,.\end{aligned} \tag{2.17}$$

The derivatives $\partial k_A/\partial \tau_B$ and $\partial k_A/\partial \tau_C$ measure the size of base spillovers resulting from country B and country C's tax rate changes, respectively. This says that country A's relative response to countries B and C depends on relative size of base spillovers. If strategic spillovers depend on the size of base spillovers, we can simply state that strategic spillovers are larger between two countries if base spillovers are larger between those two countries. Corporate tax competition therefore predicts that countries should respond more to countries that generate larger base spillovers. Base spillovers therefore define the structure of tax competition.

2.1.6 Three Firms

I now extend the model to a three-country, three-firm model. Each country has a home multinational, denoted by the lower case of the country name: a, b, c. Each multinational has production capacity in each of the three countries, and each has the same profit function $\pi(k)$. I do not consider competition in the goods market or strategic price setting. The only feature differentiating these multinational firms is the origin of their capital: each multinational firm raises its capital at home, but can deploy it in whichever country it wishes. Denote k_{aA} as the amount of capital originating in country A that is employed in production in country A. The government of country A's revenue function is therefore:

$$R_A = \tau_A \left[\pi(k_{aA}) + \pi(k_{bA}) + \pi(k_{cA})\right]. \tag{2.18}$$

This says that the government has taxing rights over the profit of all three multinational firms *that are generated within its jurisdiction*. It does not assume taxing rights over the home multinational's foreign profits. This is the source principle of international taxation. The government's new first-order condition for revenue maximisation is:

$$\frac{\partial R_A}{\partial \tau_A} = \pi(k_{aA}) + \pi(k_{bA}) + \pi(k_{cA}) + \tau_A \left[\pi'(k_{aA})\frac{\partial k_{aA}}{\partial \tau_A} + \pi'(k_{bA})\frac{\partial k_{bA}}{\partial \tau_A} + \pi'(k_{cA})\frac{\partial k_{cA}}{\partial \tau_A}\right] \tag{2.19}$$

Proposition 2.3. Base Spillovers. The best response of country A to country B is increasing quadratically in three types of base spillover in response to a tax increase in country B:

1. the outflow of capital from country A,
2. the inflow of capital to country A from country B, and
3. the inflow of capital to country A from country C.

These base spillovers are defined by the set of partial derivatives:

$$\left\{\frac{\partial k_{aA}}{\partial \tau_B}, \frac{\partial k_{bA}}{\partial \tau_B}, \frac{\partial k_{cA}}{\partial \tau_B}\right\}. \tag{2.20}$$

Proof.

The cross partial derivative, which signs the reaction function, can then be updated to:

$$\begin{aligned}\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} &= \pi'(k_{aA})\frac{\partial k_{aA}}{\partial \tau_B} + \pi'(k_{bA})\frac{\partial k_{bA}}{\partial \tau_B} + \pi'(k_{cA})\frac{\partial k_{cA}}{\partial \tau_B} \\ &+ \tau_A \left[\pi''(k_{aA})\frac{\partial k_{aA}}{\partial \tau_A}\frac{\partial k_{aA}}{\partial \tau_B} + \pi''(k_{bA})\frac{\partial k_{bA}}{\partial \tau_A}\frac{\partial k_{bA}}{\partial \tau_B} + \pi''(k_{cA})\frac{\partial k_{cA}}{\partial \tau_A}\frac{\partial k_{cA}}{\partial \tau_B}\right]\end{aligned} \tag{2.21}$$

Each of these partial derivatives can be interpreted as an *observable* flow of capital from one country to the other. For example, ∂k_{cA} represents the outflow of capital from country C to country A. Beginning from a symmetric equilibrium where $\tau_A = \tau_B = \tau_C$, then

$$\frac{\partial k_{aA}}{\partial \tau_A} = -\frac{\partial k_{aA}}{\partial \tau_B}. \tag{2.22}$$

If capital flows are symmetric in equilibrium, then we can rewrite the cross-partial derivative of the revenue function as:

$$\begin{aligned}\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} &= \pi'(k_{aA})\frac{\partial k_{aA}}{\partial \tau_B} + \pi'(k_{bA})\frac{\partial k_{bA}}{\partial \tau_B} + \pi'(k_{cA})\frac{\partial k_{cA}}{\partial \tau_B} \\ &+ \tau_A \left[\pi''(k_{aA})\left(\frac{\partial k_{aA}}{\partial \tau_B}\right)^2 + \pi''(k_{bA})\left(\frac{\partial k_{bA}}{\partial \tau_B}\right)^2 + \pi''(k_{cA})\left(\frac{\partial k_{cA}}{\partial \tau_B}\right)^2\right]\end{aligned} \tag{2.23}$$

Further simplifying using the assumption of symmetry of multinational firms so that $\pi'(k_{aA}) = \pi'(k_{bA}) = \pi'(k_{cA}) = \pi'(k_A)$ and $\pi''(k_{aA}) = \pi''(k_{bA}) = \pi''(k_{cA}) = \pi''(k_A)$, then

$$\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} = \pi'(k_A)\left[\frac{\partial k_{aA}}{\partial \tau_B} + \frac{\partial k_{bA}}{\partial \tau_B} + \frac{\partial k_{cA}}{\partial \tau_B}\right] -$$

$$\tau_A \pi''(k_A) \left[\left(\frac{\partial k_{aA}}{\partial \tau_B} \right)^2 + \left(\frac{\partial k_{bA}}{\partial \tau_B} \right)^2 + \left(\frac{\partial k_{cA}}{\partial \tau_B} \right)^2 \right] \tag{2.24}$$

The response of country A to a tax change in country B is expressed as a quadratic function of three capital flows. Similarly, the relative responsiveness of country A to countries B and C is also an increasing function of these three capital flows. This can be shown by dividing

$$\frac{d\tau_A}{d\tau_B} \Big/ \frac{d\tau_A}{d\tau_C} = \frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} \Big/ \frac{\partial^2 R_A}{\partial \tau_C \partial \tau_A} \,. \tag{2.25}$$

What determines this ratio? This ratio would depend on $\{\partial k_{aA}/\partial \tau_C, \partial k_{bA}/\partial \tau_C, \partial k_{cA}/\partial \tau_C\}$, and on $\{\partial k_{aA}/\partial \tau_C, \partial k_{bA}/\partial \tau_C, \partial k_{cA}/\partial \tau_C\}$. This implies that it is the relative ratio of these base spillovers from country B to A, and from C to A that determine the relative optimal response of country A to countries B and C.

A tax change in country B has three effects on country A's tax base: total outflows, inflows from B, and third market inflows from country C. Similarly, a tax change in country C has three effects on country A's tax base: total outflows, inflows from C, and third market inflows from country B. The relative size of these flows determines the relative size of a country's best responses to its neighbours. By extending the model to three multinational firms, we can identify the specific capital flows that matter for tax competition. And these specific capital flows match the bilateral cross-border capital data that is available.

2.2 Empirical Strategy

2.2.1 Identification

The standard approach to estimating the magnitude of strategic spillovers is the spatial econometric approach. This approach expresses the tax rate in country A as a linear function of the tax rates in countries B and C:

$$\tau_A = \rho_B \tau_B + \rho_C \tau_C + \varepsilon \tag{2.26}$$

As we increase the number of countries who might be neighbour to Country A, this estimation method becomes impractical due to over-parameterisation. Consider a full set of countries indexed $i, j, k \in 1, \ldots, n$. The solution is to linearly combine the tax rates of all neighbours into a *spatial lag*:

$$\tau_i = \rho \sum_{j \neq i}^{n} w_{ij} \tau_j + \varepsilon. \tag{2.27}$$

This is the **spatial autoregressive process**. Identification of a spatial autoregressive process comes from the chosen spatial structure—the **weight matrix** W. This requires imposing spatial structure on the model. For each pair of countries i and j, the strength of the relationship between the two of them is measured by a weight w_{ij}. The closer the weight matrix comes to approximating the true underlying spatial structure, the stronger and more convincing identification will be.

The theoretical model tells us that the relative *weight* placed on countries j's and k's tax rate changes depend on the expected effects their respective tax rate changes will have on country i's tax base. Denote k_{ji} as capital originating in country j but located in country i. Theory suggests that the correct weight placed on country j depends on the full set of partial derivatives:

$$\left\{ \frac{\partial k_{ii}}{\partial \tau_j}, \frac{\partial k_{ji}}{\partial \tau_j}, \frac{\partial k_{ki}}{\partial \tau_j} \right\} \tag{2.28}$$

Tax competition is rationalised by the presence of a base spillover. Therefore the intensity of tax competition is identified by the intensity of the base spillover. If there is no base spillover between two countries, then there is no reason for competition to exist between them. For example, Wilson and Wildasin (2004) define tax competition as non-cooperative tax setting *where each government's choices affect the allocation of a mobile tax base among them*.

In reality, governments do not have complete information about the full set of partial derivatives $\partial k_{ij} / \partial \tau_j$ for all $i, j = 1, \ldots, n$. Becker and Davies (2017) focus on this incomplete information, modelling the process of governments learning these elasticities based on previous outcomes (capital allocations) and strategies (tax rate choices). Even the academic literature is mainly limited to estimating a single semi-elasticity using data on a number of countries. This literature is

reviewed in Feld and Heckemeyer (2011). If a government has an estimate of a single average semi-elasticity ($\bar{e}$), then it can approximate the expected effect of a specific country's tax rate change based on the size of existing cross-border investment between them. Using the definition of the semi-elasticity of capital with respect to the foreign tax rate, then for any pair of countries we get

$$-\bar{e} \cdot k_{ij} = \frac{\partial k_{ij}}{\partial \tau_j}. \tag{2.29}$$

So for a constant tax semi-elasticity, the larger the bilateral capital stock between country i and country j, the larger will be the partial derivative. Where the government does not know the country-specific semi-elasticities but has knowledge of some average semi-elasticity, it can estimate of $\partial k_{ij}/\partial \tau_j$ using the size of the bilateral stock of investment between these two countries: k_{ij}.

I empirically implement this strategy by calculating w_{ij} for each pair of countries using a weighting scheme similar to those used by the United States Federal Reserve and European Central Bank to produce trade-weighted exchange rates (see Loretan (2005) and Buldorini et al. (2002) for further details). This weighting scheme accounts for the three partial derivatives in Equation 2.28 by using capital inflows from j to i, capital outflows from i to j and the competition between j and i for capital inflows from a third country k.

The weight that country i places on country j is given by w_{ij} and uses data on inflows x_{ji} from j to i, outflows v_{ij} from i to j, and a measure of their competition for inflows from a third market k. The weights for inflows is given as the proportion of total inflows and that come from country j:

$$w_{ij}^{X} = \frac{x_{ji}}{\sum_{j \neq i}^{N} x_{ij}} \tag{2.30}$$

Similarly, the weight for outflows is calculated as the proportion of total outflows from country i that go to country j:

$$w_{ij}^{V} = \frac{v_{ij}}{\sum_{j \neq i}^{N} v_{ij}} \tag{2.31}$$

The third market competitiveness weight, w_{ij}^{C}, combines the importance of inflows from each third country k to country i's total inflows (w_{ik}^{X}) and the level of

market share that country j has in that third market k, given by w^V_{kj}.

$$w^C_{ij} = \sum_{k \neq j \neq i}^{N} \frac{w^X_{ik} \cdot w^V_{kj}}{1 - w^V_{ki}} \tag{2.32}$$

These three weights are then combined, weighting them by the relative importance of outflows and inflows to country i:

$$w_{ij} = \left[\frac{\sum_{j \neq i}^{N} v_{ij}}{\sum_{j \neq i}^{N} x_{ji} + \sum_{j \neq i}^{N} v_{ij}} \times w^V_{ij} \right] + \left[\frac{\sum_{j \neq i}^{N} x_{ji}}{\sum_{j \neq i}^{N} x_{ji} + \sum_{j \neq i}^{N} v_{ij}} \times (0.5 \cdot w^X_{ij} + 0.5 \cdot w^C_{ij}) \right] \tag{2.33}$$

I use the square of all k_{ij} values to approximate the quadratic form derived in the theoretical model. Many ad hoc weighting schemes in the literature apply the quadratic form to the inputs (for example Heinemann et al. (2010) and Overesch and Rincke (2011)). The reason is that it emphasises local clustering—making near neighbours very important—while not ignoring the possibility of global effects (Kopczewska et al., 2017). Additionally, using squared values creates a degree of sparsity in the spatial structure; and sparsity generates clearer identification.

2.2.2 Heckman Two-Step Correction

Tax competition is a dynamic game, with tax changes being made in steps rather than a one-shot jump to equilibrium. To produce an empirically useful model, we need to think of tax competition as a dynamic game. Corporate tax rates are not reset each year. This might be perceived as 'sluggishness', implying an autoregressive process (Overesch and Rincke, 2011). Or it might be the result of a discrete choice decision problem (Heinemann et al., 2010). We observe tax rates following a jump process, with piece-wise constant trajectories—rather than drifting slowly over time like other macroeconomic variables. This suggests that it is much more likely that tax competition should be modelled as a discrete choice problem.

In those periods where tax rates did not change, I see two possible explanations. Either the numerous determinants of the optimal corporate tax rate remained unchanged, or there is some adjustment cost of changing the tax rate to its optimal value. It seems more plausible that there are fixed adjustment costs

of changing the tax rate. In this case, we can consider the static tax competition model to be the stage game of a repeated game.

In period t, the government can either play its best response from the tax competition stage game or leave its tax rate unchanged. The fixed cost of changing its tax rate is c. The benefit of changing the tax rate is the additional revenue the government would receive from playing its best response. The government would only choose to change its tax rate when the benefits of doing so outweigh the costs.

$$\tau_A^t = \begin{cases} \tau_A^*(\tau_B^t) & \text{if } R(\tau_A^*(\tau_B^t)) - R(\tau_A^{t-1}) > c \\ \tau_A^{t-1} & \text{otherwise} \end{cases} \tag{2.34}$$

We do not observe the value of c, especially as it might be a perceived or implicit cost rather than a real cost. This cost of changing the tax rate can arise from various sources: political constraints, the cost of implementing new legislation, or the cost of business uncertainty. The most crucial implication is that we cannot know whether periods with unchanged tax rates are a best response to the tax competition stage game. Only in periods where the tax rate is changed can we be sure that we are observing the government's best response to the tax competition stage game.

It is important to view tax competition as a two-stage process. First, I model the government's decision to change the tax rate. Second, I consider the best response to the tax competition game. I do not treat periods where no tax change occurred as being a best response to the tax competition state game. There is a strong chance that the decision to change the tax rate depends on the value of the underlying true best response. Small changes in the best response might not result in a tax rate change if the costs exceed the benefits of a small change in the tax rate.

To model this two-stage process I adopt the Heckman (1976) sample selection approach. I first model the decision to change the tax rate as a function of the foreign tax rate and a number of controls capturing the dynamics of the political process. Heinemann et al. (2010) examine the factors that influence the government's decision to change its tax rate. I use the fraction of seats held by the government to measure the ease with which the government might be able to pass new legislation. I also include the Herfindahl Index Government which

is measured as the sum of the squared seat shares of all parties in the government. This gives a more detailed measure of the concentration of government power. I add a categorical variable capturing the economic policy orientation of the governing party: left, right, or centre. Finally, I add a dummy for if there was a legislative election in the year and a dummy for if there was an executive election in the year. These political variables are all taken from the Inter-American Development Bank Database of Political Institutions. The estimation includes country fixed effects. From the first stage regression, I calculate the Inverse Mills Ratio (IMR) and include it in the second stage (the main model).

2.2.3 Other Empirical Matters

Controls I include a number of country-specific controls that are likely alternative determinants of the tax rate. These are mostly in line with the preceding literature. I include a de jure measure of capital account openness: I use the Chinn and Ito (2008) capital account openness index to control for the potential that increasing openness alone drives corporate tax rates down. I also include a measure of trade openness: imports plus exports as a ratio of GDP. I control for the personal income tax in case the corporate tax acts as a backstop to the personal tax, or if tax reforms are undertaken as a full package. I include government consumption expenditure to gross domestic product (GDP) as a first-order proxy of the demand for public goods. I also include second-order determinants of the demand for the public good. I use the share of the population under 14 and the share of the population over 65, since these are the portions of the population ineligible to work and typically most dependent on government spending. I also include the share of the population living in urban areas. Finally, I add a variable that captures the share of a country's total outward foreign direct investment stock that is located in tax havens. This should separate responses to pure tax competition from responses to artificial profit shifting into tax havens. This final variable is the only real deviation from preceding works in the set of controls.

Simultaneity Bias The spatial econometric literature has had to deal with one major concern in the spatial autoregressive model: simultaneity bias. If all gov-

ernments choose their tax rates at the same time, then we are likely to encounter simultaneity. This implies that the foreign tax rate is endogenous, as it would depend on the home country's tax rate. Where tax rates are expected to be strategic complements (moving in the same direction), simultaneity bias—if it exists—should bias the ordinary least squares estimate upward. There are two accepted methods of dealing with simultaneity bias in the spatial autoregressive model. The first is the spatial instrumental variable approach used in the majority of the preceding literature on tax competition. This approach uses the weighted average of neighbours' controls to instrument for the endogenous foreign tax rate. There are serious concerns with this approach. Lyytikäinen (2012) shows that the spatial instrumental variable approach finds large strategic spillovers where a natural experimental approach on the same data shows no evidence of strategic spillovers. In fact, initial estimates using the instrumental variable approach produce a larger coefficient than the OLS estimates. This is odd, since the problem that we are trying to fix is that OLS estimates are biased upward (De Giorgi et al., 2016). The approach appears to create additional bias rather than eliminating it. Both Elhorst and Fréret (2009) and Fréret and Maguain (2017) report and discuss these inflated estimates.

I adopt the second approach to dealing with simultaneity bias, which is estimation via maximum likelihood. It requires careful specification of the spatial patterns through theory in order to support credible causal interpretation. The maximum likelihood approach likely provides greater clarity and requires less caution in interpretation than the spatial instrumental variable approach (Fréret and Maguain, 2017).

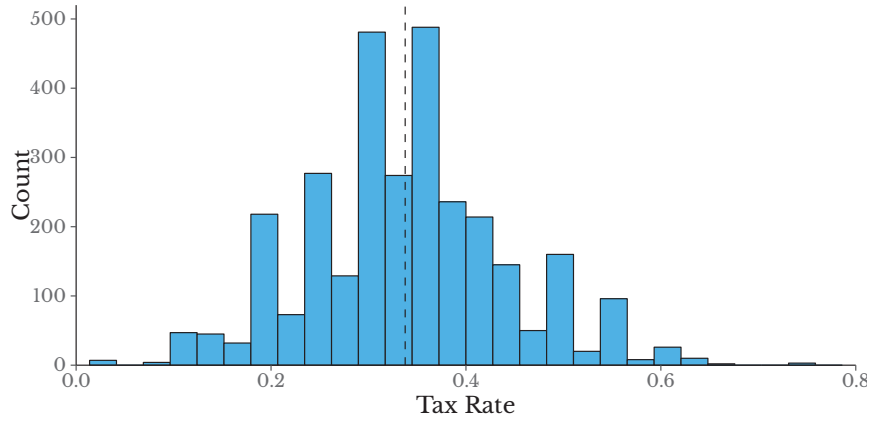
Weight Matrix Endogeneity The possibility exists that the network structure itself might be endogenous to the tax rate. The tax rate is a determinant of the foreign direct investment flows to a country. A number of approaches to solving the endogeneity problem are discussed in Qu and Lee (2015). The most intuitive approach is the instrumental variable approach, which requires either an instrumental variable or knowledge of the network formation process. Fortunately, there is a rich gravity model literature examining the theoretical and empirical underpinnings of foreign direct investment flows across borders. I use a gravity model without the tax rate as a predictor. I estimate a simple version of the

gravity model with foreign direct investment expressed in natural logs. Predictors included are the natural log of gross domestic product, the Chinn-Ito capital account openness index, the total population size, the urban population size, government consumption to GDP, the sum of imports and exports as a ratio of GDP, and dummies for the existence of a signed or in force bilateral trade agreement between the countries. I also include a full set of country-pair fixed effects and year fixed effects. I use the predicted values from the gravity model in the main spatial model to construct the weight matrix.

2.2.4 Data and Descriptive Statistics

I use tax rate data for 131 countries to calculate the weighted average foreign tax rate for each country, using all other countries in the dataset. I obtain data on top corporate tax rates from a number of sources. The main source is the Oxford University Centre for Business Taxation's top corporate tax rate. For countries where the Centre for Business Taxation does not have tax rate data, I augment it with data from the International Monetary Fund's Fiscal Affairs Division[2]. Tax rates vary from 75 percent in Iran from 1990 to 1992, to 0 percent in Moldova from 2008 to 2011. Figure 2.1 shows that tax rates have been concentrated in the range of 20 to 40 percent.

Figure 2.1: Histogram of Tax Rates



Bilateral foreign direct investment (FDI) data are obtained from a combination of the UN Conference on Trade and Development's (UNCTAD) database

[2]I must express thanks to Ruud De Mooij for providing the data used in Crivelli, De Mooij, and Keen (2016).

and the Organisation for Economic Co-operation and Development's (OECD) database. The primary source is the OECD's database, with UNCTAD data used to fill the gaps.

The Chinn-Ito index of capital account openness Chinn and Ito (2008) is used to measure capital account openness. Personal income tax rates are obtained from a combination of sources including the Urban-Brookings Tax Policy Center and the OECD. The top personal income tax rate is used. In some cases, top local tax rates are combined with top federal tax rates to produce an overall top personal income tax rate. Public consumption is quantified as public expenditure as a percentage of nominal GDP. This data is obtained from the World Bank. Gross Domestic Product (GDP) and population data are also obtained from the World Bank. The proportion of the population under 14, the proportion of the population over 65, and the proportion of the population living in urban areas are obtained from the World Bank's World Development Indicators. All political variables used in the first stage of the two-stage Heckman sample selection model are obtained from the Inter-American Development Bank's Database of Political Indicators.

To capture the effect of profit shifting activity on tax rates, I employ the stock of foreign direct investment held by country i in all tax havens as a proxy. This is measured as a percentage of total outward foreign direct investment from country i. Corporate profit shifting requires setting up a subsidiary in a tax haven irrespective of the form profit shifting takes (Palan et al., 2013). Setting up subsidiaries leaves a trail of investment that is captured in foreign direct investment statistics. That tax havens attract a level of foreign direct investment vastly disproportionate to their size is a smoking gun. Even excluding three outlier tax havens with inward foreign direct investment to GDP ratios in excess of 1,000 percent, the average inward foreign direct investment stock of tax havens was still 129.5% of GDP. In the full data set, the average foreign direct investment held in tax havens as a percentage of total outward foreign direct investment is 10.8 percent. There are a large number of zero observations, implying either that we do not observe the bilateral foreign direct investment stocks or there is no bilateral investment into tax havens. The average, excluding these zero values, is 15.3 percent. Tax havens are defined as in Davies et al. (2017): countries with abnormally corporate-friendly tax policies that are likely to encourage artificial

location of profits. The primary sample of tax havens is drawn from the OECD's original blacklist of 37 countries. I broaden this sample to include a number of countries that are widely acknowledged to be tax havens, giving a total of 65 tax havens.[3]

2.3 Estimates of Strategic Spillovers

I estimate the reaction function for 76 countries where there were 359 corporate tax rate reforms from 1984 to 2015. This is less than the full dataset of 131 countries since data for the controls variables are not available for all countries, and not all countries change their tax rates. However, all available tax rate data are used in the construction of the weighted average foreign tax rate (the spatial lag).

The main results of this study are obtained from a maximum likelihood estimation using the proposed foreign direct investment weights instrumented using the predictions from a foreign direct investment gravity model. The results of this gravity model are presented in Table 2.6. I demean the main data so that the model controls for country fixed effects. This eliminates between-country variation and uses only within-country variation, controlling for country-specific time-invariant characteristics. I also include the Inverse Mills Ratio, estimated from a first-stage regression on the decision to change the tax rate using 1,771 observations. The results of this first-stage regression are shown in Table 2.7. The dependent variable is therefore $1(t \in T)$, where t denotes the periods where the tax rate was changed so that $\tau_t \neq \tau_{t-1}$. The Inverse Mills Ratio should account for possible selection bias in estimating the best responses to the tax competition game. The main estimated model is therefore:

$$\tau_{it} = \alpha_i + \rho \sum_{j \neq i}^{n} w_{ijt} \cdot \tau_{jt} + \beta X_{it} + \gamma \text{IMR} + \varepsilon_{it}. \tag{2.35}$$

for all $t \in T$. The main results of this essay are presented in Table 2.1. These results are estimated using only periods where the corporate tax rate was changed. The coefficient of interest is ρ, which measures the average strategic spillover from corporate tax competition.

[3]The list of tax havens is available on request from the author.

I first estimate the model using only a small set of controls: government consumption, the personal income tax rate, the Chinn-Ito capital account openness index, and the share of foreign direct investment to tax havens. This estimation returns a strategic spillover of 0.409. The second model estimated includes the shares of the population under 14 and over 65, along with the share of the population living in urban areas. These demographic controls improve the fit of the model and reduce the estimated strategic spillover to 0.242. Adding the sum of imports and exports as a ratio of GDP further reduces the estimated coefficient to 0.227. Finally, estimating the full model, but excluding the Inverse Mills Ratio increases the estimate only marginally to 0.232.

The preferred estimate of 0.227 is interpreted as *a 1 percentage point decrease in the weighted average foreign tax rate induces a 0.227 percentage point decrease in the home tax rate*. This is substantially smaller than the main estimates of 0.69 uncovered by Devereux et al. (2008) and Overesch and Rincke (2011), and the 0.71 uncovered by Redoano (2014). These previous estimates are *three times larger* than my estimate. This is partially explained by the modelling strategy, and partially explained by the choice of weight matrix.

Two factors in particular seem to play a strong role in the reduction of corporate tax rates: capital account openness and trade openness. Their impacts are unsurprising. In fact, a substantial portion of the early literature on tax competition focused on the effect of increasing openness on tax rates, discussed in Devereux and Loretz (2013). Given the optimal corporate tax rate formula in Equation 2.7, it is intuitive to think that higher levels of mobility lead to lower optimal corporate tax rates. The results suggest that greater openness has led to lower corporate tax rates. Increasing foreign direct investment to tax havens also seems to play a role in tax rate cuts.

I re-estimate these models without instrumenting the foreign direct investment values with predictions from the gravity model. The estimated strategic spillovers are given in Table 2.2, and are only slightly different to the main results in Table 2.1. The model appears robust to concerns of the weight matrix being endogenous.

Table 2.1: Main Estimates of Strategic Spillovers on Corporate Tax Rates

	Model 1	Model 2	Model 3	Model 4
$w \cdot \tau_J$	0.409^{***}	0.242^{*}	0.227^{*}	0.232^{*}
	(0.096)	(0.111)	(0.106)	(0.103)
Gov't consumption	0.045	0.139	0.112	0.112
	(0.092)	(0.095)	(0.094)	(0.094)
Personal tax rate	0.069	0.040	0.106	0.131
	(0.369)	(0.346)	(0.341)	(0.338)
Chinn-Ito Index	-0.052^{***}	-0.037^{*}	-0.028	-0.033^{*}
	(0.015)	(0.015)	(0.016)	(0.015)
FDI to tax havens	-0.089^{***}	-0.033	-0.032	-0.027
	(0.017)	(0.017)	(0.017)	(0.017)
Population 0-14		0.649^{**}	0.570^{*}	0.655^{**}
		(0.238)	(0.251)	(0.231)
Population 65 and up		-0.784^{***}	-0.699^{**}	-0.499^{**}
		(0.236)	(0.230)	(0.169)
Urban Population		-0.040	-0.007	-0.070
		(0.120)	(0.122)	(0.117)
(Imports+Exports)/GDP			-0.055^{***}	-0.056^{***}
			(0.015)	(0.014)
Inverse Mills Ratio	-0.013^{**}	-0.013	-0.010	
	(0.004)	(0.008)	(0.008)	
R^2	0.315	0.416	0.433	0.431
Observations	359	359	359	359

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The dependent variable is the statutory tax rate τ_i.

Country Sample Are these different results a function of using a broader sample of countries? Earlier studies such as Devereux et al. (2008), Overesch and Rincke (2011) and Redoano (2014) focused on developed countries—OECD or European countries. More recent studies such as Crivelli et al. (2016) examine a broad range of countries (173) including developed and developing countries. Their results suggest that base spillovers are actually larger for developing countries, implying that their optimal response to tax competition should be larger than those of developed countries. More importantly, their results seem to back this up. Using OECD countries as in Devereux et al. (2008), Crivelli et al. (2016)

Table 2.2: Estimates of Strategic Spillovers without Instrumented FDI Weights

	Model 1	Model 2	Model 3	Model 4
$w \cdot \tau_J$	0.433^{***}	0.271^{**}	0.251^{**}	0.255^{**}
	(0.085)	(0.098)	(0.094)	(0.092)
R^2	0.331	0.423	0.438	0.435
Observations	359	359	359	359

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The dependent variable is the statutory tax rate τ_i.

find no significant evidence of strategic spillovers. However, they find strategic spillovers of 0.5 for non-OECD countries. For low- and middle-income countries, their estimate of strategic spillovers is even larger at 0.7. The results of Crivelli et al. (2016) suggest that by including low- and middle-income countries, the estimate of strategic in this essay should actually be *higher* than if I focused solely on developed or high-income countries. This strongly suggests that including developing countries in this essay should not bias the estimates in this essay downward. Table 2.A shows the World Bank income classifications of the countries in my sample.

Two-Stage Process The decision to model tax competition as a two-stage process also results in lower estimates of strategic spillovers. I re-estimate the main model without using the Heckman two-stage process. All observations available are included in the regression, giving 1,356 observations rather than the 359 used in Table 2.1. Table 2.3 shows the results of this exercise. The main estimate increases from 0.227 to 0.379. This suggests that including all observations as best responses inflates estimates of strategic spillovers. The likely reason for this inflation is that treating all observations as best responses would mean that it appears small changes in the foreign tax rate in a single year induce large changes in the home tax rate. The truth, however, is that small changes in the foreign tax rate over a series of years will accumulate into large foreign tax changes that force a large response by the home country.

Table 2.3: Using All Observations as Best Responses

	Model 1	Model 2	Model 3	Model 4
$w \cdot \tau_J$	0.523^{***}	0.414^{***}	0.379^{***}	0.387^{***}
	(0.042)	(0.047)	(0.045)	(0.047)
R^2	0.346	0.393	0.427	0.430
Observations	1356	1356	1356	1345

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. Models 1 to 3 use the same controls as Models 1 to 3 in Table 2.1. In Model 4 I add the controls used in the first stage regression in the Heckman sample selection model.

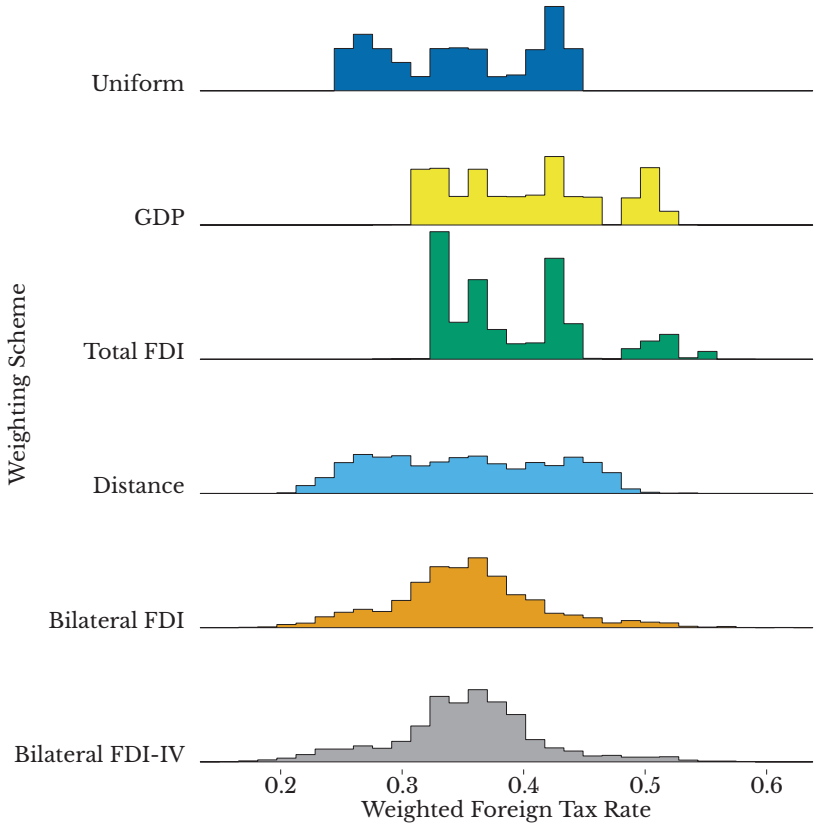
2.3.1 Comparisons

Previous works have used weighting schemes that aim to loosely approximate the true nature of interaction between countries. These can be broken into two types: aggregate weights and bilateral weights. Aggregate weighting schemes assume that all countries have approximately the same importance to all other countries. An aggregate weighting scheme constructs a leave-out-one weighted average in calculating the foreign average tax rate, where the country left out is the home country. Therefore variation in the foreign tax rate across countries depends on the importance of the home country in the weighting scheme. Examples are the uniform weight (or unweighted average), gross domestic product (GDP) weights, total foreign direct investment weights (Devereux et al., 2008), and population size (Exbrayat, 2017). Bilateral weights acknowledge the heterogeneity of importance across neighbours. For example, Canada might be more important to the United States than China is, but China is more important to India than Canada is. The main form of bilateral weights used are distance weights (Overesch and Rincke, 2011; Redoano, 2014). Other bilateral weights used include market potential weights (Davies and Voget, 2011), and trade integration (Exbrayat, 2017). A further survey of the literature can be found in Leibrecht and Hochgatterer (2012).

Does the foreign direct investment weight matrix actually provide a substantial improvement over previous weighting schemes *not* derived from theory? Is there some means of testing whether any of the weighting schemes provide convincing empirical identification? Identification depends on the variation in

the exogenous variable—the weighted average foreign tax rate. While we cannot manipulate the corporate tax rates of neighbours to provide identification, we can attempt to observe those neighbour tax rates that matter the most. The weighted average foreign tax rate—the source of identification—depends heavily on the choice of the weight matrix.

Figure 2.2: Histogram of Weighted Foreign Tax Rates



Since identification depends on the calculated foreign average tax rates, I plot the distribution of the foreign average tax rate for a range of weighting schemes. I use the popular ones: uniform weights, GDP weights, total inward plus outward foreign direct investment weights (aggregate foreign direct investment), and inverse distance. I compare these to the weights I propose: bilateral foreign direct investment and bilateral foreign direct investment instrumented by the gravity model. The distributions of these weighted average foreign tax rates are plotted as histograms in Figure 2.3.1. They show that the aggregate weighting schemes (uniform, GDP, foreign direct investment) produce very odd distributions of the weighted average tax rate, concentrated in a specific range and truncated very sharply. More oddly, they exhibit patches in the middle of the distribution where no observations fall. The distance weights exhibit a more reasonable distribu-

tion. There is neither severe truncation nor holes in the distribution. However, from the range of a 25 percent to 48 percent tax rate, the distribution appears almost uniform. In contrast, the bilateral foreign direct investment weights both generate almost normal distributions of the weighted average foreign tax rate.

LeSage and Pace (2014) make clear that *small* changes in the weight matrix should not induce substantial changes in the estimated coefficients. To examine whether these weight matrices are similar (or not substantially different), they suggest a simple method. They suggest generating a standard independent normal $n \times 1$ vector u and calculating the correlation $\text{Corr}(W_1u, W_2u)$ to capture the correlation between two alternative weight matrices W_1 and W_2. If these two are highly correlated, the results of the models should not be economically different.

Table 2.4: Correlations of Alternative Weight Matrices

	FDI-IV	FDI-Bi	FDI	Distance	GDP	Uniform
FDI-IV	1					
FDI-Bi	0.908	1				
FDI	0.060	0.066	1			
Distance	0.073	0.071	0.305	1		
GDP	-0.026	-0.018	0.003	-0.044	1	
Uniform	0.027	0.026	0.369	0.342	-0.007	1

Correlations between weight matrices are computed according to LeSage and Pace (2014) as the pairwise correlation $\text{Corr}(W_1u, W_2u)$ for each pair of matrices.

Table 2.4 presents the proposed correlation matrix for the various weighting schemes. As expected, the two bilateral foreign direct investment weight matrices are highly correlated (0.91). Concurring with LeSage and Pace (2014), they have been also shown to generate very similar estimates of strategic spillovers. In stark contrast, the bilateral foreign direct investment weights show very low correlation with any of the other weighting schemes. Correlation with the aggregate foreign direct investment weights is 0.060, with distance 0.073, with GDP -0.026, and with the uniform weight matrix, 0.027. The implication is that there is almost no correlation between bilateral foreign direct investment weights and popular ad hoc weights, suggesting that the finding of economically significant differences in estimates is justified.

Having shown that the variation used to identify tax competition is substantially different when using bilateral foreign direct investment tax rates, I now

Table 2.5: Estimates Strategic Spillovers Using Alternative Weight Matrices

	Uniform	GDP	FDI	Distance
$w \cdot \tau_J$	0.511^{***}	0.499^{***}	0.395^{***}	0.389^{***}
	(0.113)	(0.124)	(0.110)	(0.090)
R^2	0.461	0.455	0.446	0.461
Obs.	398	398	380	398

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The models estimated in the table are the same specification as that estimated in Model 3 of Table 2.1. Models include all controls and are estimated using the Heckman sample selection method. For each model estimated, the specified weight matrix is given by the column name.

re-estimate the main tax competition model using these alternative weighting schemes. For comparability, I continue to use the Heckman two-stage approach, treating only tax rate changes as best responses. The results of these estimates are presented in Table 2.5. They include the full set of available controls as in Model 3 of Table 2.1.

The estimated strategic spillover is 0.511 for uniform weights, 0.499 for GDP weights, 0.395 for aggregate foreign direct investment weights, and 0.389 for distance weights. These estimated coefficients are between 1.7 to 2.2 times larger than the corresponding estimated coefficient of 0.227 for the bilateral foreign direct investment weights. Note that even these estimates are substantially smaller than the estimates produced in previous works using the same weight matrices. The main reason for this difference is the exclusion of periods where tax rates did not change. Including periods where the tax rate did not change, the uniform weights generate a coefficient of 0.653, very close to the main result of 0.69 from Devereux et al. (2008) (see Table 2.9 in the Appendix).

The main estimate of 0.69 in Devereux et al. (2008) is based on an unweighted network structure. Devereux et al. (2008) also include a model that weighs each country by their total inflows plus outflows of foreign direct investment, producing a smaller coefficient of 0.34. However, they reject these estimates on the grounds of endogeneity. The estimate of 0.69 in Overesch and Rincke (2011) is based on distance weights. Similarly, Redoano (2014) use distance weights in her main estimate of 0.71. Redoano (2014) explicitly explains that distance is a proxy

for the cost of bilateral cross-border investment flows, which is expected to be inversely related to cross-border investment flows. I take a more direct approach and simply use cross-border flows as the weights. Crivelli et al. (2016) find an estimate around 0.47 using an inverse distance weighting matrix for 125 countries, which is still twice as large as the estimated coefficient in this essay.

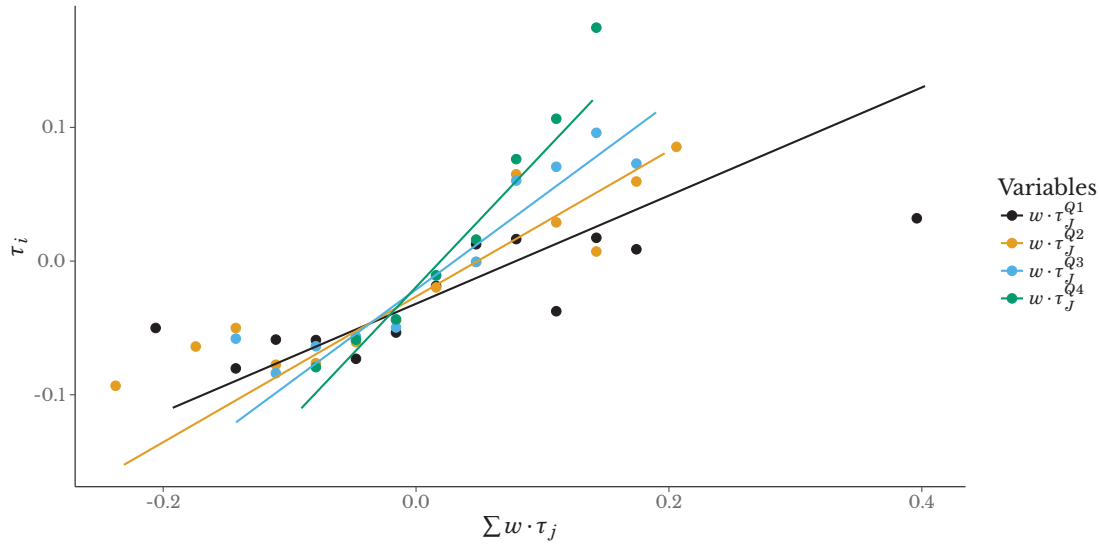
2.3.2 Graphical Evidence

Tax competition presents a simple testable prediction for identification: *a country should respond more to a tax cut by a 'close' neighbour compared to a similar tax cut by a 'far' neighbour*. Nearness is defined by the empirical weight w_{ij} we choose to represent the relationship between two countries. This simple prediction is the basis of identification in a spatial model.

