A theoretical and empirical evaluation of the corporate tax base elasticity in OECD countries from a Norwegian viewpoint.

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Preface

This completes my Economics degree,
it is called a Master of Philosophy.
I have many to thank for a great education,
now the world await my skills with anticipation.
In particular, I am grateful for excellent guidance,
Vidar Christiansen's supervision in the economic science.
Many thanks also, to Oslo Fiscal Studies, a magnificent place
for support, scholarship and my own office space.
To my fellow students, friends and everyone in 10th,
thanks for discussions, help and encouragement.
Thanks to two authors, Riedl and Rocha-Akis, who weren't wary
to provide their sources, and answer my query.
Now at last, only one thing remain,
any errors herein are, solely, to my own name.

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Summary

For the past 30 years, the corporate income tax rates in the OECD countries have decreased from 45 percent in 1982 to below 27 percent in 2012. At the same time, the corporate income tax revenue as share of GDP has increased. Tax competition is seen as the main source of this development.

Firms respond behaviourally to the tax rate and the tax systems deductions and allowances in order to maximise their after-tax returns. The larger the behavioural effect is, the greater the revenue costs and dead weight loss for society becomes. Firms decide in which country to locate based on comparing their expected after-tax profits between countries. Further, a multinational firm can shift their profits to be taxed in countries with low taxes. A firm, or an entrepreneur, will also choose legal form based on tax incentives. Investments and the financial structure of the firm are also influenced, determining how much to invest and the composition of debt and equity.

I use panel data of 19 OECD countries in the period of 1982 to 2012 to estimate the long run effects of the domestic and neighbouring tax rates on the corporate tax base. The regression controls for various macro data variables such as income per capita, GDP, growth, cost of labor and EU-membership as well as country specific, time invariant and country trend effects.

The results of this analysis is that the tax base is elastic with regards to changes in the domestic tax rate, specifically, the elasticity of -1.17 in the tax base with a one percent change in domestic tax rate. The effects of neighbouring countries changes in tax rates are inelastic and of low significance. A comparison of my results to the closely related literature of similar methodology shows a higher elasticity of the tax base and less effect of the neighbouring tax rates then previous findings. Extensions show that replacing the data for Norway with oil-revenue corrected data increases the estimated elasticity of the domestic tax rate and lowers the effect of the foreign tax rate.

The dynamic model estimations show that in the short run the tax base is inelastic, where half the effect of a change in the domestic tax rate occurs in the immediate year. The resulting long run semi-elasticity of -2.9 % is close to the aggregate effect estimated in a meta-analysis by De Mooij and Ederveen (2008) of -3.1 % of a one percentage point change in the tax rate.

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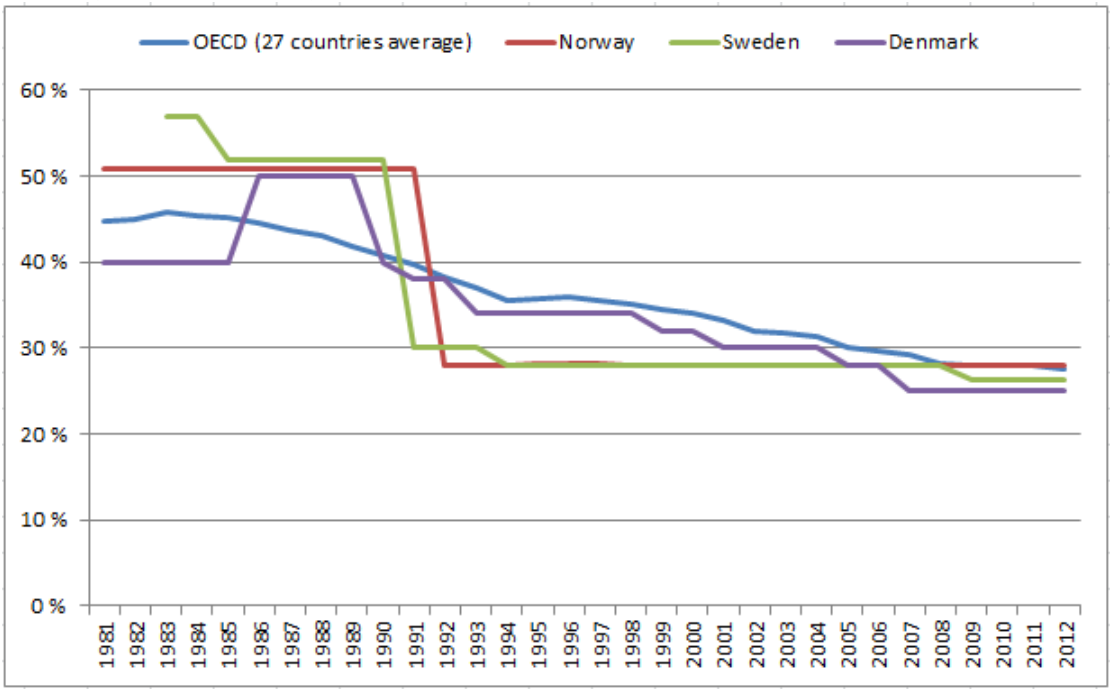
1 Background and motivation

The government collects tax revenue in order to provide public goods and welfare services or correct externalities. To raise revenue the government can use a repertoire of taxes and fees on labor, goods, capital and corporations. The corporate income tax (CIT) is one of these tax instruments, and the focus of this thesis. The challenge of taxation is to find the least distortive ways of raising the needed tax-revenue. For the past 30 years, the corporate income tax has been under international downward pressure. The development is characterized by countries taxing at a lower income tax rate, see Figure 1, but, at the same time, broadening the base of taxable capital (Auerbach et al., 2008; Haufler, 2001). The Norwegian Ministry of Finance pointed to the international development and increased tax competition when they appointed a committee to investigate the necessity of a reform of the Norwegian corporate income tax (MOF, 2014).

Figure 1: Statutory tax rates in Norway, Sweden, Denmark and OECD

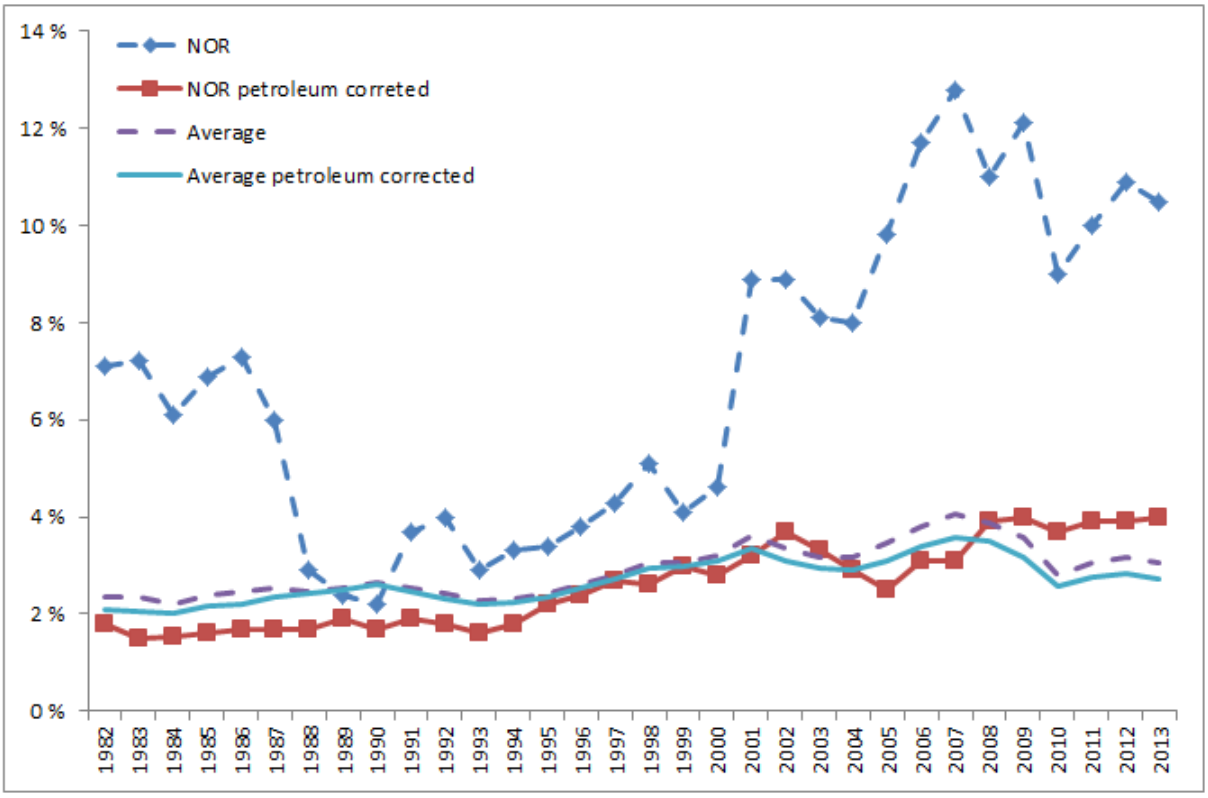


Years: 1981 – 2012. Source: OECD (2015).

As shown in Figure 2, the declining statutory tax rates have not resulted in a decrease in the corporate income tax's share of gross domestic products. There are arguments against taxing capital and the classical result of a small open economy is not to tax it at all (Gordon and MacKie-Mason, 1995). In a globalised economy, capital is mobile and taxation will, therefore, create distortions. However, while capital is mobile, the long term nature of real capital investments[1] is that firms in the short and

[1]Real capital investments include factories, equipment and inventories.

Figure 2: Corporate tax revenue as % of GDP.



Sources: OECD, SSB and Ministry of Finance (MOF). Norway with and without correcting for petroleum sector and averages.

medium run are not perfectly mobile. Some countries, like Norway, have access to rich natural resources, such as oil, which provides ample room for a rent-specific corporate taxation. Given the international downward pressure through tax competition and the states eagerness to respond the empirical question arises, how harmful is it to tax mobile capital? More specifically the question this thesis seeks to answer is; How sensitive is the corporate tax base to changes in the corporate tax rate?