To examine this prediction, I separate neighbouring countries into four groups of 'nearness' for each weight matrix. Near neighbours are those neighbours we expect to induce a higher strategic spillover. Far neighbours are those we expect to induce a smaller strategic spillover. Quartile 1 ($Q1$) are far neighbours while quartile 4 ($Q4$) are near neighbours. Nearness is calculated based on an average of w_{ij} over the entire period. I recalculate the weighted average foreign tax rate within each quartile. As graphical evidence, I plot a scatterplot of the home tax rate, τ_i, against the weighted average foreign tax rate for each quartile, $\sum w_{ij} \cdot \tau_j$. Note that these are expressed as deviations from the mean for comparability across countries (as is used in the regression estimates). For visual clarity I bin the scatter points. I add simple bivariate regression lines for each quartile. Identification is convincing if the regression lines are steepest for near neighbour and flattest for far neighbours.

The results for the main bilateral foreign direct investment weighting scheme instrumented by the gravity model are presented in Figure 2.3. Identification in the bilateral foreign direct investment weighting scheme says that a country should respond *more* to a tax cut by a country with which it has a strong cross-border investment relationship, than to tax cut by a country with which it has little cross-border investment activity. The graphical evidence strongly suggests that the bilateral foreign direct investment weights achieve the predicted iden-

Figure 2.3: Binned Scatterplot by Quartile for Foreign Direct Investment-Instrumental Variable Weights



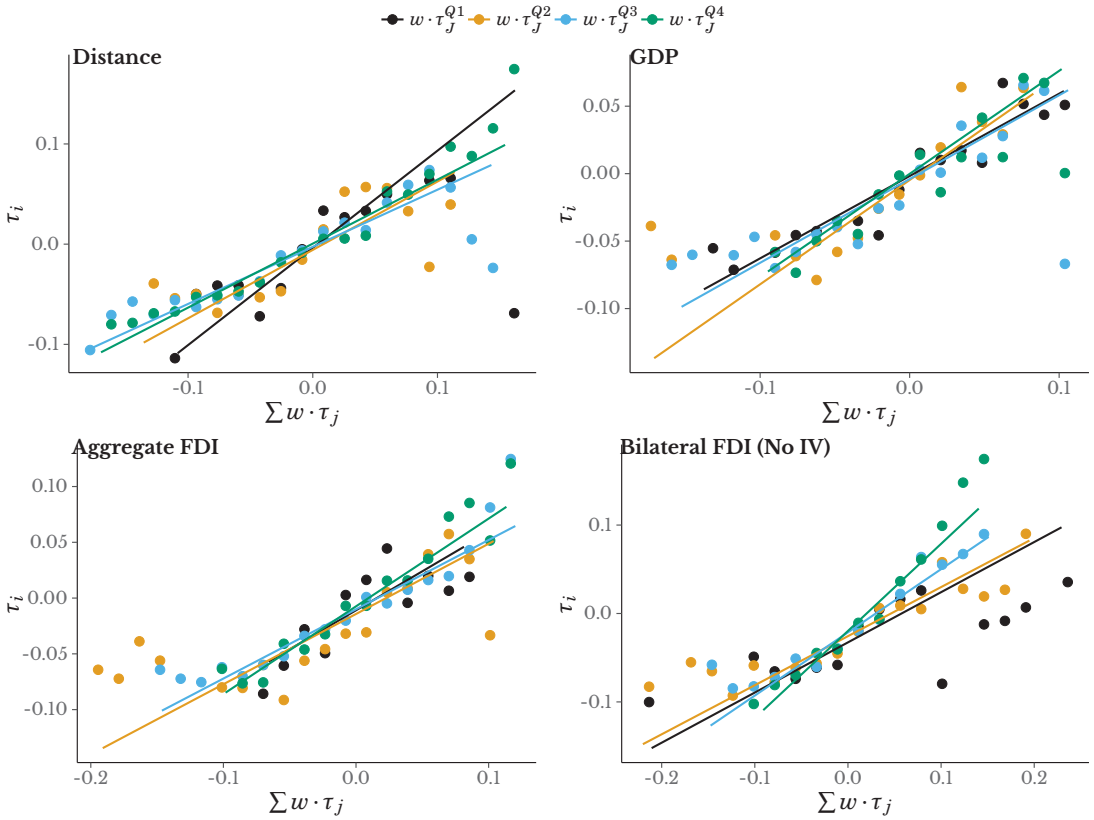
The chart plots the weighted average tax rate against the home tax rate. All data are expressed in deviations from the country-specific mean. Only periods where the tax rate was changed are included. Binned values are the average home tax rate for a range of the weighted average foreign tax rate. Regression lines are a separate bivariate regression for each quartile.

tification. The steepest slope is quartile 4—the nearest neighbours. The flattest slope is quartile 1—farthest neighbours. In fact, all four quartiles show increasing strategic spillovers as nearness increases. Under the theoretically-implied bilateral foreign direct investment weight matrix, we find that countries respond more to tax rate changes in near neighbours than in far neighbours.

Is this identification unique to the bilateral foreign direct investment weights? To consider this question, I conduct the same exercise for the alternative weight matrices. The results are shown in Figure 2.4. Tellingly, we cannot conduct this exercise for the uniform weights used in Devereux et al. (2008) since these weights assume that all countries are equally near/far.

For distance weights, the scatterplot suggests that countries respond most intensely to their farthest neighbours. This displays the potential confusion in using distance alone as a measure of cross-border investment. Competition for multinational firms depends in a complex manner on distance, depending heavily on the type of foreign direct investment being considered—horizontal, vertical, or export-platform. It is difficult to argue that distance is a clear predictor of the size of base spillovers.

Figure 2.4: Binned Scatterplot by Quartile Alternative Weights



The chart plots the weighted average tax rate against the home tax rate. All data are expressed in deviations from the country-specific mean. Only periods where the tax rate was changed are included. Regression lines are a separate bivariate regression for each quartile. Binned values are the average home tax rate for a range of the weighted average foreign tax rate. Each chart represents a different weighting scheme.

For the aggregate weights—GDP and aggregate foreign direct investment—there is no clear identification. The slopes across quartiles are very similar for both weights. GDP weights show an incorrect ordering, but at least identifies that the slope is steeper for the biggest (nearest) neighbours than smallest (farthest) neighbours. The slope for aggregate foreign direct investment weights are almost all equal, but captures the fact that countries respond somewhat more to big (near) neighbours.

I also include the un-instrumented bilateral foreign direct investment weights for comparison. Identification is almost as clear as in the instrumented version: countries respond most intensely to their nearest neighbours, and less intensely to their farthest neighbours. The only difference is in the farthest neighbours—the slope of the reaction functions for quartiles 1 and 2 are almost equal. Countries are shown to respond with the same intensity to their farthest half of neigh-

bours.

This exercise shows that the bilateral foreign direct investment weighting scheme instrumented by the gravity model generates convincing identification. Countries respond more to tax rate changes by their near neighbours than tax rate changes in their far neighbours. The alternative weighting schemes considered do not provide convincing identification.

2.4 Under-Provision of the Public Good

What difference does it make if the strategic spillover between countries on corporate tax rates is 0.69 or 0.23? Considering that the coefficient is reasonably expected to run from 0 to 1, it makes an economically significant difference. Tax competition is predicted to result in the under-provision of public goods, but the magnitude of under-provision depends on how large strategic spillovers are.

Different works have tried to quantify the under-provision of the public good that results from tax competition in different ways. Wildasin (1989) estimates the magnitude of the inefficiency attributable to tax competition. Parry (2003) tries to answer the question of welfare costs of tax competition by parameterising a generalised version of the Wildasin (1989) model, based on assumptions about how governments set optimal tax rates in the absence of tax competition and about how governments respond to fiscal externalities. Benassy-Quere et al. (2007) consider the case where public goods are inputs into the firm's production process and positively impact on marginal productivity. While lower tax rates cause an inflow of capital, it also demands lower public input provision and mitigates the potential for inflow. The intuitive result is that the under- or even over-provision of the public good depends on the relative size of two elasticities: the elasticity of capital with respect to the tax rate, and the elasticity of capital with respect to the public input. They find that capital still flows out even when an increase in the tax rate is combined with an increase in public inputs, meaning that we remain in the under-provision interval of the potential tax competition outcomes. Sørensen (2000, 2001) simulates the effects of tax coordination using a computational general equilibrium approach for the European Union. Men-

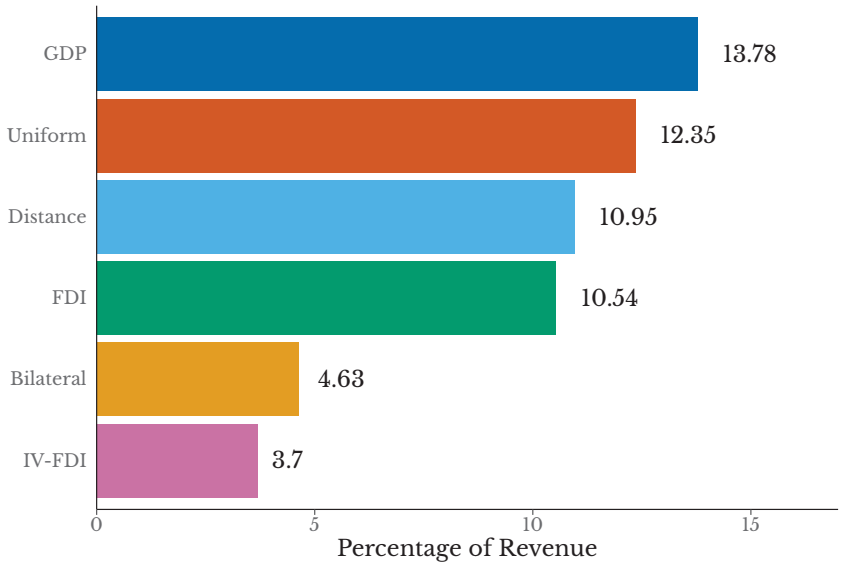
doza and Tesar (2005) suggest that due to the large distortions of the capital tax, competition leading to a race to the bottom actually entails large welfare gains, and therefore the gains from coordination are small. The only real efficiency losses that might arise are those from the misallocation of capital when considering asymmetric countries with different production possibilities.

I use a simple back-of-the-envelope calculation to compare the potential public good under-provision from tax competition implied by various estimates of strategic spillovers. Public good under-provision can be measured as the tax revenue lost as a result of lower equilibrium tax rates due to tax competition. The revenue lost can be measured as the counterfactual tax rate multiplied by the counterfactual tax base minus actual corporate tax revenue. Strategic spillovers can be used to estimate the counterfactual tax rates that would exist if there were no changes in the foreign tax rate. For these simple calculations, I make the assumption that the global tax base is fixed. This is not an entirely realistic assumption since we know that the higher tax rate would induce behavioural responses that would lower the tax base. However, it provides an upper bound on lost tax revenue and allows me to highlight the differences in the levels of under-provision implied by various estimates.

Using data for 2012, I calculate the counterfactual tax rate for each country in the dataset as if there were no tax competition. I set the coefficient on the weighted average foreign tax rate to zero and compare the original fitted values of the model to the counterfactual tax rate with no strategic spillovers. I use the preferred estimate of 0.227 for the bilateral foreign direct investment weights, and the results from the corresponding specifications for the alternative weighting schemes.

I measure the under-provision of the public good in terms of the implied percentage of revenue lost due to tax competition. Figure 2.5 shows the result of this back-of-the-envelope calculation. The estimate of strategic spillovers using GDP weights implies a 13.78 percent reduction in public good provision due to tax competition. Uniform weights imply a 12.35 percent reduction in public good provision. Distance weights imply a 10.95 percent reduction in public good provision. Aggregate foreign direct investment weights imply a 10.54 percent reduction in public good provision. The simple bilateral foreign direct investment

Figure 2.5: Public Good Underprovision Due to Tax Competition



weights imply a much smaller 4.63 percent reduction in public good provision. The preferred instrumented bilateral foreign direct investment weights imply a small 3.7 percent reduction in public good provision.

The difference between the public good under-provision implied by the alternative weight matrices and the bilateral foreign direct investment weight matrices is economically substantial. The strategic spillovers I estimate in this essay suggest that the losses from tax competition are modest compared to the losses implied by previous estimates. The losses implied by previous estimates ranging from 0.6 to 0.7 would be even larger than those presented above. Estimates in the range of 0.6 to 0.7 have been used to inform analyses such as the IMF (2014) spillover analysis. In analysing the spillover effects from the United States corporate tax rate cut from 35 to 21 percent, Beer et al. (2018) suggest that a strategic spillover estimate of 0.6 would triple the estimated loss in tax revenue from base spillovers in neighbouring countries. The results of this essay suggest that tax competition generates far more muted under-provision of the public good than previous estimates suggest. Magnitudes matter, and this exercise highlights the importance of clearly identified estimates of tax competition for informing the policy debate on the race to the bottom.

2.5 Conclusion

Corporate tax competition is expected to lead to an under-provision of the public good. At the Nash equilibrium of the tax competition game, tax rates are below the social optimum. But how far below that social optimum? And how much under-provision of the public good does it imply?

This essay seeks to answer those questions. I estimate the magnitude of strategic spillovers on corporate tax rates between governments. I extend the standard model of tax competition to a three-country model with three multinational firms. This model implies that the size of a government's response to a neighbour's tax cut depends on the size of the base spillover implied by that tax cut. I use the stock of foreign direct investment between two countries to measure that bilateral base spillover. I convert these bilateral foreign direct investment ties into a weight matrix using the approach typically applied to trade-weighted exchange rates. Using this weight matrix derived from the theory of tax competition, I estimate a spatial autoregressive model of tax competition.

The results of this estimation suggest that a 1 percentage point reduction in the weighted average foreign tax rate leads to a 0.23 percentage point tax cut by the home country in response. This estimate of strategic spillovers is substantially smaller than previous estimates using ad hoc weighting schemes. The consensus existing estimate suggests the home country would respond by 0.6 to 0.7 percentage points. I show that these ad hoc weights do not appropriately identify the structure of tax competition. In fact, only the theoretically-implied bilateral foreign direct investment weights manage to satisfy a simple test of identification: that countries should respond more to a tax cut by near neighbours than to a similar tax cut by far neighbours.

I use a back-of-the-envelope calculation to measure the difference in the public good under-provision implied by the various weighting schemes. The ad hoc weights—uniform, GDP, aggregate foreign direct investment, and distance—all suggest public good under-provision between 10 and 14 percent of annual revenue. The bilateral foreign direct investment weights suggest that the level of public good under-provision is approximately 4 percent of revenue. This study finds that strategic spillovers on corporate tax rates between national govern-

ments exist, but the magnitude of these spillovers is a third of the size of existing estimates. The implication is that tax competition appears to result in only modest under-provision of the public good.

2.A Appendix

Table 2.6: Gravity Model for FDI Instruments

$\ln(GDP_i)$	0.751^{***}
	(0.082)
$\ln(GDP_j)$	-0.360^{***}
	(0.089)
Chinn-Ito $Openness_i$	0.345^{***}
	(0.070)
Chinn-Ito $Openness_j$	0.561^{***}
	(0.079)
Urban $Population_i$	0.780
	(0.568)
Urban $Population_j$	-1.205^{*}
	(0.626)
Population $Growth_i$	-0.067^{**}
	(0.027)
Population $Growth_j$	-0.040
	(0.026)
Government $Consumption_i$	-0.761^{*}
	(0.457)
Government $Consumption_j$	-1.507^{***}
	(0.434)
(Imports+Exports)/GDP_i	1.071^{***}
	(0.086)
(Imports+Exports)/GDP_j	1.411^{***}
	(0.097)
Bilateral Investment Treat In Force	0.285^{***}
	(0.076)
Bilateral Investment Treat Signed	-0.175^{**}
	(0.079)
Observations	56,195
R^2	0.935

Notes: Country *i* is the capital-receiving country. Country *j* is the capital-sending country. Model includes country-pair and year fixed effects. Standard errors in parentheses. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

Table 2.7: Estimation of Probability of Changing Tax Rate

$w \cdot \tau_J$	−0.077
	(0.654)
Majority	−0.392**
	(0.186)
Legislative Election	−0.131*
	(0.071)
Executive Election	0.003
	(0.107)
Herfindahl Index Government	−0.546***
	(0.147)
Exec. Left/Right/Centre	−0.037
	(0.036)
Observations	1,772
Log Likelihood	−1,208.134
Akaike Inf. Crit.	2,428.268

Notes: Estimated as probit model. Standard errors in parentheses. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

Table 2.8: Number of Countries in Main Regression by World Bank Income Classification in 1990 (rows) and 2014 (columns)

	Low	Lower Middle	Upper Middle	High	NA	Sum
Low	4	10	1	1	0	16
Lower Middle	1	4	13	3	0	21
Upper Middle	0	0	4	5	0	9
High	0	0	0	18	0	18
NA	0	3	3	6	0	12
Sum	5	17	21	33	0	76

'NA' is where the World Bank did not have an income classification for the country. Rows represent the classification in 1990 and 2014 represents the classification in 2014.

Table 2.9: All Observations as Best Responses for Alternative Weight Matrices

	Uniform	GDP	FDI	Distance
$w \cdot \tau_J$	0.653***	0.623***	0.475***	0.511***
	(0.050)	(0.051)	(0.051)	(0.035)
R^2	0.447	0.434	0.424	0.458
Obs.	1620	1620	1508	1620

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The models estimated in the table are the same specification as that estimated in Model 3 of Table 2.3. Models include all controls without using the Heckman sample selection method. For each model estimated, the specified weight matrix is given by the column name.

Chapter 3

Understanding Corporate Tax Base Spillovers

3.1 Introduction

Tax reforms do not occur in a vacuum. A single country's tax reform can have a large impact on neighbouring countries. Corporate income tax reforms generate international externalities because of the highly mobile nature of multinational firms. International externalities resulting from corporate tax rate reforms are defined as **corporate tax base spillovers**: the effect of a change in one country's tax rate on another country's tax base. In 2011 the International Monetary Fund, the Organisation for Economic Cooperation and Development, the United Nations, and the World Bank presented a joint report to the G-20 Development Working Group that recommended G-20 countries should "undertake 'spill over' analyses of the impact of any significant changes in our own tax systems on those of developing countries" (IMF et al., 2011). Spillover analysis is required because the actions of countries designed to improve the competitiveness of their own tax system have the impact of reducing the ability of its neighbours to raise corporate tax revenue. And corporate tax base spillovers are the fundamental force underlying corporate tax competition.

Intuition tells us that corporate tax base spillovers are substitutionary: a de-

crease in a country's corporate tax rate will steal profits away from its neighbour. This intuition stems mainly from the theory of the horizontal multinational firm and from multinational firms' artificial profit shifting behaviour. And empirical evidence confirms this to be true *on average* across many countries (Heckemeyer and Overesch, 2017; Beer et al., 2018). However, there are other theories that predict various other behavioural responses of the multinational firm. The vertical multinational firm and multinational firms which rely on cheaper internal financing may generate complementary spillovers instead. These are not competing theories. They describe different organisational structures and strategies of the multinational firm. And multinational firms are complex creatures, such that many of these behavioural responses might even happen within the same firm. Corporate tax base spillovers, therefore, may not always be purely substitutionary.

In this essay, I estimate corporate tax base spillovers disaggregated at the country level and the country-pair level. I first estimate the average spillover impact that tax reforms in each of 17 European Union countries had on their European neighbours. I then estimate the corporate tax base spillover from each country i to each other European country j individually. This gives a matrix of 425 country-pair corporate tax base semi-elasticities for the period 2007 to 2016. I find that there is significant heterogeneity in the estimates; spillovers vary in magnitude, direction, and significance. Spillovers appear to fall on a continuum between complementary and substitutionary.

Conceptually, to estimate the spillover from country A's tax rate change to country B's tax base, I use multinational firms with affiliates in both country A and B. I compare the profits of its affiliate in country B to domestic firms in country B and multinational firms which operate in country B but not in country A. This gives two control groups, and results remain robust to excluding domestic firms. I implement this strategy using a generalised difference-in-differences methodology combined with coarsened exact matching on within-industry firm size. Importantly, I use the inverse hyperbolic sine of profits to capture the full response of firms—including both positive profits and negative profits (losses). I use data on firms in 26 European countries from 2007 to 2016 from the Bureau van Dijk's Amadeus database.

I estimate average country-specific spillovers in a number of different forms to attempt to elicit patterns from the data. I estimate tax base spillovers for horizontal multinational firms and for vertical multinational firms. I also control for changes in the tax base. I include measures of real factors of production to see whether artificial profit shifting drives tax base spillovers. The results seem to suggest that horizontal multinationals generate more substitutionary spillovers than vertical multinationals, and that artificial profit shifting might make up a substantial portion of corporate tax base spillovers.

To understand the heterogeneity of spillovers, I take advantage of the substantial variation in estimated country-pair semi-elasticities. I regress the country-pair semi-elasticities on country-pair characteristics. These characteristics are derived from the body of theory on multinational firms and tax competition. Horizontal multinational firms are predicted to arise when trade costs are higher and when countries have more similar endowments. I find that the more similar two countries' purchasing power is, the more likely spillovers are to be substitutionary between them. Vertical multinational firms are predicted to arise when factor endowments are very different. Surprisingly, using labour cost differential as a proxy, I find that the larger the wage differential, the more substitutionary the spillover. I find that country size and public inputs seem to provide a location-specific rent that mitigates the substitutionary spillover effects of a corporate tax rate change. These findings provide a first practical step towards understanding how corporate tax base spillovers work. The importance of this work arises when we need to make policy predictions about the spillover effects of corporate tax rate reforms. This work provides us with the foundational tools to be able to predict spillovers more accurately at a country-by-country level. And we can base these predictions on empirically relevant economic mechanisms.

The recent United States' Tax Cut and Jobs Act has sparked a debate on the spillover effects of their tax reform. Beer et al. (2018) is a key work examining the spillover effects of the United States tax rate cut from three sides: the artificial spillover effects, the real spillover effects, and the policy spillover effects. Drawing on previous average spillover estimates, they define heterogeneity among countries based on the relative importance of the United States market to each country. They use the number of multinational firm links in the Orbis dataset,

and as a robustness check, the bilateral foreign direct investment flows between countries. Beer et al. (2018) predict that the United States' corporate tax rate cut of 14 percentage points (from 35 percent to 21 percent) will likely reduce other countries' tax revenue from multinational firms by 1.6 to 4.5 percent on average.

Boumans et al. (2019) conduct surveys of German firms. Only a few firms in the survey derive at least 5 percent of their revenue from the United States (approximately 13). Of firms deriving more than 5 percent of their revenue in the United Stats, only 18 percent expect a change in the tax burden in the short run, and that rises to only 25 percent in the long run. Only 14 percent of them intend to increase investment in the United States, while 6 percent intend to reduce investment in the United States. And 26 percent of those firms who plan to increase investment in the United States will counterbalance that with a reduction in investment in Germany. Two things from their research are striking, and provide motivation for this research. First, only a small portion of German firms surveyed intend to change their investment activity. Three percent of all firms intend to change investment activity in the United States and only 1.8 percent intend to change investment activity in Germany. Second, there exists quite a bit of heterogeneity in responses to the tax reform.

This essay is related to a wide range of papers that measure various forms of spillover effects. A large number of papers measure the impact of a home country tax change on the inflow of capital (Feld and Heckemeyer, 2011). Becker et al. (2012) find that an increase in the tax rate not only reduces the level of foreign investment, but also the reported profitability of firms locating there. Without further assumptions, these estimates do not tell us exactly how other countries' corporate tax base (profits) are impacted. In general, there are two types of tax base spillover effects that the literature has focused on: location of real investment, and artificial profit shifting (Beer et al., 2018). Using firm-level data, Becker and Riedel (2012) and Davies et al. (2016) examine the effect of tax changes on firm cross-border investment. Becker and Riedel (2012) find complementarity in cross-border investment at the firm level, but substitutionary effects when considering artificial profit shifting. Following the conceptual frameworks of Hines Jr and Rice (1994) and Huizinga and Laeven (2008), a number of works measure artificial profit spillovers as a function of tax differentials between affiliates. This work is reviewed by Heckemeyer and Overesch (2017) and Beer et al. (2018).

Methodologically, this essay is similar to Griffith et al. (2014), who also estimate cross tax elasticities in Europe. Their cross tax elasticities are for location of ownership of intellectual property rather than for profits. This paper is also linked to the broader theme of base spillovers conducted at the aggregate level. Works such as Crivelli et al. (2016) and IMF (2014) estimate the size of average aggregate revenue spillovers.

I make two key contributions to the literature. First, I present the first evidence on disaggregated corporate tax spillovers by estimating cross-tax or spillover semi-elasticities of profit for European countries. This evidence suggests that average spillover effects mask substantial heterogeneity in country-pair spillovers. Second, I provide the first meaningful understanding of how these spillover semi-elasticities are determined. This is a step towards a structural understanding of the heterogeneity of corporate tax base spillovers. These are significant contributions that can help us to make better policy predictions in the future.

In the following section I outline a number of theories that detail the potential responses a multinational firm might have to a corporate tax rate change. I describe the data used in Section 3.3. In Section 3.4 I estimate the average spillover for each country's tax rate reforms, and extend this to disaggregated country-pair spillovers in Section 3.5. Using the country-pair semi-elasticities in a meta-analytical style, I provide new evidence for why corporate tax base spillovers may be heterogeneous across countries in Section 3.6.

3.2 Potential Spillovers

A multinational firm is a business that conducts productive economic activity in more than one country. The multinational firm is the 'organizational form that defines foreign direct investment' (Kogut, 2001). Multinational firms tend to be complex creatures. As a result, a multinational firm might have a range of optimal responses to a tax change. These responses might result in competing effects that may lead to an ambiguous overall response. Therefore, for any single multinational firm the spillover response may be either substitutionary or complementary. A substitutionary response says that an increase in the tax rate in one

country leads the multinational firm to generate more profits in another country. A complementary response suggests that a tax increase in any country would lead it to reduce profits in other countries. The result is that it may be useful to think of spillover responses as operating on a continuum from purely substitutionary to purely complementary, depending on which effect dominates. Desai et al. (2005) notes that substitutionary behaviour and complementary behaviour are likely to be operational for different firms at different times.

In the following section, I examine various theories that make predictions about the spillover responses of multinational firms to corporate tax rate changes. Note that each model depends on a somewhat different organisational form for the multinational firm. The organisation of the multinational firm heavily influences how it responds to corporate tax rate changes. This, by no means, serves as an exhaustive list of the potential responses of multinational firms to corporate tax rate changes.

3.2.1 The Horizontal Multinational

The first formal model of the horizontal multinational firm is found in Markusen (1984). Horizontal multinational firms replicate productive activity across countries to avoid trade barriers or transport costs from servicing a foreign market (Brainard, 1993). The firm either produces everything in the home country to satisfy demand in both the home and foreign country, or it sets up production in both countries. Setting up production in a foreign country carries an additional fixed cost. Horizontal multinational firms are therefore market-oriented—they are concerned with serving the foreign market profitably.

Consider a firm with productive capacity in two countries $f(k_1)$ and $f(k_2)$, where k is capital and countries are indexed by 1 and 2. The firm's production functions carry the standard assumption that $f'(k) > 0$ and $f''(k) < 0$. The firm has limited capital available K, which it allocates between k_1 and k_2. The firm seeks to maximise its global profits by solving the problem:

$$\max_{k_1,k_2} \quad \Pi = (1-\tau_1)(f(k_1)-rk_1)+(1-\tau_2)(f(k_2)-rk_2)$$

$$\text{s.t.} \quad k_1 + k_2 = K. \tag{3.1}$$

This gives the optimality condition:

$$(1-\tau_1)(f'(k_1)-r) = (1-\tau_2)(f'(k_2)-r). \tag{3.2}$$

Using the implicit function theorem, we can examine the effect of a change in the tax rate in country 2 on the equilibrium allocation of profits in country 1. This gives:

$$\frac{\partial k_1}{\partial \tau_2} = \frac{-(f'(k_2)-r)}{(1-\tau_1)f''(k_1)+(1-\tau_2)f''(k_2)} > 0. \tag{3.3}$$

The term $\partial k_1/\partial \tau_2$ is positive. An increase in the corporate tax rate in one country will lead horizontal multinational firms to increase profits in affiliate countries. That is, for horizontal multinationals, their response to tax reform is substitutionary. An increase in country 2's tax rate leads the multinational firm to substitute activity away from country 2 and into country 1. This is the standard type of result that underpins the theory of tax competition (Keen and Konrad, 2014). It is this type of firm behaviour that is expected to lead to a race to the bottom in corporate tax rates as governments compete for multinational firm activity.

Notice, however, that if a firm's capital stock K is large, it can bid the marginal product all the way down to $f'(k) = r$ in both countries, so that $\lambda = 0$. That is, the marginal increase in global profit resulting from an extra unit of capital stock is zero. This has a severe impact on the expected substitutionary spillover: the effect $\partial k_1/\partial \tau_2$ would go to zero. This means that the more cash-rich firms are, the less likely their capital responses are to be substitutionary in this traditional manner. This discussion resembles the new view versus old view discussion of the neoclassical theory of the firm (Chetty and Saez, 2010; Becker and Fuest, 2011).

Becker and Riedel (2012) find substantial evidence that multinational firms' real spillover responses are complementary. Their theoretical model alters the standard horizontal multinational model in a manner that generates complementarity. Specifically, they include a common input across both affiliates that increases the productivity of capital. This good is 'common' in the sense that it is non-rival so that its use in country 1 does not prohibit its use in country 2. This can be thought of as the firm-specific advantage of Dunning (1988).

3.2.2 The Vertical Multinational

Vertical multinational firms take advantage of a country's comparative advantage. Vertical multinational firms split their supply chain across countries to take advantage of differences in factor prices, factor endowments, and technology across countries (Helpman, 1984). Most multinational firms carry some vertical element. For example, horizontal multinationals do not duplicate all activities, but frequently rely on the home affiliate for headquarter services. This makes the theory of the vertical multinational at least partly relevant for almost all multinational firms.

Note that many perceive vertical multinationals as substitutionary because they tend to outsource production from one country to another. However, in this essay I am concerned with the intensive margin—once multinational plants have already been set up. Once vertical plants have been set up, economic output in one country is used as an input to production in another country. This means that profits generated in these two countries should be mutually interdependent.

Consider a multinational firm that produces an intermediate good x_2 in country 2. This intermediate good is needed for production of final output in country 1. Due to the existence of some fixed factor of production in both countries, the firm generates positive profits in both countries. The final output production function in country 1 is $f(x_2)$, with $f'(x_2) > 0$ and $f''(x_2) < 0$. The intermediate input in country 2 is most efficiently produced at cost $c(x_2)$ with $c'(x_2) > 0$ and $c''(x_2) > 0$. The intermediate input is sold at an arm's length price w from the multinational affiliate in country 2 to the affiliate in country 1. The multinational firm takes this price as fixed. I make this assumption so as to exclude transfer pricing concerns from the analysis. I focus on tax base spillovers generated by movement of real factors in this simple model. The price of the final output is normalised to 1.

The firm is taxed on profits it generates in both countries. In country 1 it is taxed at the rate τ_1, and in country 2 it is taxed at the rate τ_2. The firm's global profit function therefore takes the form:

$$\Pi = (1-\tau_1)(f(x_2) - wx_2) + (1-\tau_2)(wx_2 - c(x_2)). \tag{3.4}$$

The multinational firm's aim is to maximise global profits, choosing the amount of x_2 it wishes to produce and use. The firm's first-order condition for maximising global profit is:

$$\frac{\partial \Pi}{\partial x_2}: \quad (1-\tau_1)(f'(x_2)-w)+(1-\tau_2)(w-c'(x_2))=0. \tag{3.5}$$

We are interested in how a change in the corporate tax rate in country 2 affects profits generated in country 1. Before-tax profits in country 1 are defined as:

$$\pi_1(x_2)=(f(x_2(\tau_1))-wx_2(\tau_1)). \tag{3.6}$$

Taking the derivative of this equation with respect to τ_2, I get:

$$\frac{\partial \pi_1(x_2)}{\partial \tau_2}=\frac{\partial x_2}{\partial \tau_2}\left(\frac{\partial f(x_2)}{\partial x_2}-w\right). \tag{3.7}$$

If marginal before-tax profits in country 1 are positive, then the sign of $\partial\pi_1(x_2)/\partial\tau_2$ depends on the sign of $\partial x_2/\partial t_2$. This can be signed using the implicit function theorem for the first-order condition of the firm:

$$\frac{\partial x_2}{\partial \tau_2}=\frac{w-c'(x)}{(1-\tau_1)f''(x_2)-(1-\tau_2)c''(x_2)}. \tag{3.8}$$

By the assumptions that $f''(x_2)<0$ and $c''(x_2)>0$, if marginal profit in country 2 is positive, then $\partial x_2/\partial\tau_2$ is negative. This says that an increase in the tax rate in country 2 reduces the production of the intermediate good x_2. This implies that the firm reduces profit in country 1 in response to a tax increase in country 2 if the firm is vertically fragmented such that x_2 is needed for production in country 1 to take place.

This represents an extreme version of the idea that imported inputs are needed for multinational production. This is the most intuitive way to think of vertically integrated or 'fragmented' multinationals. Boehm et al. (2019) find strong evidence that the relationship between imported and domestic inputs is close to the Leontief technology. More specifically, they find that the short-run elasticity of substitution between domestic and imported inputs is close to zero. I capture this simply by assuming that the intermediate input produced in country 2, x_2, is the single input the firm chooses in country 1.

Becker and Riedel (2012) empirically identify complementarity, finding that a 10 percent increase in the corporate tax rate in one country leads European multinational firms to reduce the capital stock by 5.6 percent in affiliate countries. Desai et al. (2005, 2009) find that outward foreign direct investment complements domestic American economic activity rather than substituting for American economic activity. Complementarity coincides with the likelihood that the multinational firm's level of global production is not fixed, but rather responds to profit opportunities. Substitution would hold when a multinational's global production level is fixed due to resource limits, capacity constraints, or market competition. It is intuitive to think that if investment flows into a country after a tax cut, then it is necessarily substituting away from investment somewhere else. But this does necessarily not hold for a vertical multinational firm.

3.2.3 Profit Shifting

Artificial profit shifting is one of the more popular explanations for corporate tax base spillovers that affect both horizontal and vertical multinational firms. Artificial profit shifting represents a key reason why we intuitively tend to think of corporate tax base spillovers as being substitutionary. Artificial profit shifting is the use of some tax devices to move the location of profits from a high tax jurisdiction to a low tax jurisdiction on paper, without moving the actual location of economic activity. The aim is to minimise tax liability without disrupting the real allocation of production. As Becker and Riedel (2012) discover, even if the real investment behaviour of firms is complementary, profits may still respond in a substitutionary manner due to the strong effects of profit shifting.

Empirical evidence is mounting that profit shifting is quite large. For example, Tørsløv et al. (2018) estimate that 40 percent of multinational firm profits are shifted to tax havens each year. Similarly, Janský and Palanský (2019) estimate that around 1 percent of the gross domestic product of the 79 countries in their sample is shifted to tax havens each year. This adds up to around 37 percent of multinational firm profits, similar to Tørsløv et al. (2018). Crivelli et al. (2016) highlight that this loss is particularly high for developing countries, who are estimated to lose around 1.7 percent of gross domestic product to profit shifting.

Consider a multinational firm who generates profits in country 1. The firm's actual profits are fixed but it can shift profits across borders. Actual profits generated in country 1 are denoted π_1, while profits artificially shifted from country 1 to country 2 are denoted q_2. There is a cost attached to shifting profits from country 1 to country 2, denoted $c(q_2)$. Assume a cost of profit shifting function that is positive and increasing at an increasing rate in the level of profits shifted so that $c(q_2) > 0$, $c'(q_2) > 0$ and $c''(q_2) > 0$. This is standard in the literature on the notion that the more profits shifted, the more likely a firm is to be caught and fined (Devereux et al., 2008). The firm's profit function is:

$$\Pi = (1 - \tau_1)(\pi_1 - q_2) - c(q_2) + (1 - \tau_2)(q_2) \tag{3.9}$$

The firm's optimal choice of q_2 is determined by the condition:

$$\tau_1 - \tau_2 = c'(q_2). \tag{3.10}$$

I am interested in the effect that an increase in country 1's tax rate would have on the amount of profits shifted. This is given by the implicit partial derivative

$$\frac{\partial q_2}{\partial \tau_1} = \frac{1}{c''(q_2)} > 0. \tag{3.11}$$

An increase in the tax rate in country 1 will increase artificial multinational profits booked in lower-tax countries. This reflects a pure substitutionary effect as a firm seeks to minimise its tax liability. An increase in the tax in country 1 increases the profits shifted to country 2. Conversely, an increase in country 2's tax rate should lead to less profits being shifted into country 2. Much of the literature on corporate tax spillovers has focused on artificial spillovers. Since Huizinga and Laeven (2008) various works have measured the impact of tax rate differentials on artificial spillovers across countries.

3.2.4 Internal Capital

Hubbard (1998) proposes a very simple idea. When taxes are lowered, firms have more after-tax profits. These after-tax profits can then be reinvested into the firm. Extending this idea to a multinational firm, this means these profits can

be reinvested in any country the multinational operates in. That is, lower taxes in one country can increase the multinational affiliate's retained earnings, and therefore increase the internal capital of the entire multinational firm group. Where the multinational chooses to invest then depends on which affiliate has the highest marginal return on capital.

But why would a multinational firm prefer to use internal capital when it can borrow on the external capital market? Hubbard (1998) suggests that this happens because external capital is more costly. External investors do not have perfect information about the multinational firm's behaviour or prospects, and choose to add an additional monitoring cost to the cost of external borrowing. This additional cost makes external financing more expensive relative to the internal opportunity cost of capital. Increasing the cost of capital would lead the multinational firm to optimally choose to underinvest. This means that some output is left on the table. When the firm's tax bill is reduced, the firm receives greater after-tax profits, all else being equal. If it has investable projects available, then the firm now has greater retained earnings which it can invest at a lower cost—the opportunity cost of capital. Internal funds mitigate the distortion induced by the additional monitoring cost that comes with external capital.

Consider a firm with two sources of capital: internal capital E and external capital D. It can either invest internal capital at the world safe interest rate r_E or invest in the firm. To borrow on the external market, it has to pay a premium above the safe interest rate $r_D = r_E + \delta$. The firm's weighted average cost of capital is $r_E[E/(E+D)] + r_D[D/(E+D)]$. Assume the firm has some fixed amount of internal capital available to it $\overline{E}$, accumulated as retained profits. As before the firm's production function is simply $f(k)$ where k is the sum of internal and external capital: $k = E + D$. The firm chooses capital $k = D + E$ to maximise profits:

$$\begin{aligned} \max_{D,E} \quad & \pi = f(k) - \left(r_E \frac{E}{E+D} + r_D \frac{D}{E+D} \right)(E+D) \\ \text{s.t.} \quad & E \leq \overline{E}. \end{aligned} \tag{3.12}$$

The firm's first-order conditions are:

$$f'(k) - r_D = 0; \tag{3.13}$$

$$f'(k) - r_E = \lambda. \tag{3.14}$$

An increase in one country's tax rate will reduce profits in affiliate countries if multinational firms rely on internal capital. The firm chooses external capital up to the point where the marginal product of capital is equal to the rate of return on capital. Notice that we can rewrite $r_D = r_E + \delta$, such that the first-order condition becomes $f'(k) - r_E = \delta$. This gives us $\lambda = \delta$, where λ is the value of relaxing the constraint: $\partial\pi/\partial\overline{E}$. Since a reduction in the tax rate in any country where the multinational firm has an affiliate will increase its retained earnings (internal capital $\overline{E}$), then this is the relevant derivative. This implies that the effect of an increase in internal capital is to increase profits by δ. The implication of this simple model of internal capital is that a reduction in tax rates in any country can lead the multinational firm to potentially increase profits in affiliate countries. Egger et al. (2014) provide a full theoretical and empirical discussion of the influence of corporate taxes on the multinational firm's internal capital market.

3.3 Data

I use data from Bureau van Dijk's Amadeus database on companies operating in 26 European countries from 2007 to 2016. Amadeus provides administrative financial accounts from business registers collected by local Chambers of Commerce across Europe. For most European countries, it is a requirement for firms of all sizes to file balance sheet information. However, the data does not provide complete coverage. The Amadeus database also contains firm ownership information.