It is well known that the excess burden of taxation increases exponentially with the amount of taxation, and the loss is higher the more elastic the response to taxation is (Stiglitz, 2000). Empirical estimates of the elasticity of the corporate tax base to changes in corporate tax rates provide important information for assessing both revenue and welfare implications of corporate tax policies (Dwenger and Steiner, 2008).

There has been substantial amount of empirical research on the subject of corporate tax elasticity. A meta-analysis done by De Mooij and Ederveen (2008) cover 31 of these studies. They find that the semi-elasticity, namely the percentage change in the tax base from a 1% point change in the tax rate, has to an aggregate effect of -3.1% on the tax base[2]. The Swedish Committee of Corporate Taxation (SOU, 2014) uses the estimates

[2]This is the total effect ignoring spillover effects and assuming a unilateral equal change in the statutory, average- and marginal effective tax rates of one percentage point.

of De Mooij and Ederveen (2008) to find that a one percentage increase of the CIT will have an effect of decreasing the Swedish' tax base by -1.85%. The committee appointed by the Ministry of Finance in Norway (MOF, 2014) uses the same method and finds a similar estimate of -1.76% for the Norwegian tax base.

The empirical methodology in this paper will be based on the method of Riedl and Rocha-Akis (2012). They explored the tax base elasticity in 17 OECD countries in the period of 1982 to 2005. The authors found that a country's aggregate reported corporate profits are negatively and significantly affected by CIT rate reduction in neighboring countries. Furthermore, they found that a unilateral decrease in a country's domestic statutory tax rate decreases the aggregate corporate income tax revenue. They estimated that the corporate tax base is inelastic in the long run, as a one percentage increase in the efficient average tax rate leads to a -0.86% decrease in the tax base. In the terms of semi-elasticity this amounts to a -1.24% decrease in tax base. As the corporate income tax is highly current topic, of constant development, with the availability of newer and potentially higher quality data it is interesting to re-examine this issue in a new and broader analysis.