The properties of this data are well-known and Kalemli-Ozcan et al. (2015) discuss how to produce a representative sample. I clean the data as suggested by Kalemli-Ozcan et al. (2015). I keep only data which reflects accounts over a 12-month period. If the financial account closes on or before June 1, it is counted as the previous financial year. Otherwise it is counted as the current financial year. This is not a major problem as most financial accounts close at the end of the year. All companies with Bureau van Dijk identification numbers that do not accurately reflect the country that the data says they are from are dropped. All values are expressed in euros converting using Eurostat's average annual ex-

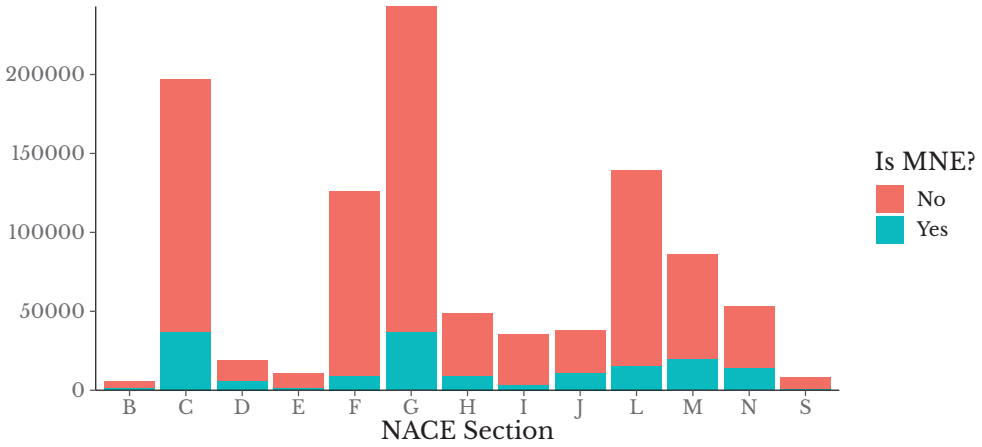
change rate data. Where any negative value is observed for total assets, the entire company is dropped. Where there are year-firm duplicates, I keep only the most recent observation since this is likely due to a change in the accounting period. I do not use data from Malta and Cyprus since there are not enough observations. Note that there is no data for Denmark prior to 2012, but I keep Denmark in the study.

Multinational affiliates are identified as corporations with an ultimate owner who is also the ultimate owner of affiliates located in other countries. In this essay I define ownership as a shareholder owning 51 percent or more of the firm's equity. This is the clearest case where we can identify the International Financial Reporting Standards' definition of control needed for consolidation of financial statements: that the shareholder has the power to direct the firm's activities affecting its return, that the shareholder is exposed to variable returns from the firm, and that the shareholder has the ability to use that power to affect the firm's returns. While this may occur with minority shareholders, I have chosen the conservative definition of ownership, since this is the only case I can be sure that control exists. Data from Bureau van Dijk has the substantial benefit of capturing cross-border ownership structures, which is the main reason for using it in this study. In the raw data there are 924,168 multinational affiliates owned by European parents and 823,818 affiliates owned by non-European parents.

Using the Nomenclature des Activités Économiques dans la Communauté Européenne (NACE) Revision 2 Section classification, I keep only firms operating in the non-financial business economy. This includes sectors of industry, construction and distributive trades and services. More specifically, Eurostat considers the non-financial business economy to be captured by NACE Revision 2 Sections B to J and L to N, and also including Group S95. Within each industry within each country, I split the firm into quartiles based on their average total real assets over the period. Each firm then has a specific country-industry-size group to which it belongs. Figure 3.1 plots the distribution of multinational firms and domestic firms across the various industries. Industry here is defined by the firm's NACE Section classification.

I use data on tax rates drawn from a variety of sources. This includes the Oxford University Centre for Business Taxation's database, the International Mon-

Figure 3.1: Distribution of Industry for Domestic and Multinational Firms

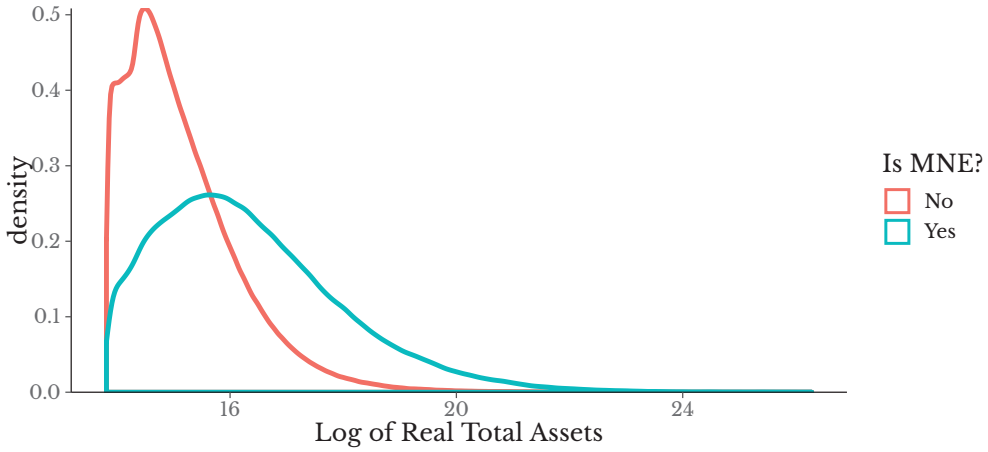


etary Fund's database[1], Ernst and Young's Worldwide Corporate Tax Guides, KPMG's Corporate Tax Rate Survey, the European Commission's Taxes in Europe Database, and the University of Michigan's World Tax Database. There are 17 European countries which conducted corporate tax rate reforms from 2007 to 2016. This gives me 41 tax reforms, the full list of which is detailed in Table 3.A.

The mean return on assets for multinational firms is 5.26 percent, while the mean return on assets for domestic firms is slightly lower at 4.51 percent. This conforms to the traditional expectation that multinational firms are more profitable. The distribution of returns on assets are very similar across the two groups. From the perspective of size, however, the distributions of real assets are somewhat different. Multinational firms tend to be larger than domestic firms. The average of real assets held by a multinational affiliate is €114 million while the average for domestic firms is €10 million. The medians are also quite different. The median for multinational firms is €9.8 million while the median for domestic firms is €3 million. Figure 3.2 plots the difference in the distribution of the log of real total assets for multinational versus domestic firms.

[1]So kindly provided by Ruud de Mooij from their paper "Base Erosion, Profit Shifting and Developing Countries" (Crivelli et al., 2016).

Figure 3.2: Distribution of Firm Size for Domestic and Multinational Firms



3.4 Estimating Country-Specific Tax Base Spillovers

This section presents the main results of this chapter. I examine the heterogeneity of corporate tax base spillovers using a generalised difference-in-differences strategy. I extend the analysis to horizontal spillovers and artificial spillovers. In all the following analysis, the variable of interest is profit or loss before taxes. Profit before tax most closely approximates the taxable income of the firm and is the base that matters to governments.

The parameter of interest is the semi-elasticity of profits in country j with respect to the tax rate in country i. To transform the data in a manner that allows us to estimate the semi-elasticity while still keeping zero-valued and negative-valued observations, I use the inverse hyperbolic sine of profits. The inverse hyperbolic sine transformation, defined by the arcsinh notation, is given by the formula:

$$\text{arcsinh}(\pi_j) = \ln\left(\pi_j + \sqrt{\pi_j^2 + 1}\right). \tag{3.15}$$

It is used in practice by Bahar and Rapoport (2018) for migration, trade, and foreign direct investment data, Clemens and Tiongson (2017) for income data, and by McKenzie (2017) for firm profits. Bellemare and Wichman (2019) show that we can convert the inverse hyperbolic sine to traditional semi-elasticities

using the formula:

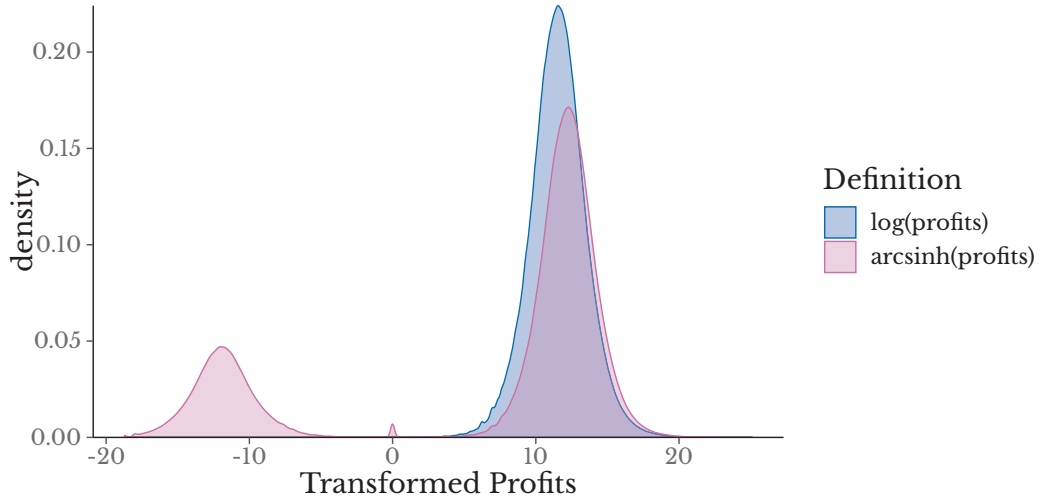
$$\frac{\partial \pi_j}{\partial \tau_i}\frac{1}{\pi_j} = \hat{e}_{ij} \cdot \cosh(\text{arcsinh}(\pi_j)) \cdot \frac{1}{\pi_j} = \hat{e}_{ij} \cdot \frac{\sqrt{\pi_j^2 + 1}}{\pi_j}, \tag{3.16}$$

where $\hat{e}_{ij}$ is the coefficient from a regression of $\text{arcsinh}(\pi_j)$ on τ_i. For large enough values of π_j, the estimated coefficient $\hat{e}_{ij}$ will be almost equivalent to the semi-elasticity. For example, if $\pi_j = 100$, then the second term in the final expression $\sqrt{(\pi_j^2 + 1)}/\pi_j = 1.00005$. Even at this low value of profits, the adjustment is marginal and becomes insignificant for the averages of π_j I use to recover the semi-elasticity.

Economists frequently estimate semi-elasticities by transforming profits using the natural logarithm. But the natural log of negative numbers is undefined, meaning that this strategy only keeps observations where firms are profitable. Using natural logs limits the relevance of the estimated semi-elasticity since firms frequently make losses. Losses can even be part of the firm's optimal response to corporate tax changes (Johannesen et al., 2016; Koethenbuerger et al., 2019). Using the inverse hyperbolic sine increases the number of observations available by 30 percent. It eliminates selection bias that would be induced by focusing only on the responses of profitable firms. Importantly, the inverse hyperbolic sine captures part of the firm's spillover response that is typically ignored in these studies—firm losses.

Figure 3.3 plots the density distribution of log profits and of arcsinh profits. For positive values the distributions are very similar in shape. The arcsinh transformed positive distribution is just shifted slightly to the right compared to the log distribution. Figure 3.3 shows that firms make losses for a substantial proportion of observations. The distribution of losses is similar to the distribution of profits. These losses are included in the arcsinh transformation but ignored by the natural logarithmic transformation.

Figure 3.3: Comparing the Distributions of Profits Under log and arcsinh Transformations



The distribution of log transformed profits are shown in blue, while the distribution of inverse hyperbolic sine transformed profits are shown in pink. Note that the log distribution does not include values below zero.

3.4.1 Empirical Strategy

A multinational firm's profits in country j are a function of the tax rates in all countries in which it operates. For each firm operating in country j, a dummy D_i captures whether it has an affiliate operating in country i. For domestic firms, this dummy is equal to zero for all $i \in N$. Only firms with an affiliate in country i are affected by country i's tax rate change.

To identify the effect of a tax change in country i on profits in country j, we compare the country j profits of firms with an affiliate in country i against firms without an affiliate in country i. Two types of firm act as controls: country j domestic firms and multinational firms with an affiliate in country j but not in country i. Using these control units, we can form a counterfactual: what would the multinational affiliate's profits be in country j if the tax rate in country i did not change.

Implementing this strategy means expressing each firm's profits in country j as a function of all countries' tax rates. Each tax rate is interacted with a dummy D_i that captures whether the firm has an affiliate in country. I estimate a gener-

alised difference-in-differences model using the two-way fixed effects strategy:

$$\text{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{kt} + \sum_{i=1}^{N} e_i \cdot D_{mit} \cdot \tau_{it} + \sum_{i=1}^{N} \theta_{ij} \cdot \Delta D_{mit} + \varepsilon_{mt}, \tag{3.17}$$

where m indexes the firm, j is the country being affected by the spillover, i is the country whose tax rate reform we are investigating, and k is a grouping variable. Firm fixed effects are included as α_m and group-specific time effects are included as γ_{kt}. The first summation captures the interaction of the dummies and tax rates for all other countries. The coefficients e_i are the semi-elasticities we are interested in estimating. Note that $D_{mjt} = 0$, meaning we do not estimate own-country tax effects. The second summation captures the change in D_i so as to eliminate variation in the previous summation that arises from the change in affiliate location. This means we focus only on variation that comes from changes in the tax rate τ_i.

I consider different grouping levels to include as disaggregated time fixed effects. Goodman-Bacon (2018) shows that with disaggregated time fixed effects the estimated semi-elasticity will be a weighted average of the two-way fixed effects estimates for each grouping. Naturally, the weight each group receives in calculating the average depends on the number of firms in each group and the within-group variance. The baseline grouping is at the country j level. This grouping means that we estimate the spillover effect on country j by comparing all firms operating in country j but not in country i to all firms operating in country j and i. I consider more narrow comparisons: within industry defined by the NACE Section classification; within industry defined by the NACE Section 4-Digit; and within size deciles within industry, where size is defined by the average of real total assets.

Firms are assigned asset size deciles within their NACE Section within each country. The cut-off for each decile is created using the distribution of multinational firm assets within that NACE Section and country. Both multinational and domestic firms are assigned a size decile based on these cut-off points. This means that domestic firms whose assets fall outside the range of multinational assets within their country-industry grouping are dropped. These do not serve as appropriate controls.

The aim is to create balance on covariates across multinational and domestic firms so that the empirical distribution of covariates is similar across these two groups. Examining the distributions of industry and size, we observe some difference between the two groups. In particular, multinational firms tend to be larger than domestic firms. I use a simple covariate balancing method based on the already-defined country-industry-size bins. I apply exact matching to these bins to produce weights that reflect the coarsened exact matching weights proposed by Iacus et al. (2011). All multinational firms receive a weight $w_{mt} = 1$, while a domestic firm in grouping k receives a weight:

$$w_{mkt} = \frac{W_{kt}(0)}{W_{kt}(1)} \times \frac{W(1)}{W(0)} \tag{3.18}$$

where $W_{kt}(0)$ is the number of domestic firms in the grouping at time t, and $W_{kt}(1)$ is the number of multinational firms in the grouping at time t. The term $W(0)$ is the sum of all domestic firm observations in the data, while $W(1)$ is the sum of all multinational firm observations. All unmatched firms receive a weight of zero. Matching provides a non-parametric way of controlling for any confounding influence of covariates. Coarsened exact matching is an intuitive method that gives full control over the level of remaining covariate imbalance. These weights are applied to the observations in the following regressions.

3.4.2 Main Results

Estimating Equation 3.17 gives us an average corporate tax base spillover for each individual country that reformed their tax rate during the period 2007 to 2016. The results of this estimation are presented in Table 3.1. Each regression in this table uses a different level of disaggregated time effects: country, country-industry (NACE Section or NACE 4-Digit Class), or country-industry-size (using NACE Sections).

Since these are semi-elasticities, they are interpreted as 'a one percentage point decrease in France's tax rate reduces the profit of multinational firms in other European countries by 1.7 percent on average'. I also remind the reader that the country listed is the country changing its tax rate, so that the coefficient measures the effect on *all other European countries*.

Table 3.1: Estimates of Average Corporate Tax Spillovers by Tax Reforming Country

	Country	NACE Section	NACE 4-Digit	Size
	(1)	(2)	(3)	(4)
Denmark	1.419***	1.518***	1.652***	1.566***
	(0.284)	(0.284)	(0.284)	(0.295)
Estonia	0.111	0.535	0.690	1.111
	(0.900)	(0.904)	(0.916)	(0.943)
Finland	−0.002	0.344	0.092	0.325
	(0.478)	(0.487)	(0.477)	(0.499)
France	1.664***	1.684***	1.692***	1.715***
	(0.280)	(0.280)	(0.282)	(0.283)
Germany	−0.608	−0.696*	−0.604	−0.754*
	(0.395)	(0.397)	(0.398)	(0.409)
Greece	−0.136	−0.454	−0.327	−0.591
	(0.502)	(0.503)	(0.508)	(0.519)
Hungary	3.262***	3.445***	3.014***	3.637***
	(0.676)	(0.677)	(0.681)	(0.694)
Italy	1.861***	1.616***	1.544***	1.503***
	(0.422)	(0.422)	(0.425)	(0.428)
Lithuania	−0.575	−0.134	−0.044	−0.061
	(0.826)	(0.828)	(0.849)	(0.880)
Luxembourg	−1.063***	−1.184***	−1.235***	−1.186***
	(0.257)	(0.258)	(0.261)	(0.259)
Netherlands	0.958***	0.795***	0.735**	0.763***
	(0.304)	(0.299)	(0.292)	(0.290)
Portugal	2.200***	2.122***	2.123***	2.210***
	(0.456)	(0.457)	(0.460)	(0.466)
Slovakia	1.460***	1.519***	1.592***	1.539***
	(0.446)	(0.446)	(0.448)	(0.452)
Slovenia	2.747***	1.780***	1.503**	1.832***
	(0.685)	(0.689)	(0.694)	(0.698)
Spain	0.864***	0.732**	0.708**	0.714**
	(0.334)	(0.333)	(0.335)	(0.338)
Sweden	1.563***	1.172**	1.139**	1.145**
	(0.511)	(0.511)	(0.511)	(0.516)
United Kingdom	−0.974**	−1.289***	−1.108***	−1.439***
	(0.388)	(0.388)	(0.389)	(0.396)
Observations	9,503,645	9,503,645	9,503,645	9,503,645
R^2	0.508	0.512	0.520	0.521

Notes: All models include firm fixed effects. Model (1) includes country-year fixed effects. Model (2) includes country-NACE Section-year fixed effects. Model (3) includes country-NACE 4 Digit-year fixed effects, and Model (4) includes country-NACE Section-size-year fixed effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Notice that these estimated semi-elasticities are quite consistent across model specifications, and do not change signs. Table 3.1 shows that a corporate tax rate cut in most European nations reduces profits in neighbouring European countries. That is, on average, most corporate tax base spillovers are substitutionary. Substitutionary effects are statistically significant for Denmark, France, Hungary, Italy, the Netherlands, Portugal, Slovakia, Slovenia, Spain, and Sweden. These semi-elasticities range in magnitude from 0.7 for Spain to 3.6 for Hungary.

Not all semi-elasticities are positive and significant, however. I am unable to precisely estimate a significant spillover elasticity for Estonia, Finland, or Lithuania. I estimate three negative elasticities: for Germany, Luxembourg and the United Kingdom. For Germany, the effect is weakly statistically significant. For Luxembourg and the United Kingdom there is a much clearer suggestion that these semi-elasticities are negative. On the face of it, these estimates imply that these two countries have generated *complementary* corporate tax base spillover effects over the past decade.

With respect to magnitude, these estimates fall in the region of what might be expected based on preceding literature. Becker and Riedel (2012) report an investment spillover semi-elasticity of -0.6, suggesting that an increase in the multinational parent country's tax rate would reduce real investment in the spillover country. In the profit shifting literature, the meta-analysis of Beer et al. (2018) suggests that a tax rate that is one percentage point lower than other countries will increase artificially shifted profits by 1.5 percent. Heckemeyer and Overesch (2017) find a smaller consensus estimate of 0.8. Further de Mooij and Ederveen (2008) report an average responsiveness of inward foreign direct investment to a change in the *home* tax rate of 2.4 percent. Their estimate is not necessarily a spillover effect, but gives us an idea of whether the magnitudes of spillover effects estimated here make sense. The spillovers I estimate here are total profit spillovers that include both real and artificial profits. Note that I do not capture the extensive margin response.

3.4.3 Controlling for Tax Base Changes

Slemrod and Kopczuk (2002) point out that the definition of the tax base af-

fects the elasticity of personal taxable income. The tax elasticity can therefore be thought of as a policy choice based on the definition of the tax base. This point is even more poignant in the case of the corporate income tax, where the effective marginal tax rate, based on a combination of tax rate and tax base rules, is perceived as being important for some marginal investment decisions (Devereux and Griffith, 2003). For us, this might confound the analysis since Kawano and Slemrod (2016) highlights that the definition of the tax base changes frequently in the corporate income tax context. There are three main types of tax base changes that we might consider to be very important to the estimation of elasticities.

The first type of tax base change is the shift from worldwide to territorial tax systems or vice versa. A worldwide tax system imposes corporate tax on the foreign profits of home-based multinational firms, while a territorial tax system imposes tax only on the profits of all firms generated within the country. Only the United Kingdom made the shift from a worldwide to a territorial tax system during the period under investigation. In 2009, the United Kingdom government abolished the home taxation of profits made abroad. This means that if profits are booked in low-tax countries, they would no longer be taxed again at the United Kingdom rate. Langenmayr and Liu (2019) show that this switch in regime incentivised UK-based multinationals to increase profits in low-tax countries compared to non-UK-based multinational firms. I add a dummy that is zero for firms who do not have an affiliate in the United Kingdom, and only takes the value 1 for multinational firms who have an affiliate in the United Kingdom from 2009 onwards.

The second tax base change is transfer pricing regulations that dictate how firms are to define prices on cross-country intra-firm transactions. The aim of such regulations is to limit the firm's ability and incentive to artificially shift profits through transfer mispricing. Transfer pricing regulations will commonly include guidance on how arm's length prices should be determined, what penalties can be applied if prices are determined to be improperly set, and how a government might determine the probability of transfer mispricing. Most recently Liu and De Mooij (2018) examine the unilateral adoption of transfer pricing regulations and how it may affect the multinational firm's investment decision. Three countries in the sample introduced transfer pricing regulations over the period:

Finland (2008), Greece (2008), and Luxembourg (2011). For Luxembourg, these transfer price regulations coincided with a change in their corporate tax rates. I add dummy variables that take the value one for multinational firms with affiliates in those countries after the transfer pricing regulation was introduced, and are zero otherwise.

The third type of tax base change is the standard tax allowances for investment. Devereux and Griffith (1998) define the net present value of tax allowances per unit of investment, separately for straight-line and declining-balance methods of depreciation. This tax base term is expected to alter the firm's real investment decision. Works such as Gruber and Rauh (2007) consider the marginal effective tax rate elasticity of earnings before interest and tax for the United States, where the marginal effective tax rate considers both tax rate and tax base policy changes. To calculate the net present value of tax allowances per unit of investment (α), I first identify whether the country uses a straight-line or declining balance method of depreciation. For each method, Devereux and Griffith (1998) define the formulas:

$$\alpha_{SL} = \frac{\hat{\delta}\tau(1+\rho)}{\rho}\left[1 - \frac{1}{(1+\rho)^T}\right] \tag{3.19}$$

$$\alpha_{DB} = \frac{\hat{\delta}\tau(1+\rho)}{\rho+\hat{\delta}}, \tag{3.20}$$

where $\hat{\delta}$ is the rate at which capital can be offset against tax, T is the allowed length of depreciation in years, and ρ is the nominal discount rate. The value of α is calculated for each of three types of asset: industrial buildings, plant and machinery and intangibles (patents). These are then weighted by the percentage of these assets in total fixed assets and the weighted sum of these three are taken to give an overall value of α. To ensure that variation in α stems only from policy changes, I set all non-tax base parameters to be equal for all countries for all time periods. The interest rate ρ is given by the European Union average of the convergence criterion bond yield. The weights for assets is taken from the average weights across all firms in the Amadeus dataset from 2007 to 2016. And the tax rate is the average tax rate across all countries in the dataset for the period 2007 to 2016.

Only six countries change their tax allowances over the period 2007 to 2016:

Germany, Spain, the United Kingdom, Greece, Italy, and the Netherlands. There is some concern that tax rate changes coincide with tax base changes for all of these countries except the Netherlands. For most of these countries, there are periods where the tax rate changes but the tax base does not change, allowing identification of the tax rate effect. For Italy and Germany, however, there is only one tax rate change in the period under consideration and it coincides with a tax base change. This makes the results less convincing for these two countries.

The results of adding these tax base reforms progressively are shown in Table 3.2. I first add the territorial dummy for the United Kingdom, then dummies for the introduction of transfer pricing regulations, and finally I add investment allowances. I continue to include all countries in the reported results, including those that did not undergo significant corporate tax base reform during the period. The reason is that each multinational affiliate's profits are a function of a large number of variables all at once, such that controlling for one additional effect might imply changes in the estimated effect of another country's tax rate change. This is the complexity cost of the estimation strategy.

Controlling for Germany's changes to their tax allowances gives a positive, but insignificant estimate. Similarly with Italy, the estimated coefficient changes sign. Identification is unclear with these two countries given that the tax base change confounds the tax rate reform. For the United Kingdom, controlling for tax base changes does not alter the negative sign, but it makes the estimate less precise. Interestingly, Greece's average spillover effect appears to become larger in magnitude and more negative when considering tax base reforms. For Netherlands, controlling for changes in the investment allowance causes the estimate to spike, but be insignificantly estimated. Spillovers from Spain are estimated as being negative and significant once I control for investment allowances. For countries such as Luxembourg, Slovenia, and Finland, the tax base controls seem to make little difference. And while I do not include tax base reforms for Sweden, there appears to be mitigation of the magnitude of the average spillover I estimate for their tax rate reform.

Controlling for potentially important tax base changes appears to make a substantial difference to some countries, while not having a large effect for others. Tax base changes are potentially complex and might alter the overall tax

Table 3.2: Estimating Spillover Effects Controlling for Tax Base Changes

	Territorial Tax Sys.	Transfer Pricing Reg.	Investment Allowances
	(1)	(2)	(3)
Denmark	1.499***	1.602***	1.796***
	(0.297)	(0.298)	(0.317)
Estonia	1.043	0.896	1.001
	(0.944)	(0.946)	(0.946)
Finland	0.253	0.323	0.552
	(0.500)	(0.632)	(0.646)
France	1.676***	1.693***	1.667***
	(0.284)	(0.284)	(0.286)
Germany	−0.641	−0.439	0.446
	(0.411)	(0.416)	(1.075)
Greece	−0.584	−1.502**	−1.935**
	(0.519)	(0.623)	(0.943)
Hungary	3.420***	3.389***	3.544***
	(0.700)	(0.699)	(0.702)
Italy	1.504***	1.611***	−0.729
	(0.428)	(0.431)	(1.090)
Lithuania	−0.132	−0.168	−0.100
	(0.881)	(0.881)	(0.881)
Luxembourg	−1.227***	−0.888**	−0.933***
	(0.260)	(0.349)	(0.350)
Netherlands	0.711**	0.691**	9.179
	(0.291)	(0.291)	(6.361)
Portugal	2.122***	2.160***	2.245***
	(0.467)	(0.468)	(0.470)
Slovakia	1.404***	1.392***	1.348***
	(0.457)	(0.457)	(0.460)
Slovenia	1.770**	1.798***	1.814***
	(0.697)	(0.697)	(0.700)
Spain	0.716**	0.709**	−2.822**
	(0.338)	(0.338)	(1.102)
Sweden	1.158**	1.011*	0.812
	(0.516)	(0.519)	(0.522)
United Kingdom	−1.537***	−1.591***	−1.325
	(0.411)	(0.416)	(3.135)
Observations	9,503,645	9,503,645	9,503,645
R^2	0.521	0.521	0.521

Notes: The first model includes a dummy for the change in the tax system in the United Kingdom. The second model includes dummies for changes in transfer pricing regulations in Finland, Greece, and Luxembourg The third model includes the investment allowance for Germany, Greece, Italy, Netherlands, Spain, and the United Kingdom. All models include firm fixed effects and country-industry-size year effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

burden of the firm in a manner not captured by the main change in the headline corporate tax rate. Spillover effects become even more heterogeneous when considering the potential implications of tax base changes.

3.4.4 Horizontal and Vertical Multinational Firms

The theoretical models predict substantially different behaviour between horizontal and vertical multinational firms. Our simple models predict that horizontal multinational firms should exhibit substitutionary behaviour, while vertical multinational firms are expected to exhibit more complementary behaviour. However, multinational firms are far more complex than these simplified distinctions, and their behaviour may not be so easy to classify. In fact, being able to identify a multinational affiliate as being a horizontal or vertical affiliate is, in itself, a difficult task. Making the comparison between vertical and horizontal multinationals is an important aspect of dissecting the corporate tax base spillover.

I take a simple approach. Horizontal multinational firms are those which replicate an economic activity across countries. Therefore, two affiliates of the same multinational group are considered to be in a horizontal multinational group if they also conduct similar economic activity. The level of similarity of their economic activity can be identified from their NACE classification. This suggests that vertical multinational firms would be the complement. I identify vertical multinational groups as two affiliates of the same multinational group which conduct different economic activity. Again, I identify difference in economic activity based on whether their NACE classifications are different.

To operationalise this definition, I use the affiliate dummy variable. If a firm has an affiliate operating in the same economic activity (a horizontal affiliate) in country i, then the dummy $D^H_{mi} = 1$. If a firm does not have a horizontal affiliate in country i, but has an affiliate in country i which does not operate in the same economic activity, then I define them as having a vertical affiliate in country i. For a vertical affiliate, then the dummy $D^V_{mi} = 1$. This effectively disaggregates the main results into tax base spillover driven by vertical and horizontal affiliates. This is not a clean separation, but is a useful approximation to the already

blurred conceptual distinction between horizontal and vertical multinationals.

Operating in the same economic activity is defined at three levels: the NACE Section level (letter code), the NACE Division level (2-digit code), and the NACE Class level (4-digit code). This makes the grouping for horizontal multinationals progressively more narrow, while making the grouping for vertical multinationals progressively broader. The model estimated is the same as the main average country spillover model given in Equation 3.17, but splitting elasticities into horizontal base spillovers and vertical base spillovers:

$$\text{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{kt} + \sum_{i=1}^{N} e_i^H D_{mit}^H \tau_{it} + \sum_{i=1}^{N} e_i^V D_{mit}^V \tau_{it} + \sum_{i=1}^{N} \theta_{ij} \Delta D_{mit} + \varepsilon_{mt}. \quad (3.21)$$

The results are presented in Table 3.3. For almost all countries where there are statistically significant effects, horizontal base spillovers are more positive than vertical base spillovers. For example, consider Italy, where the horizontal base spillover effect is positive and statistically significant across all specifications, but the vertical base spillover is statistically not different from zero. Even in the cases where the semi-elasticity is negative—Germany, Luxembourg, and the United Kingdom—the horizontal base spillover is more positive than the vertical base spillover. Finland represents the exception, with a vertical base spillover that is more positive than the horizontal base spillover, although the results are not consistent. For most countries, the semi-elasticities do not change substantially as the definition of horizontal and vertical multinational changes. This suggests that the horizontal versus vertical differentiation I use is sufficiently clear to approximate potentially different behavioural patterns.

To some extent these results validate the theoretical prediction that horizontal base spillovers would be more substitutionary while vertical base spillovers would be more complementary. Here, we begin to observe an important concept: that tax base spillovers operate on a negative to positive continuum. Different forces pull them in either direction and we can observe some differences along that continuum. But we are dealing with organisationally and behaviourally complex multinational firms that conduct a wide range of activity and exhibit behaviours that can be captured and explained by various theories of the multinational firm.

Table 3.3: Corporate Tax Spillovers for Horizontal and Vertical Multinationals

	Section (letter)		Division (2-digit)		Class (4-digit)	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Denmark	2.371***	0.330	2.456***	0.571*	2.005***	1.090***
	(0.360)	(0.371)	(0.392)	(0.341)	(0.475)	(0.301)
Estonia	1.057	1.019	0.795	1.089	−0.067	1.152
	(1.294)	(1.172)	(1.389)	(1.100)	(1.855)	(0.993)
Finland	0.416	1.026	−0.225	1.254**	0.150	0.916*
	(0.627)	(0.626)	(0.691)	(0.580)	(0.881)	(0.530)
France	1.579***	0.986***	1.427***	1.139***	1.397***	1.167***
	(0.352)	(0.376)	(0.376)	(0.344)	(0.441)	(0.321)
Germany	−0.387	−0.889*	−0.020	−1.087**	0.125	−0.941**
	(0.497)	(0.496)	(0.547)	(0.464)	(0.672)	(0.434)
Greece	0.383	−1.284**	−0.238	−0.650	−0.262	−0.478
	(0.669)	(0.647)	(0.741)	(0.622)	(0.953)	(0.556)
Hungary	4.221***	2.573***	4.151***	2.873***	4.716***	2.853***
	(0.905)	(0.793)	(1.049)	(0.743)	(1.418)	(0.690)
Italy	1.678***	0.184	1.288**	0.536	1.650**	0.422
	(0.512)	(0.480)	(0.557)	(0.453)	(0.678)	(0.429)
Lithuania	0.950	−0.883	1.349	−0.794	1.805	−0.376
	(1.134)	(1.231)	(1.230)	(1.111)	(1.560)	(0.973)
Luxembourg	−0.675	−1.404***	−0.446	−1.365***	−0.333	−1.226***
	(0.426)	(0.263)	(0.480)	(0.252)	(0.810)	(0.240)
Netherlands	0.326	0.821***	0.458	0.711**	0.109	0.708**
	(0.380)	(0.317)	(0.431)	(0.293)	(0.558)	(0.276)
Portugal	3.118***	0.907	2.973***	1.453***	3.385***	1.711***
	(0.589)	(0.603)	(0.652)	(0.557)	(0.842)	(0.498)
Slovakia	1.368**	1.575***	1.668**	1.398***	2.875***	1.129**
	(0.592)	(0.575)	(0.668)	(0.514)	(0.839)	(0.475)
Slovenia	1.606*	1.583*	2.806***	1.083	4.163***	1.000
	(0.946)	(0.897)	(1.078)	(0.799)	(1.417)	(0.718)
Spain	0.554	0.040	0.449	0.187	0.579	0.145
	(0.413)	(0.403)	(0.455)	(0.375)	(0.566)	(0.348)
Sweden	1.588**	1.024	1.586**	1.174	1.531*	1.137*
	(0.660)	(0.836)	(0.729)	(0.753)	(0.894)	(0.678)
United Kingdom	−1.351**	−2.843***	−1.691***	−2.616***	−1.502**	−2.540***
	(0.530)	(0.690)	(0.575)	(0.622)	(0.681)	(0.579)
Observations	9,503,645	9,503,645	9,503,645	9,503,645	9,503,645	9,503,645
R^2	0.521	0.521	0.521	0.521	0.521	0.521

Notes: All models include firm fixed effects and country-industry-size-year fixed effects. Horizontal multinational affiliates are those operating within the same economic activity. Vertical multinational affiliates are those which do not operate within the same economic activity. Economic activity is defined either by NACE Section (letter), NACE Division (2-digit), or NACE Class (4-digit). Standard errors in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

3.4.5 Controlling for Real Factors

Public perception of substitutionary corporate tax base spillovers is heavily driven by the idea of multinational firms engaging in artificial profit shifting. The key concern with profit shifting, as spelt out by the OECD and G20's Base Erosion and Profit Shifting project, is the failure to align taxable profits with the location where economic activity took place or where value was created. This suggests that artificial profit shifting occurs where firms shift profits to lower tax jurisdictions without actually shifting productive economic activity.

If artificial profit shifting spillovers occur when profits do not align with real activity, then we can identify profit shifting spillovers as those that do not result from changes in real factors of production. This is the approach used by Huizinga and Laeven (2008). However, since I use a difference-in-differences approach to estimating spillovers, this analysis does not suffer from the concern that some firms may appear to be more profitable simply because they are more productive. Since I am concerned only with *changes* in profitability controlling for *changes* in real factors, then the only concern here might be that some firms experience heterogeneous temporal shocks based on their firm type. I do not measure total profit shifting. Instead I measure profit shifting *spillovers* that result from corporate tax rate reform.

I add controls for the two main factors of production: capital and labour. The aim is to eliminate variation in profits that are due to a real expansion of output. Conceptually the remaining variation should be due to artificial changes in profits. While the previous literature has used the notion of controlling for real factors of production as a means of identifying profit shifting, there are some reasons why this might not be a perfect method. In particular, firms can alter real output without necessarily increasing or decreasing capital or labour. Many firms have spare capacity. For example, in Europe's industry capacity utilization rate averaged 80.5 percent from 1980 to 2019.

To control for capital and labour, I use data on the affiliate's total assets and the cost of employees respectively. Additionally, I also use fixed assets and the number of employees as secondary variables. These are the variables used in Huizinga and Laeven (2008). The results of controlling for these real factors of

production are presented in Table 3.4. Since data on wages and employees are not available for a large number of firms in the Amadeus database, the number of observations is substantially reduced. To make an appropriate comparison between the main estimates and the models controlling for real factors, I re-estimate the main model on the reduced sample of firms for which there are data on assets, wages, and employees. This is presented in column 1 of the table. The second and third models use different definitions for capital and labour, while the fourth includes both definitions for capital and both definitions for labour. The fifth column also includes controls for the tax base reforms identified previously.

The most striking finding is that controlling for real factors of production does not substantially reduce the estimated elasticities. This is striking but not surprising. The results of Becker and Riedel (2012) suggest that firms' real economic activity might actually be complementary on average rather than substitutionary. But estimating the response of total profits, they find substantial substitutionary effects that are likely due to artificial profit shifting. Further, they find—as I do—that the profit shifting effect is quantitatively dominant and therefore economically important for understanding corporate tax base spillovers.

The main exceptions are Germany and the United Kingdom, countries where tax base reforms occurred. Controlling for tax base reforms in Germany causes the coefficient to switch from negative to substantially positive. This suggests that Germany's tax rate cut may have had substitutionary profit shifting spillover effects on its neighbours once accounting for tax base reform. For the United Kingdom, the coefficient becomes even more negative. The negative sign remains for Luxembourg as well. In the long run, countries that act as tax havens or as tax-friendly jurisdictions may actually benefit their neighbours. This is not entirely counter-intuitive. Since we are examining the *change* in these countries' tax rate rather than the decision to set up an affiliate in a tax-friendly jurisdiction, it is likely that most of the substitutionary effects may have already occurred—much as with vertical multinationals. This is not unheard of in the economic literature; for example, Rose and Spiegel (2007) find that financial tax havens have a beneficial impact on neighbouring countries' financial sectors.

Table 3.4: Corporate Tax Base Spillovers Controlling for Real Factors of Production

	(1)	(2)	(3)	(4)	(5)
Denmark	2.222***	2.235***	2.142***	1.796***	1.730***
	(0.389)	(0.388)	(0.388)	(0.357)	(0.419)
Estonia	0.749	0.542	0.613	0.299	0.390
	(1.605)	(1.604)	(1.605)	(1.566)	(1.607)
Finland	0.427	0.340	0.393	0.620	−0.402
	(0.773)	(0.772)	(0.773)	(0.745)	(1.410)
France	1.718***	1.523***	1.632***	1.479***	1.313***
	(0.389)	(0.387)	(0.388)	(0.367)	(0.389)
Germany	−1.378**	−1.661**	−1.456**	−1.412**	6.905*
	(0.670)	(0.668)	(0.669)	(0.626)	(3.595)
Greece	0.250	0.342	0.248	0.480	−1.070
	(0.674)	(0.674)	(0.674)	(0.649)	(1.212)
Hungary	2.998***	2.895***	2.932***	2.359***	2.611***
	(0.920)	(0.916)	(0.920)	(0.885)	(0.923)
Italy	2.068***	1.427*	1.929***	1.235*	0.675
	(0.744)	(0.742)	(0.744)	(0.709)	(3.381)
Lithuania	2.068*	1.906*	1.960*	1.559	1.641
	(1.134)	(1.131)	(1.133)	(1.094)	(1.128)
Luxembourg	−1.693***	−1.558***	−1.686***	−1.577***	−1.283***
	(0.343)	(0.342)	(0.343)	(0.332)	(0.468)
Netherlands	0.691*	0.703*	0.654*	0.741**	9.142
	(0.382)	(0.380)	(0.381)	(0.367)	(8.138)
Portugal	2.401***	2.177***	2.275***	2.020***	1.917***
	(0.629)	(0.628)	(0.628)	(0.600)	(0.630)
Slovakia	2.399***	2.343***	2.279***	1.979***	1.904***
	(0.716)	(0.713)	(0.714)	(0.693)	(0.716)
Slovenia	0.629	0.299	0.536	0.642	0.445
	(0.954)	(0.948)	(0.952)	(0.919)	(0.948)
Spain	0.227	−0.105	0.147	0.363	−1.714
	(0.483)	(0.482)	(0.483)	(0.458)	(1.382)
Sweden	0.829	0.074	0.687	0.411	0.326
	(0.859)	(0.853)	(0.859)	(0.816)	(0.860)
United Kingdom	−2.668***	−3.286***	−2.696***	−2.619***	−6.969*
	(0.576)	(0.575)	(0.575)	(0.522)	(3.615)
log assets		2.082***		2.826***	2.912***
		(0.055)		(0.023)	(0.058)
log fixed assets		−0.019		−0.008	0.017
		(0.042)		(0.018)	(0.045)
log wages			−0.201***	−0.837***	−0.881***
			(0.024)	(0.010)	(0.026)
log employees			0.770***	0.054***	0.060
			(0.048)	(0.021)	(0.056)
Tax base				Yes	
Observations	4,382,779	4,382,779	4,382,779	4,382,779	4,382,779
R^2	0.536	0.539	0.537	0.512	0.541

Notes: All models include firm fixed effects and country-industry-size year effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

3.4.6 Robustness

I consider a number of robustness checks. The results of these estimations are included in the Appendix.