In the next section I will examine what the corporate tax base is and what affects it. In section 3, i will present the empirical methodology and the data used. In section 4 I will discuss the findings and robustness of the results before the conclusion.

2 Model of the corporate tax base

The government's corporate income tax revenue is given by a tax rate τ multiplied with the corporate tax base b. The tax base can be defined as the sum of taxable profits of all the number of firms in the economy. There are multiple factors deciding the size of the corporate tax base, including the corporate income tax rate, tax laws including depreciation rates in addition to business cycles, as well as individual and firm behaviour.

The pre-tax profits as observed from the government, denoted $\tilde{\pi}$, of a single firm i is given by equation (1). This consists of sales income that is given by the product price p multiplied by the production function $F_i(L_i, K_i, Z_i)$. The production function is dependent upon the input factors labor (L_i), capital (K_i) and other factors (Z_i) as well as their respective costs. If I assume the cost of labor to be the hourly wage w_i and payroll tax per hour t multiplied with hours of input L_i. The cost of holding a unit of capital is given by the interest rate i on the value of a unit of capital plus the value of its depreciation, denoted δ where $0 < \delta < 1$. I can gather the cost of all other input factors in s_i where θ could be some other associated cost, for instance an environmental tax.

$$\tilde{\pi}_i = p_i F_i(L_i, K_i, Z_i) - (1+t)w_i L_i - (i+\delta)q_i K_i - (1-\theta)s_i Z_i \tag{1}$$

I assume that the firm is a single price taker in commodity and factor markets. The firm maximizes its net post tax profits $\pi_{posttax} = \pi - \tau\tilde{\pi}$ where $\tilde{\pi}$ is the firms taxable profits[3]. I see that taxes t, θ, input factor costs w_i, q_i and depreciation allowance from the government α affect the tax base directly. The governments tax total base will be the sum of the taxable profits $\tilde{\pi}$ of all firms in the economy. This gives the following expression for the sum of total taxable corporate profits, or in other words the governments corporate tax base denoted b:

$$b = \sum_{i=1}^{N} \tilde{\pi}_i = \sum_{i=1}^{N} (p_i F_i(L_i, K_i, Z_i) - (1+t)w_i L_i - (i+\alpha)q_i K_i - (1+\theta)s_i Z_i) \tag{2}$$

In addition to prices and taxes other factors like labor productivity, access to capital, natural resources, state and institutional factors such as political stability and infrastructure can be assumed to be important. In the globalized economy the investor and firm will compare all these factors both within and between countries in the investment decision.

[3]The reason for not simply stating that the firm's profit is $(1-\tau)\pi$ is that the deductions and adaptions as allowed in the tax system might not be entirely equal to the firm's true valuations of these. Meaning the firm's true profits might be different then the one "observed" and taxed by the government allowing the firm to optimize over this discrepancy.

Following in this section I will elaborate on the different measures of the corporate tax rate. Further I will cover the most important dimensions of how firm behaviour are affected by corporate taxes, specifically how the firms location of investments, legal form, financial structure and profit shifting affect the corporate tax base.

2.1 Effective, marginal and statutory tax rates

The statutory tax rate is the most simple measure of a country's tax rate. It can consist of multiple rates for different layers of government with local, state and federal taxes with the possibility of deductions between these. It can also be proportional or progressive where firms below a certain size belongs to a lower tax bracket.

An international investor or firm will compare statutory tax rates but also other tax- or judicial rules, regulations and allowances that impact the post-tax profits of the firm. The impact of taxes on the investment decision can be measured through the impact on the cost of capital using the effective marginal tax rate (EMTR). The EMTR as described by Devereux and Griffith (1998) describes the proportionate difference between the pre-tax and post-tax required rates of return of a marginal investment. The higher the EMTR the greater the required pre-tax return is and subsequently a lower incentive to invest. For a firm comparing multiple profitable investment projects it will compare the effective average tax rate (EATR). The EATR is a weighted average between the EMTR and the statutory tax rate. For the marginal investment the EATR is equal to the EMTR and as the economic rents (pure profits) increase the EATR approaches the statutory tax rate measure.

As firms are not homogeneous and countries tax systems can be complex with sets of deductions depending on industries the average effective tax rate will vary between firms within a country. The EATR measure for a country is estimated with certain assumptions about the representative investment such as the composition of short- and long lived capital as well as the representative firm's financial structure (Devereux et al., 2009).

Devereux and Griffith (1998) presents evidence that the three measures of corporate tax rate are all useful determinants of where a firm invests (extensive margin), how much it invests (intensive margin) and lastly where it shifts profits. The authors found that US firms moving to Europe would determine where to locate themselves by comparing the EATR between the countries. After choosing country the amount of investments was best described by the EMTR measure. While lastly the location where the firm wishes to shift and extracts it's profits was most influenced by the statutory tax rate measure.

2.2 Localization decision

In the neoclassical view of the firm with mobile capital, the investor will chose countries from around the globe where the returns to capital are highest, which in turn will equalize the return to capital in all countries (Haufler, 2001). De Mooij and Ederveen (2008) assume that there might be multinationals with the ability to receive firm-specific rents that are mobile across countries. In the presence of rents, the average effective tax rate will be the relevant measure for the firm to evaluate localization decision in order to maximise after their tax profits.

However, more factors vary than just the marginal and average tax rates. Diverging from the neoclassical view a managerial firm will take internal considerations such as the firms interests and objectives (Stiglitz, 2000). The firm will also consider the external factors influencing the labor market, such as labor regulations, social policies and other factors contributing to the cost of labor. The firm will also consider the goods and services market with standards, closeness to market, competition regulation, infrastructure and foreign trade policies. Lastly the firm will consider capital market conditions[4].

Devereux and Griffith (1998) find that, in addition to the effective average tax rate, agglomeration effects are important in the firms localization decision. Agglomeration effects is when a large installed capital base has positive externalities onto new investors, such effects could lower the sensitivity of changes in the tax rate (Keen and Konrad, 2012). De Mooij and Ederveen (2008) find in their meta study a substantial effect of the effective average tax rate on localization choice.

2.3 Profit shifting

In the global economy, a multinational firm operating in several countries can be assumed to optimize its profits over all companies as a whole, taking into account the various tax rates, deductions and allowances. The arm's length principle is the ruling principle of dividing the tax base between parties of common interests. The principle states that transactions between related parties shall be done at the same terms, hereunder prices, as the same transaction between unrelated parties (Auerbach et al., 2008). However this principle is often challenged when confronted with nontraditional transactions such as intellectual property rights (Fuest et al., 2013).

If I assume a company in country a supplies a good or service to the company in country b. The service has a market value of 1. The firms can however deviate from the arm's length principle and set a different price to shift profits to be taxed under a different country. Using the model for the tax base with equation (2) I can

[4]Hereunder monetary policies, fiscal policy with corporate income tax, dividends tax, interest taxes and subsidies

interpret the earlier Z_i as an input factor or service bought from a mother company. The subsidiary firm can for instance pay royalties for using intellectual property rights such as the brand name of a mother company. A deviation from the market price s (set to unity $s = 1$) will shift profits either to or from the company. Profit shifting comes at an undeductable concealment cost $\phi(s)$ which is assumed to have the following properties: $\phi(1) = 0$, $\phi'(1) = 0$ and $\phi''(1) > 0$.

I will for simplicity assume that all other taxes and variables are equal between the countries a and b. This entails providing full deductability of capital costs and a depreciation at the true rate such that the sum of the real corporate profits are equal to the tax base[5]. The multinational firm maximizes its total profits taking both subsidiaries into consideration and optimizing with regards to the transfer price s.

$$\pi_{MNC} = (1 - \tau_a)\pi_a + (1 - \tau_b)\pi_b - \phi(s) \tag{3}$$

Inserting for a simplified expression for the firms profit where prices are equated and the subsidiary firm in country a buys a service at value 1 and price s from the firm in country b.