First, I re-estimate the model without re-weighting the sample for covariate balance between domestic and multinational firms. This means that each 2×2 difference-in-differences estimate within the model is weighted based on how many observations are in each group and the within-group variance of the location dummy. The results of this robustness check are shown in Table 3.9. The results are qualitatively the same, and change only slightly quantitatively.

Second, I re-estimate the model excluding domestic firms altogether. This means that the control group consists entirely of multinational firms. How does this work? It relies on sparsity in affiliate networks to identify the spillover effects of tax reforms. Consider a pair of countries i and j, when country i changes its tax rate. The control group is made up of multinational firms which have an affiliate in country j, but not in country i. This should eliminate any remaining selection bias that arises due to inherent differences between domestic firms and multinational firms, possibly due to permanent productivity differences. The results of this robustness check are shown in Table 3.10. Once again the results are qualitatively the same, and change somewhat quantitatively.

Third, I re-estimate the main model using the natural log of profits rather than the inverse hyperbolic sine. This means that I include only profitable firm-year observations. This shrinks the data set from 9.5 million observations to 7.3 million observations, indicating the importance of including unprofitable firm-year observations. Interestingly, the model fits much better, increasing the R^2 from 0.521 in the arcsinh profits model to 0.819 in the log profits model. Most striking is the vastly reduced magnitude of the spillover estimates. This is expected since we only account for changes from one profitable year to another profitable year. These changes in profits will therefore be much smaller. The results are qualitatively different in some cases. Greece shows substantially complementary spillover effects when not accounting for firm losses. The United Kingdom is now estimated to generate substitutionary, rather than complementary effects. Denmark and Germany are estimated to generate no spillover ef-

fects, while there is a significant and positive spillover semi-elasticity for Finland. The qualitative difference in these results highlights the unmistakable importance of including firm losses in estimating the spillover effects of tax reforms. The results of this estimation are presented in Table 3.11.

Fourth, I include only firms that operate in the manufacturing sector. This restriction relies on the empirical evidence presented by Hanson et al. (2001) and Namini and Pennings (2009) that affiliates operating in the manufacturing sector are most likely to be vertical multinational affiliates, while affiliates operating in other sectors are most likely to be horizontal multinational affiliates. Hanson et al. (2001) suggest that multinational firms seem to face the decision of whether to set up production-oriented affiliates or distribution-oriented affiliates. Evidence on spillovers in the manufacturing sector is presented in Table 3.12.

Finally, I re-estimate the main model, splitting the data into five quantiles based on the size of total assets. This checks to see whether there is substantial heterogeneity in spillovers across the size distribution of firms. The results of this estimation are presented in Table 3.13. For Spain and the United Kingdom there appear to be systematic variation in spillovers across the size distribution. For Italy, the smallest quantile displays substantially substitutionary behaviour, while no other quantiles have statistically significant effects. There seems to be no general systematic variation in spillover effects by firm size.

3.4.7 Comparing Semi-Elasticities

I summarise these result in graphical form for easy comparison. For each type of tax base spillover—total, horizontal, vertical, and artificial—I plot the semi-elasticities implied from the main model, converted using Bellemare and Wichman (2019). Note that there is basically no change in the semi-elasticities using this conversion. For the total spillover, I plot the semi-elasticities from the main model with country-NACE Section-size time effects. For the horizontal and vertical base spillovers, I use the narrowest definition of a horizontal multinational, the NACE Class. For artificial spillovers, I use the model including all four variables as controls for capital and labour.

Figure 3.4: Box Plot of Country-Specific Spillovers

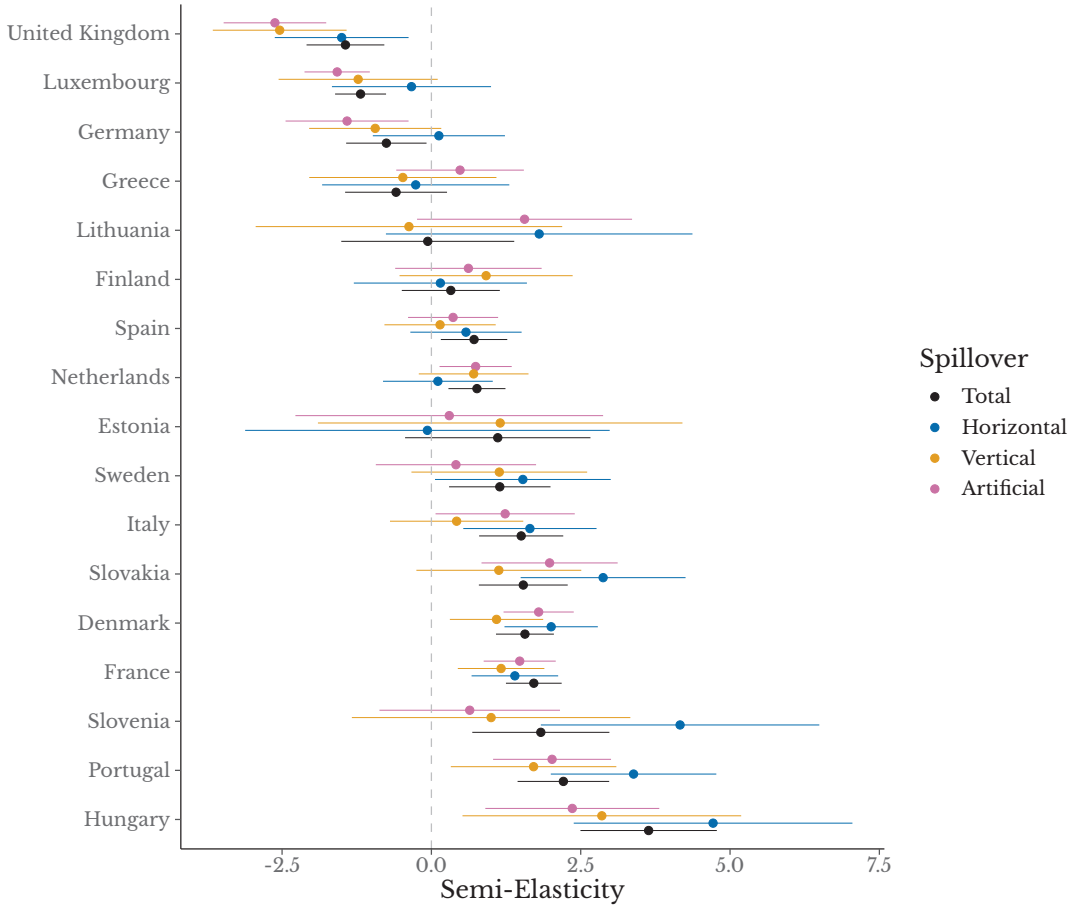


Figure 3.4 shows a clear comparison of the semi-elasticities across models. Elasticities are pretty consistent within countries, as those with complementary spillover effects displaying general complementarity across all specifications and vice versa for substitutionary spillovers. For some countries such as Spain, there is very little variation in the estimated elasticities. The variation is greater for other countries such as Slovenia, Lithuania and Hungary. But even these present a relatively consistent picture. Importantly, notice that the majority of countries generate substitutionary corporate tax base spillovers to their neighbours on average. While this is consistent with the evidence that corporate tax base spillovers are substitutionary, we can already notice that a word of caution is required due to the substantial heterogeneity across countries.

This chart highlights the emerging notion that spillover elasticities operate along a continuum. One can mentally draw a diagonal trend line through the chart. There is no discrete distinction between countries which generate com-

plementary elasticities and countries which generate substitutionary elasticities. No one theoretical model of spillovers is correct; each one likely carries a measure of validity in determining the eventual corporate tax base spillover that a country's tax rate reform generates.

3.5 Country-Pair Spillovers

I now explore the heterogeneity of country-pair spillovers. The previous estimates give an average of the effect a country's tax spillovers has on all its European neighbours. An average effect might mask the fact that some country-pair spillovers are complementary while others are substitutionary. What effect does a country i's tax rate change have on a specific neighbour j? And is the effect homogeneous across neighbours?

To estimate the spillover effect between a pair of countries, I extend Equation 3.17 by multiplying each of 17 country-i tax rate terms by a full set of 26 country-j dummies, D_{mj}. That is, I effectively estimate the effect of each country i's tax rate change separately for each country j. The regression I estimate to recover country-pair spillover semi-elasticities is:

$$\text{arcsinh}(\pi_{mjt}) = \alpha_m + \gamma_{jkt} + \sum_{j \neq i}^{N} \sum_{i=1}^{N} e_{ij} \cdot D_{mit} \cdot D_{mjt} \cdot \tau_{it} + \sum_{i=1}^{N} \theta_{ij} \cdot \Delta D_{mit} + \varepsilon_{mt}. \quad (3.22)$$

This results in a matrix of semi-elasticities e_{ij} with $j \in N$ rows and $i \in N$ columns, where each entry is a spillover from country i's tax rate reform to country j's tax base. I do not consider the effect of the corporate tax reform on the country's own tax base so the diagonal entries are missing.

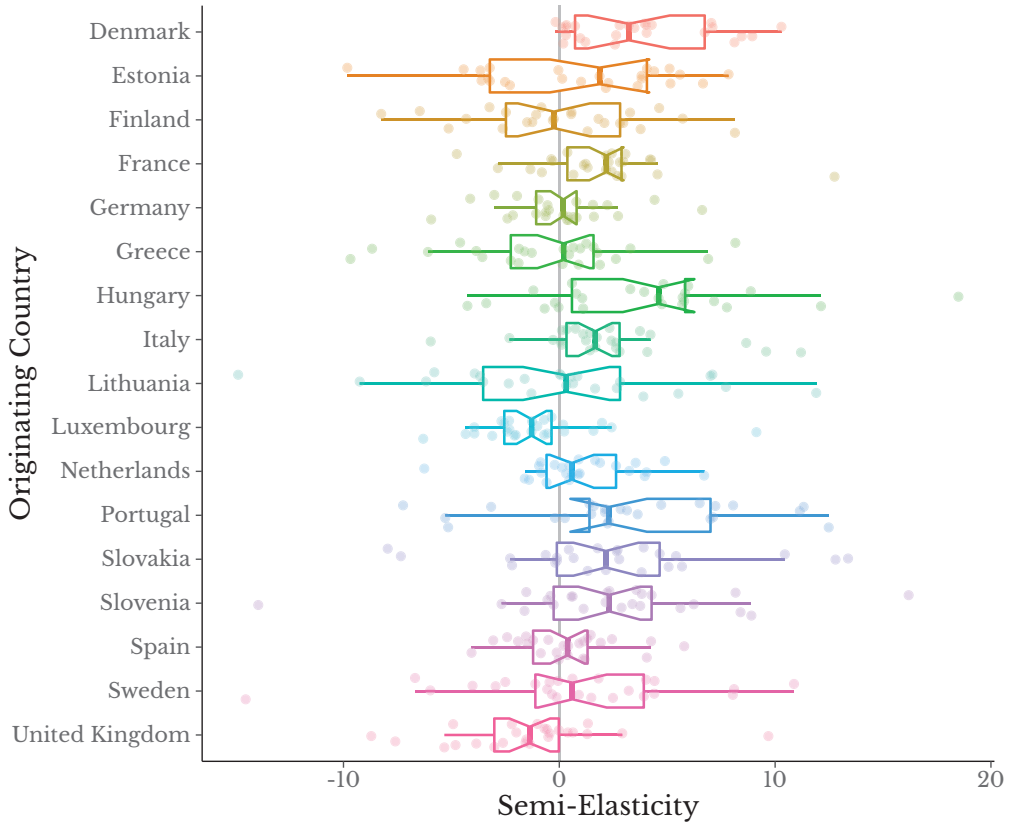
I use the final model in Table 3.1, with country-industry-size year fixed effects. This gives us 425 country-pair spillover semi-elasticities. Each semi-elasticity represents the effect a country i's corporate tax rate reform had on a specific neighbouring country j. The results of these estimates are presented in matrix form. The columns are the country which changes its tax rate (the originating or reform country) and the rows are the countries which are affected by the tax rate change (the spillover or affected country). The full results are presented in

Table 3.5: Matrix of Country-By-Country Spillovers

	DE	DK	EE	ES	FI	FR	GB	GR	HU	IT	LT	LU	NL	PT	SE	SI	SK
AT	1.600	3.480*	5.590	-1.480	5.720	2.880	0.630	0.200	0.590	1.740	5.520	2.420	4.890*	6.500*	10.870**	6.230	4.650
BE	-0.640	0.310	4.400	0.200	0.550	1.220	1.290	-1.610	4.830*	2.600	2.810	-0.560	0.940	2.240	-0.340	1.120	0.660
BG	4.410	2.630	7.840	-4.070	-3.240	0.650	-0.680	-3.850	8.870	11.200**	11.900*	-4.340	-0.940	11.320	-14.530*	-1.530	13.380***
CZ	-0.960	2.580**	-9.820**	2.440	-1.490	2.960**	-1.560	1.760	7.760***	4.220**	0.020	1.980	-0.830	7.010***	3.920*	5.610**	5.410***
DE		-0.170	1.870	0.410	-1.070	1.310	-0.450	0.450	3.940*	1.670	-2.350	-2.330***	-0.210	2.840**	2.490*	-0.410	0.440
DK	-2.150		-0.040	-1.910	-2.470	0.370	-1.520	0.890	-0.210	-2.310	-3.920	-0.700	2.630	-5.150	-0.450	0.570	2.660
EE	0.800	8.120***		4.250	-8.250**	4.200	-0.590	-8.670*	-0.680	-5.960	-6.170*	-2.680	-0.870	-7.240	4.010	-1.610	2.780
ES	-0.480	4.050***	-2.290		0.560	2.430***	-3.010***	2.620	5.700***	4.080***	1.660	-0.700	0.580	3.140***	-0.060	2.140	1.310
FI	-0.620	3.220**	3.810	-0.510		1.140	-1.990	1.250	-0.040	0.120	2.660	-3.940*	3.540*	-5.280	4.410*	3.750	1.780
FR	-1.070	1.210*	5.110**	-0.120	3.770***		-0.510	-3.570***	4.600***	0.110	-1.610	-2.310***	0.900	-0.200	1.820	-0.550	-0.190
GB	-2.400**	0.330	0.140	1.920**	-1.250	-0.320		0.640	1.060	-0.290	-1.290	-0.360	0.890	0.260	3.220**	3.380*	-0.630
GR	-1.960	7.100**	3.630	1.310	3.280	12.750**	-1.010		12.130*	9.580*	7.010	-2.020	1.660	-3.160	-5.980	2.890	2.700
HR	2.230	6.740**	2.160	-0.860	1.820	2.170	-4.810	8.160	-3.390	3.740	-9.250	-6.310*	1.890	2.120	-6.680	3.820	-7.950**
HU	0.370	0.970	-3.600	0.380	-0.250	2.420	-2.200	6.900*		2.790	-3.530	-3.110	-0.590	1.600	0.910	8.170**	2.160
IE	-5.940*	0.730	6.660	-2.420	4.630	-1.340	-0.020	-9.680**	4.750	1.110	-5.790	1.580	3.240	4.720	-2.500	-2.680	-7.340
IT	0.790	4.030***	5.150	1.450*	-2.630	2.680***	-1.370	0.150	7.170***		0.640	0.230	0.460	3.630***	0.610	2.220	3.910***
LT	0.190	10.290***	4.060	4.050	-6.470	-2.850	9.690*	1.580	18.490	2.630		9.130*	-6.260	11.150*	8.040	8.900	12.800*
LU	-3.010	7.040**	2.270	-1.210	8.140	2.180	2.920	-1.280	1.100	8.660	-14.880		6.710**	12.480**	-0.560	-13.950*	-2.280
LV	6.620	3.960	-2.510	-0.030	-0.300	-0.810	-8.710*	-1.860	-1.200	1.420	0.070	-1.020	-1.600	7.230	-0.130	2.320	3.810
NL	2.720	0.300	-3.220	-3.060	2.960	3.060	0.400	-4.590	5.830	1.240	0.530	-2.070		2.120	4.400	16.190***	5.060
PL	0.660	4.280***	1.010	1.170	-5.130**	4.250***	-2.610*	0.970	0.790	2.320	3.900	-2.410**	0.460	8.050***	-4.020**	3.570	-0.110
PT	1.560	2.790*	-4.430	1.110	2.820	2.290	-3.850**	3.300	5.710	1.430	7.720	-1.290	-1.400		1.480	-0.260	-0.110
RO	-4.130*	8.450***	3.820	0.930	-0.830	4.550**	-5.330**	-6.090**	5.970	2.420	7.090	-1.260	4.040**	7.120**	-2.950	8.400**	10.450***
SE	0.420	0.190	-3.650	1.110	2.090*	-0.370	1.330	-1.890	-4.260	0.070	0.320	0.180	0.320	2.290		0.620	-2.190
SI	0.420	8.940***	-3.220	5.790	-4.310	-4.750	-4.920	1.880	3.290	0.330	0.840	-3.940	3.960	1.400	8.100		5.690
SK	-0.550	0.130	-3.310	-1.540	1.310	2.810	-7.600**	-2.250	5.780	0.750	-3.670	-2.550	0.120	1.480	-1.110	4.280	

Table 3.5. For simplicity, I present a summary of these results in two graphs.

Figure 3.5: Box Plot of Country-Pair Spillover Semi-Elasticities



Each dot represents a country-pair semi-elasticity originating from the country on the y-axis. The centre line of the box is the median, and the outside lines measure the 25th and 75th percentiles. The notch in the box is the 95% confidence interval for the median.

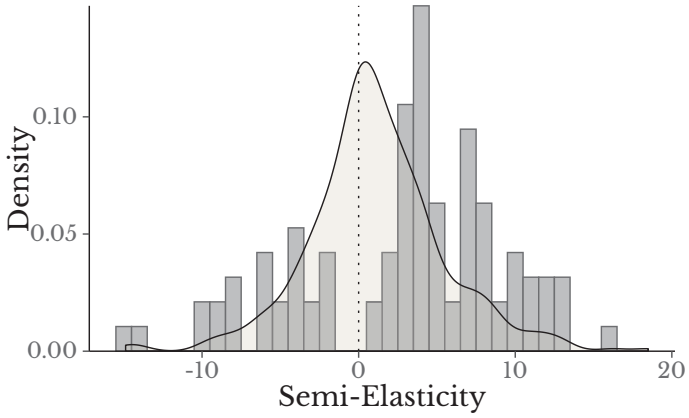
Figure 3.5 presents a box and whisker plot of the country-pair semi-elasticities generated by each country's corporate tax rate reform. The estimated semi-elasticities are plotted as dots. The centre vertical line of each box represents the median estimate. The box spans from the 25th percentile to the 75th percentile. The notch in the box (where the diagonal part meets the horizontal part) measures approximately a 95 percent confidence interval for comparing medians across boxes.

It is relevant to remind the reader that these country-pair semi-elasticities are estimated from the same data and specification as Model 4 in Table 3.1. The only difference is the inclusion of dummy variables that are interacted with the tax rates so as to disaggregate the effect into a country-pair spillover rather than aggregating to an average spillover. The heterogeneity of these estimates is there-

fore striking. Average country-specific semi-elasticities in Table 3.1 ranged from -1.4 to +3.6. In contrast, country-pair semi-elasticities range from -14.8 to +18.5.

This is a central finding of this essay: not all neighbouring countries are affected in the same way when a country changes its tax rate. While the average effect from a tax change may be substitutionary, it is misleading to assume that all countries are affected by spillovers in the same way. Only for Denmark does it appear that the tax reform resulted in unambiguously substitutionary spillovers for all country-pairs—no other country has this unambiguous effect. Instead, spillovers operate on a continuum. Spillovers across country-pairs likely fall somewhere on that continuum between complementary and substitutionary depending on the characteristics of the two countries and their relationship.

Figure 3.6: The Distribution of Country-Pair Spillovers

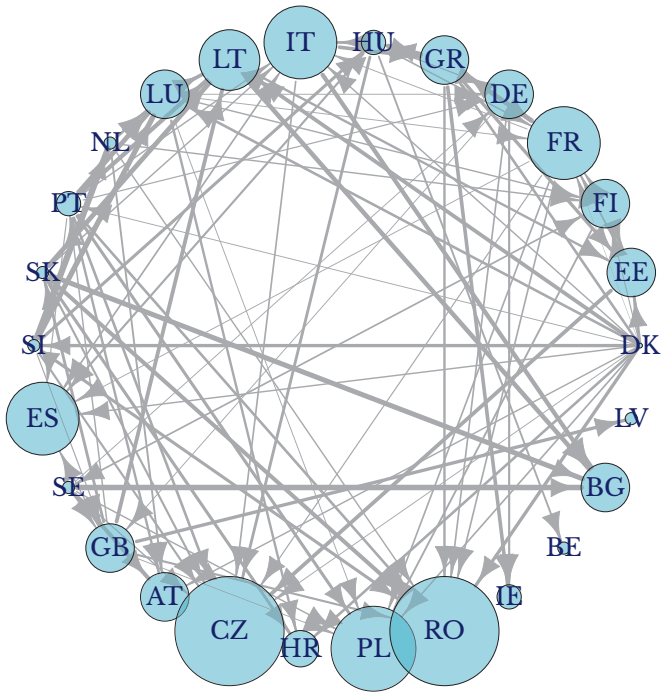


The histogram represents the distribution of only significant semi-elasticities, while the density distribution represents the distribution of all semi-elasticities.

Not all of these semi-elasticities can be defined as being statistically significantly different from zero. Of 425 semi-elasticities, we can identify 95 as being statistically significant at the 10 percent level. Many are found to be statistically insignificant. In Figure 3.6, I plot a histogram of those semi-elasticities which are statistically significant at the 10 percent level based on standard errors clustered at the firm level to adjust for within-cluster correlation resulting from temporal autocorrelation. The overlaid shaded density distribution shows the distribution of all estimated semi-elasticities, including those that are insignificant. There are much more statistically significant substitutionary semi-elasticities relative to complementary semi-elasticities. Sixty-nine of 95 statistically significant semi-elasticities are positive (substitutionary), meaning that 73 percent

statistically significant semi-elasticities are positive. Of the semi-elasticities clustered in the range -1 to 1, only 26 are statistically significantly different from zero. In contrast, 196 of the semi-elasticities in this range cannot be reasonably distinguished from zero. And even if they were precisely estimated, the magnitude of these elasticities is economically insignificant.

Figure 3.7: A Network of Statistically Significant Country-Pair Spillovers



Statistical significance is measure by a p-value < 0.1. Each node of the network represents a country. Each directed edge or arrow represent a spillover effect from the tax reform country to the affected country. The size of the arrow captures the absolute size of the estimated spillover semi-elasticity. The size of the node captures the strength or importance of the country in the network based on the number of connections and the size of those connections.

Given the striking nature of the finding that we cannot convincingly estimate significant spillover effects for many country-pairs, I plot a network of all statistically significant spillover semi-elasticities in Figure 3.7. Each node (circle) represents a country in the data set. Directed arrows represent the country reforming

its tax rate (from) and the country being affected by the tax base spillover (to). The width of the arrow represents the absolute magnitude of the spillover effect. The size of each node then reflects the weighted vertex in-degree or strength of each node. Strength (s_i) simply measures the weighted number of arrows pointing towards a country:

$$s_i = \sum_{i \neq j} a_{ij} e_{ij}, \tag{3.23}$$

where a_{ij} takes the value of 1 if there is a significant tax base spillover from country i to j, and e_{ij} is the relevant country-pair elasticity. The size of a node then captures how much corporate tax base spillovers affected that country's tax base.

The first thing to note is that the network is shown to be sparse given the low ratio of significant elasticities. The ratio of significant elasticities suggests that only 2 out of every 10 neighbouring countries are highly likely to be significantly affected by a country's corporate tax rate reform. This says that concerns about widespread tax base spillovers might be unjustified. Spillover effects are likely to be localised to a few important neighbours.

The second thing of interest is that those countries most likely to be affected by corporate tax spillovers are the smaller European states: Romania, Poland, and the Czech Republic have the largest weighted in-degree (strength) in the network. The next tier of countries on the in-degree ranking, however, are France, Italy, and Spain—three of the largest economies in Europe. This suggests that it is not only small countries who are affected by corporate tax base spillovers.

Finally, notice that some countries are relatively well insulated. Belgium, Latvia, the Netherlands, Slovenia, Slovakia, and Sweden have experienced little base spillover effects due to corporate tax reforms in Europe over the past decade.[2] This suggests that there is substantial heterogeneity too in which countries are likely to be affected by corporate tax base spillovers, even within Europe.

There are a few important implications to be drawn from this new evidence on country-pair tax base spillovers. First, many neighbouring countries do not appear to be significantly impacted by spillover effects. Second, the majority of these spillover effects are substitutionary but I uncover some economically

[2] I exclude Denmark because its low in-degree is likely due to the fact that it does not have data available before 2012.

significant complementary spillover effects. Third, it is clear that country-pair spillover effects vary substantially in magnitude.

3.6 Understanding Why Spillovers Vary

What features of these countries or the relationships between these countries cause spillovers to vary so substantially across country-pairs? In this section, I use the cross-sectional variation in country-pair spillover semi-elasticities estimated in the previous section to explore whether I can uncover any structural patterns in the magnitude and direction of spillovers. I explore a simple regression of the form:

$$e_{ij} = \beta_i X_i + \beta_j X_j + \beta_{ij} X_{ij} + \varepsilon_{ij}. \tag{3.24}$$

The matrix X_i captures features of the tax reform *originating country* (i). The matrix X_j captures features of the affected or *spillover country* (j). The matrix X_{ij} is most important, describing the relationship between the two countries (ij). The form of this regression is similar to a cross-sectional gravity model, but the type of analysis resembles a meta-analysis which might use a range of coefficients from various studies across countries to explain the heterogeneity of results. For example, using regression on elasticities, Havranek et al. (2015) find that cross-country heterogeneity in inter-temporal substitution elasticities is mostly explained by income and asset market participation.

This is an empirical approximation of a structural understanding of spillovers. The aim of this approach is to try to understand what frictions, incentives, or characteristics generate heterogeneity in observed country pair elasticities. Ideally, researchers want to be able to identify the structural spillover elasticity. The reason is that structural elasticities are functions of the primitives of our stylised economic models. Having structural elasticities based on primitives allows us to make clear out-of-sample predictions and to create useful counterfactuals Chetty (2009).

But even with new approaches using administrative data such as bunching, a wide range of optimisation frictions make it difficult for us to truly observe the underlying structural elasticities that govern economic behaviour. This makes

it difficult to move from estimates to policy (Kleven, 2016). A small estimated elasticity could be either the result of a large structural elasticity and large adjustment costs or a small structural elasticity and small adjustment costs (Chetty, 2012). And this observational equivalence is compounded by the fact that multiple models might apply to a multinational firm. Each model describes a different set of behaviours displayed by complex multinational firms.

The aim of this estimation then, is to identify the key features that cause observed elasticities to deviate from a single homogeneous elasticity as we might derive in a simple theoretical framework. Much of the theoretical literature on spillovers is found as the intermediate step in deriving models of tax competition: an originating country changes its tax rate, leading to a base spillover, which induces a strategic response by the spillover country. One particular feature the tax competition literature has found to be important in driving heterogeneity in spillovers is asymmetry across countries (Bucovetsky, 1991; Haufler and Wooton, 1999; Peralta and van Ypersele, 2005; Stöwhase, 2005; Johannesen, 2010).

What Asymmetries are Important? The most important asymmetry in the tax competition literature is economic size (Bucovetsky, 1991; Haufler and Wooton, 1999). Wilson (1991) for example finds that a small country might be an important beneficiary of spillovers if the difference between countries is large. But it is not always clear how size might affect the intensive margin since firms themselves may sort across jurisdictions (Haufler and Stähler, 2013). The benefits of agglomeration—which is likely correlated with size—also influence the sensitivity of capital to tax rate changes (Baldwin and Krugman, 2004).

However, we have noted that artificial profit shifting spillovers are likely of substantial importance. Stöwhase (2005) finds that introducing profit shifting into a model alters the sensitivity of countries. Low-tax countries experience reduced sensitivity of their tax base to tax rate changes, while high-tax countries experience increased sensitivity. But Johannesen (2010) proposes that the existence of tax havens also reduces non-haven countries' competition for artificial profits since tax havens have effectively already 'won' that game.

Benassy-Quere et al. (2007) emphasise the importance of public capital in

determining the responsiveness of real capital flows to tax rate changes. That is, firms might be willing to accept higher tax rates when public capital provision is high. This can reduce firms' sensitivity to tax rate changes in that country, or even in neighbouring countries. The importance of public capital is also highlighted in Wilson (1987), Hindriks et al. (2008), Dhillon et al. (2007), Zissimos and Wooders (2008). While each of these models is set in a different context, they all highlight the importance of public capital in attracting real capital flows.

Certainly, the main asymmetry identified in the theoretical and empirical analysis deserves attention—the differentiation between vertical and horizontal multinationals. At the country level, both vertical and horizontal multinationals will operate across all countries. Therefore at this aggregated level, asymmetry will arise if there are key characteristics of the country-pair relationship that make it more likely that there will be horizontal or vertical multinationals operating between these two countries.

Data on Asymmetries In order to identify the asymmetries outlined above, I require some empirical proxies.

As a measure of the incentive to engage in horizontal activity, I use two variables: distance and the difference in log purchasing power. Horizontal multinational firms are more likely to exist when trade barriers or trade costs are high. Within the European Union there are no such trade barriers, but the cost of trade is likely increasing in distance. Distance acts as a proxy for trade costs. Markusen and Venables (2000) shows that horizontal multinational firms are more likely to exist when countries are more similar in endowments. I use the difference between two countries' purchasing power to measure their similarity. This is intuitive: horizontal multinationals are trying to access new markets. They will likely attempt to access markets that are as similar to theirs as possible. I express the difference in log purchasing power as an absolute difference, since it is only the size of the differential that matters and not the direction. Purchasing power is expressed as a per capita measure. Data on distance is obtained from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) and data on purchasing power is obtained from Eurostat.

Typically vertical multinationals span countries that are dissimilar in factor endowment. Helpman (1984) finds that the share of multinational intra-firm trade should increase with the factor endowment differential. The most important factor driving intra-firm trade is the cost of labour. I measure the incentive to become a vertical multinational across two countries by the difference in log wages between the two countries. Wages are measured as the compensation of employees plus taxes minus subsidies in the business economy (NACE Section B to N), measured in euros. This data is obtained from Eurostat. As with purchasing power, I express the difference in log wages as an absolute difference as it is only the size of the differential that matters.

For the country size differential, I use the natural log of gross domestic product (GDP) as a measure of size. Data on GDP are obtained from Eurostat. As a measure of the difference in public capital, I use data on public capital to GDP from the International Monetary Fund (2017) Investment and Capital Stock Dataset.

I include a dummy for whether the originating country (the tax reform country) is a tax haven and a dummy for if the spillover country (the affected country) is a tax haven. Tax havens are defined as the five countries on the European Parliament (2019) list which are in my dataset: Belgium, Hungary, Ireland, Luxembourg, and The Netherlands. I include the difference in corporate tax rates to investigate whether there is any substantial non-linearity in the elasticity.

Asymmetries are expressed as differences in the form $x_{ij} = x_i - x_j$, except for wages and purchasing power. This means these differences as interpreted as becoming more positive when the originating country's x_i is larger than the spillover country's x_j. The absolute differences used for wages and purchasing power are expressed as $x_{ij} = |x_i - x_j|$. This implies that these differences capture any positive or negative asymmetries between two countries. All variables are expressed as averages over the period 2007 to 2016.

Results I consider all elasticities in the regressions in Table 3.6. However, noting that some elasticities are precisely estimated while others are not, it is prudent to give more weight to those that are more precisely estimated. The models in

Table 3.6 give increasing weight to more statistically significant semi-elasticities. This is done by weighting observations based on the t-statistic of the estimated country-pair semi-elasticity. I consider unweighted estimates, estimates weighted by the absolute value of the t-statistic, estimates weighted by the square of the absolute value of the t-statistic, and estimates weighted by the cube of the absolute value of the t-statistic. I scale all data to be between zero and one using the simple formula: $x_{ij}/(\max\{x_{ij}\} - \min\{x_{ij}\})$.

Table 3.6: Meta-Regression on Country-Pair Semi-Elasticities

	(1)	(2)	(3)	(4)
Is tax haven (origin)	0.414*	0.553*	0.408	0.137
	(0.247)	(0.308)	(0.335)	(0.344)
Is tax haven (spillover)	0.129	0.343	0.806**	1.386***
	(0.229)	(0.306)	(0.359)	(0.391)
Diff in log wage	0.569*	1.093***	1.643***	2.050***
	(0.314)	(0.387)	(0.392)	(0.366)
Diff in log purchasing power	−1.187***	−1.872***	−2.238***	−2.340***
	(0.341)	(0.422)	(0.451)	(0.448)
Diff in log GDP	−0.233	−0.388	−0.644*	−0.904**
	(0.245)	(0.334)	(0.377)	(0.393)
Diff in corporate tax rates	0.328	0.518	0.756**	0.973***
	(0.292)	(0.361)	(0.376)	(0.361)
Diff in public capital to GDP	−0.108	−0.107	−0.278	−0.539**
	(0.252)	(0.291)	(0.277)	(0.241)
Distance	−0.179	−0.208	−0.148	−0.118
	(0.218)	(0.268)	(0.283)	(0.274)
Constant	1.918***	3.021***	3.448***	3.717***
	(0.569)	(0.694)	(0.720)	(0.690)
Weights	None	Abs(T-Stat)	Abs(T-Stat)^2	Abs(T-Stat)^3
Observations	425	425	425	425
R^2	0.035	0.049	0.070	0.135

Notes: The dependent variable in this model is the set of semi-elasticities estimated in Table 3.5. These models differ in the weight given to each observation. Model (1) includes no weights. Model (2) weights observations by the absolute value of the t-statistic. Model (3) weights observations by the square of the absolute value of the t-statistic. Model (4) weights observations by the cube of the absolute value of the t-statistic. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Taking substitutionary spillovers as the default behaviour, we can explain negative coefficients in two ways. A variable can either be indicative of increasing complementarity or reducing substitutionary effects. Guidance as to how to interpret a coefficient depends on the discipline provided by economic theory.

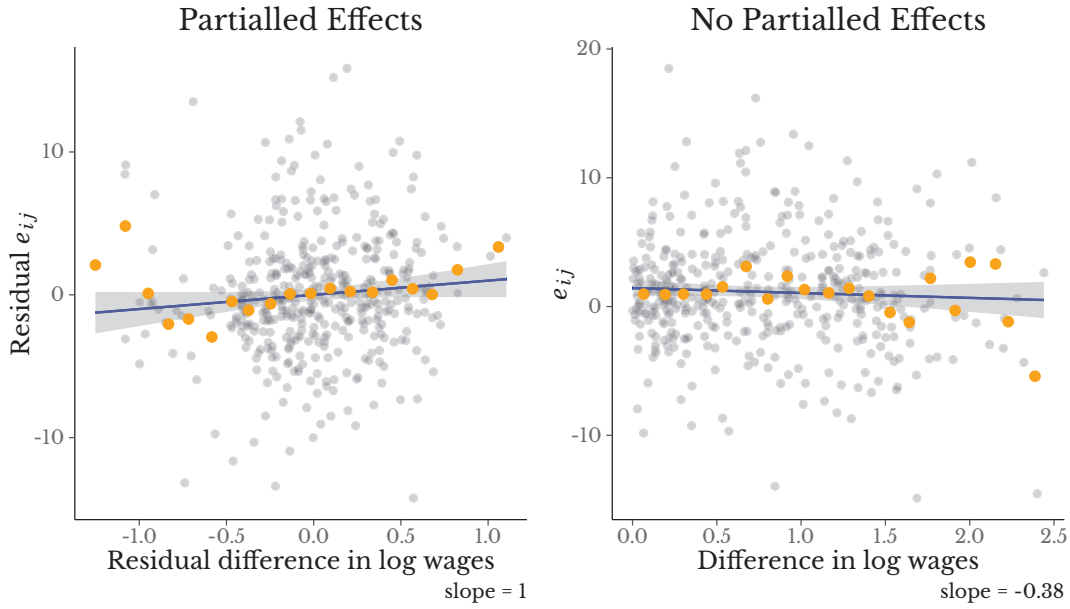
The first thing to note is that the direction of these estimates is consistent across estimates. While the size of coefficients changes, the interpretation does not change for any of the significant coefficients. This suggests that the effects are relatively stable across all country pairs.

The second point of interest is that there is a negative, significant and large coefficient for the absolute differential in purchasing power. This says that the more different two countries are in economic size, the more likely spillovers will be complementary rather than substitutionary. In contrast, the closer countries are in size, the more substitutionary the spillovers will be. This aligns perfectly with theory. Countries that are more similar in size are expected to increase the incentive to create horizontal multinational firms. And horizontal multinational firms are predicted to have more substitutionary spillovers. Therefore, we can expect countries that are closer in size to generate more substitutionary spillovers.

The third point is that there is a positive, significant, and large coefficient for the absolute differential in log wages. This suggests that as the absolute difference between two countries' wage costs increase, spillovers become more substitutionary. This runs counter to the theoretical prediction that countries with greater wage differentials should incentivise vertical multinational firms, where vertical multinational firms are expected to generate more complementary spillovers. Because of the surprising nature of this result, I plot a binned scatter plot of the relationship between the absolute log of the wage differential and the semi-elasticity. Figure 3.8 shows, in the left panel, the binned relationship having partialled out the effects of the other control variables. In the right panel, I show the results without partialling out these effects. Notice that without controlling for other variables, the relationship in the data is negative. However, when controlling for other covariates, the partialled effect of the absolute difference in the log of wages is positive. This is a surprising result. Similar results hold for alternative definitions of wages such as total wages and salaries, and limiting it to

wages in the manufacturing sector. Countries with the lowest average wages are Bulgaria, Romania, and Lithuania, while the countries with the highest average wages are Denmark, Belgium, and Sweden. The largest absolute wage differentials are therefore between these two groups of countries.

Figure 3.8: Binned Scatter Plot of the Relationship Between Wage Differentials and Semi-Elasticities



This is a binned scatter plot of wages with a line of best fit plotted for the bins. The plot on the left partials out the effects of other control variables using the Frisch-Waugh-Lovell Theorem. That is, the y-axis is the residual of the semi-elasticity controlling for all other variables, and the x-axis is the residual of the differential in log wages controlling for all other variables. The plot on the right does not partial out the effects of other control variables, and therefore plots the raw data.

The results suggest that the greater the level of public capital in the tax reforming country, the less substitutionary the effect is expected to be. When a high-public capital country changes its tax rate, it does not generate large substitutionary spillovers to low-public capital countries. This lines up with the existing evidence which suggests that the own-tax elasticity of foreign direct investment is substantially declining in the level of public capital. Benassy-Quere et al. (2007) find that the own-tax elasticity is insignificant for high public capital countries, while the opposite holds for low-public capital countries. Their suggestion is that tax decisions have less importance for foreign direct investment in high public capital countries. A similar result is uncovered in Bellak et al. (2009), whose central finding is that the own-tax elasticity of foreign direct investment shrinks in magnitude as the level of public infrastructure increases. In

fact, they even suggest that the negative own-tax elasticity becomes insignificant for the highest levels of public infrastructure. The proposed rationale for this finding is that high levels of public capital generate substantial location-specific rents which can be taxed without generating substantial distortionary responses by multinational firms.