$$\begin{aligned} \pi_{MNC} &= (1 - \tau_a)(pF_a(K_a) - (i + \alpha)qK_a - s + 1) \\ &+(1 - \tau_b)(pF_b(K_b) - (i + \alpha)qK_b + s - 1) - \phi(s) \end{aligned} \tag{4}$$

This gives a first order condition for the optimal transfer price s between the two companies:

$$\frac{\partial \pi_{MNC}}{\partial s} = (\tau_a - \tau_b) - \phi'(s) = 0 \tag{5}$$

$$(\tau_a - \tau_b) = \phi'(s) \tag{6}$$

The equilibrium behaviour of the multinational firm is to shift profits to the point where the marginal cost of shifting one more unit of profit equals the marginal benefit of shifting tax-country. If $\tau_a > \tau_b$ it can be optimal for the multinational company do exert profit shifting from country a to country b. If tax rates are equal the good will be priced at its true value in both markets.

2.4 Choice of legal form

For small businesses or single entrepreneurs the relationship between the corporate income tax and the personal income tax (PIT) is a potential source of distortions. An active shareholder can choose between receiving labor income or dividends of the cor-

[5]The instance where the company's profits and the governments tax base are the same, and equal to $\pi(1 - \tau)$.

porate profits. Differences between PIT and CIT can also create arbitrage opportunities for personal consumption to be covered by the firm or firm profits to be provided as loans to the shareholder. Gordon and Slemrod (1998) looks at US data in a period in the 1980's with personal income tax cuts. The authors write that income shifting plays havoc with the usual interpretation of many kinds of data as it blurs the division between return to capital and the return to labor.

De Mooij and Nicodème (2008) find that when corporate income taxes are falling, the change in legal form from self-employed to incorporation has lead to an increase in the tax base and the stabilization of corporate tax revenues. The change from self employment to corporate form will in most countries move the income from the personal to the corporate income tax bracket. The larger the difference between the corporate and personal income tax rates will incentivize a change of legal form leading to distortions. The authors however finds that other non-tax benefits such as limited liabilities are more important in the decision of legal form. De Mooij and Ederveen (2008) takes the average of two studies and estimates that a one percent increase in corporate taxes will lead to a 0.7% decrease in the corporate tax base through change in legal form.

Norway, under the dual income tax system from 1992 taxed labor income progressively and capital income proportionally (MOF, 2014). The underlying assumption for the difference in tax rates was that capital was mobile and labor immobile, therefore taxing labor income higher would be less harmful. The dual system lead to necessary split income rules for small businesses to hinder income shifting. The split model applied to sole proprietors and corporations with more than two-thirds of the shares held by active owners. Under the split model the return to labor of active owners were counted as labor income irrespective of it being paid as dividends, wages or retained profits. An entrepreneur who wanted to shift income from the personal bracket to the lower bracket belonging to the corporate form could do so by making changes to the ownership structure of the firm. The self-employed or closely held corporation would need to become "widely held" where at least one third was owned by a passive shareholder. Alstadsæter (2007) finds that the dual income tax system can lead to over-investment in low risk real capital as a device to shift income from personal to corporate income taxation. Thoresen and Alstadsæter (2010) confirm empirically that economically successful small firms have a substantial tax minimizing incentive to avoid the split model, by satisfying the one third passive shareholder requirement and becoming a widely held corporation. The main purpose of the 2006 tax reform was to remove this distortion created in the split model by evening out the highest taxes on labor and firm ownership through lowering of the marginal labor tax and introducing a dividends tax for individuals (Børresen et al., 2014).

2.5 Investments and financial structure

The tax system can create distortions on the financial structure of the firm by a potentially strong behavioural response on the composition of debt and equity (Mirrlees et al., 2011). A firms investment can either be financed by debt, issued equity or retained earnings. Sandmo (1974) shows that if depreciation allowance is unequal to the true rate of depreciation the pre-tax factor prices are distorted and therefore leads to under or over-investment in capital/labor. If rates of depreciation allowance and interest deductability are generous they may actually encourage investments relative to a no-tax situation (Stiglitz, 2000).