The larger the originating country is relative to the spillover country, the less substitutionary the elasticity. This effect is not, however, consistently significant across all models. It suggests that the effect of economic size works similarly to the effect of public capital. It is possible that economic size is capturing the effects of agglomeration rents. Agglomeration rents are also location-specific rents that reduce the responsiveness of the multinational firm to corporate tax changes. It is similarly possible that, with greater economic size comes greater market access. A horizontal multinational that is set up to serve a foreign market is unlikely to substantially alter its real allocation of output if it needs to be close to the market it is serving or if exporting is costly.

The results also suggest that as the corporate tax rate in the originating (tax reforming) country is larger relative to the spillover (affected) country, the more substitutionary is the corporate tax base spillover. That is, when higher-tax countries cut their tax rates, they are likely to generate substantial negative tax base effects on lower-tax countries. In contrast, tax reform by a lower tax country generates a more complementary or less substitutionary spillover effect on higher-tax neighbours.

Finally, the tax haven dummies are each statistically significant in two of the models. In the first two models, which place less weight on the statistically significant semi-elasticities, the results suggest that spillovers originating *from* a tax haven are more substitutionary. In the final two models, which place a greater weight on statistically significant semi-elasticities, the results suggest that spillover *to* a tax haven are more substitutionary. Both results confirm the notion that spillovers to and from tax havens are likely to be quite substitutionary. This is the main effect predicted by the theoretical models of profit shifting.

The benefit of analysing the heterogeneity of corporate tax base spillovers is in being able to use these results to predict spillovers in the future. This new evi-

dence allows us to make richer policy predictions rather than needing to assume that all countries are affected evenly. I provide a deeper understanding of what leads to substantial heterogeneity in country-pair corporate tax base spillovers.

3.7 Conclusion

In this essay I estimate corporate tax base spillovers across Europe. First, I estimate the spillover effect of 17 countries' tax rate reforms, averaged across all European neighbours. Second, I estimate country-pair spillovers, examining how each country's reforms affected each neighbouring country. For each set of estimates I examine the deeper causes of these spillover effects. The aim of this essay is to help us to understand corporate tax base spillovers.

I use data on European firms from the Amadeus database. I specify an approach that uses multinational firms as the transmission mechanism for corporate tax base spillovers while using domestic firms as the counterfactual. With this approach, I find that corporate tax base responses in Europe are—on average—substitutionary in total. However, there is substantial variation, and some spillovers are complementary.

I find that, on average, horizontal spillovers are more likely to be substitutionary than vertical spillovers, but the difference is not great. I find that controlling for real factors of production does not substantially reduce the size of the estimated elasticity, likely implying that much of the total spillover effect is due to artificial profit shifting.

These average effects mask even deeper heterogeneity in country-pair elasticities. Most importantly I find that we cannot identify significant spillover effects for a large number of country-pairs. This suggests there is sparsity in the corporate tax base spillover network, as a small number of countries are likely substantially affected by a single country's tax rate change. The natural implication for future policy predictions is that all countries are not affected evenly by spillovers from a corporate tax rate reform. Further, as these spillovers are expected to drive tax competition, it may mitigate our concern about 'retaliatory'

tax rate cuts.

Finally, I am able to use the variation in country-pair elasticities to try to uncover richer facts about how spillover effects are determined. In particular, I find that countries that have similar levels of purchasing power generate more substitutionary effects. Features such as high levels of public capital and country size mitigate the substitutionary spillover effects of tax rate reforms, likely due to the location-specific rents they generate. As one might expect, tax havens generate substantially substitutionary spillovers, likely due to artificial profit shifting. Surprisingly, I find that countries with larger wage differentials appear to generate more substitutionary spillovers.

One key takeaway from this essay is that corporate tax base spillovers operate on a continuum from complementary to substitutionary. There is no clear divide. Multiple theories give varying predictions of how multinational firms' responses might generate corporate tax base spillovers. They all likely hold some measure of importance in determining the final effect on a country's tax base. Therefore the aggregate country-pair spillover is, itself, some weighted average of the various behavioural responses of the multinational firm.

3.A Appendix

Table 3.7: Number of Firms in Each Country by Domestic versus Multinational

Country	Total	Domestic	Multinational
Austria	8206	4517	3689
Belgium	47501	39343	8158
Bulgaria	12047	10949	1098
Czechia	23254	18208	5046
Germany	64805	50658	14147
Denmark	24477	19706	4771
Estonia	5153	3826	1327
Spain	137932	125083	12849
Finland	15714	12797	2917
France	148478	121670	26808
United Kingdom	79979	53226	26753
Greece	11570	10674	896
Croatia	7988	6845	1143
Hungary	16468	14741	1727
Ireland	8034	4739	3295
Italy	218436	203053	15383
Lithuania	3633	2906	727
Luxembourg	6055	3421	2634
Latvia	4056	3268	788
Netherlands	10933	6624	4309
Poland	39206	32226	6980
Portugal	31710	27584	4126
Romania	20106	16575	3531
Sweden	45643	35593	10050
Slovenia	6235	5180	1055
Slovakia	12298	9972	2326

Table 3.8: Corporate Tax Rate Reforms in Europe from 2007 to 2016

Country	Year	Previous Tax Rate	New Tax Rate
Germany	2008	26.38	15.82
Denmark	2014	25.00	24.50
Denmark	2015	24.50	22.00
Estonia	2008	22.00	21.00
Estonia	2015	21.00	20.00
Spain	2008	32.50	30.00
Spain	2015	30.00	28.00
Spain	2016	28.00	25.00
Finland	2012	26.00	24.50
Finland	2014	24.50	20.00
France	2012	34.43	36.10
France	2014	36.10	38.00
United Kingdom	2009	30.00	28.00
United Kingdom	2011	28.00	26.00
United Kingdom	2012	26.00	24.00
United Kingdom	2013	24.00	23.00
United Kingdom	2014	23.00	21.00
United Kingdom	2015	21.00	20.00
Greece	2010	25.00	24.00
Greece	2011	24.00	20.00
Greece	2013	20.00	26.00
Greece	2015	26.00	29.00
Hungary	2010	16.00	19.00
Italy	2008	33.00	27.50
Lithuania	2009	15.00	20.00
Lithuania	2010	20.00	15.00
Luxembourg	2009	29.63	28.59
Luxembourg	2011	28.59	28.80
Luxembourg	2013	28.80	29.22
Netherlands	2011	25.50	25.00
Portugal	2011	25.00	27.50
Portugal	2012	27.50	30.00
Sweden	2009	28.00	26.30
Sweden	2013	26.30	22.00
Slovenia	2008	23.00	22.00
Slovenia	2009	22.00	21.00
Slovenia	2010	21.00	20.00
Slovenia	2012	20.00	18.00
Slovenia	2013	18.00	17.00
Slovakia	2013	19.00	23.00
Slovakia	2014	23.00	22.00

Table 3.9: Unweighted Estimates of Average Corporate Tax Spillovers

	Country	NACE Section	NACE 4-Digit	Size
	(1)	(2)	(3)	(4)
Denmark	1.094***	1.039***	1.136***	1.711***
	(0.253)	(0.254)	(0.254)	(0.259)
Estonia	−0.219	0.081	0.147	0.325
	(0.887)	(0.886)	(0.885)	(0.890)
Finland	0.114	0.440	0.345	0.489
	(0.446)	(0.446)	(0.447)	(0.449)
France	1.328***	1.317***	1.327***	1.659***
	(0.270)	(0.269)	(0.269)	(0.270)
Germany	0.143	0.167	0.127	−0.217
	(0.373)	(0.373)	(0.373)	(0.378)
Greece	−0.186	−0.440	−0.373	−0.053
	(0.492)	(0.493)	(0.493)	(0.497)
Hungary	2.947***	2.777***	2.489***	3.094***
	(0.660)	(0.657)	(0.657)	(0.661)
Italy	2.318***	2.076***	1.967***	1.972***
	(0.412)	(0.411)	(0.411)	(0.412)
Lithuania	−0.522	−0.160	−0.063	0.003
	(0.772)	(0.771)	(0.773)	(0.776)
Luxembourg	−0.972***	−1.096***	−1.175***	−1.007***
	(0.250)	(0.250)	(0.250)	(0.250)
Netherlands	0.826***	0.709**	0.622**	0.689**
	(0.276)	(0.275)	(0.275)	(0.276)
Portugal	2.570***	2.143***	2.097***	2.790***
	(0.438)	(0.437)	(0.437)	(0.440)
Slovakia	1.004**	0.871**	0.926**	1.439***
	(0.436)	(0.435)	(0.434)	(0.438)
Slovenia	2.897***	1.876***	1.779***	1.795***
	(0.669)	(0.668)	(0.669)	(0.671)
Spain	1.215***	0.987***	1.015***	0.832***
	(0.320)	(0.319)	(0.319)	(0.321)
Sweden	1.646***	1.263***	1.141**	1.134**
	(0.485)	(0.484)	(0.484)	(0.486)
United Kingdom	−0.687*	−0.530	−0.444	−1.192***
	(0.354)	(0.353)	(0.352)	(0.354)
Observations	9,646,299	9,646,299	9,646,299	9,646,299
R^2	0.473	0.476	0.479	0.480

Notes: All models include firm fixed effects. Model (1) includes country-year fixed effects. Model (2) includes country-NACE Section-year fixed effects. Model (3) includes country-NACE 4 Digit-year fixed effects, and Model (4) includes country-NACE Section-size-year fixed effects. Observations are unweighted. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3.10: Country-Specific Spillovers Excluding Domestic Firms

	Country	NACE Section	NACE 4-Digit	Size
	(1)	(2)	(3)	(4)
Denmark	0.711**	0.814***	0.829***	1.027***
	(0.282)	(0.284)	(0.287)	(0.291)
Estonia	−0.436	−0.123	0.044	0.231
	(0.906)	(0.909)	(0.913)	(0.921)
Finland	−0.019	0.308	0.286	0.269
	(0.463)	(0.466)	(0.470)	(0.473)
France	0.739***	0.757***	0.820***	0.766***
	(0.279)	(0.280)	(0.280)	(0.283)
Germany	−0.526	−0.456	−0.507	−0.442
	(0.404)	(0.403)	(0.407)	(0.412)
Greece	0.282	0.082	0.079	0.010
	(0.501)	(0.503)	(0.509)	(0.513)
Hungary	1.491**	1.625**	1.543**	1.751**
	(0.671)	(0.670)	(0.675)	(0.682)
Italy	0.383	0.177	0.039	0.113
	(0.428)	(0.427)	(0.430)	(0.434)
Lithuania	−0.362	−0.057	0.270	0.256
	(0.786)	(0.788)	(0.803)	(0.805)
Luxembourg	−0.976***	−0.996***	−0.853***	−0.953***
	(0.252)	(0.254)	(0.258)	(0.258)
Netherlands	0.893***	0.779***	0.682**	0.803***
	(0.280)	(0.280)	(0.283)	(0.285)
Portugal	0.463	0.447	0.426	0.498
	(0.455)	(0.457)	(0.461)	(0.465)
Slovakia	−0.211	0.105	0.229	0.193
	(0.455)	(0.456)	(0.461)	(0.466)
Slovenia	2.623***	2.091***	2.112***	1.992***
	(0.685)	(0.687)	(0.694)	(0.700)
Spain	1.170***	1.066***	1.141***	1.061***
	(0.337)	(0.337)	(0.339)	(0.341)
Sweden	1.669***	1.401***	1.191**	1.389***
	(0.508)	(0.509)	(0.516)	(0.518)
United Kingdom	0.231	0.001	0.158	−0.072
	(0.372)	(0.372)	(0.374)	(0.377)
Observations	1,324,428	1,324,428	1,324,428	1,324,428
R^2	0.505	0.509	0.517	0.521

Notes: This table re-estimates the main results for country-specific spillovers excluding domestic firms. This means that only multinational firms with no affiliate in country i serve as the control units used to create counterfactual outcomes. No reweighting is done. All models include firm fixed effects. Model (1) includes country-year fixed effects. Model (2) includes country-NACE Section-year fixed effects. Model (3) includes country-NACE 4 Digit-year fixed effects, and Model (4) includes country-NACE Section-size-year fixed effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3.11: Country-Specific Spillovers Using Natural Log of Profits

	Country	NACE Section	NACE 4-Digit	Size
	(1)	(2)	(3)	(4)
Denmark	−0.009	−0.024	−0.021	0.013
	(0.037)	(0.037)	(0.038)	(0.040)
Estonia	0.098	0.180	0.210*	0.145
	(0.118)	(0.119)	(0.121)	(0.122)
Finland	0.194***	0.234***	0.193***	0.196***
	(0.062)	(0.062)	(0.063)	(0.063)
France	0.169***	0.178***	0.166***	0.206***
	(0.039)	(0.039)	(0.039)	(0.039)
Germany	0.079	0.065	0.070	0.080
	(0.053)	(0.053)	(0.054)	(0.055)
Greece	−0.206***	−0.222***	−0.204***	−0.190***
	(0.064)	(0.065)	(0.065)	(0.066)
Hungary	0.281***	0.336***	0.319***	0.388***
	(0.092)	(0.092)	(0.092)	(0.094)
Italy	0.416***	0.400***	0.401***	0.387***
	(0.057)	(0.057)	(0.057)	(0.058)
Lithuania	0.020	0.044	−0.000	0.095
	(0.110)	(0.111)	(0.113)	(0.116)
Luxembourg	−0.060*	−0.075**	−0.093***	−0.071**
	(0.035)	(0.035)	(0.035)	(0.035)
Netherlands	0.088**	0.055	0.043	0.044
	(0.040)	(0.041)	(0.040)	(0.040)
Portugal	0.176***	0.179***	0.145**	0.206***
	(0.064)	(0.065)	(0.065)	(0.066)
Slovakia	0.128**	0.154**	0.163***	0.155**
	(0.061)	(0.061)	(0.061)	(0.062)
Slovenia	0.455***	0.359***	0.319***	0.322***
	(0.087)	(0.088)	(0.088)	(0.089)
Spain	0.287***	0.267***	0.262***	0.236***
	(0.045)	(0.045)	(0.045)	(0.046)
Sweden	0.382***	0.344***	0.313***	0.312***
	(0.070)	(0.070)	(0.070)	(0.071)
United Kingdom	0.219***	0.179***	0.201***	0.130**
	(0.052)	(0.052)	(0.052)	(0.053)
Observations	7,306,857	7,306,857	7,306,857	7,306,857
R^2	0.813	0.815	0.819	0.819

Notes: This table uses the natural log of profits as the dependent variable. This reduces the number of observations available. All models include firm fixed effects and year effects interacted with country, country-industry, or country-industry-size. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3.12: Corporate Tax Spillovers for Manufacturing Multinationals

	Section (letter)	Division (2-digit)	Class (4-digit)
	(1)	(2)	(3)
Denmark	−0.950	−0.610	−0.793
	(0.874)	(0.863)	(0.885)
Estonia	1.473	2.912	1.393
	(2.823)	(2.913)	(2.874)
Finland	0.095	0.343	−0.025
	(1.587)	(1.381)	(1.639)
France	2.461***	1.829**	2.436***
	(0.803)	(0.819)	(0.817)
Germany	−0.586	−0.228	−0.693
	(1.053)	(1.053)	(1.070)
Greece	−0.126	0.999	−0.009
	(2.204)	(2.273)	(2.293)
Hungary	5.280***	4.698**	4.888**
	(1.968)	(1.961)	(1.958)
Italy	2.047*	1.858	1.984*
	(1.129)	(1.162)	(1.151)
Lithuania	−5.343	−4.354	−6.047*
	(3.255)	(3.355)	(3.352)
Luxembourg	−1.824	−1.032	−1.784
	(1.492)	(1.501)	(1.524)
Netherlands	−0.461	−0.476	−0.297
	(0.847)	(0.817)	(0.820)
Portugal	9.122***	7.613***	9.153***
	(1.752)	(1.781)	(1.803)
Slovakia	3.824***	4.146***	3.799**
	(1.462)	(1.489)	(1.475)
Slovenia	−3.849	−5.180	−4.184
	(3.651)	(3.718)	(3.711)
Spain	−1.012	−0.365	−1.040
	(0.958)	(0.971)	(0.979)
Sweden	−1.692	−2.028	−1.205
	(1.723)	(1.675)	(1.688)
United Kingdom	−2.097**	−1.593	−2.120**
	(1.040)	(1.049)	(1.072)
Observations	1,819,604	1,819,604	1,819,604
R^2	0.468	0.495	0.477

Notes: All models include firm fixed effects. Model (1) includes country-year fixed effects. Model (2) includes country-NACE 4 Digit-year fixed effects, and Model (3) includes country-size-year fixed effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Manufacturing firms are those operating in Section C of the NACE Classification. Standard errors in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3.13: Estimates by Firm Size

	Quantile 1	Quantile 2	Quantile 3	Quantile 4	Quantile 5
	(1)	(2)	(3)	(4)	(5)
Denmark	1.880***	2.419***	1.176**	1.211**	1.526**
	(0.629)	(0.578)	(0.575)	(0.568)	(0.610)
Estonia	−0.967	−0.370	1.100	−0.002	1.182
	(2.521)	(2.097)	(1.959)	(1.979)	(1.698)
Finland	1.107	−0.190	−0.340	1.188	0.222
	(1.081)	(1.036)	(0.987)	(0.956)	(0.977)
France	1.134*	2.606***	1.046*	1.402**	1.757**
	(0.581)	(0.572)	(0.585)	(0.611)	(0.693)
Germany	−0.129	−1.903**	−0.475	0.048	−0.708
	(0.871)	(0.806)	(0.823)	(0.852)	(0.935)
Greece	−2.115*	2.401*	0.780	−1.502	−0.775
	(1.281)	(1.228)	(1.099)	(1.036)	(0.995)
Hungary	3.603**	2.439	0.503	4.979***	3.834***
	(1.647)	(1.584)	(1.507)	(1.369)	(1.356)
Italy	4.007***	1.336	1.108	0.093	0.859
	(1.005)	(0.903)	(0.886)	(0.901)	(0.978)
Lithuania	−2.452	−0.704	0.811	2.110	−0.239
	(2.178)	(1.807)	(1.847)	(1.717)	(1.623)
Luxembourg	−1.535**	−2.383***	−0.988*	−0.410	−0.813
	(0.624)	(0.566)	(0.545)	(0.544)	(0.518)
Netherlands	0.112	0.567	0.997*	0.551	1.257**
	(0.711)	(0.634)	(0.601)	(0.587)	(0.592)
Portugal	1.283	3.776***	2.117**	2.441**	1.011
	(1.100)	(0.999)	(0.981)	(0.962)	(0.958)
Slovakia	1.631	0.405	2.102**	0.944	1.740*
	(1.141)	(1.010)	(0.977)	(0.937)	(0.896)
Slovenia	1.355	0.433	2.922*	−0.650	3.658***
	(1.795)	(1.636)	(1.604)	(1.465)	(1.268)
Spain	2.711***	1.543**	0.424	0.031	0.095
	(0.737)	(0.704)	(0.677)	(0.714)	(0.797)
Sweden	1.016	1.081	1.404	2.681**	0.253
	(1.197)	(1.057)	(1.091)	(1.047)	(1.091)
United Kingdom	0.584	−0.341	−0.783	−2.171***	−3.043***
	(0.791)	(0.733)	(0.770)	(0.821)	(0.918)
Observations	4,510,081	2,252,751	1,377,322	854,232	509,259
R^2	0.469	0.500	0.514	0.522	0.517

Notes: This table splits the firms into five quantiles based on total asset size. The model is estimated separately to see if there is substantial heterogeneity of spillover across size groups. All models include firm fixed effects and country-industry-year fixed effects. Standard errors are in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3.14: Number of Observations per Country-Pair

	DK	EE	FI	FR	DE	GR	HU	IT	LT	LU	NL	PT	SK	SI	ES	SE	GB
AT	3642	1857	4482	9568	12906	4109	8061	11855	1648	3367	5118	5855	9343	5590	9192	7913	9754
BE	10097	6448	14345	46489	31808	9962	16523	33338	4477	16481	21560	20055	15520	7055	32191	23898	35459
BG	1241	1107	1951	3394	3477	2126	2758	3969	1064	1007	1705	2093	2657	1847	3215	2558	3463
CZ	5434	4563	8559	18834	21159	5918	14485	19563	3458	5967	9477	10268	21889	6921	17563	14042	18442
DE	13065	7791	20637	50282	0	14377	26192	51377	6443	16103	27972	26408	21930	10773	46235	36085	49703
DK	0	2853	7395	7986	8350	2402	3915	7357	1961	2090	4744	4156	3487	2166	7155	12229	9665
EE	1422	0	4375	2489	2524	851	1623	2263	3996	529	1247	1518	1633	914	2229	4439	2764
ES	10709	7098	17534	57761	42814	17076	22594	55855	5024	13395	22492	52054	21193	10019	0	29804	50204
FI	6395	8189	0	9960	10486	3104	5288	9021	3885	2286	5328	5312	4654	2431	9083	18229	11391
FR	32128	25238	49303	0	112814	48992	69603	132456	31258	65298	68267	87716	67243	38274	138847	83601	129941
GB	31930	17906	45716	108321	91587	30453	45407	93699	11108	33606	56323	51647	38236	18289	93322	73664	0
GR	1463	1194	2764	4837	4397	0	2922	4763	873	1456	2623	3441	2482	1701	4567	3631	5034
HR	1197	1092	1906	3466	3670	1705	3484	4624	851	1019	1825	2382	3482	4501	3668	2715	3456
HU	3012	2334	4812	9328	9566	3637	0	9871	1526	2959	5078	5849	7507	3929	8740	7509	9442
IE	3833	2701	5553	11040	9060	4129	5455	9157	1377	4182	6498	6317	4787	1909	9172	8483	16258
IT	13825	7085	20192	69417	50603	18816	26989	0	5212	20260	24038	33420	24399	12785	61914	36250	60154
LT	888	2845	1769	1612	1674	606	1057	1557	0	410	806	1015	1093	622	1426	2113	1690
LU	1666	799	2218	7130	5953	1507	2647	6061	602	0	3106	3231	2623	854	5574	4081	6450
LV	1200	4257	2209	1941	2050	920	1414	2022	2967	484	1068	1328	1450	903	1793	2822	2206
NL	4766	2463	6759	15252	15274	5393	7412	14079	1457	4541	0	7481	5927	3347	13493	10890	16530
PL	7929	6179	11594	26337	29452	7910	15477	25660	5724	7894	15000	14113	17697	6754	25024	19850	25025
PT	3542	2494	5971	17929	12586	6730	8330	15657	1837	4164	8058	0	6193	3299	25583	8848	14507
RO	3569	2658	5226	13135	12353	4956	9277	14991	2040	3796	6106	7355	9144	4385	11967	8259	12004
SE	23326	16747	38817	31588	31641	6941	14685	27120	8789	6903	16492	14038	11945	6335	26039	0	36985
SI	1047	962	1668	2951	3653	1510	2647	3765	714	721	1589	1944	2840	0	2893	2344	2979
SK	2732	2308	3972	7910	8190	2867	6728	8454	1855	2540	4334	4903	0	3650	7419	6048	7692

Chapter 4

Optimal Benefit-Based Corporate Income Tax

4.1 Introduction

The view that 'corporations must pay their fair share' dominates public opinion. In 2017, Americans' biggest complaint about the federal tax system was the feeling that some corporations do not pay their fair share of tax. Sixty-two percent of respondents said they were bothered 'a lot' by corporations who did not pay their fair share (Pew Research Center, 2017a). In 2018, only 26 percent of Americans believed that corporations paid their fair share of tax. Sixty-two percent felt that corporations paid too little tax (Gallup, 2018). Fifty-nine percent of Americans felt that corporations made too much profit (Pew Research Center, 2017b). Even the Organisation for Economic Co-operation and Development (OECD) and the G20's combined Base Erosion and Profit Shifting Project justifies its existence on the grounds that multinational firms "avoid paying their fair share" through artificial profit shifting (OECD, 2019).

But what is anyone's fair share of tax? For example, Datt (2014) says the Australian Taxation Office's call for corporations to pay a 'fair share of tax' is not an objective calculation of tax liability. Is there any way for us to convert the idea of a 'fair share' into a formal guideline for tax liability? The concern is not that

a 'fair share' is not a good fundamental principle. The concern is that it implies no formal guideline for the calculation of tax liability.

To be useful, guidelines for the optimal taxation of corporations must be rooted in a purpose. Weisbach (2015) says:

> The basic point is that we cannot know what the optimal pattern of international capital income taxation should be without understanding the reasons for taxing capital income in the first place... To understand the design of firm-level taxation, however, we need to know why we are taxing firms.

To be able to define the purpose for taxing corporations, we first have to ask: *'why does the corporate tax exist?'*

In academia, the dominant view of the corporate tax is that it serves an administrative purpose (for example, see the OECD 2001 and Mirrlees et al. 2011). The administrative view encompasses three arguments. The first is that the corporate income tax exists to prevent individuals from incorporating themselves to avoid personal taxation. The second is that the corporate income tax exists to prevent firms from hoarding profits to avoid dividend taxation. The third is that it is easier to tax a firm's profits rather than to tax individual shareholders. According to the administrative view, the corporate tax exists to support taxes on individuals.

I propose an alternative **benefit-based** view: *firms should contribute to the provision of the public input according to the benefits they receive from the use of the public input.* The corporate income tax should exist for firms to contribute to public input provision. This is an application of the classical principle of benefit-based taxation to corporations (Weinzierl, 2018a). I will refer to this simply as benefit-based taxation. This benefit-based view of corporate taxation justifies and is supported by the widespread norm that firms should pay tax where the relevant economic activity takes place (OECD, 2013; Pogge and Mehta, 2016a). Similarly, the IMF (2019) suggests that the only widely-accepted principle of inter-nation equity is that governments should have taxing rights over location-specific rents that arise in their country. Since the public input creates a location-specific rent,

Musgrave and Musgrave (1972) conclude that the benefit principle automatically satisfies the notion of inter-nation equity. The benefit-based view of corporate taxation is supported by our widely-held norms of corporate taxation.

I model the benefits of public spending by putting a non-excludable non-rival productive public good in the firm's production function. I refer to this productive public good as the public input. To identify an optimal benefit-based corporate tax rate, I use the Lindahl (1919) method of solving the cost-sharing problem. I modify the Lindahl (1919) thought experiment to account for the distortionary nature of the corporate tax by supposing that the government chooses the public input and the corporate tax separately for each firm type. I draw heavily from Weinzierl (2018b), who integrates the Lindahl (1919) thought experiment into modern tax theory under the case of non-distorting labour income taxation.

I derive a simple optimal benefit-based corporate tax rate formula:

$$t^* = \frac{e^G}{1 + e^T}.$$

The formula is a function of two estimable elasticities: the elasticity of profits with respect to the (net of) tax rate (e^T), and the elasticity of profits with respect to the public input (e^G). While the tax elasticity accounts for the distortionary effects of corporate taxation, the public input elasticity captures the benefits generated by the public input. This optimal tax formula integrates the benefit view with more popular efficiency concerns.

I apply the benefit-based optimal tax formula to the United States. Using Compustat data, I estimate the necessary elasticities for public corporations, which tend to be the largest and most visible corporations. The preferred estimate of the public input elasticity is 0.653, and of the tax elasticity is 0.427. These estimates imply the optimal benefit-based corporate income tax rate is $t^* = 0.653/(1 + 0.653 \times 0.427) = 46$ percent for United States public corporations. This exceeds both the new and the old United States corporate tax rates of 21 percent and 35 percent respectively. It suggests that the Tax Cuts and Jobs Act of 2017 moves the tax rate in the opposite direction of what an optimal benefit based tax on public corporations would suggest. A full range of estimates suggest that the optimal benefit-based tax lies in the range of 35 to 59 percent.

The benefit principle gives three guidelines for designing the international corporate tax system. The first guideline is that corporate taxation should follow the source principle so that governments can tax the returns to their own public inputs. The second guideline is the tax base should be narrowed to economic rents so as to target returns to the public input. This implies we should distort other factors of production as little as possible. The third guideline is that profit shifting is unfair. Despite the efficiency-enhancing nature of profit shifting, it allows firms to evade their contribution to providing the public input.

This paper does not attempt to impute the benefit principle as the reason why the corporate income tax was first implemented. Zucman (2014) already points out that its original purpose when introduced across the world shortly after the first World War was to stop shareholders from hoarding profits within the firm and to stop individuals from incorporating themselves. That is, the corporate tax is originally a backstop to the personal income tax. Instead, I propose that the corporate income tax's most fundamental economic use is as a benefit-based tax. I also do not propose a full package of policies, but instead a series of principles that should serve as the normative foundation for detailed policy work on how to implement the benefit-based corporate income tax. The benefit principle serves as the guiding light for answering difficult policy questions such as: "how should digital companies be taxed?" The approach is not the standard approach either, since it does not focus on maximising a social welfare function as modern public economics demands. The use of the Lindahl (1919) method achieves the desired solution, but the method used to achieve that solution does not wholly replicate or describe reality as most economic models seek to do.

In the following section, I present the case for benefit-based taxation as the fundamental principle of corporate taxation. In Section 4.3, I formalise these insights to derive an optimal benefit-based corporate tax formula. I then apply this model to the case of the United States in Section 4.4. In Section 4.5, I describe the policy insights that can be gained from applying the benefit principle to the corporate income tax.

4.2 The Case for Benefit-Based Corporate Taxation

There is no clear consensus on why the corporate income tax exists. Even in canonical public economics texts there is a great deal of vagueness on the purpose of the corporate tax. For example, Kaplow (2011) and Myles (1995) find it difficult to rationalise the tax's existence. And while Atkinson and Stiglitz (1980) tries to examine the validity of some of the beliefs behind the various justifications of the corporate income tax, none of these authors provide a convincing explanation.

Bird (1996) collects a number of potential economic justifications for the corporate income tax's existence. He concludes that none of the justifications he uncovers are particularly strong. But the combination of these justifications is enough for him to recommend that the corporate tax should exist. He separates these justifications into three categories. First, because the corporate tax is desirable. Second, because it is necessary to achieve some objectives. Third, because it is convenient.

Avi-Yonah (2004) advances the view that the corporate income tax is justified as a means to control the excessive accumulation of power in the hands of corporate management. He describes power as the ability to influence behaviour or the ability to get what one wants. This power arises as the result of financial power at the disposal of the firm. Excessive financial power likely arises through excess profits, which are themselves the result of uncompensated factors of production. The most obvious use of such financial power is in the political sphere as examined by Mikler (2018), but a firm's economic size may give it power in economic interactions too. Avi-Yonah (2004) therefore suggests that the aim of the corporate tax is the redistribution of power in society. However, in the limit, this rationale for the corporate income tax's existence would imply that society is better off *even if the tax revenue is thrown into the sea*. The corporate power argument, therefore, provides no fundamental economic purpose for the existence of the corporate tax.

I propose a fundamental economic purpose for the corporate income tax. I argue that the corporate income tax *should exist* as a benefit-based tax. The case for benefit-based taxation is built on two arguments. First, I argue that benefit-

based taxation is fair. Second, I argue that benefit-based taxation is feasible. I now present logical evidence in support of these arguments.

4.2.1 Benefits-Based Taxation as Normatively Fair

Benefits-based taxation has root in Adam Smith's (1776) first maxim of taxation: "The subjects of every state ought to contribute towards the support of the government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state." This maxim reflects Smith's normative perspective on how firms should be taxed. Ideally, he says, tax liability should be linked to the revenue a firm derives from the state's public services. This is the foundation of benefit-based taxation.

Benefit-based taxation of corporations leads to a quite natural conclusion: *firms should pay tax where profit-generating production takes place.* Graetz (2000) says:

> The services a nation provides may contribute substantially to the ability of both residents and foreigners to earn income there. Taxing that income is one way for the source country to be compensated for its expenditures on the services it provides. One need not thoroughly embrace the benefit theory of taxation—the idea that the expenses of government should be paid by those who benefit in proportion to the benefits they receive—which is fraught with difficult problems of measurement and allocation, to recognize a country's legitimate claim to tax income produced within its borders.

In fact, the legitimacy of a country's claim to tax income generated within its borders is a principle on which we are in widespread agreement. The essays in Pogge and Mehta (2016a) collectively demand that tax liability should arise where the income-generating economic activity takes place. This principle is also the fundamental driving force behind the OECD's Base Erosion and Profit Shifting (BEPS) project. Weinzierl (2018a) reverse-engineers these views, point-

ing out that this principle is a natural implication of the benefit principle of taxation. Further, the benefit principle provides a normative foundation for this broad notion of inter-nation fairness. Under benefit taxation, the multinational firm pays tax where its income-generating economic activity takes place because that activity is supported and made possible by the government where that activity takes place.

This principle is effectively a statement of **inter-nation equity**. Inter-nation equity concerns the allocation of national gains and losses in an international context, aiming to ensure that each country is allocated an equitable share of the tax revenues that arise from international or cross-border activity of corporations (OECD, 2014). In practical terms, it discusses who should have the ability to tax a multinational's profits—the source, residence, or destination country. Kaufman (1997) says that "fairness exists in the international tax system only when states distribute among themselves the competence to tax in a way that conforms to prevailing views of justice internationally."

The notion of inter-nation equity was developed by Musgrave and Musgrave (1972), and their original conclusion is striking: "Inter-nation equity under the benefit principle would be self-implementing." That is, a benefit-based corporate tax would automatically achieve inter-nation equity. According to Musgrave and Musgrave (1972), the benefit idea would be an ideal manner to allocate gains among countries by entitling each country to charge for the cost of public services rendered to the firm. This perspective of inter-nation equity is echoed by the IMF (2019). The IMF (2019) report says while that there is little agreement on standards of inter-nation equity, there is one principle of inter-nation equity on which we broadly agree: that taxing rights of location-specific rents should be allocated to the jurisdiction in which they arise.

From the perspective of within-country equity, benefit-based corporate taxation complies with the **just deserts principle** proposed by Mankiw (2010). The just deserts principle simply says "people should get what they deserve", implying no desire for redistribution from rich to poor. What does a firm deserve? The firm does not 'deserve' to receive returns to the public input. Instead, the returns to the public input should accrue to the public input's owner: the government. And even if the government does not want these rents, the firm still has no legit-

imate claim that it 'deserves' these returns. The corporate income tax is the only means of fairly allocating their 'just deserts' between firm and government.

Unlike the administrative view of corporate taxation, benefit-based taxation does not need to invoke the need for redistribution of income across households. Instead, benefit-based taxation justifies the firm as the unit of taxation since it is the firm that uses the public input to produce, and it is the firm that receives the benefits of the public input. Because the benefits of the public input are generated at the firm level, then these benefits should be taxed at the firm level. Using the firm as the unit of taxation gives us a clear framework to determine what a firm's 'fair share' of tax is.

Support for benefit-based taxation is widespread. Between 62 and 79 percent of American survey respondents prefer benefit-based taxation to conventional optimal tax logic based on the diminishing marginal social welfare of income (Weinzierl, 2017). Why is the benefit principle's popularity of relevance? Diamond and Saez (2011) provide the answer: optimal tax policy should be socially acceptable and should not violate widely-held normative views.

The main economic arguments against the corporate tax as a benefit tax are positive rather than normative. For example, Weichenrieder (2005) does not argue that the benefit principle is invalid, but rather that the existing corporate tax system is an imperfect way to achieve the aims of the benefit principle. De Mooij (2005) makes a similar claim: since there exists a weak relationship between the taxes paid by a company and the benefits the company receives from public services, then the existing corporate income tax does not comply with the benefit principle. These are valid arguments against the *existing* corporate tax as a benefit tax. However, they do not invalidate the central thesis of this essay: *the corporate income tax should be a benefit-based tax.*

Fairness and equity should be a fundamental concern of the corporate income tax. Cui (2016) concludes that "theories that do not take into account distributional consequences and focus only on efficiency concerns are unlikely to be accepted as setting out adequate normative criteria for international taxation." And optimal international corporate tax system must be based both on the fairness and efficiency of the proposed tax.

4.2.2 The Ability to Tax Returns to Public Inputs

The seminal work of Gordon (1986) suggests that a small open economy cannot impose a tax on multinational firms. Gordon (1986) assumes an infinite elasticity of capital with respect to tax; even a small corporate income tax would cause all capital to disappear. The assumption of an infinite elasticity of capital requires the absence of location-specific rents. Any modern re-statement of Gordon's findings includes the qualification that a small open economy cannot impose a tax on multinational firms *if there are no location-specific rents* (Griffith et al., 2010). The obvious implication is that the existence of location-specific rents provides an opportunity for a small open economy to impose a non-zero corporate tax.

Huizinga and Nielsen (1997) then consider optimal corporate taxation in the presence of location-specific rents. Full taxation of location-specific rents becomes optimal. A tax on location-specific rents is not distortionary because the factors generating location-specific rents are immobile. However, if there is an upper limit on the tax rate on location-specific rents, the use of a distortionary tax on capital income becomes warranted. Similarly, if a government is forced to tax capital and rents at the same rate, it might be forced to impose a non-zero tax on capital. In reality, a government might be forced to tax them both at the same rate because it cannot distinguish between returns to capital and rents (Auerbach and Devereux, 2018). In the same manner, Keen and Piekkola (1997) find that if profits arising from location-specific rents are not taxed, then taxing returns to capital becomes optimal. In fact, McKeehan and Zodrow (2017) suggest that the main reason corporate income taxes have not simply converged to zero is the existence of location-specific rents. Therefore, location-specific rents give government the *ability* to impose positive corporate income taxes.

What exactly are these location-specific rents that give the government the ability to impose corporate taxes? First, the concept of Paretian rent, defined by Wessel (1967) is *"the excess earnings over the amount necessary to keep the factor in its present occupation."* Pure profits arising from a decreasing returns to scale production function suggests that there are some unobservable factors of production at work. Since it should always be possible to perfectly replicate production by replicating all rival factors, then decreasing returns to scale in observable factors must reflect the scarcity of (or normal returns to) an underlying unlisted factor of

production. The popular microeconomic theory text by Mas-Colell et al. (1995) provides a proof for the proposition that any decreasing returns to scale production function can be represented by a constant returns to scale production function with implicit fixed inputs (page 134, Proposition 5.B.2).

If economic rents can be attributed to underlying factors of production, these factors can then be broadly divided into two categories: firm-specific factors or location-specific factors. That is, the factors generating economic profits must belong either to the firm or to the country in which production takes place. The most common example of an unobserved firm-specific asset is entrepreneurial inputs. Such firm-specific rents are considered to be highly mobile and subject to flight as described by Mirrlees et al. (2011). Firm-specific assets are a key element of the theory of the multinational firm, as described by Dunning (1988) in terms of specialized and patented technological knowledge, superior managerial skills or production techniques, or valuable product brands, trademarks, reputations, and other intangible assets (McKeehan and Zodrow, 2017).

Locations-specific rents appear in various forms such as returns to immobile natural resources, agglomeration rents due to industrial concentration (Baldwin and Krugman, 2004), country-size rents due to savings on aggregate transportation costs (Haufler and Wooton, 1999), or more traditional imperfectly competitive domestic markets. A salient example of location-specific assets is natural resources. The Handbook of National Accounting (UN and FAO, 2005) describes economic rents of a natural resource as the value of capital services flows rendered by a natural resource, or their share in gross operating surplus. Mirrlees et al. (2011) list a couple more possible sources of location-specific rents: the presence of workers not reflected in labour costs, or proximity to large markets not reflected in the cost of land. The latter is most easily thought of in the context of agglomeration rents, a topic that is central to the New Economic Geography literature. Koh et al. (2013) find that, within the context of German municipalities, greater agglomeration effects increase a municipality's tax rate. One might also think of location-specific rents being the result of government regulation.

More importantly, the public input is a key source of location-specific rents. **The public input** is defined as a productive public good that the firm uses in its production process. Empirically, the public input is represented as public

capital generating a flow of public services. Aschauer (1989) argues that public inputs are very important to the production process. The need for public goods and services arise when private agents are unwilling or unable to provide them. This might happen if private agents cannot charge a user fee for these goods, neither can they exclude agents from using the public good. It might also happen when the provision of a good requires economies of scale so large that only a government is willing to undertake provision. The body of empirical literature following Aschauer (1989) finds economically significant elasticities output with respect to public capital across a range of countries (Bom and Ligthart, 2014b). Most importantly, however, is the case where location-specific rents are the result of an uncompensated public input. Most easily, one can think of the abundance of public capital. Recent work by Karabarbounis and Neiman (2018) suggests that to account for economic profits as income to unmeasured capital in the US, the value of unmeasured capital would need to be approximately 30 percent of total private capital. It is not surprising then that according to the International Monetary Fund's Investment and Capital Stock Dataset (2015), the size of public capital was 53 percent of private capital in the US from 1970 to 2015.

The public input is an important location-specific factor of production. The location-specific rents generated by the public input allows governments the *ability* to impose a positive corporate income tax. This ability to tax exists even in a small open economy where optimal corporate tax rates are traditionally thought to be zero. A benefit-based corporate income tax that links a firm's tax liability to its returns generated by the public input is not only fair, but also feasible.