Projects financed by debt are in most tax systems provided with pre-tax deduction of interest payment while there are no deductions for the opportunity cost of equity. A tax systems' non-neutral treatment of finance sources influence the choice of capital in that it stimulates an equity or usually debt-bias. Debt bias is the situation where the firm has a financial structure with a greater share of debt because of its adjustment to a distortion created by the tax system where debt is biased over equity. Under the assumption that debt is initially a cheaper form of finance then equity for the firm the firm will initially use some share of debt financing. However, as the debt-equity ratio increases, the cost of debt also increases. The lender is increasingly exposed to the risk of bankruptcy and assumeingly increasing costs as a result of asymmetric information, uncertainty and other agency costs. Under the assumption that the firm will always finance a share of an investment with equity a debt bias will increase the cost of capital and debt-equity ratio above the socially optimal. Deductions of interest payments leading to a debt-bias opens the economy up for thin capitalization and inefficiencies (MOF, 2014). This is used as one of the main arguments for the coming Swedish tax reform (SOU, 2014). Sørensen (2014) has estimated that the current tax system of Norway distorts the firms choice of equity-debt ratio where the debt-asset ratio is 4-5 percent points above the socially optimal. Several countries have introduced thin capitalization rules to limit large scale conversions of equity to debt in order to avoid taxation (SOU, 2014).

2.6 Fundamental tax competition model

A fundamental result in the literature is that tax competition with mobile capital leads to an inefficiently low capital tax rate and therefore, an under provision of public goods, as shown by the benchmark model for tax competition presented by Zodrow and Mieszkowski (1986). This section follows the presentation of Haufler (2001) where returns to capital is taxed in the country it occurs, also known as source taxation. Considering a static model of n identical countries, where $n \in [1, \ldots, \infty]$, each individual in every country has an identical supply of one unit of labor and owns k units of capital

stock. With immobile labor and perfectly mobile capital the rate of return R is equal in all jurisdictions. Denoting the amount of capital employed in each jurisdiction by k_i, capital market clearing implies:

$$\sum_{i=1}^{N} k_i = \sum_{i=1}^{N} \bar{k} = \bar{K} \tag{7}$$

The countries produce a single and homogeneous output good. The production function is identical across countries and given by $f(k_i)$ with the fixed labor input suppressed and assumed perfectly competitive output and factor markets. The production function is twice differentiable with decreasing returns to scale:

$$f'(k_i) > 0, \qquad f''(k_i) < 0$$

Investors compare the net-of-tax returns of capital, $f'(k^i) - t^i$ where t^i is the country levied source tax rate. From the perspective of a typical country i the arbitrage condition is:

$$f'(k_i) - t_i = R(t_i) \qquad \forall i \in [1, \ldots, n]$$

The interest rate R is equalized worldwide and a function of t_i when the amount of countries n is finite. With implicit differentiation of country i's tax rate on itself, and the other country, I can find the effects of a marginal increase from country i's tax rate. The differentiation shows that an increase in the capital taxation, in any country, reduces the amount of capital employed there. The capital flows to all other countries until the new equilibrium is achieved.

$$f''(k_i)\frac{\partial k}{\partial t} - 1 = \frac{\partial R}{\partial t} \tag{8}$$

$$\frac{\partial k_i}{\partial t_i} = \frac{(1 + \frac{\partial R}{\partial t_i})}{f''(k_i)} \tag{9}$$

$$f'(k_j) - t_j = R \tag{10}$$

$$\frac{\partial k_j}{\partial t_i} = \frac{\frac{\partial R}{\partial t_i}}{f''(k_j)} \qquad \forall i, j, i \neq j \tag{11}$$

With the perspective of country i and denoting all other countries as j differentiation of the market clearing condition gives us:

$$k_i + (n-1)k_j = \bar{K} \tag{12}$$

$$\frac{\partial k_i}{\partial t_i} + (n-1)\frac{\partial k_j}{\partial t_i} = 0 \tag{13}$$