4.3 A Model of Benefit-Based Corporate Taxation

I apply the Lindahl (1919) approach to classical benefit-based taxation to the corporate income tax. I extend the Lindahl thought experiment laid out in Weinzierl (2018b) to incorporate a distortionary corporate tax instrument. To do so, I consider a thought experiment where the government chooses each firm's optimal level of public input provision and corporate tax rate individually. This differs to the standard Lindahl thought experiment where firms would choose their own

optimal level of public input provision, and no distortionary tax exists.

4.3.1 Setup

There are I firm types and each firm type is indexed by i. To simplify the presentation of the model, I restrict attention to a single country. A firm of type i has a profit function $\pi_i(k_i, G)$ which is a function of private capital (k_i) and the public input (G). Each firm type is endowed with financial capital K_i which it can either invest in production or in an outside option. Investing in production generates profits through the profit function $\pi_i(k_i, G)$ while investing in the outside option offers a fixed return of return r.

For simplicity, I assume firms are price takers and there is no strategic interaction. Note that profits described here are not economic profits. Instead, they are the sum of the returns to equity capital and the returns to the public input. This definition of profits matches the common definition of corporate profits in the real world. I also normalise prices to unity.

The firm chooses k_i to maximises total income Π—the sum of profit and returns from the outside option. Each firm type i faces an ad valorem tax on its profits of t_i. The firm takes both the tax rate and the amount of the public input provided as given. This is the standard approach in tax theory, but it diverges from the traditional Lindahl thought experiment since firms do not choose the level of public input themselves. Firm type i's problem is:

$$\max_{k_i} \quad \Pi = (1 - t_i)\pi_i(k_i, G) + r(K_i - k_i). \tag{4.1}$$

Firm type i's first-order condition of the maximization problem with respect to k_i is given by:

$$(1 - t_i)\frac{\partial \pi_i(k_i, G)}{\partial k_i} - r = 0. \tag{4.2}$$

Intuitively, Equation 4.2 says that the firm uses capital in production up to the point where marginal after-tax profit is equal to the fixed return on the outside option. The outside option is the opportunity cost of investing in productive economic activity. I use the outside option to include any alternative uses of financial capital or behavioural responses a firm might have. This includes shift-

ing from equity to debt, profit shifting, shifting the geographical location of productive activity, or even shifting to passive investment classes outside of the firm. The firm can be considered to be either a domestic or a multinational firm without altering the setup of the model.

Distorting Corporate Tax The firm's first-order condition in Equation 4.2 implies that the firm's optimal choice of capital—and therefore its maximized profits—depend on the tax rate. How? Using the first-order condition, the implicit differential of k_i with respect to the net-of-tax rate $(1-t_i)$ is

$$\frac{dk_i}{d(1-t_i)} = \frac{-\partial\pi_i(k_i,G)/\partial k_i}{(1-t_i)\partial^2\pi_i(k_i,G)/\partial k_i^2} \neq 0. \tag{4.3}$$

Consequently, the effect of a change in the net of tax rate on profits is also non-zero, given by:

$$\frac{d\pi(k_i,G)}{d(1-t_i)} = \frac{\partial\pi_i(k_i,G)}{\partial k_i}\frac{dk_i}{d(1-t_i)} \neq 0. \tag{4.4}$$

A change in the net-of-tax rate invokes a change in the firm's optimal value of k_i. Standard restrictions on the profit function so that $\partial\pi_i(k_i,G)/\partial k_i > 0$ and $\partial^2\pi_i(k_i,G)/\partial k_i^2 < 0$ would imply that increasing the tax rate leads to a decrease in profit. More importantly in this simple setup, I show that the corporate income tax distorts the firm's choice of profits.

4.3.2 Optimal Corporate Tax

Lindahl (1919) devised a means for two parties to determine 'by free agreement' how much of a common good they would purchase. Lindahl's solution was based on the idea that either party would want the group to purchase less of the common good if they have to cover a larger share of the cost. If each party must cover half the cost of the common good but their valuations of the common good are different, then they will not agree on how much to purchase. Lindahl's solution is simple: increase the share of the cost covered by the party with a higher valuation of the common good. The high-valuation party now thinks the group should purchase less of the common good since they bear a greater portion of the burden. Meanwhile, the low-valuation party now thinks the group should

purchase more. Lindahl suggests adjusting the share each party contributes until they agree on exactly how much of the common good should be purchased.

While Lindahl's solution is by no means the only proposition for how best to enforce benefit-based taxation, it is intuitive. Weinzierl (2018b) integrates Lindahl's approach into optimal tax theory by making the assumption that an individual's income is a function of the public good. I extend the Lindahl (1919) solution to the optimal corporate income tax.

The existing Lindahl (1919) method unrealistically assumes a non-distortionary tax instrument. But since Pigou (1947) we recognise that using distortionary tax instruments generates an additional cost to raising funds for provision of the public good (Stiglitz and Dasgupta, 1971; Atkinson and Stern, 1974). I use the term 'distortion' in the original sense of Atkinson and Stern (1974) as the excess burden the corporate income tax on profits generates compared to the alternative of lump-sum taxation (Browning and Liu, 1998). This distortion is created by the firm's behavioural responses to taxation, which we know to be empirically relevant (de Mooij and Ederveen, 2008; Devereux et al., 2014; Bachas and Soto, 2018; Seegert et al., 2018).

To find an implementable and realistic application of the benefit principle, I modify the traditional Lindahl approach. I introduce a Modified Lindahl Approach that adds the distortionary character of the corporate income tax to Lindahl's solution for provision of a public input.

Definition 4.1. Modified Lindahl Approach: *The Modified Lindahl Approach is a thought experiment where the government chooses the optimal level of public input provision g_i and the optimal tax on profits t_i for each firm type individually. The government is constrained by the condition*:

$$t_i \pi_i(k_i, g_i) - \tau_i g_i = 0 \tag{4.5}$$

so that the amount of tax paid by the firm must be equal to a fixed share τ_i of the cost of the provision of the public input g_i.

The Lindahl approach uses a firm-specific choice of public input g_i rather than the single aggregate value G that holds in reality. This firm-specific public

input is a key mechanism in Lindahl's solution. The original Lindahl (1919) approach would ask: what if each individual firm could choose its optimal level of public input provision? Instead the modified approach asks: what if the government chose the optimal level of public input provision for each firm separately? The modified thought experiment incorporates the existence of a distortionary corporate tax. Moving the choice of g_i outside the firm means the firm does not internalise the link between the tax it pays and public input provision. The firm is separately aware that it pays tax and that it uses a public input, but it does not recognise that higher taxes imply higher public input provision. If a firm internalises the effect of a higher tax rate on public input provision then the corporate tax would not be distorting.

Maximising Profits I assume that the government's aim in setting tax rates and choosing the public input is to maximise the value of the firm's profits. The firm's domestic profits are derived from domestic production. I use the firm's outside option to describe any alternative use of the firm's financial capital endowment. In the broader scheme, this might include activities that the government does not mind. However, this essay is narrowly focused on the question of the optimal corporate tax system and abstracts away from other possibly-beneficial investment activity. There are two reasons for this. First, the fundamental advice of the classical benefit principle is that we must consider each benefit in isolation. This is why user fees are considered to be the optimal means for implementing benefit taxation—it charges the user separately for each usage of the public input (Gugl and Zodrow, 2015a). Second, for clarity of exposition. The benefit principle is analytically coherent when we focus our attention narrowly on the tax base where benefits show up: corporate profits.

This assumption is standard in the literature considering public inputs and corporate taxation. Haufler and Schjelderup (1999) specifically model a multinational firm, but assume that investment in the foreign country (the outside option) is fixed. This implies that utility maximisation is equivalent to maximising the net rents derived from public input provision. Gugl and Zodrow (2015a,b) and Matsumoto and Sugahara (2017) assume that households own a fixed amount of capital that can either be invested in the firm or in an outside option which generates return r. Since the firm rents capital in their model, including both

the cost of renting capital (rk) and the returns to renting capital (rk) in the government's objective function means that these will cancel out. The government is therefore left maximising only the firm's profits. In Appendix 4.A.2, I show the outcome of maximising over the firm's total income.

The Government's Lindahl Problem For the tax collected from firm i to be equal to firm i's share of the cost of the public input, the government uses the firm-specific constraint $t_i\pi_i(k_i, g_i) = \tau_i g_i$. For each firm, the government chooses a tax rate and level of public input provision for each individual firm type that maximises the firm's profits. The Lagrangian for the government's problem for firm type i is:

$$\max_{t_i, g_i} \quad \mathscr{L} = (1 - t_i)\pi_i(k_i, g_i) + \lambda(t_i\pi_i(k_i, g_i) - \tau_i g_i). \tag{4.6}$$

where k_i^* is the policy function from the firm's maximisation problem. From the first-order conditions of the firm, we know that k_i^* is a function of both g_i and t_i.

I define the elasticities of profit with respect to public inputs and the net-of-tax rate as:

$$e_i^G = \left(\frac{d\pi_i(k_i^*, g_i)}{dg_i}\right)\left(\frac{g_i}{\pi_i(k_i^*, g_i)}\right) \tag{4.7}$$

$$e_i^T = \left(\frac{d\pi_i(k_i^*, g_i)}{d(1 - t_i)}\right)\left(\frac{1 - t_i}{\pi_i(k_i^*, g_i)}\right) \tag{4.8}$$

Optimal Public Input Condition I derive the first-order condition with respect to the public input to characterise optimal public input provision in a setting with a productive public input. Full derivations are shown in Appendix 4.A.1. I derive the condition:

$$\left(\frac{e_i^G}{1 - e_i^G}\right)\left(\frac{1 - t_i}{t_i}\right) = \lambda. \tag{4.9}$$

Increasing the public input directly and indirectly increases the firm's profits. Directly through the profit function, and indirectly through the effect on the firm's optimal choice of capital. By increasing firm profits, the public input also

increases the government's tax base.

Optimal Corporate Tax Condition I derive the government's optimal choice of the net-of-tax rate $(1-t_i)$. The first-order condition is:

$$\frac{1+e_i^T}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}=\lambda. \tag{4.10}$$

An increase in the net-of-tax rate of firm type i induces a mechanical and a behavioural effect. The mechanical effect is the reduction in the tax rate the firm faces, holding profits constant. The behavioural effect is the firm's optimal response to the change in the tax rate through its first-order conditions and captures the distorting effect of the corporate tax. Normally a higher tax rate leads to lower profits and vice versa.

Definition 4.2. Lindahl Equilibrium: *A Lindahl equilibrium is a policy comprising a set of personalised tax shares* $\{\tau_i\}$ *and public input choice* G^* *where the following conditions hold*:

$$g_i = G^* \quad \forall i, \tag{4.11}$$

$$\sum_{i\in I}\tau_i = 1 \tag{4.12}$$

A Lindahl equilibrium is defined by the set of tax shares $\{\tau_1,\tau_2,...,\tau_I\}$ that leads the government to optimally choose the same level of public input provision $\{g_i\}$ for all firms. This level is the optimal level of public input provision G^*. This equilibrium concept requires that these tax shares must completely fund the provision of the optimal level of public input provision. Even though the Lindahl equilibrium concept remains unchanged, it is no longer a first-best equilibrium. It does, however, give us a solution for the set of optimal tax rates.

Optimal Tax Rate Formula How does the government set the optimal tax rate that achieves Lindahl equilibrium? First I use **Definition 4.2** of Lindahl equilibrium to replace g_i with G^*. Then I combine the government's first-order conditions for optimal public input provision and for optimal taxation for an

individual firm type i:

$$\left(\frac{e_i^{G^*}}{1-e_i^{G^*}}\right)\left(\frac{1-t_i}{t_i}\right)=\frac{1+e_i^T}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}. \tag{4.13}$$

I can now state this essay's main proposition.

Proposition 4.1. *In a Modified Lindahl Equilibrium, the optimal benefit-based corporate income tax rate for any firm type i with a distortionary tax instrument is:*

$$t_i^*=\frac{e_i^{G^*}}{1+e_i^T} \tag{4.14}$$

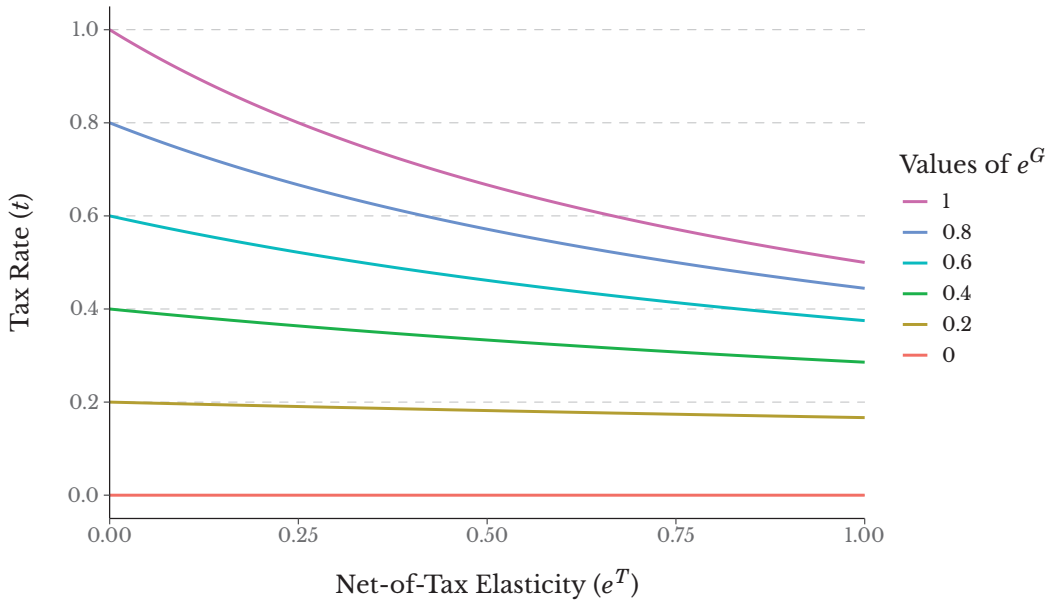
where $e_i^{G^*}$ is the elasticity of profits with respect to the public input and e_i^T is the elasticity of profits with respect to the net-of-tax rate.

Proof is shown in Appendix 4.A.1. The optimal corporate tax rate is expressed in terms of two estimable elasticities. A higher public input elasticity of profits implies a higher corporate tax rate since the firm derives a greater benefit. If the corporate tax rate is not distortionary such that $e_i^T=0$, then the optimal corporate tax rate is $t_i^*=e_i^{G^*}$. As the firm's behavioural response to taxation increases, then the optimal corporate tax rate falls.

In a standard Lindahl equilibrium, the firm should pay for the public good according to the benefit they receive from the public good. When a firm is optimising, the marginal benefit the firm receives should be equal to their willingness to pay for an extra unit of the public input. The firm's total tax payment should be equal to their total willingness to pay for the optimal level of public inputs. This optimal tax formula therefore combines the firm's willingness to pay for the good with the fiscal externality induced by the behavioural response of the agent (Hendren, 2016).

The optimal tax formula in Equation 4.14 implies that a firm type contributes more to public input provision when it values the public input more. This is the classical logic of benefit-based taxation. Firms with a higher behavioural response to corporate taxation see their optimal corporate tax rate adjusted downward. Note, however, that there is only an economically significant adjustment to the optimal corporate tax rate for firms who receive a high benefit from the

Figure 4.1: Optimal Tax Rate for Range of Elasticities



public input. This is shown in Figure 4.1. Those with a public input elasticity of 0.2 or below see almost no adjustment in their optimal corporate tax rate when their behavioural responses increase.

Notice that a firm that has a high level of profits independent of the public input so that $e^G = 0$ would pay no corporate income tax under this benefit-based corporate income tax system. This approach does not account for the 'ability to pay' rationale for taxation that underpins the Mirrlees (1971) approach. The ability to pay concept stems from an individual's inherent ability, an unobserved heterogeneity among individuals (Mankiw et al., 2009). Fleming Jr et al. (2001) make the argument that

Modified Samuelson Condition For comparability with traditional tax literature, I can rewrite these findings in a modified version of the Samuelson (1955) condition for optimal public input provision. Rearranging the optimal public input condition to isolate the benefit received by the firm:

$$e_i^G \pi_i(k_i^*, g^i) = \tau_i g_i \left(\frac{\lambda_i}{1 - t_i + \lambda_i t_i} \right). \tag{4.15}$$

Substituting in for λ from the condition for optimal taxation gives:

$$e_i^G \pi_i(k_i^*, g^i) = \tau_i g^i (1 + e_i^T) \tag{4.16}$$

for each firm type. By **Definition 4.2** of Lindahl equilibrium, I replace g_i with G^* and sum the above condition across all firms. I propose a modified Samuelson condition for the optimal provision of the public input:

$$\sum e_i^G \pi_i(k_i^*, G^*) = G^* \sum \tau_i (1 + e_i^T) \tag{4.17}$$

Effectively this implies that at the second-best optimal provision of the public input, the sum of the firms' marginal rates of substitution (MRS) between public inputs and private profits is equal to the marginal rate of transformation (MRT) between them times the marginal cost of public funds (MCPF). This is the standard modified Samuelson condition that arose from the early work of Atkinson and Stern (1974) and Stiglitz and Dasgupta (1971). As reviewed in Ballard and Fullerton (1992), this line of work implies a modified Samuelson condition that takes the form $\sum \text{MRS}_i = \text{MRT} \times \text{MCPF}$. The question then is whether the marginal cost of public funds is equal to or greater than 1. The size of the MCPF depends on the aggregate behavioural responses of the firm. In this model, these behavioural responses are a weighted average $\sum \tau_i (1 + e_i^T)$. Under- or over- provision of the public good depends on each firm's share of provision and their behavioural response.

4.3.3 Profit Shifting

Profit shifting is likely the biggest concern with the present international corporate taxation system. Any model of optimal corporate taxation must account for this enormous phenomenon. Tørsløv et al. (2018) estimate that close to 40% of multinational profits are artificially shifted to tax havens. Profit shifting is at the centre of the OECD's massive and wide-ranging project on Base Erosion and Profit Shifting.

Suppose firms can shift an amount q of the profits generated in the home country to a tax haven. While profits booked in the tax haven are not taxed,

the act of shifting profits itself incurs a cost $c(q)$. The cost of profit shifting is increasing in the amount of profits shifted because it increases the likelihood of being caught and penalised. Because of this cost, the firm will not optimally shift all of its profits to the tax haven. The firm receives shifted profits free of tax but net of the cost of shifting. The firm's after-tax profits are now:

$$(1-t_i)[\pi(k_i,G)-q_i]+q_i-c(q_i) \tag{4.18}$$

with first-order condition for the choice of profits shifted $c'(q_i)=t_i$ so that the marginal benefit of shifting an extra dollar of profit t_i is equal to the marginal cost of doing so. The firm cannot deduct the cost of profit shifting from its tax base. Consider reported profits $\hat{\pi}_i$ to be actual profits less profits shifted: $\hat{\pi}_i=\pi_i-q_i$. We can simplify the new solution by redefining our elasticities to be elasticities of reported profits. In reality, we observe reported rather than real profits. Redefining the elasticities as reported profit elasticities, the optimal benefit-based corporate tax formula remains exactly the same. This is based on the tax evasion mechanism described in Feldstein (1995, 1999). Chetty (2009) shows that if we do not consider the entire cost of evasion to be lost to society (if costs are transfers to other agents or firms overestimate the cost of profit shifting), then we may need to consider some combination of the elasticities of actual profits and the elasticities of reported profits. This concern, however, extends beyond the scope of this essay and can be examined in future work.

4.3.4 Related Works

The model I present bears some resemblance to Haufler and Schjelderup (1999). Haufler and Schjelderup (1999) model the efficient provision of public inputs in the presence of profit shifting. The authors focus on the theoretical under-provision or over-provision of the public input due to profit shifting. Profit shifting allows firms to escape contributing to the provision of the public input. Their main trade-off is also between the benefits of increasing public inputs and the costs of increased taxation.

The resulting trade-off of this essay is also similar to the results of Benassy-Quere et al. (2007). However, Benassy-Quere et al. (2007) consider the effects of

taxation and public investment on foreign direct investment alone. They propose that the elasticities of foreign direct investment with respect to public inputs and with respect to the tax rate identify the under-provision or over-provision of public inputs. Benassy-Quere et al. (2007) are concerned with optimal public input provision, but also suggest that the optimal tax rate should be set based on the marginal returns of the public input.

A recent set of papers by Gugl and Zodrow (2015a,b) and Matsumoto and Sugahara (2017) measures the efficiency of production taxes and capital taxes against the benefit-based holy grail of user fees. Their finding is not unambiguous, since neither tax perfectly substitutes for an explicit user fee. Instead, the relative efficiency of these taxes depends on the elasticity of substitution between capital and the public input.

The conceptual mechanisms of benefit-based taxation resemble the Tiebout (1956) model. The standard Tiebout model says that individuals will choose to locate where the local public good provision (and resulting tax) matches their preferences. In this essay I answer a variant of the policy question deemed important by Tiebout (1956): how should the government ascertain firms' demand for the public input and the accompanying tax?

The Tiebout (1956) model raised debate whether the property tax used to fund local public goods is a non-distortionary benefit tax or whether it acts as a distortionary capital tax. Most relevant is the proposal that the level of taxation and public good provision depends directly on whether the tax is considered to be a benefit tax or a capital tax. The literature broadly viewed the two characteristics of the tax as opposing, but Mieszkowski and Zodrow (1989) attempt to show that they can be reconciled. Wildasin (1986) suggests a 'theoretical synthesis', where the Tiebout property tax is both a benefit tax and a distortionary tax instrument. The model I present follows this theoretical synthesis.

4.4 Empirical Illustration: United States

In this section, I empirically demonstrate the application of the optimal benefit-based tax formula. Application requires the estimation of two key elasticities: the net-of-tax elasticity of profits, and the public input elasticity of profits.

Public corporations, while only 1 percent of the number of United States corporations, contribute 70 percent of corporate tax receipts. When voicing opinions are about firms not paying their 'fair share', it is typically public corporations that are the source of discontent. These are the most visible and are frequently attacked by the press for their practices and attempts to limit their tax liability. I use available data on public corporations from the Compustat database published by Standard and Poor's to implement the optimal benefit-based tax formula.

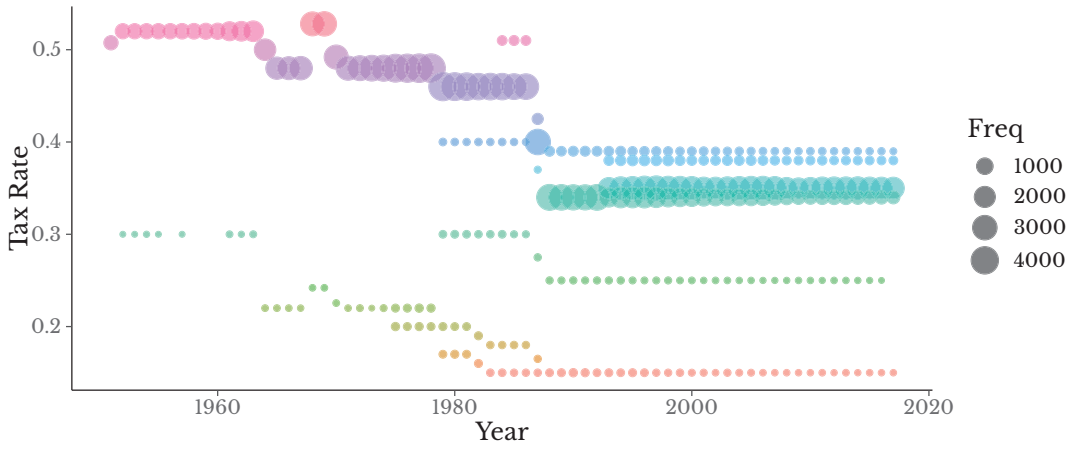
From 1993 until 2017 the United States' main corporate tax rate was 35 percent. In December 2017, the United States government enacted major tax reform, including a substantial revamp of the corporate tax system. The tax reform reduced the top corporate tax rate from 35 percent to 21 percent. How does this reform compare to the optimal corporate tax rate implied under a benefit-based corporate tax?

4.4.1 Net-of-Tax Elasticity of Profits

From 1950 until 1992, the majority of United States public corporations in the Compustat dataset fell into the same corporate tax band. Figure 4.2 shows the number of firms which fell into each corporate tax band in a given year. Only after the tax reform of 1993 did the tax schedule create substantial variation in the marginal corporate tax rate facing public corporations.

1950 to 1992 Reforms Since most firms experienced the same changes in marginal tax rates in the 1950 to 1992 period, it means that meaningful identification can only come from temporal variation in the corporate tax rate. I use a panel differences specification, using temporal variation in the corporate tax rate to estimate

Figure 4.2: Firm-Level Corporate Tax Rates by Year



The size of the bubble represents the number of firms with a specific tax rate. Each tax rate is coloured differently to differentiate between them. Note that the total number of firms increases over time.

the tax elasticity of corporate income.

For each firm i, I express the data in log changes, using one-year $(s+1)$, to four-year $(s+4)$ differences. The variables of interest are therefore expressed as growth rates. The estimated equation takes the form:

$$\log\left(\frac{\pi_{is+1}}{\pi_{is}}\right) = e^T \cdot \log\left(\frac{1-t_{is+1}}{1-t_{is}}\right) + \delta_i + f(\pi_{is}) + u_{is} \tag{4.19}$$

where e^T is the elasticity of interest, δ_i are firm-specific fixed effects, and $f(\pi_{is})$ are a function of base-year profits. Using firm-specific fixed effects in this differences equation is the equivalent to including firm-specific linear times trends in the levels model. This eliminates firm-specific differences in the average growth rate. Identification therefore comes from within-firm changes in the growth rate of profit, eliminating between-firm variation in the level of the growth rate of profit. I control for base year profits using either the log of base year profits or a ten-piece spline of log base-year profit. The main aim of including controls in base year profits is to control for the strong possibility of mean reversion. This is especially important for profits since they are commonly thought to be mean reverting (De Bondt and Thaler, 1989; Canarella et al., 2013). All variables are expressed in real terms to control for inflation-induced common shocks.

As usual, there is mechanical endogeneity present. The corporate tax rate a firm faces is determined by the firm's profits. To deal with this endogeneity,

I adapt the standard instrumental variable strategy of Gruber and Saez (2002), which is also applied to public corporations in Gruber and Rauh (2007). For year $s+1$, I calculate the tax rate that the firm would have faced if it made the same profits as at time s, but using the tax schedule as at time $s+1$. This predicted tax rate t^P allows tax policy to vary, holding profits constant. This means the instrument will be zero whenever the statutory tax schedule is unchanged, but non-zero when the government makes a policy intervention. The first-stage regression is therefore:

$$\log\left(\frac{1-t_{is+1}}{1-t_{is}}\right) = \alpha \cdot \log\left(\frac{1-t^P_{is+1}}{1-t_{is}}\right) + \delta_i + f(\pi_{is}) + \epsilon_{is}. \tag{4.20}$$

This first stage regression limits the identifying variation to tax rate changes that were induced by policy reform. All estimates are weighted by real sales so that estimates are effectively dollar-weighted. Note that sales are winsorized at the 95th percentile within each year to ensure that very large firms do not have an outsized impact on the estimates. All standard errors are clustered at the firm level. The results of this estimation are given in Table 4.6.

Table 4.1: Estimate of Tax Elasticity using Temporal Variation from 1950 to 1991

	1 Year		2 Year		3 Year	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(1-\tau)$	0.381***	0.246**	0.501***	0.390***	0.527***	0.427***
	(0.097)	(0.097)	(0.092)	(0.093)	(0.095)	(0.095)
Base-Year Profit	Log	Spline	Log	Spline	Log	Spline
Observations	109,216	109,216	98,932	98,932	90,850	90,850
R^2	0.216	0.250	0.294	0.316	0.342	0.356

Notes: Standard errors in parentheses. Standard errors are clustered at the firm level. Regressions include firm-level fixed effects. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

The results suggest a net-of-tax elasticity of profits between 0.246 in the short run to 0.527 in the long run. Adding non-linear base year profit controls reduces the size of the estimated tax elasticities at each difference length. Previous works on tax elasticities have frequently found estimates to be sensitive to the choice of base-year controls.

Importantly, long-run responses are higher than short-run responses as you might intuitively expect. Using longer differences (beyond a one-year difference)

is important. Not only does it capture medium- or long-run responses, but it also allows us to consider cases where tax reform occurred over a period of more than one year. Multi-year reforms occurred from 1964 to 1965, 1970 to 1971, 1982 to 1984, and 1986 to 1988. The longest multi-year reform was three years. As per Weber (2014), long-differences are one way to encompass the response to multi-year reforms. One concern, however, is that they might capture overlapping responses. For example, the three-year difference from 1984 to 1986 captures the difference between the response to the 1984 reform and the response to the 1986 reform. On the other hand, one-year responses capture only the initial response to taxation, ignoring potential longer-run responses. At the same time, it might pick up second- or third-year responses for other tax changes.

A conservative estimate of the long-run response to changes in the corporate tax rate is that a 1 percent increase in the net-of-tax rate would lead to a 0.427 percent increase in taxable income for United States public corporations over a period of three years. In the short run, we would expect that 1 percent increase in the net-of-tax rate to lead to a 0.246 percent increase in profits in the first year.

1993 Reform I use the 1993 reform to add graphical evidence of these estimated elasticities. In 1993, a new category of taxation was created for the largest firms, with profits over $18.3 million being taxed at 35 percent, up from the previous marginal tax rate of 34 percent.

I adopt the share-based approach outlined by Saez et al. (2012) and used by Saez (2017) for the 2013 increase in the capital income tax rate. I consider this the simplest methodology given the typically noisy nature of both aggregate and firm-level corporate profit. The methodology proposes to measure the short-run elasticity of taxable income by using the share of income going to the top earners affected by the tax rate reform. In this case, the top earners are those firms whose profits exceed $18.3 million. The elasticity simply compares the share of income going to firms in the top tax band before and after the tax reform. It is measured as:

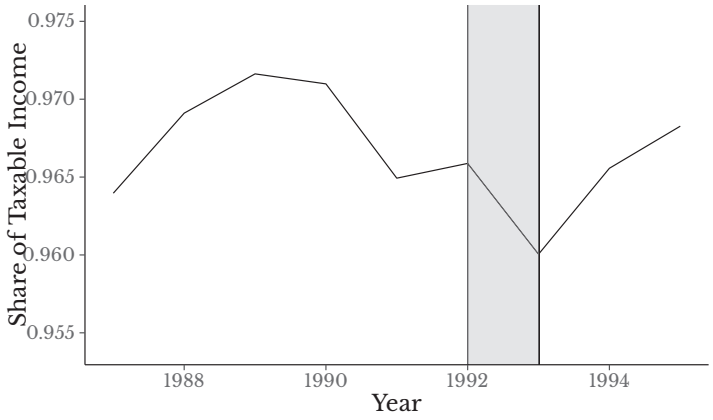
$$e_S = \frac{\log(sh_{1993}) - \log(sh_{1992})}{\log(1 - t_{1993}) - \log(1 - t_{1992})} \tag{4.21}$$

That is, it is the difference in the logged share of profits above $18.3 million from

1992 to 1993 divided by the change in the logged net of tax rate. This would provide an unbiased estimate if the assumption holds that the share of income above $18.3 million had remained the same in the absence of the tax reform. If this identification assumption holds then the elasticity e_S should capture the effect of the tax rate reform on the log change in income. The substantial benefit of this approach is that it controls for changes in economic activity. Profits are particularly volatile and sensitive to the business cycle. The relative stability of shares allows for easier and more convincing inference. One concern with this approach is that firms with profits above $18.3 million do account for an enormous share of the total profits of public corporations even though they only accounted for 24 percent of the number of public corporations in 1993.

The share of profits in the range above $18.3 million decreased from 96.58 percent in 1992 to 96.00 percent in 1993. This appears small, but this is in response to a 1 percentage point increase in the marginal tax rate from 34 to 35 percent. It therefore implies a short-run tax elasticity of 0.396 using the 1993 corporate tax reform. This behavioural response is shown in Figure 4.3, captured by the grey shading. Closer inspection of the chart suggests firstly that the reform only had a short-run impact, as the share quickly reversed course. This simple share-based method for the 1993 corporate tax reform provides confirmation that the previous estimates for the 1950 to 1992 period are convincing.

Figure 4.3: Share of Profits of Public Corporations in the Tax Band Above $18.3 Million



The line represents the share of total profit of all firms in Compustat going to firms with profits over $18.3 million. The grey column represents the period of change under investigation: from the tax rate schedule in 1992 to the new schedule in 1993.

Comparison to Existing Estimates Seegert et al. (2018) find an elasticity of 0.55 using a bunching estimator on data for the population of private United States corporations from the Internal Revenue Service (IRS). They use variation in the net operating losses faced by firms to estimate the elasticity over a 10-year period from 2004 to 2014. While private corporations are typically smaller than public corporations, the number of public corporations is only 0.5% of all C-corporations in IRS data during that period. Using temporal variation with standard regression methods, I find a short-run elasticity of 0.246 and a long-run elasticity reaching 0.527 with data from 1950 to 1991. Using a simple and transparent share-based approach for the largest 24 percent of United States public corporations, I find a short-run elasticity of 0.396.

Gruber and Rauh (2007) provide an early estimate of the elasticity for public corporations in the United States. They use cross-sectional variation in the tax rate between industries that arises because some firms make profits and face a positive marginal (statutory) tax rate and other make losses and therefore face a zero marginal tax rate. Their definition of profit is quite different, since they do not remove interest payments from total profits. They find a large but statistically insignificant (imprecisely estimated) elasticity of 1.122. This elasticity is not the central result in their paper.

4.4.2 Public Input Elasticity of Profits

Economic research has mainly focused on estimating the elasticity of *output* with respect to public inputs. This is a broader measure of the provision of the public input on the entire economy, rather than simply on the returns to corporations. This literature was made popular by Aschauer (1989). A meta-study by Bom and Ligthart (2014b) combines 578 estimates of the public input elasticity of output from 68 studies from 1983 to 2008 focusing on OECD countries. These studies typically focus on the tangible capital stock owned by the public sector. This may be measured at different levels of government, from central government to the local or regional level. Other studies focus on only 'core' public capital—roads, railways, airports, and utilities. The assumption is made that public services flow to firms in proportion to the level of installed public capital. Output is usually an aggregate measure such as real GDP less public sector output. This is used

because public capital is also an aggregate measure. The average elasticity of output in these studies is 0.106, correcting for publication bias. The short-run elasticity is smaller at 0.083, but considering only core capital installed by local government raises the elasticity to 0.154. Further extending this measure to the long run raises the estimated elasticity a bit further to 0.193. Using a standard Cobb-Douglas production function, these elasticities represent the share of output generated by the public input. If most of the returns to the public input are captured by profits, and profits make up a small portion of total output, then one might expect that returns to the public input actually make up a substantial portion of profits.

I take a simple approach to the estimation of the public input elasticity of profits. As in the theoretical model, I express profits as a function of public inputs. I do not control for private capital because I require the total derivative. I estimate the model in natural logs for simplicity. The estimated equation is

$$\log(\pi_{is}) = \alpha_i + e^G \cdot \log(G_s) + u_{is} \tag{4.22}$$

I also estimate an auxiliary model with a single intercept so that $\alpha_i = \alpha \; \forall i$. Identification of the public input elasticity comes from temporal variation in the public input.

I use data on firm-level domestic profit from Compustat. Using domestic profits shrinks the sample size substantially, but allows for clear estimation of the correct public input elasticity. As in most of the literature discussed in Bom and Ligthart (2014b), I assume that public services flow from public capital in proportion to the stock of public capital. I use the stock of public capital as the measure of the public input. All variables are expressed in real values.

To measure the public capital stock, I follow the methodology of Kamps (2006) and Gupta et al. (2014) used by the International Monetary Fund's Fiscal Affairs Department to produce the Investment and Capital Stock Dataset. The IMF (2017) manual describes the perpetual inventory equation:

$$G_{s+1} = (1-\delta_s)G_s + \left(1 - \frac{\delta_s}{2}\right) I_s \tag{4.23}$$

where δ_s is the time-varying rate of depreciation and I_s is new investment in

public capital. To measure new investment, I use data for gross federal government fixed non-defence investment. To estimate this measure of the public capital stock, the International Monetary Fund assumes that the public capital stock is zero in the year 1860 and that investment grew by 4 percent a year to reach its five-year-forward moving average in the first year of data available. The first year of data available is 1929. I alter this assumption slightly, setting the capital stock equal to zero in 1790, as the first United States Secretary of the Treasury, Alexander Hamilton, was sworn in during 1789. While the International Monetary Fund uses 1860 for consistency across countries, I do not require cross-country consistency. Private capital is measured as gross property, plant and equipment. All variables are deflated by the Consumer Price Index (1982-1984=100).

I consider the possibility of changes in both public capital and profits being driven by the business cycle. To control for this possibility, I use the lag of public capital as an instrument for public capital. With public investment usually being decided in the preceding year, using the lag of public capital as an instrument would mean that public investment is determined a full two years in advance of profits being realised.

In addition, I consider the possibility that there is some sample selection bias for those firms which report domestic profits. In Figure 4.5 I plot the real average profits, sales, total assets, and plant, property, and equipment for each firm. I separate the plot into two histograms to consider whether the distribution of the size of firms that report domestic profits is different from the distribution of the size of firms that do not. To control for the possibility of selection bias being incurred by the fact that larger firms may be more likely to report more detailed figures, I re-weight the sample. I put each firm into a bin that reflects the interaction of the decile of total assets and the decile of sales for each year. I split the bins into firms that report domestic profits (Dom=1) and firms that do not (Dom=0). Suppose that a bin q contains n_q firms in year s. Then the weight for each bin q in period s is calculated as:

$$w_q = \frac{n_q(\text{Dom=0}) + n_q(\text{Dom=1})}{n_q(\text{Dom=1})}. \tag{4.24}$$

This re-weights the sample so that the distribution of firms reporting domestic profits matches the overall distribution of firms. I define the distribution on the

interaction of total assets and sales. This re-weighting is done within each year.

The results of the estimation are presented in Table 4.2. All estimates are weighted by real sales, which are winsorized at the 95th percentile for each year. Note that for the re-weighted specification I multiply the binned weight by real winsorized sales.

Table 4.2: Public Input Elasticity of Profits for U.S. Public Corporations

	(1)	(2)	(3)	(4)
$\ln(G)$	0.535***	0.653***	0.645***	0.739***
	(0.084)	(0.068)	(0.068)	(0.068)
Fixed Effects		Yes	Yes	Yes
IV			Yes	
Reweighted				Yes
Observations	34,051	34,051	33,026	33,026
R^2	0.014	0.852	0.852	0.861

Notes: Fixed effects, when included, are firm fixed effects. When included, the instrument used for public capital is the one-year lag of public capital. All estimates are weighted by real sales, winsorized each year at the 95th percentile. Standard errors in parentheses. Standard errors are clustered at the firm level. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

The results of this estimation are given in Table 4.2. Three main estimates are presented: without firm fixed effects, with firm fixed effects, and with firm fixed effects and the instrumental variable, and re-weighted with firm fixed effects. The estimated elasticities range from 0.535 to 0.739. Adding firm fixed effects so as to consider only within-firm variation increases the estimated elasticity from 0.535 to 0.653. Using the lag of public capital as an instrument reduces the elasticity only marginally to 0.647. Re-weighting the estimates so that the distribution of firms reporting domestic profits matches the overall distribution of firms in Compustat, I retrieve a higher elasticity of 0.739. These estimates suggest that public capital plays a substantial role in generating corporate profits. I now consider whether these corporation-level estimates are corroborated by aggregate elasticities.

Aggregate Evidence To confirm whether these firm-level estimates for public corporations are plausible, I estimate an aggregate version of the model. I use quarterly data from the Federal Reserve Bank of St. Louis' Economic Database. I calculate the quarterly public capital stock using the quarterly version of the perpetual inventory equation. I estimate a model similar to the firm-level model:

$$\log(\Pi_s) = \alpha + e^G \cdot \log(G_s) + u_s \tag{4.25}$$

I lag public capital by 1, 4, 8, and 12 quarters to eliminate concerns that both profits and public capital are affected by the business cycle. Results are shown in Table 4.3.

Table 4.3: Aggregate Time Series Estimate of the Public Input Elasticity

	(1)	(2)	(3)	(4)	(5)
ln(G)	0.611***	0.608***	0.587***	0.560***	0.544***
	(0.033)	(0.034)	(0.035)	(0.036)	(0.037)
Lag of G	0 periods	1 periods	4 periods	8 periods	12 periods
Observations	232	231	228	224	220
R^2	0.592	0.588	0.561	0.526	0.503

Notes: Regressions are estimated using quarterly data from the Federal Reserve Bank of St Louis Economic Database. A constant is included in all regressions but the coefficient is excluded. Standard errors in parentheses. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

The aggregate public input elasticity estimated using this simple method is quite similar to that estimated using firm-level Compustat data. Using the contemporaneous of public capital gives an estimated elasticity of 0.611. Lagging the value of public capital reduces the estimated elasticity. Using a 12-quarter (3-year) lag, the elasticity falls to 0.544. This range is quite nearly the same as those estimated using firm-level data. These aggregate estimates appear to corroborate the firm-level finding that the public input elasticity of profits is economically quite large.

Consider also the average public capital elasticity of output of 0.106 from Bom and Ligthart's (2014a) review of 68 studies with 578 estimates. If we make the assumption of a well-behaved constant returns to scale aggregate production function, we can use the shares of total output accruing to factors to make some statement about the relevant elasticity of output. To move to an elastic-

ity of profit, we need to make the additional assumption that all rents from the public input accrue to profits. This may be a somewhat ambitious assumption since workers may also benefit to some extent from the public input. However, it would mean that the average public capital elasticity of output from Bom and Ligthart (2014a) acts as an upper bound. With this assumption, I propose that the public input elasticity of profits can be recovered from the ratio of the public capital elasticity of output (σ) divided by total before-tax corporate profitability (π/Y):

$$e^G = \frac{\sigma}{\pi/Y}. \tag{4.26}$$

To approximate before-tax corporate profitability, I use data on the aggregate profit per unit of real gross value added of non-financial corporate business in the United Stated from the United States Bureau of Economic Analysis. At the peak, corporate profitability in the United States amounted to 15.7 percent of corporate output in 2014. Assuming a Cobb-Douglas production function with constant returns to scale would imply that 10.6 percent of total output are actually returns to the public input. That would imply a public input elasticity of profits of $0.106 \div 0.157 = 0.675$. Once again, this is very similar to the estimated public input elasticity of profits for public corporations. Average corporate profitability from the first quarter of 2010 to the first quarter of 2019 has been lower, at 13.6 percent. This would give an even higher implied public input elasticity. Further, notice that Bom and Ligthart (2014a) finds substantial heterogeneity in the average elasticity—an average short-run elasticity of 0.083, and an average long-run elasticity of 0.122. Restricting the sample to only studies for the United States, the average elasticity actually increases to 0.133. This would imply an even higher public input elasticity of profits of $0.133 \div 0.157 = 0.847$. This reflects an upper bound on the public input elasticity of profits—one which the firm-level estimates do not breach. The extent to which this should be dampened would depend on the extent to which other factors of production—particularly labour—manage to extract rents that are due to the public input. This exercise justifies the magnitude of the public input elasticities I uncover using firm-level data. Together, these aggregate findings provide substantial confidence in the estimated public input elasticity.

4.4.3 Estimated Optimal Tax Rates

In December 2017, the United States Congress passed the Tax Cuts and Jobs Act of 2017. This bill substantially lowered the top corporate tax rate from 35 percent to 21 percent. Note that under the previous corporate tax schedule, the average tax rate for firms over $18.3 million was equal to the 35 percent marginal tax rate. Many argued both for and against this lower corporate tax rate, mostly on the grounds of the impact it would have on investment and wages. A few discussed the normative underpinnings of the corporate income tax and whether the tax was being used to fulfil a purpose. I focus on deepening the normative discussion by applying the benefit principle to the Unites States tax reform.

I focus on the optimal tax rate for one type of firm—public corporations. Public corporations generate the largest proportion of revenue as they are the biggest and most visible corporations. The corporate tax rate on these firms is likely to have the greatest impact on revenue and on public perception of the fairness of the corporate tax. This optimal tax analysis only holds for public corporations. The estimated elasticities can be used to give guidance as to what an optimal benefit-based corporate income tax rate would look like in the United States. I do this by applying the elasticities to the optimal tax formula given in Equation 4.14:

$$t^* = \frac{e^G}{1 + e^T} \tag{4.27}$$

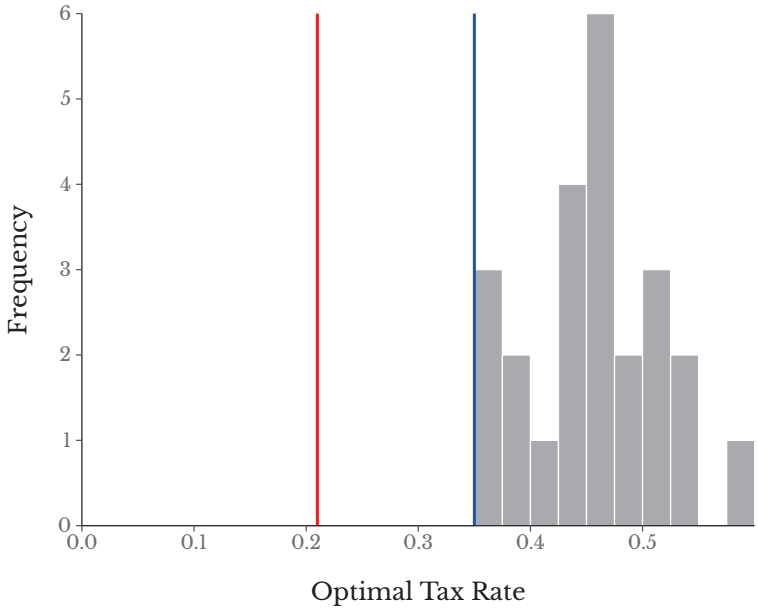
for public corporations. I treat public corporations as an individual firm type.

The preferred estimate of the tax elasticity is the longer run (three-year differences) estimate with a log-spline of base-year profits: 0.427. The preferred estimate of the public input elasticity is the within-firm estimate without the instrumental variable: 0.653. These are both estimated using the Compustat firm-level data for public corporations. Plugging these estimated elasticities into the optimal tax formula gives a preferred estimate of the optimal benefit-based corporate income tax rate of $t^* = 0.653/(1 + 0.427) = 46$ percent.

To present a range of estimated tax rates, I use all combinations of the public input elasticity and the tax elasticity in the optimal tax formula. The resulting histogram of 18 estimated optimal tax rates are presented in Figure 4.4. This

should provide a plausible range for the optimal benefit-based tax on public corporations in the United States.

Figure 4.4: Histogram of Estimates of Optimal Benefit-Based Tax in the United States



The blue line represents the pre-reform top corporate tax rate of 35 percent. The red line represents the post-2017 reform rate of 21 percent. This histogram shows the estimated optimal benefit-based corporate tax rate for all the combinations of tax and public input elasticities.

Strikingly, these estimated optimal benefit-based tax rates are all above the pre-reform corporate tax rate of 35 percent. They range from 35.0 percent to 59.3 percent. The median estimate is substantially higher at 46.1 percent. This suggests that the pre-reform rate was actually a lower bound on an data-driven benefit-based tax rate. The clear implication of these estimates is that large public corporations' 'fair share' of tax is actually a much larger proportion of their profits than they currently pay in tax.

In contrast, a simple revenue-maximising tax rate would be calculated as $1/(1+e^T) = 70$ percent. To justify the tax rate cut to 21 percent as revenue-maximising, the tax elasticity would need to be in the range of 3.8. This is near the magnitude of elasticity uncovered by Bachas and Soto (2018) for Costa Rica, a developing economy with poor tax enforcement. In contrast, if we hold the tax elasticity fixed at 0.427, the public input elasticity would need to be approximately 0.30—around half the estimated value—to justify the 2017 tax rate cut to 21 percent.

The reliability of these optimal tax rate depends crucially on the estimated elasticities. None of these elasticities appear unreasonable. If most of the benefits of the public input accrue to profits, then it appears that these estimated public input elasticities of profits are consistent with a long line of literature estimating the public input elasticity of output. Similarly, the net of tax elasticity of profits is not substantially smaller than that estimated in previous works—particularly Seegert et al. (2018). In addition, they are consistent with the aggregate-level estimates I am able to recover.

4.5 Design of the Corporate Tax System

The debate on the optimal design of the corporate income tax commonly encompasses four policy questions. First, which country should have taxing rights over multinational firms' profits? Second, what should be the corporate income tax base? Third, is profit shifting good or bad? Fourth, what is the optimal tax rate? The question of the optimal tax rate is already the central focus of this essay. But the principle of benefit-based taxation can also be used to provide guidance on how to answer the other three questions.

4.5.1 Taxing Rights

Benefits-based taxation makes a direct link between the use of a specific government's public input and taxing rights it bestows on that government. If Firm A's profits are generated by the use of Government A's public inputs, then it gives Government A taxing rights over the profits generated using Government A's public input. But if Firm A's profits are not generated by the use of the public input of Government B, then what claim does Government B have over firm A's profits? Government B provides no benefits to Firm A.

Public inputs generate profits by their use in the production process. Therefore the use of the public input is reflected in the location of the profit-generating *production*. Public inputs are almost entirely immobile. I ignore the possibility of public goods with spillover effects for broad applicability and simplicity.

Some works that consider this possibility include Koide (1985), Bjorvatn and Schjelderup (2002) and Bloch and Zenginobuz (2007). The use and benefit of the public good of Government B is limited to the geographical jurisdiction of Government B. The geographical jurisdiction of Government B is the link between the benefits of the public input and the taxing rights of the government.

This implies that taxing rights of a government should be limited to profit-generating production taking place within its borders. This is a re-statement of the source principle of international taxation. The source principle of taxation is implemented by the territorial tax system. A territorial tax system does not tax foreign income. Instead, a territorial tax system will tax only profits generated from production within the country's borders, disregarding questions of firm ownership or firm nationality. In this sense, benefit taxation is a matter of cross-country equity. Benefit taxation makes a very clear statement about who should receive the returns to the public input (the government) and which country should be able to tax those returns (the country of production).

Benefits-based taxation provides strong normative support for the source-based principle of corporate taxation. Kane (2015) writes that "A more promising route is to rely on the distinguishing feature of whether the rent is a return on sovereign investment. This has the advantage that if we define the category in this way then the taxing right is clear. It should be allocated to only the sovereign that made the investment." Given the widespread views aligning with the benefit principle, it is unsurprising that the territorial tax system is the most common corporate tax system in the world today.

In contrast, the residence principle of taxation gives rise to a worldwide tax system that taxes profits made abroad. Focusing purely on economic efficiency, Devereux et al. (2015) show that a worldwide tax system is optimal whether you wish to achieve national or global optimality. This follows the classical results of international tax theory, which propose taxing the worldwide income of home multinational firms to ensure the global allocation of capital remains undistorted (Musgrave, 1963). But governments are disregarding this advice, moving towards territorial tax systems. Devereux et al. (2015) suggest it is either the lower administrative cost or the mobility of firm residence that is causing governments to shift to the territorial tax system.

The benefit principle provides a normative argument why taxing rights should not be assigned to where consumption takes place. With the existence of public inputs, the destination-based tax system transfers taxing power from the country of production to the country of consumption. Under the destination-based tax system, a government would not have taxing rights over the returns to its public input. The destination of final sale of a commodity only creates taxing rights to the extent that value is created in that country by the retail process. That is, the government should have the right to tax the profits of the retail sector to the extent that its profits rely on the public input. In practice, however, note that the profit margins of the retail industries are consistently among the lowest globally. This argument holds for the accounting services provided by tax havens—their taxing rights should extend only to the economic activity generated within that jurisdiction.

4.5.2 Tax Base

The central prediction of the classical benefit principle is that the tax should aim to capture benefits from (or returns to) the public input. It implies that in an ideal world, the corporate tax base should be narrowly defined as returns to the public input. A tax base narrowly defined as returns to the public input would imply a 100 percent tax rate and would be non-distortionary. This ideal is very difficult to achieve. Returns to the public input do not appear as a line item in the firm's income statement. There is no easy way to separate various forms of location-specific rents, or even to separate mobile rents from immobile rents (Graetz, 2000; Auerbach and Devereux, 2018). In fact, most tax systems do not separate rents from normal returns to capital.

In this essay, the tax base has been modelled as the sum of the normal and supernormal returns to equity capital. This reflects the standard corporate tax system across most countries. In this model, what would be the optimal corporate tax base? as is standard, I use α to reflect the corporate tax base where $0 \leq \alpha \leq 1$. However, this is a somewhat narrower definition than in the literature, where α tends to denote the deductibility of debt interest costs and returns to equity. Here, I focus on returns to equity only, considering whether these are deductible or not. If $\alpha = 1$, then the normal returns to equity are fully deductible

from taxable income. If $\alpha = 0$ then the normal returns to equity are fully taxed as is standard. I insist the normal returns to equity accrue to the firm as happens in reality. Therefore the normal returns must be added back to the firm's total income after taxable income is calculated by deducting it. The firm's profit function is now:

$$\max_{k_i} \quad (1-t_i)[\pi(k_i,G) - \alpha rk] + \alpha rk + r(K_i - k_i). \tag{4.28}$$

And the first-order condition for capital is now:

$$\frac{\partial \pi_i(k_i,G)}{\partial k_i} = r\frac{(1-\alpha t_i)}{(1-t_i)}. \tag{4.29}$$

In the case where $\alpha = 1$, this condition reduces to $\partial\pi_i(k_i,G)/\partial k_i = r$ and the corporate income tax does not have a distorting impact on the allocation of capital. Where $\alpha = 0$, we get the original first-order condition from Equation 4.2. This alters the final optimal tax formula substantially. Now $e^T = 0$, so that the corporate income tax has no behavioural impact on the profit of the firm. Holding the primitives of the firm's profit function constant, the optimal benefit-based tax rate would now be higher for all firms. The modified Samuelson condition in Equation 4.17 tells us that the optimal provision of public inputs would now be higher. This suggests fully offsetting the normal returns to equity would move us to a first-best Lindahl equilibrium by making the corporate income tax non-distorting.

This will not hold perfectly in reality due to the existence of unobservable firm-specific assets. These are also an important source of rents, particularly for multinational firms. The importance of the firm-specific asset dates back to Dunning (1988), and has recently been incorporated by both McKeehan and Zodrow (2017) and Auerbach and Devereux (2018). For a firm that can earn rents on such firm-specific capital in another jurisdiction, the corporate income tax remains distorting.

Consider a firm endowed with a limited quantity of an unobservable firm-specific asset $\bar{M}$ that is internationally mobile. The firm can invest m_i of that asset in the country under analysis or it can invest that asset overseas and earn a rate of return w. Because the asset is unobservable, there is no way to distinguish returns to the firm-specific asset and returns to the public input. The firm's income is

given by:

$$\max_{k_i, m_i} \quad (1-t_i)[\pi(k_i, m_i, G) - \alpha rk] + \alpha rk + r(K_i - k_i) + w(\bar{M} - m_i). \tag{4.30}$$

The firm's first-order condition for capital remains the same, but it now has to make a decision over the firm-specific asset:

$$(1-t_i)\frac{\partial \pi_i(k_i, m_i, G)}{\partial m_i} - w = 0. \tag{4.31}$$

Theoretically, only a single distortion remains if returns to equity capital are fully deductible. The only potential offsetting feature is the second-order effect of m_i on k_i and vice-versa through the cross-partial derivatives (complementarity or substitutability of factors). Practically, however, the distortion is now limited to a very small number of firms, but likely large firms. And the distortion of the tax is limited to only one factor. And if the firm-specific asset is a good whose supply is not limited—like ideas, intellectual property, reputation—then there should be no distortion.

Therefore, we can at least propose that the benefit principle implies that the tax base should be narrowly defined. Since the purpose of the corporate tax under the benefit principle is not to tax capital owners, then the normal returns to capital should be excluded from the tax base. This would eliminate an economically significant distortion that plagues the use of the corporate income tax under existing tax regimes. Importantly, we know how to separate rents from the normal returns to capital. Many authors have dealt with this issue including Meade (1978); King (1987); Bond et al. (1996) and Bond and Devereux (2003). The cash flow tax, allowance for corporate equity or the rate of return allowance tax systems would achieve a tax on economic rent (Cnossen, 2018).

In the model, the tax base has been defined as accounting profits: normal returns to capital plus total rents, mobile and immobile. Narrowing the tax base would change the definition of the elasticity to be estimated since the definition of profits would change. It would not, however, alter the optimal tax formula itself or the key principles underlying the benefit principle. Policy reform to limit the base of the corporate income tax to rents is supported by the benefit principle of taxation.

4.5.3 Profit Shifting

An important question that has been taken for granted is whether there is actually a significant economic argument against profit shifting. Consider that the corporate tax distorts real economic activity. Profit shifting—by reducing corporate tax liability—limits the real economic distortion of the corporate tax. Profit shifting also reduces the tax burden on mobile factors and makes real investment decisions less sensitive to tax rates (Hong and Smart, 2010). Empirically, Suárez Serrato (2018) shows that closing profit shifting loopholes substantially increased the distorting effects of corporate taxation, as firms reduce investment and employment in non-haven countries. Liu and De Mooij (2018) find that multinational firms reduce domestic investment after the introduction of transfer pricing regulations, effectively increasing the corporate tax burden of the firm. So what is the economic argument against profit shifting?

Slemrod and Wilson (2009) model tax havens as 'parasites' in order to justify initiatives against them. As is standard, they assume that there is some cost to profit shifting. The firm optimises profit shifting behaviour where the benefit of shifting an extra dollar of profit is equal to the cost of shifting an extra dollar. Slemrod and Wilson (2009) assume that the entirety of the cost of profit shifting is deadweight loss. However, as modelled by Devereux et al. (2008), if the cost of profit shifting is a probability of being caught and fined, this does not imply substantial deadweight loss. Further, Chetty (2009) clarifies that a government fine is not a deadweight loss, but simply a resource transfer from firm to government. Combining the inefficiency-reducing effects of profit shifting with limited deadweight costs resulting from profit shifting, it seems near impossible to justify the OECD/G20 Base Erosion and Profit Shifting Action Plan purely on efficiency grounds.

The OECD/G20 Base Erosion and Profit Shifting Action (2013) emphasises three key problems created by profit shifting. First, governments are faced with lower corporate tax revenue, particularly in developing countries. Second, individual taxpayers are forced to bear a greater portion of the tax burden as a result. Third, profit shifting creates unfair competition as some firms can shift profits to minimise their tax liability while others can not.

The benefit principle instead approaches the question from a normative perspective of fairness. If the purpose of paying corporate income tax is to support the provision of public inputs that are used to generate profits, then profit shifting is bad because it allows firms to escape contributing to the provision of the public input. Even more compelling is the insight that under the benefit principle, firms are not even paying tax out of their share of the returns to production—they are merely handing over the returns that should rightly accrue to the owner of the public input: the government. This casts profit-shifting multinationals not just as doing what is best for themselves, but as engaging in a socially egregious activity that undermines the fabric of modern capitalist society. Previous works have implicitly identified this underlying normative principle. Haufler and Schjelderup (1999) examine how multinationals' evasion of responsibility leads to under-provision of the public input. Pogge and Mehta (2016b) focus on how profit shifting allows multinational firms to escape contributing to the provision of wider public goods in developing countries—impoverishing them further.

The simple thesis that firms should contribute to the public input in accordance with the benefits they receive from that public input is a strong argument that profit shifting is normatively wrong. This thesis places responsibility for provision of the public input squarely on the firm. Using the benefit principle, the effect of profit shifting on global efficiency does not justify the inter-country inequity generated by profit shifting activity. The benefit principle implies that profit shifting is normatively bad.

The trivial response to this proposition is that "we already know that profit shifting is bad." Rather than relying on intuition, I attempt to identify what principle we use to define it as bad. Having identified that principle, we can now think about what it implies for *how* we try to solve the profit shifting problem. This principle implies, for example, that simply taxing multinationals anywhere in the world is not the solution we should seek. Profit shifting is fundamentally a question of taxing rights. And it can only be solved by a global consensus on how taxing rights should be assigned. The benefit principle provides a clear normative principle for how taxing rights should be assigned to solve the artificial profit shifting problem.

4.6 Conclusion

In this essay, I apply the normative principle of benefit taxation to corporate income tax. A benefit-based corporate tax satisfies both a public and policy perception of fairness. It also satisfies within-country and inter-nation notions of equity. Not only is a benefit-based corporate tax fair, but it is also feasible even in a small open economy because it relies on taxing location-specific rents.

I propose an optimal corporate income tax rate using the Lindahl (1919) approach to benefit taxation. I modify the Lindahl thought experiment to incorporate the distortionary effects of corporate taxation. The optimal benefit-based corporate tax rate formula is a function of two estimable elasticities: the elasticity of profit with respect to the public input, and the elasticity of profit with respect to the net-of-tax rate. The formula tells a simple story about the optimal benefit-based tax. A higher public input elasticity of profit implies a higher optimal tax rate because those who benefit more will be willing to pay more for the public input. A higher net-of-tax elasticity of profit implies a lower optimal tax rate because a larger behavioural response to taxation implies greater distortion.

The benefit principle proves to be helpful in providing guidance in the design of the international corporate tax system. Three simple principles arise. First, a government should have taxing rights over firm profits generated using its public input. Benefit taxation endorses the source principle of international taxation. Second, the optimal tax base is the benefits generated by the public input. Narrowing the tax base to economic rents would improve both fairness and efficiency. Third, profit shifting is unfair even if efficiency-enhancing. Profit shifting allows firms to avoid contributing to the provision of public inputs.

Diamond and Saez (2011) propose three conditions an optimal tax theory should meet to consider it a useful policy proposal. First, it should be based on a mechanism that is first-order to the problem at hand. I propose two mechanisms: the impact of the public input on firm profits, and the behavioural response of firms to corporate taxation. I show them both to be empirically relevant in the United States. Second, the result should be robust to modelling assumptions, particularly heterogeneity. I model individual optimal tax rates for firm types with heterogeneous production functions. Third, the policy rec-

ommendation should be socially and administratively implementable. Benefits-based taxation has been shown to be socially acceptable by Weinzierl (2017) and the demand that firms contribute a fair share is a first-order concern for the public.

In this essay, I do not take the existence of the corporate income tax as given. Instead, I begin from first principles and seek a justification for the existence of the corporate income tax. I argue that benefit-based taxation can justify the existence of the corporate income tax, and therefore the corporate tax should be implemented on a benefit basis. I show that this is not merely wishful thinking; I provide an implementable optimal corporate tax rate formula and apply it to public corporations in the United States.

4.A Appendix

4.A.1 Derivation of the Optimal Benefit-Based Tax Formula

I derive the government's optimal conditions for maximising profits under the benefit-based tax. The first-order condition with respect to the public input is:

$$\begin{aligned}
(1-t_i)\frac{d\pi_i(k_i^*,g_i)}{dg_i}+\lambda\left(t_i\frac{d\pi_i(k_i^*,g_i)}{dg_i}-\tau_i\right)&=0\\
(1-t_i)e_i^G\frac{\pi_i}{g_i}+\lambda\left(t_ie_i^G\frac{\pi_i}{g_i}-\tau_i\right)&=0\\
(1-t_i)e_i^G\frac{\pi_i}{g_i}+\lambda\left(e_i^G-\frac{\tau_ig_i}{t_i\pi_i}\right)&=0\\
e_i^G\frac{(1-t_i)}{t_i}+\lambda\left(e_i^G-1\right)&=0\\
\left(\frac{e_i^G}{1-e_i^G}\right)\left(\frac{1-t_i}{t_i}\right)&=\lambda. \qquad (4.32)
\end{aligned}$$

Note that this uses the government's firm-specific budget constraint to simplify $\tau_ig_i/t_i\pi_i=1$. The first-order condition with respect to the net-of-tax rate is:

$$\begin{aligned}
\pi_i(k_i^*,g_i)+(1-t_i)\frac{\partial\pi_i(k_i^*,g_i)}{\partial(1-t_i)}+\lambda\left(-\pi_i(k_i^*,g_i)+t\frac{\partial\pi_i(k_i^*,g_i)}{\partial(1-t_i)}\right)&=0\\
\pi_i(k_i^*,g_i)-\pi_i(k_i^*,g_i)e_i^T+\lambda(-\pi(k_i^*,g_i)+\pi(k_i^*,g_i)e_i^T\frac{t_i}{1-t_i})&=0\\
1+e_i^T+\lambda\left(-1+e_i^T\left(\frac{t_i}{1-t_i}\right)\right)&=0\\
\lambda=\frac{1+e_i^T}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}. \qquad (4.33)
\end{aligned}$$

Combining these two conditions:

$$\begin{aligned}
\left(\frac{e_i^G}{1-e_i^G}\right)\left(\frac{1-t_i}{t_i}\right)&=\frac{1+e_i^T}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}\\
\frac{1-t_i}{t_i}\left(1-e_i^T\left(\frac{t_i}{1-t_i}\right)\right)&=(1+e_i^T)\left(\frac{1-e_i^G}{e_i^G}\right)\\
\frac{1-t_i}{t_i}-\frac{e_i^Tt_i(1-t_i)}{t_i(1-t_i)}&=(1+e_i^T)\left(\frac{1-e_i^G}{e_i^G}\right)
\end{aligned}$$

$$
\begin{aligned}
\frac{1-t_i-e_i^T t_i}{t_i} &= (1+e_i^T)\left(\frac{1-e_i^G}{e_i^G}\right) \\
\frac{1-t_i(1+e_i^T)}{t_i(1+e_i^T)} &= \left(\frac{1-e_i^G}{e_i^G}\right) \\
\frac{1}{t_i(1+e_i^T)} &= 1+\left(\frac{1-e_i^G}{e_i^G}\right) \\
\frac{1}{t_i(1+e_i^T)} &= \left(\frac{e_i^G+1-e_i^G}{e_i^G}\right) \\
\frac{1}{t_i(1+e_i^T)} &= \left(\frac{1}{e_i^G}\right) \\
\frac{e_i^G}{1+e_i^T} &= t_i^* \qquad (4.34)
\end{aligned}
$$

4.A.2 Maximising Total Income

I consider the less intuitive case where the government maximises the firm's total income. The Lagrangian for the government's problem for firm type i is:

$$\max_{t_i,g_i} \quad \mathscr{L} = (1-t_i)\pi_i(k_i^*,g_i) + r(K_i-k_i^*) + \lambda\left(t_i\pi_i(k_i^*,g_i) - \tau_i g_i\right). \tag{4.35}$$

I redefine the elasticities of profit with respect to public inputs and the net-of-tax rate as:

$$e_i^G = \left(\frac{\partial\pi_i(k_i^*,g_i)}{\partial g_i}\right)\left(\frac{g_i}{\pi(k_i^*,g_i)}\right) \tag{4.36}$$

$$\varepsilon_i^G = \left(\frac{d\pi_i(k_i^*,g_i)}{dg_i}\right)\left(\frac{g_i}{\pi(k_i^*,g_i)}\right) = \left(\frac{\partial\pi_i(k_i^*,g_i)}{\partial g_i} + \frac{\partial\pi_i(k_i^*,g_i)}{\partial k_i^*}\frac{\partial k_i^*}{\partial g_i}\right)\left(\frac{g_i}{\pi(k_i^*,g_i)}\right) \tag{4.37}$$

$$e_i^T = \left(\frac{d\pi_i(k_i^*,g_i)}{d(1-t_i)}\right)\left(\frac{1-t_i}{\pi_i(k_i^*,g_i)}\right) \tag{4.38}$$

where I differentiate between the *partial* elasticity of profit with respect to public inputs (e_i^G) and the *total* elasticity of profit with respect to public inputs(ε_i^G). The former is the mechanical impact of a change in the public good on profits, while the latter also encompasses the firm's behavioural response to taxation.

Since the government's objective function is the firm's optimised value func-

tion, then I can use the envelope theorem to simplify the analysis. I take the partial derivative of the firm's objective function with respect to g_i and t_i evaluated at k_i^*. The first-order condition with respect to the public input is:

$$\left(\frac{e_i^G}{1-\varepsilon_i^G}\right)\left(\frac{1-t_i}{t_i}\right)=\lambda. \tag{4.39}$$

An increase in public input provision has two effects on profits: a mechanical effect through the profit function, and an indirect effect due to the behavioural response of the firm. The term $\partial k/\partial g$ has long been thought to be positive. For example, work by Seitz (1994) suggests there is complementarity between public and private capital in the manufacturing sector in West Germany. Similarly, the theoretical literature typically assumes complementarity between private capital and the public input (Zodrow and Mieszkowski, 1986; Keen and Marchand, 1997; Gugl and Zodrow, 2015b; Feehan and Matsumoto, 2017).

Since firms are already optimising, the behavioural effect does not have a first-order impact on their profits. It does, however, affect the government's tax base. Holding the tax rate constant, this would increase the dollar amount of the firm's contribution to the public input. I derive the government's optimal choice of the net-of-tax rate $(1-t_i)$. The first-order condition is :

$$\lambda=\frac{1}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}. \tag{4.40}$$

An increase in the net-of-tax rate of firm type i induces a mechanical and a behavioural effect. The mechanical effect is the reduction in the tax rate the firm faces, holding profits constant. The behavioural effect is the firm's optimal response to the change in the tax rate through its first-order conditions and captures the distorting effect of the corporate tax. Normally a higher tax rate leads to lower profits and vice versa.

The resulting optimal tax formula is

$$\left(\frac{e_i^{G^*}}{1-\varepsilon_i^{G^*}}\right)\left(\frac{1-t_i}{t_i}\right)=\frac{1}{1-e_i^T\left(\frac{t_i}{1-t_i}\right)}. \tag{4.41}$$

I can simplify the first-order conditions to an optimal benefit-based corporate

tax rate formula:

$$t_i^* = \frac{e_i^{G^*}}{1 - \varepsilon_i^{G^*} + e_i^{G^*} + e_i^T e_i^{G^*}}. \tag{4.42}$$

Since the term ε^G is the total impact of an increase in the public input on profits and $e_i^{G^*}$ is the partial impact, we can decompose $-\varepsilon_i^{G^*} + e^{G^*}$ into:

$$\begin{aligned}
e^{G^*} - \varepsilon_i^{G^*} &= \left(\frac{\partial \pi_i(k_i^*, g_i)}{\partial g_i}\right)\left(\frac{g_i}{\pi(k_i^*, g_i)}\right) - \left(\frac{\partial \pi_i(k_i^*, g_i)}{\partial g_i} + \frac{\partial \pi_i(k_i^*, g_i)}{\partial k_i^*}\frac{\partial k_i^*}{\partial g_i}\right)\left(\frac{g_i}{\pi(k_i^*, g_i)}\right) \\
&= \left(\frac{g_i}{\pi(k_i^*, g_i)}\right)\left(\frac{\partial \pi_i(k_i^*, g_i)}{\partial g_i} - \frac{\partial \pi_i(k_i^*, g_i)}{\partial g_i} + \frac{\partial \pi_i(k_i^*, g_i)}{\partial k_i^*}\frac{\partial k_i^*}{\partial g_i}\right) \\
v_i^{G^*} &= \left(\frac{\partial \pi_i(k_i^*, g_i)}{\partial k_i^*}\frac{\partial k_i^*}{\partial g_i}\right)\left(\frac{g_i}{\pi(k_i^*, g_i)}\right).
\end{aligned} \tag{4.43}$$

I define the new elasticity $v_i^{G^*}$ as the indirect public input elasticity of profits, while $e_i^{G^*}$ is the direct public input elasticity of profits. The direct elasticity captures the impact of the public input directly on the firm's profits through the profit function. The indirect elasticity captures effect of the firm's behavioural response to public inputs on profits through capital changes. If capital and the public input are complementary, then the indirect elasticity should be positive. You might think of the direct elasticity as being an unchangeable part of the firm's technology, while the indirect elasticity depends on the firm's behavioural response. Both elasticities, however, might be defined as being the result of the firm's profit function. The optimal tax formula can then be rewritten as:

$$t_i^* = \frac{e_i^{G^*}}{1 - v_i^{G^*} + e_i^T e_i^{G^*}}. \tag{4.44}$$

The optimal benefit-based corporate tax rate is expressed as a function of three elasticities: the direct public input elasticity of profits, the indirect public input elasticity of profits and the net-of-tax elasticity of profits. The firm has two behavioural responses: a response to an increased tax rate and a response to an increased public input. While a higher behavioural response to tax changes will lower the optimal tax rate, a higher behavioural response to the public input will increase the optimal tax rate. These behavioural responses can offset one another.

Higher direct or indirect public input elasticities both imply a higher corpo-

rate tax rate. They both imply an increase in the benefit the firm receives from the public input. Interestingly, a pure benefits-based tax should not imply that the indirect effects of the public input be accounted for. In this model, they are not. Instead, the indirect effects of the public input are balanced with the behavioural response of the firm to taxation.

4.A.3 Additional Estimates

Table 4.4: First-Stage Regression Results for Estimate of Tax Elasticity

	$\Delta \ln(1-\tau)$					
	1 Year		2 Year		3 Year	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(1-\tau^P)$	0.996***	0.998***	0.995***	0.998***	0.995***	0.998***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Base-Year Profit	Log	Spline	Log	Spline	Log	Spline
Observations	109,216	109,216	98,932	98,932	90,850	90,850
R^2	0.924	0.944	0.964	0.975	0.975	0.982

Notes: The dependent variable is the actual marginal net of tax rate, while the regressor is the predicted marginal net of tax rate. Standard errors in parentheses. Standard errors are clustered at the firm level. Regressions include firm-level fixed effects. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

Table 4.5: Estimate of Tax Elasticity using Sample of Firms Reporting Domestic Profits

	1 Year		2 Year		3 Year	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(1-\tau)$	1.141***	1.197***	0.851***	0.879***	0.907***	0.880***
	(0.316)	(0.318)	(0.225)	(0.216)	(0.284)	(0.288)
Base-Year Profit	Log	Spline	Log	Spline	Log	Spline
Observations	4,849	4,849	3,685	3,685	2,805	2,805
R^2	0.600	0.610	0.722	0.727	0.798	0.801

Notes: Standard errors in parentheses. Standard errors are clustered at the firm level. Regressions include firm-level fixed effects. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

Table 4.6: First-Stage Regression Results for Estimate of Tax Elasticity using Sample of Firms Reporting Domestic Profits

	$\Delta \ln(1-\tau)$					
	1 Year		2 Year		3 Year	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(1-\tau^P)$	1.002***	1.000***	1.003***	1.000***	1.004***	1.000***
	(0.002)	(0.001)	(0.004)	(0.001)	(0.004)	(0.000)
Base-Year Profit	Log	Spline	Log	Spline	Log	Spline
Observations	4,849	4,849	3,685	3,685	2,805	2,805
R^2	0.976	0.984	0.992	0.996	0.997	0.998

Notes: The dependent variable is the actual marginal net of tax rate, while the regressor is the predicted marginal net of tax rate. Standard errors in parentheses. Standard errors are clustered at the firm level. Regressions include firm-level fixed effects. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1.

4.A.4 The American Recovery and Reinvestment Act of 2009

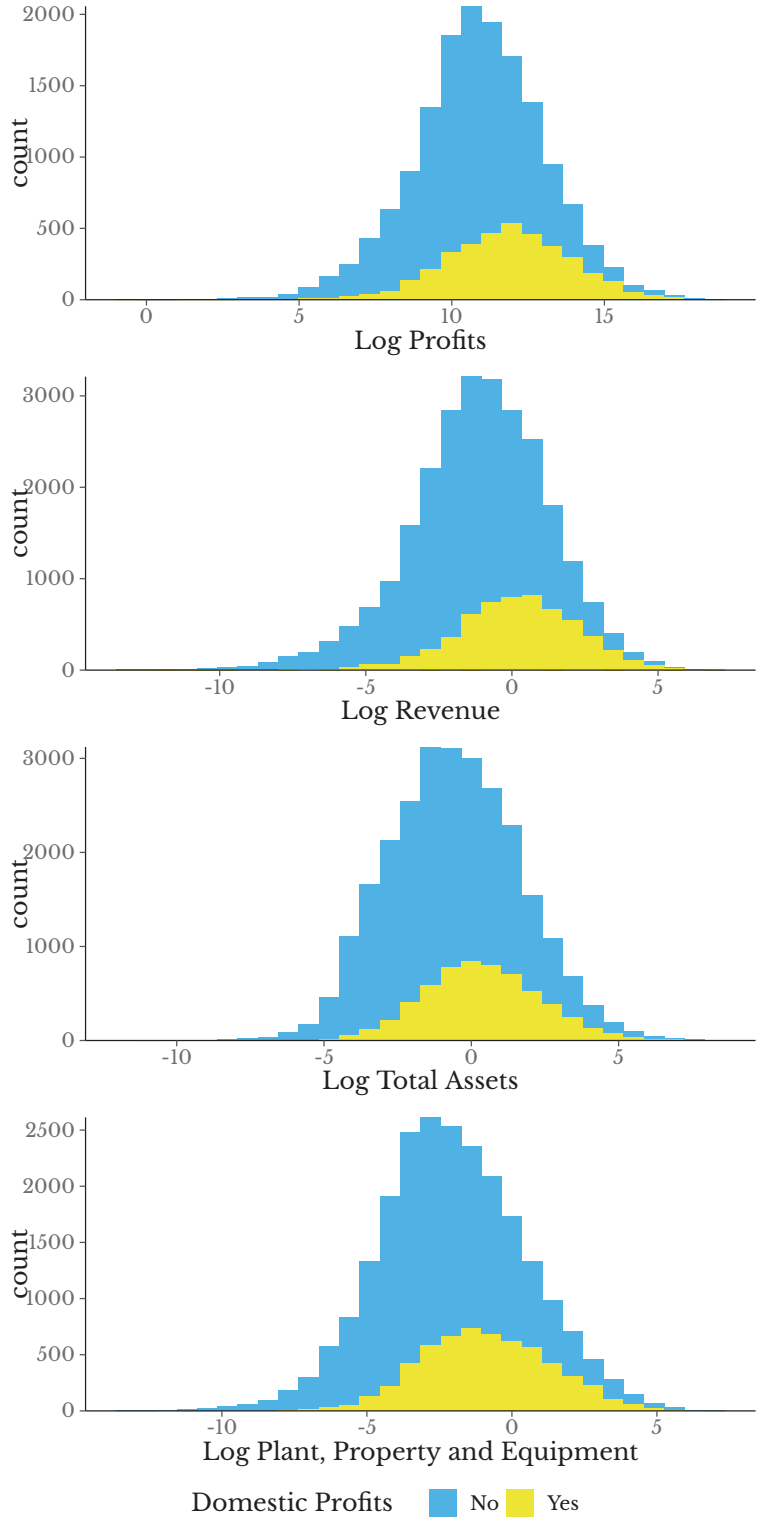
To show how public inputs directly and indirectly affect profits, I consider an extreme example in the United States. In response to the economic recession precipitated by the financial crisis, the American Recovery and Reinvestment Act of 2009 (ARRA) was passed by Congress and signed into law by President Barack Obama. The ARRA was designed to stimulate spending and to invest in new infrastructure. The bill induced stimulus spending of $831 billion, of which $105.3 billion was to be investment in public infrastructure. Infrastructure targeted by the bill included transport, water, sewerage, buildings, communications, security, and energy. This generated a broad-based shock to the level of public capital.

I show graphical evidence of the aggregate movements of profits, public inputs and private investment just before, during, and after the American Recovery and Reinvestment Act of 2009 was implemented. I plot aggregate quarterly series for domestic profits, federal gross nondefense investment (not just fixed investment), private nonfinacial fixed investment, and personal consumption expenditures. All variables are deflated using the Consumer Price Index. The plots are shown in Figure 4.6.

The American Recovery and Reinvestment Act was signed into law in Febru-

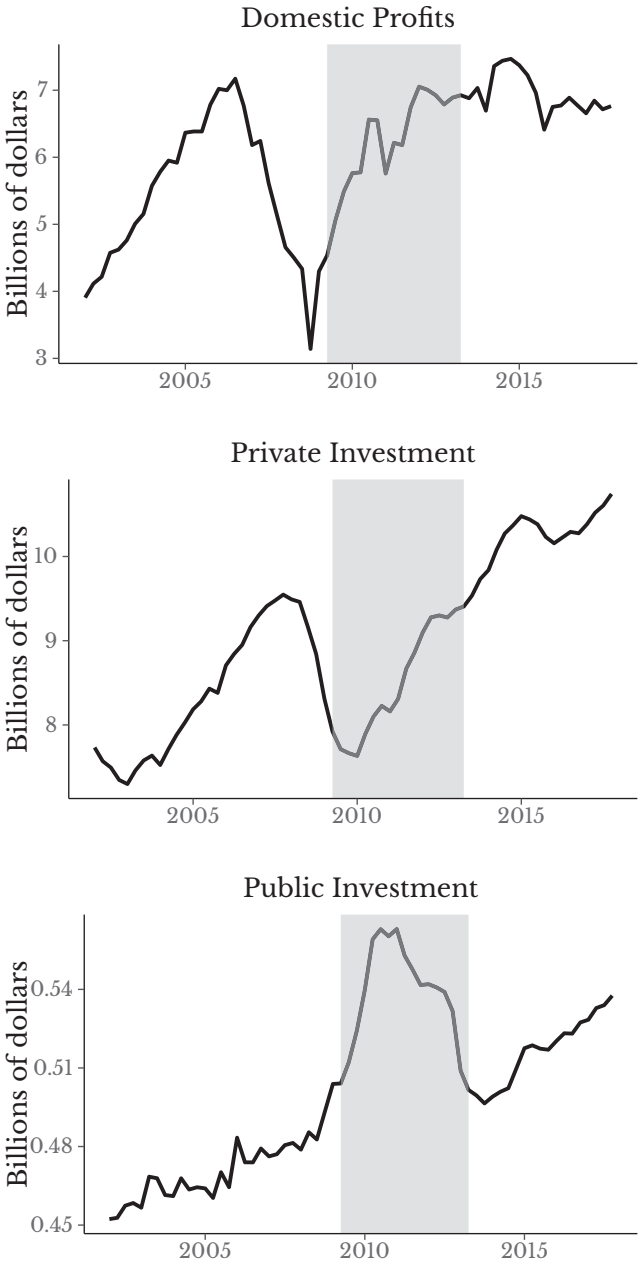
ary 2009. The observed increase in public investment began in the third quarter of 2009. Public investment remained at an elevated level until the end of 2012. During this period, domestic profits rose rapidly, albeit from a depressed level due to the recession. Two observations suggest that public investment played a role in the increase in profits. First, while profits and public investment began to increase in 2009, private fixed investment did not begin to increase until 2010. Even then, private investment grew at a steady pace reflecting the pre-crisis trend. Second, when public investment fell back from its elevated level in 2012, profits stopped growing as well. However, private capital experienced only a one-quarter pause and continued to grow up until 2015. These visual observations suggest there might be an economically significant impact of public investment on corporate profits.

Figure 4.5: Histograms of Average Differences Between Firms Reporting Domestic Profits or Not



All values are deflated using the seasonally adjusted Consumer Price Index with 1982-1984=100. These are average real values for each firm.

Figure 4.6: Graphical Evidence of the Effects of the American Recovery and Reinvestment Act of 2009



All values are deflated using the seasonally adjusted Consumer Price Index with 1982-1984=100.

Chapter 5

Conclusion

This thesis takes three small steps towards advancing our understanding of the international tax landscape. These advances in our knowledge are designed to help us make better policy. More importantly, these steps aim to help draw us closer to a consensus on the effects and principles of international corporate taxation.

In Chapter 2 I find that tax competition is not as substantial a policy concern as previous estimates might suggest. A combination of appropriate methodology and theoretical insight helps me derive a more convincing estimate of corporate tax competition. The obvious implication I stress is that this implies much less under-provision of the public good due to tax competition than was previously suggested. But a more nuanced implication is that the corporate tax rate around the world has been falling for less nefarious reasons than simply tax competition. In fact, as shown in the introduction, corporate tax revenue has remained steady around the globe—even growing—despite falling corporate tax rates and concerns of tax revenue lost to profit shifting. It suggests that governments have been making approximately optimal corporate tax changes over the past few decades. In particular, if a simple revenue-maximising corporate tax rate is some negative function of the tax elasticity of profits as in Chapters 2 and 4, then there appears a simple explanation for falling optimal corporate tax rates: the increasing mobility of the multinational firm and of capital more generally.

Chapter 3 investigates the magnitude, direction and potential causes of country-

pair cross-country tax base spillovers due to corporate tax reforms in Europe. The key takeaway from this essay is that corporate tax base spillovers are heterogeneous and depend critically on the characteristics of the countries involved and their relationship. This follows on from the idea in Chapter 2 that governments do not know exactly how their tax bases will be affected by a neighbour's tax rate cut. In fact, prior to this work, researchers themselves have only provided evidence of average spillover effects that give little guidance on how a specific country's tax rate change might affect another specific country's tax base. The implication is that a unilateral corporate tax reform in one country might not cause widespread damage to the international tax community. Even more importantly, since tax base spillovers are the mechanism through which tax competition works, the substantial heterogeneity of these elasticities might give us a clue as to why corporate tax competition is much weaker than we previously thought. And this substantial heterogeneity in spillovers justifies the use of heterogeneous spillover-approximating weights in estimating the size of tax competition responses in Chapter 2.

Chapter 4 switches from a positive to a normative approach, proposing that the fundamental purpose for the corporate income tax is as a benefit tax. In Chapter 4, I account for both the corporate tax landscape and advances in modern tax theory, in order to design an optimal corporate income tax that satisfies both our desire for fairness and our need for efficiency. Not only is such an optimal tax possible, but it is also implementable and provides us with clear signposts for what an optimal corporate tax should achieve. The implied message is that some measure of fairness is required for us to reach a global consensus on taxation. And the past three decades have taught us that the corporate tax system cannot be fixed without cooperation.

In 1923, the original international tax system was intellectually designed by four economists: Professor Edwin Seligman from the United States, Professor Luigi Einaudi from Italy, Professor G. W. J. Bruins from the Netherlands, and Sir Josiah Stamp from the United Kingdom. The four economists had to contend with a fundamental tension between the interests of capital-exporting countries and capital-importing countries. Their report to the League of Nations laid the foundations for the international tax system by inspiring the 1928 League of Nations Model Treaty. Their report considered two key ideas. First, they proposed

that we should differentiate between active and passive income. Second, they proposed that it is appropriate for active income to be taxed at source, while passive income should be taxed at residence. Active income reflects business income, the tax base with which this entire thesis is concerned.

Fascinatingly, Avi-Yonah (2005) dubs this period, from 1918 to 1960 (particularly the interwar years), "The Age of Benefits". The reason for this is that the principle ideology underpinning the international tax regime's foundation was the benefit principle—that a jurisdiction's right to tax arose from the provision of benefits. It was the belief of these four economists that the benefits principle should guide the design of the international tax system. But this period was followed by a period of distinct emphasis on efficiency rather than fairness. And as the emphasis on efficiency grew, it eventually gave way to tax competitive behaviour (Avi-Yonah, 2005). Competitive behaviour has led to a need for cooperation. However, cooperation over the past two decades has consistently failed at almost every level. Governments do not internalise the base spillover effects their tax reforms have on neighbouring countries, and neither do they seem to consider the potential for strategic responses.

But cooperation on corporate tax is unlikely to ever exist without first agreeing on a purpose for the corporate tax. The foundations of the corporate tax system were established by cooperation through the League of Nations. And the purpose that united various competing interests was the idea that taxation should reflect benefits received. This particularly holds for active income, which the four economists recommended should be taxed at source.

Cooperation can exist where we agree that inter-nation equity is just as important as achieving efficiency. Inter-nation equity is a notion that has been broadly forgotten over the past few decades. As in the International Monetary Fund's report on *Corporate Taxation in the Global Economy* (2019), only passing reference is made to the notion that the design of corporate tax needs to be fair *across countries*. Fairness in international corporate tax design is now only a weapon used to denounce tax havens. But inter-nation fairness should be an equal partner with economic efficiency in the determination of the optimal corporate tax system. It is likely that consensus will only arise when fairness is once again part of the broad discussion.

Realistically, cooperation by governments is a political topic. We know that the choice of corporate tax policy is inevitably coloured by political consideration. Policy reforms frequently appear to either be suboptimal in maximising a nation's welfare or fail to reflect the public's opinions and preferences. This is particularly relevant in the context of profit shifting and tax rate cuts.

First, while profit shifting is widely condemned, many governments maintain loopholes that allow firms to reduce their tax liability to almost nothing (Gardner et al., 2019). There is no doubt that the extent of profit shifting is a policy choice. Our entire tax systems which enable profit shifting are created by policy, and can be redesigned to eliminate profit shifting if politicians so wished. Yet the two loudest voices on profit shifting—the United States and Europe—have, in their midst, their very own untroubled tax havens. The European Commission cannot name European tax havens identified by the European Parliament (2019) on its own blacklist.

Second, while surveys suggest that voters would prefer increased taxes on corporations, corporate tax rates continue to fall (Pew Research Center, 2017a,b; Gallup, 2018). This appears to flout the public will. It is most commonly assumed that this is a result of lobbying by large corporations. But is there some rational reason why government decisions on corporate tax do not appear to reflect the preferences of the voting public? As discussed in Bird (1996), it is quite possible that the government observes constraints—both domestic and international—that voters do not. For example, the government may internalise the increasing mobility of the multinational firm in a manner that individuals do not. The discussion on the incidence of the corporate tax is one we cannot take lightly. Ever since Judd (1985) and Chamley (1986), we are wary of the negative effects that taxing any form of capital might have on labour. The evidence on the incidence of the corporate tax is mixed (Auerbach, 2006; Clausing, 2011; Arulampalam et al., 2012; Suárez Serrato and Zidar, 2016; Fuest et al., 2018). This makes it difficult to understand who benefits from corporate tax cuts, and who would lose without them.

Whether these misaligned policy decisions are truly optimal for the entire country has serious implications for inequality, both from a political and an economic perspective. From an economic perspective, global markups have in-

creased by around 45 percent from 1980 to 2016, naturally implying a redistribution of resources from workers towards owners of large firms (De Loecker and Eeckhout, 2018). Kaymak and Schott (2018) suggests the decline in corporate tax rates is responsible for 40 percent of the decline in labour's share in income. And while Nallareddy et al. (2018) show that corporate tax cuts lead to higher income inequality in the United States, Boar and Midrigan (2019) propose that profit taxes are too blunt an instrument to effectively redistribute income in a closed economy because it lowers economic growth. But increasing corporate profits also increases 'corporate power', which manifests itself in political, economic and market power (Avi-Yonah, 2004). The political perspective of inequality created by the corporate tax is possibly more damaging. The increased power of corporations necessarily limits the political power of the voting public. And public perception that their preferences are being flouted by the government is damaging.

These are all questions that arise from the issues raised in this thesis. This thesis seeks to interrogate the foundations of today's international corporate tax system. Tax competition and corporate tax base spillovers are a key point of contention, along with profit shifting to tax havens. Each of these three matters are fundamental failures of cooperation and coordination. To create successful cooperation, there must exist a consensus. This thesis seeks to provide the positive and normative foundations for the re-emergence of an international consensus on the taxation of corporate income.

Bibliography

Abbas, S. M. A. and A. Klemm (2013). A partial race to the bottom: corporate tax developments in emerging and developing economies. *International Tax and Public Finance 20*(4), 596–617.

Arulampalam, W., M. P. Devereux, and G. Maffini (2012). The direct incidence of corporate income tax on wages. *European Economic Review 56*(6), 1038–1054.

Aschauer, D. A. (1989). Is public expenditure productive? *Journal of monetary economics 23*(2), 177–200.

Atkinson, A. B. and N. H. Stern (1974). Pigou, taxation and public goods. *The Review of economic studies 41*(1), 119–128.

Atkinson, A. B. and J. E. Stiglitz (1980). Lectures on public economics.

Auerbach, A. J. (2006). Who bears the corporate tax? A review of what we know. *Tax policy and the economy 20*, 1–40.

Auerbach, A. J. and M. Devereux (2018). Cash Flow Taxes in an International Setting. *American Economic Journal: Economic Policy*.

Auerbach, A. J., M. P. Devereux, M. Keen, and J. Vella (2017). Destination-based cash flow taxation.

Avi-Yonah, R. S. (2004). Corporations, society, and the state: A defense of the corporate tax. *Virginia Law Review*, 1193–1255.

Avi-Yonah, R. S. (2005). All of a Piece Throughout: The Four Ages of US International Taxation. *Va. Tax Rev. 25*, 313.

Bachas, P. and M. Soto (2018). Not (ch) your average tax system: corporate taxation under weak enforcement.

Bahar, D. and H. Rapoport (2018). Migration, knowledge diffusion and the comparative advantage of nations. *The Economic Journal 128*(612), F273–F305.

Baldwin, R. E. and P. Krugman (2004). Agglomeration, integration and tax harmonisation. *European Economic Review 48*(1), 1–23.

Ballard, C. L. and D. Fullerton (1992). Distortionary taxes and the provision of public goods. *Journal of Economic Perspectives 6*(3), 117–131.

Becker, J. and R. B. Davies (2017). Learning to Tax?-Interjurisdictional Tax Competition under Incomplete Information.

Becker, J. and C. Fuest (2011). The taxation of foreign profitsâĂŤThe old view, the new view and a pragmatic view. *Intereconomics 46*(2), 92–97.

Becker, J., C. Fuest, and N. Riedel (2012). Corporate tax effects on the quality and quantity of FDI. *European Economic Review 56*(8), 1495–1511.

Becker, J. and N. Riedel (2012). Cross-border tax effects on affiliate investmentâĂŤEvidence from European multinationals. *European Economic Review 56*(3), 436–450.

Beer, S., R. De Mooij, and L. Liu (2018). International corporate tax avoidance: a review of the channels, effect sizes, and blind spots. *IMF Working papers*.

Beer, S., A. D. Klemm, and T. Matheson (2018). *Tax Spillovers from US Corporate Income Tax Reform*. International Monetary Fund.

Beesley, A. (2019). Apple to start paying âĆň13bn to Ireland over back tax claim.

Bellak, C., M. Leibrecht, and J. P. Damijan (2009). Infrastructure Endowment and Corporate Income Taxes as Determinants of Foreign Direct Investment in Central and Eastern European Countries. *The World Economy 32*(2), 267–290.

Bellemare, M. F. and C. J. Wichman (2019). Elasticities and the Inverse Hyperbolic Sine Transformation. *Oxford Bulletin of Economics and Statistics forthcomin*.

Benassy-Quere, A., N. Gobalraja, and A. Trannoy (2007). Tax and public input competition. *Economic Policy 22*(50), 386–430.

Bird, R. M. (1996). Why tax corporations?

Bjorvatn, K. and G. Schjelderup (2002). Tax competition and international public goods. *International tax and public finance 9*(2), 111–120.

Bloch, F. and U. Zenginobuz (2007). The effect of spillovers on the provision of local public goods. *Review of Economic Design 11*(3), 199–216.

Boar, C. and V. Midrigan (2019). Markups and Inequality. Technical report.

Boehm, C. E., A. Flaaen, and N. Pandalai-Nayar (2019). Input linkages and the transmission of shocks: Firm-level evidence from the 2011 TÅNhoku earthquake. *Review of Economics and Statistics 101*(1), 60–75.

Bom, P. R. D. and J. E. Ligthart (2014a). Public infrastructure investment, output dynamics, and balanced budget fiscal rules. *Journal of Economic Dynamics and Control 40*, 334–354.

Bom, P. R. D. and J. E. Ligthart (2014b). What have we learned from three decades of research on the productivity of public capital? *Journal of economic surveys 28*(5), 889–916.

Bond, S., L. Chennells, M. P. Devereux, M. Gammie, and E. Troup (2000). *Corporate tax harmonisation in Europe: A guide to the debate*. Number R63. IFS Reports, Institute for Fiscal Studies.

Bond, S. R. and M. P. Devereux (2003). Generalised R-based and S-based taxes under uncertainty. *Journal of Public Economics 87*(5-6), 1291–1311.

Bond, S. R., M. P. Devereux, and M. J. Gammie (1996). Tax reform to promote investment. *Oxford Review of Economic Policy 12*(2), 109–117.

Boumans, D., C. Fuest, C. Krolage, and K. Wohlrabe (2019). Expected Effects of the US Tax Reform on Other Countries: Global and Local Survey Evidence.

Brainard, S. L. (1993). A simple theory of multinational corporations and trade with a trade-off between proximity and concentration. Technical report.

Browning, E. K. and L. Liu (1998). The Optimal Supply of Public Goods and the Distortionary Cost of Taxation: Comment. *National Tax Journal*, 103–116.

Bucovetsky, S. (1991). Asymmetric tax competition. *Journal of urban economics 30*(2), 167–181.

Buldorini, L., S. Makrydakis, and C. Thimann (2002). The effective exchange rates of the euro. Technical report.

Canarella, G., S. M. Miller, and M. M. Nourayi (2013). Firm profitability: Mean-reverting or random-walk behavior? *Journal of Economics and Business 66*, 76–97.

Chamley, C. (1986). Optimal taxation of capital income in general equilibrium with infinite lives. *Econometrica: Journal of the Econometric Society*, 607–622.

Chetty, R. (2009). Is the taxable income elasticity sufficient to calculate deadweight loss? The implications of evasion and avoidance. *American Economic Journal: Economic Policy 1*(2), 31–52.

Chetty, R. (2012). Bounds on Elasticities With Optimization Frictions: A Synthesis of Micro and Macro Evidence on Labor Supply. *Econometrica 80*(3), 969–1018.

Chetty, R. and E. Saez (2010). Dividend and corporate taxation in an agency model of the firm. *American Economic Journal: Economic Policy 2*(3), 1–31.

Chinn, M. D. and H. Ito (2008). A new measure of financial openness. *Journal of comparative policy analysis 10*(3), 309–322.

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

Clausing, K. A. (2011). In search of corporate tax incidence. *Tax L. Rev. 65*, 433.

Clemens, M. A. and E. R. Tiongson (2017). Split decisions: household finance when a policy discontinuity allocates overseas work. *Review of Economics and Statistics 99*(3), 531–543.

Cnossen, S. (2018). Corporation taxes in the European Union: Slowly moving toward comprehensive business income taxation? *International Tax and Public Finance 25*(3), 808–840.

Crivelli, E., R. De Mooij, and M. Keen (2016). Base erosion, profit shifting and developing countries. *FinanzArchiv: Public Finance Analysis 72*(3), 268–301.

Cui, W. (2016). Minimalism about Residence and Source. *Mich. J. Int'l L. 38*, 245.

Datt, K. H. (2014). Paying a fair share of tax and aggressive tax planning-A tale of two myths. *eJournal of Tax Research 12*(2), 410.

Davies, R. and J. Voget (2008). Tax competition in an expanding European Union.

Davies, R. B., J. Martin, M. Parenti, and F. Toubal (2017). Knocking on tax haven's door: multinational firms and transfer pricing. *Review of Economics and Statistics*.

Davies, R. B., I. Siedschlag, and Z. Studnicka (2016). The Impact of Taxes on the Extensive and Intensive Margins of FDI.

Davies, R. B. and J. Voget (2011). Tax Competition in an Expanding European Union.

De Bondt, W. F. M. and R. H. Thaler (1989). Anomalies: A Mean-Reverting Walk Down Wall Street. *Journal of Economic Perspectives 3*(1), 189–202.

De Giorgi, G., A. Frederiksen, and L. Pistaferri (2016). Consumption network effects. Technical report.

De Loecker, J. and J. Eeckhout (2018). Global market power.

De Mooij, R. A. (2005). Will corporate income taxation survive? *De Economist 153*(3), 277–301.

de Mooij, R. A. and S. Ederveen (2008). Corporate tax elasticities: a reader's guide to empirical findings. *Oxford Review of Economic Policy 24*(4), 680–697.

Desai, M. A., C. F. Foley, and J. R. Hines (2009). Domestic effects of the foreign activities of US multinationals. *American Economic Journal: Economic Policy 1*(1), 181–203.

Desai, M. A., C. F. Foley, and J. R. Hines Jr (2005). Foreign direct investment and the domestic capital stock. *American Economic Review 95*(2), 33–38.

Devereux, M. and R. Griffith (1998). The taxation of discrete investment choices. Technical report.

Devereux, M. P., C. Fuest, and B. Lockwood (2015). The taxation of foreign profits: A unified view. *Journal of Public Economics 125*, 83–97.

Devereux, M. P. and R. Griffith (2003). Evaluating tax policy for location decisions. *International tax and public finance 10*(2), 107–126.

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

Devereux, M. P., L. Liu, and S. Loretz (2014). The elasticity of corporate taxable income: New evidence from UK tax records. *American Economic Journal: Economic Policy 6*(2), 19–53.

Devereux, M. P., B. Lockwood, and M. Redoano (2008). Do countries compete over corporate tax rates? *Journal of Public Economics 92*(5), 1210–1235.

Devereux, M. P. and S. Loretz (2013). What Do We Know About Corporate Tax Competition? *National Tax Journal 66*(3), 745–774.

Dhillon, A., M. Wooders, and B. Zissimos (2007). Tax competition reconsidered. *Journal of Public Economic Theory 9*(3), 391–423.

Diamond, P. and E. Saez (2011). The case for a progressive tax: from basic research to policy recommendations. *The Journal of Economic Perspectives 25*(4), 165–190.

Dunning, J. H. (1988). The eclectic paradigm of international production: A restatement and some possible extensions. *Journal of international business studies 19*(1), 1–31.

Egger, P., C. Keuschnigg, V. Merlo, and G. Wamser (2014). Corporate taxes and internal borrowing within multinational firms. *American Economic Journal: Economic Policy 6*(2), 54–93.

Elhorst, J. P. and S. Fréret (2009). Evidence of political yardstick competition in France using a twoâĂŘregime spatial Durbin model with fixed effects. *Journal of Regional Science 49*(5), 931–951.

European Parliament (2019). Tax crimes: MEPs want EU financial police force and financial intelligence unit.

Exbrayat, N. (2017). Does Trade Liberalisation Trigger Tax Competition? Theory and Evidence from OECD Countries. *The World Economy 40*(1), 88–115.

Feehan, J. P. and M. Matsumoto (2017). Optimal rationing of productive public services under tax competition. *Economics Letters 151*, 79–81.

Feld, L. P. and J. H. Heckemeyer (2011). FDI and Taxation: A Meta-Study. *Journal of Economic Surveys 25*(2), 233–272.

Feldstein, M. (1995). The effect of marginal tax rates on taxable income: a panel study of the 1986 Tax Reform Act. *Journal of Political Economy*, *55*1–572.

Feldstein, M. (1999). Tax avoidance and the deadweight loss of the income tax. *Review of Economics and Statistics 81*(4), 674–680.

Fleming Jr, J. C., R. J. Peroni, and S. E. Shay (2001). Fairness in international taxation: the ability-to-pay case for taxing worldwide income. *Fla. Tax Rev. 5*, 299.

Fréret, S. and D. Maguain (2017). The effects of agglomeration on tax competition: evidence from a two-regime spatial panel model on French data. *International Tax and Public Finance*, 1–41.

Fuest, C., A. Peichl, and S. Siegloch (2018). Do higher corporate taxes reduce wages? Micro evidence from Germany. *American Economic Review 108*(2), 393–418.

Gallup (2018). Taxes | Gallup Historical Trends.

Gardner, M., S. Wamhoff, M. Martellotta, and L. Roque (2019). Corporate Tax Avoidance Remains Rampant Under New Tax Law. Technical report, Institution on Taxation and Economic Policy.

Goodman-Bacon, A. (2018). Difference-in-differences with variation in treatment timing. Technical report.

Gordon, R. H. (1986). Taxation of investment and savings in a world economy. *The American Economic Review*, 1086–1102.

Govindarajan, V., A. Srivastava, H. Warsame, and L. Enache (2019). The Problem with France's Plan to Tax Digital Companies.

Graetz, M. J. (2000). Taxing international income: Inadequate principles, outdated concepts, and unsatisfactory policies. *Brook. J. Int'l L. 26*, 1357.

Griffith, R., J. Hines, and P. B. Sørensen (2010). International capital taxation. In *Dimensions of Tax Design: The Mirrlees Review*, pp. 914–996. Citeseer.

Griffith, R. and A. Klemm (2004). What has been the tax competition experience of the past 20 years?

Griffith, R., H. Miller, and M. O'Connell (2014). Ownership of intellectual property and corporate taxation. *Journal of Public Economics 112*, 12–23.

Gruber, J. and J. Rauh (2007). How elastic is the corporate income tax base. *Taxing corporate income in the 21st century*, 140–163.

Gruber, J. and E. Saez (2002). The elasticity of taxable income: evidence and implications. *Journal of public Economics 84*(1), 1–32.

Guarascio, F. (2017). EU to discuss tax havens blacklist after 'Paradise Papers' leaks.

Gugl, E. and G. Zodrow (2015a). Tax competition and the efficiency of'benefit-related'business taxes.

Gugl, E. and G. R. Zodrow (2015b). Competition in business taxes and public services: are production-based taxes superior to capital taxes? *National Tax Journal 68*(3S), 767.

Gupta, S., A. Kangur, C. Papageorgiou, and A. Wane (2014). Efficiency-adjusted public capital and growth. *World Development 57*, 164–178.

Hanson, G. H., R. J. Mataloni Jr, and M. J. Slaughter (2001). Expansion strategies of US multinational firms.

Haufler, A. and G. Schjelderup (1999). Corporate taxation, profit shifting, and the efficiency of public input provision. *FinanzArchiv/Public Finance Analysis*, 481–499.

Haufler, A. and G. Schjelderup (2000). Corporate tax systems and cross country profit shifting. *Oxford Economic Papers 52*(2), 306–325.

Haufler, A. and F. Stähler (2013). Tax competition in a simple model with heterogeneous firms: How larger markets reduce profit taxes. *International Economic Review 54*(2), 665–692.

Haufler, A. and I. Wooton (1999). Country size and tax competition for foreign direct investment. *Journal of Public Economics 71*(1), 121–139.

Havranek, T., R. Horvath, Z. Irsova, and M. Rusnak (2015). Cross-country heterogeneity in intertemporal substitution. *Journal of International Economics 96*(1), 100–118.

Heckemeyer, J. H. and M. Overesch (2017). Multinationals' profit response to tax differentials: Effect size and shifting channels. *Canadian Journal of Economics/Revue canadienne d'économique 50*(4), 965–994.

Heckman, J. J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. In *Annals of Economic and Social Measurement, Volume 5, number 4*, pp. 475–492. NBER.

Heinemann, F., M. Overesch, and J. Rincke (2010). Rate-Cutting Tax Reforms and Corporate Tax Competition in Europe. *Economics & Politics 22*(3), 498–518.

Helpman, E. (1984). A simple theory of international trade with multinational corporations. *Journal of political economy 92*(3), 451–471.

Hendren, N. (2016). The policy elasticity. *Tax Policy and the Economy 30*(1), 51–89.

Hindriks, J., S. Peralta, and S. Weber (2008). Competing in taxes and investment under fiscal equalization. *Journal of public economics 92*(12), 2392–2402.

Hines Jr, J. R. and E. M. Rice (1994). Fiscal Paradise: Foreign Tax Havens and American Business. *The Quarterly Journal of Economics*, 149–182.

Hong, Q. and M. Smart (2010). In praise of tax havens: International tax planning and foreign direct investment. *European Economic Review 54*(1), 82–95.

Hubbard, R. G. (1998). Capital-market imperfections and investment. *Journal of Economic Literature 36*(1), 193.

Huizinga, H. and L. Laeven (2008). International profit shifting within multinationals: A multi-country perspective. *Journal of Public Economics 92*(5), 1164–1182.

Huizinga, H. and S. B. Nielsen (1997). Capital income and profit taxation with foreign ownership of firms. *Journal of International Economics 42*(1-2), 149–165.

Iacus, S. M., G. King, and G. Porro (2011). Multivariate matching methods that are monotonic imbalance bounding. *Journal of the American Statistical Association 106*(493), 345–361.

IMF (2014). Spillovers in International Corporate Taxation. Technical report, Washington, DC.

IMF (2015). Making Public Investment More Efficient. Technical report.

IMF (2017). FAD Investment and Capital Stock Database 2017: Manual and FAQ - Estimating Public, Private, and PPP Capital Stocks. Technical report.

IMF (2019). Corporate Taxation in the Global Economy. Technical report, Washington, DC.

IMF, OECD, United Nations, and World Bank (2011). Supporting the Development of More Effective Tax Systems. Technical report.

Janský, P. and M. Palanský (2019). Estimating the scale of profit shifting and tax revenue losses related to foreign direct investment. *International Tax and Public Finance 26*(5), 1048–1103.

Johannesen, N. (2010). Imperfect tax competition for profits, asymmetric equilibrium and beneficial tax havens. *Journal of International Economics 81*(2), 253–264.

Johannesen, N., T. Tørsløv, and L. Wier (2016). Are less developed countries more exposed to multinational tax avoidance? Method and evidence from micro-data. Technical report.

Judd, K. L. (1985). Redistributive taxation in a simple perfect foresight model. *Journal of public Economics 28*(1), 59–83.

Kalemli-Ozcan, S., B. Sorensen, C. Villegas-Sanchez, V. Volosovych, and S. Yesiltas (2015). How to construct nationally representative firm level data from the ORBIS global database. Technical report.

Kamps, C. (2006). New estimates of government net capital stocks for 22 OECD countries, 1960âĂŞ2001. *IMF staff papers 53*(1), 120–150.

Kane, M. A. (2015). A defense of source rules in international taxation. *Yale J. on Reg. 32*, 311.

Kaplow, L. (2011). *The theory of taxation and public economics*. Princeton University Press.

Karabarbounis, L. and B. Neiman (2018). Accounting for Factorless Income. Technical report, National Bureau of Economic Research.

Kaufman, N. H. (1997). Fairness and the taxation of international income. *Law & Pol'y Int'l Bus. 29*, 145.

Kawano, L. and J. Slemrod (2016). How do corporate tax bases change when corporate tax rates change? With implications for the tax rate elasticity of corporate tax revenues. *International Tax and Public Finance 23*(3), 401–433.

Kaymak, B. and I. Schott (2018). Corporate tax cuts and the decline of the labor share.

Keen, M. and K. A. Konrad (2014). The theory of international tax competition and coordination.

Keen, M. and M. Marchand (1997). Fiscal competition and the pattern of public spending. *Journal of public economics 66*(1), 33–53.

Keen, M. and H. Piekkola (1997). Simple rules for the optimal taxation of international capital income. *Scandinavian Journal of Economics 99*(3), 447–461.

King, M. A. (1987). The cash flow corporate income tax. In *The Effects of Taxation on Capital Accumulation*, pp. 377–400. University of Chicago Press.

Kleven, H. J. (2016). Bunching. *Annual Review of Economics 8*, 435–464.

Koethenbuerger, M., M. Mardan, and M. Stimmelmayr (2019). Profit shifting and investment effects: The implications of zero-taxable profits. *Journal of Public Economics 173*, 96–112.

Kogut, B. (2001). Multinational Corporation. In N. J. Smelser and P. B. Baltes (Eds.), *International encyclopedia of the social and behavioral sciences (Vol. 11)*, pp. 10197–10204. Amsterdam: Elsevier.

Koh, H.-J., N. Riedel, and T. Böhm (2013). Do governments tax agglomeration rents? *Journal of Urban Economics 75*, 92–106.

Koide, H. (1985). Spatial provision of local public goods with spillover effects. *Regional Science and Urban Economics 18*(2), 283–305.

Kopczewska, K., J. Kudła, and K. Walczyk (2017). Strategy of Spatial Panel Estimation: Spatial Spillovers Between Taxation and Economic Growth. *Applied Spatial Analysis and Policy 10*(1), 77–102.

Lagarde, C. (2019). An overhaul of the international tax system can wait no longer.

Langenmayr, D. and L. Liu (2019). *Where does multinational investment go with territorial taxation? Evidence from the UK*. International Monetary Fund.

Leibrecht, M. and C. Hochgatterer (2012). Tax competition as a cause of falling corporate income tax rates: A survey of empirical literature. *Journal of Economic Surveys 26*(4), 616–648.

LeSage, J. P. and R. K. Pace (2014). The biggest myth in spatial econometrics. *Econometrics 2*(4), 217–249.

Lindahl, E. (1919). Just Taxation âĂŤ A Positive Solution. In R. A. Musgrave and A. T. Peacock (Eds.), *Classics in the Theory of Public Finance*, pp. 168–176. London: MacMillan.

Liu, L. and R. De Mooij (2018). At a cost: the Real Effects of Transfer Pricing Regulations.

Loretan, M. (2005). Indexes of the foriegn exchange value of the dollar. *Fed. Res. Bull. 91*, 1.

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

Lyytikäinen, T. (2012). Tax competition among local governments: Evidence from a property tax reform in Finland. *Journal of Public Economics 96*(7), 584–595.

Mankiw, N. G. (2010). Spreading the wealth around: reflections inspired by Joe the Plumber. *Eastern Economic Journal 36*(3), 285–298.

Mankiw, N. G., M. Weinzierl, and D. Yagan (2009). Optimal taxation in theory and practice. *Journal of Economic Perspectives 23*(4), 147–174.

Markusen, J. R. (1984). Multinationals, multi-plant economies, and the gains from trade. *Journal of international economics 16*(3-4), 205–226.

Markusen, J. R. and A. J. Venables (2000). The theory of endowment, intra-industry and multi-national trade. *Journal of international economics 52*(2), 209–234.

Mas-Colell, A., M. D. Whinston, and J. R. Green (1995). *Microeconomic theory*, Volume 1. Oxford university press New York.

Matsumoto, M. and K. Sugahara (2017). A note on production taxation and public-input provision. *The Annals of Regional Science 59*(2), 419–426.

McKeehan, M. K. and G. R. Zodrow (2017). Balancing act: weighing the factors affecting the taxation of capital income in a small open economy. *International Tax and Public Finance 24*(1), 1–35.

McKenzie, D. (2017). Identifying and Spurring High-Growth Entrepreneurship: Experimental Evidence from a Business Plan Competition. *American Economic Review 107*(8), 2278–2307.

Meade, J. E. (1978). *The Structure and Reform of Direct Taxation. Report of a Committee Chaired by JE Meade. The Institute for Fiscal Studies*. Allen & Unwin.

Mendoza, E. G. and L. L. Tesar (2005). Why hasn't tax competition triggered a race to the bottom? Some quantitative lessons from the EU. *Journal of monetary economics 52*(1), 163–204.

Mieszkowski, P. and G. R. Zodrow (1989). Taxation and the Tiebout model: the differential effects of head taxes, taxes on land rents, and property taxes. *Journal of Economic Literature 27*(3), 1098–1146.

Mikler, J. (2018). *The political power of global corporations*. John Wiley & Sons.

Mirrlees, J., S. Adam, T. Besley, R. Blundell, S. Bond, R. Chote, M. Gammie, P. Johnson, G. Myles, and J. Poterba (2011). *Tax by design: The Mirrlees Review*, Volume 2. Oxford University Press.

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *The review of economic studies 38*(2), 175–208.

Musgrave, P. B. (1963). *Taxation of foreign investment income: an economic analysis*. Johns Hopkins Press.

Musgrave, R. A. and P. B. Musgrave (1972). Inter-nation equity. *Modern Fiscal Issues: Essays in Honour of Carl S. Shoup*, 63–85.

Myles, G. D. (1995). *Public economics*. Cambridge university press.

Nallareddy, S., E. Rouen, and J. C. Suárez Serrato (2018). Corporate tax cuts increase income inequality. Technical report.

Namini, J. E. and H. P. G. Pennings (2009). Horizontal Multinational Firms, Vertical Multinational Firms and Domestic Investment.

OECD (2001). *Corporate tax incentives for foreign direct investment*. OECD Publishing.

OECD (2013). Action Plan on Base Erosion and Profit Shifting. Technical report.

OECD (2014, sep). Fundamental principles of taxation. In *Addressing the Tax Challenges of the Digital Economy*, pp. 29–50.

OECD (2019). Ending offshore profit shifting.

Overesch, M. and J. Rincke (2011). What drives corporate tax rates down? a reassessment of globalization, tax competition, and dynamic adjustment to shocks*. *The Scandinavian Journal of Economics 113*(3), 579–602.

Palan, R., R. Murphy, and C. Chavagneux (2013). *Tax havens: how globalization really works*. Cornell University Press.

Parry, I. W. H. (2003). How large are the welfare costs of tax competition? *Journal of Urban Economics 54*(1), 39–60.

Peralta, S. and T. van Ypersele (2005). Factor endowments and welfare levels in an asymmetric tax competition game. *Journal of Urban Economics 57*(2), 258–274.

Pew Research Center (2017a). April 2017 Political Survey. Technical report.

Pew Research Center (2017b). Majority of Americans think business corporations make 'too much profit'.

Pigou, A. C. (1947). *A Study in Public Finance*. London: Macmillan.

Pogge, T. and K. Mehta (2016a). *Global tax fairness*. Oxford University Press.

Pogge, T. and K. Mehta (2016b). Introduction: the moral significance of tax-motivated outflows. In T. Pogge and K. Mehta (Eds.), *Global tax fairness*, Chapter 1, pp. 1–13. Global Tax Fairness. Oxford: Oxford University Press.

Qu, X. and L.-f. Lee (2015). Estimating a spatial autoregressive model with an endogenous spatial weight matrix. *Journal of Econometrics 184*(2), 209–232.

Redoano, M. (2014). Tax competition among European countries. Does the EU matter? *European Journal of Political Economy 34*, 353–371.

Rose, A. K. and M. M. Spiegel (2007). Offshore financial centres: parasites or symbionts? *The Economic Journal 117*(523), 1310–1335.

Saez, E. (2017). Taxing the rich more: Preliminary evidence from the 2013 Tax Increase. *Tax Policy and the Economy 31*(1), 71–120.

Saez, E., J. Slemrod, and S. H. Giertz (2012). The elasticity of taxable income with respect to marginal tax rates: A critical review. *Journal of economic literature 50*(1), 3–50.

Samuelson, P. A. (1955). Diagrammatic Exposition of a Theory of Public Expenditure. *The Review of Economics and Statistics 37*(4), 350–356.

Schreuer, M. and M. Stevis-Gridneff (2019). E.U. Court Orders Fiat Chrysler to Pay Back $33 Million in Taxes.

Seegert, N., M. Smith, E. Patel, and J. L. Coles (2018). How Do Private Firms Respond to Corporate Taxes.

Seitz, H. (1994). Public capital and the demand for private inputs. *Journal of Public Economics 54*(2), 287–307.

Slemrod, J. and W. Kopczuk (2002). The optimal elasticity of taxable income. *Journal of Public Economics 84*(1), 91–112.

Slemrod, J. and J. D. Wilson (2009). Tax competition with parasitic tax havens. *Journal of Public Economics 93*(11), 1261–1270.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. London: W. Strahan and T. Cadell.

Sørensen, P. B. (2000). The case for international tax coâĂŘordination reconsidered. *Economic Policy 15*(31), 430–472.

Sørensen, P. B. (2001). Tax coordination in the European Union: What are the issues? *Swedish Economic Policy Review 8*(1), 143–196.

Sørensen, P. B. (2007). Can capital income taxes survive? And should they? *CESifo Economic Studies 53*(2), 172–228.

Stiglitz, J. E. and P. Dasgupta (1971). Differential taxation, public goods, and economic efficiency. *The Review of Economic Studies 38*(2), 151–174.

Stöwhase, S. (2005). Asymmetric capital tax competition with profit shifting. *Journal of Economics 85*(2), 175–196.

Suárez Serrato, J. C. (2018). Unintended Consequences of Eliminating Tax Havens. *National Bureau of Economic Research Working Paper Series No. 24850*.

Suárez Serrato, J. C. and O. Zidar (2016). Who benefits from state corporate tax cuts? A local labor markets approach with heterogeneous firms. *American Economic Review 106*(9), 2582–2624.

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of political economy 64*(5), 416–424.

Tørsløv, T. R., L. S. Wier, and G. Zucman (2018). The Missing Profits of Nations.

UN, E. C. and I. M. F. FAO (2005). Handbook of national accounting: integrated environmental and economic accounting 2003. *New York, United Nations*.

UNCTAD (2017). World Investment Report 2017. Technical report, United Nations Conference on Trade and Development.

Weber, C. E. (2014). Toward obtaining a consistent estimate of the elasticity of taxable income using difference-in-differences. *Journal of Public Economics 117*, 90–103.

Weichenrieder, A. J. (2005). (Why) do we need corporate taxation?

Weinzierl, M. (2017). Popular acceptance of inequality due to innate brute luck and support for classical benefit-based taxation. *Journal of Public Economics 155*, 54–63.

Weinzierl, M. (2018a). Review of Global Tax Fairness, Thomas Pogge and Krishen Mehta, Editors. *Journal of Economic Literature 56*(2), 673–684.

Weinzierl, M. (2018b). Revisiting the Classical View of Benefit-based Taxation. *The Economic Journal*.

Weisbach, D. A. (2015). The Use of Neutralities in International Tax Policy. *National Tax Journal 68*(3), 635–652.

Wessel, R. H. (1967). A note on economic rent. *The American Economic Review 57*(5), 1221–1226.

Wildasin, D. (1986). *Urban public finance*. New York: Harwood Academic Publishers.

Wildasin, D. E. (1989). Interjurisdictional capital mobility: Fiscal externality and a corrective subsidy. *Journal of urban economics 25*(2), 193–212.

Wilson, J. D. (1986). A theory of interregional tax competition. *Journal of urban Economics 19*(3), 296–315.

Wilson, J. D. (1987). Trade, capital mobility, and tax competition. *Journal of Political Economy 95*(4), 835–856.

Wilson, J. D. (1991). Tax competition with interregional differences in factor endowments. *Regional science and urban economics 21*(3), 423–451.

Wilson, J. D. and D. E. Wildasin (2004). Capital tax competition: bane or boon. *Journal of public economics 88*(6), 1065–1091.

Zissimos, B. and M. Wooders (2008). Public good differentiation and the intensity of tax competition. *Journal of public economics 92*(5-6), 1105–1121.

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

Zucman, G. (2014). Taxing across borders: Tracking personal wealth and corporate profits. *The Journal of Economic Perspectives 28*(4), 121–148.