Inserted the differentiated arbitrage condition (7), (9) and (11) I get that the effect of a change in country i's tax rate on the world interest rate is:

$$\frac{(1+\frac{\partial R}{\partial t_i})}{f''(k_i)+(n-1)}+(n-1)\frac{\frac{\partial R}{\partial t_i}}{f''(k_j)}=0 \tag{14}$$

$$1+\frac{\partial R}{\partial t_i}+(n-1)\frac{\frac{\partial R}{\partial t_i}}{f''(k_j)}=0 \tag{15}$$

$$\frac{\partial R}{\partial t_i}=\frac{-1}{n} \tag{16}$$

A tax increase in country i will lower the world interest rate through reducing the domestic demand for capital. Given that all countries have an equal impact on the world interest rate, the effect of a tax increase in one country is decreasing in the number of countries. To see the effect of the tax increase on country i's own tax base I substitute this expression back into the arbitrage condition:

$$\frac{\partial k_i}{\partial t_i}=\frac{(1-\frac{1}{n})}{f''(k_i)} \tag{17}$$

In the benchmark case of autarki $(n=1)$ I see that the capital base is not affected by an increase in the source tax rate. The effect with mobile capital is increasing in the number of countries and it is the "mirror effect" of the interest rate which reacts less with many countries. In order to find the optimal capital tax rate in this economy I assume that the government maximizes a utility function of a representative individual $u(c_i, g_i)$. The two goods consumed are private consumption good c_i and public provided good g_i. The goods represent different use of the same output and the marginal rate of transformation between c_i and g_i is 1. The government budget constraint in each country is given by the tax on capital.

$$g_i = t_i k_i \qquad \forall i \tag{18}$$

The representative individual resident in each country receives value of production less the payments for mobile factor capital plus the net return R on capital endowment:

$$c_i = f(k_i) - f'(k_i)k_i + R\bar{k} \tag{19}$$

Each government sets their rate of taxation taking the other countries (equilibrium) tax rate as given. Inserting for the government and individual budget constraint, and imposing symmetry $k_i = \bar{k}$ in the Nash equilibrium, gives the following expression for the symmetric equilibrium in capital tax rates:

$$\frac{\partial u}{\partial t_i} = \frac{\partial u}{\partial c_i}\frac{\partial c_i}{\partial t_i} + \frac{\partial u}{\partial g_i}\frac{\partial g_i}{\partial t_i} = 0 \tag{20}$$

$$\frac{\partial u}{\partial t_i} = -\frac{\partial u}{\partial c_i}\bar{k} + \frac{\partial u}{\partial g_i}(\bar{k} + t_i\frac{(1-\frac{1}{n})}{f''(\bar{k})}) = 0 \tag{21}$$

$$\frac{\partial u}{\partial t_i} = -\bar{k} + \frac{\frac{\partial u}{\partial g_i}}{\frac{\partial u}{\partial c_i}}(\bar{k} + t_i\frac{(1-\frac{1}{n})}{f''(\bar{k})}) = 0 \tag{22}$$

$$\frac{\partial u}{\partial t_i} = \bar{k}(m(c_i, g_i) - 1) + m(c_i, g_i)\frac{(1-\frac{1}{n})}{f''(\bar{k})} = 0 \tag{23}$$

In the case of autarky, it is derived that the effect of a tax increase on the government welfare function gives us an efficient allocation with marginal rate of substitution $m(c_i, g_i) = (\partial u/(\partial g_i))/(\partial u/(\partial c_i)) = 1$ and equal to the marginal rate of transformation. For an open economy with $n > 1$ the second expression in the optimality condition is negative and increasing in n. This implies that the marginal rate of substitution $m(c_i, g_i) > 1$ must hold in the Nash equilibrium. The fundamental result is that the uncoordinated Nash equilibrium leads to an under provision of the public good. This effect is increasing with the amount of countries, n, for the equality to hold this implies an increase in the marginal rate of substitution and decreased taxation. The effect can be illustrated in a figure where the production possibility curve has slope -1. The autarky equilibrium provided public good is g_0. While in an open economy each government perceive the price of the public good to be $-b$ and therefore supplies the g_1 amount in an uncoordinated Nash equilibrium due to tax competition.

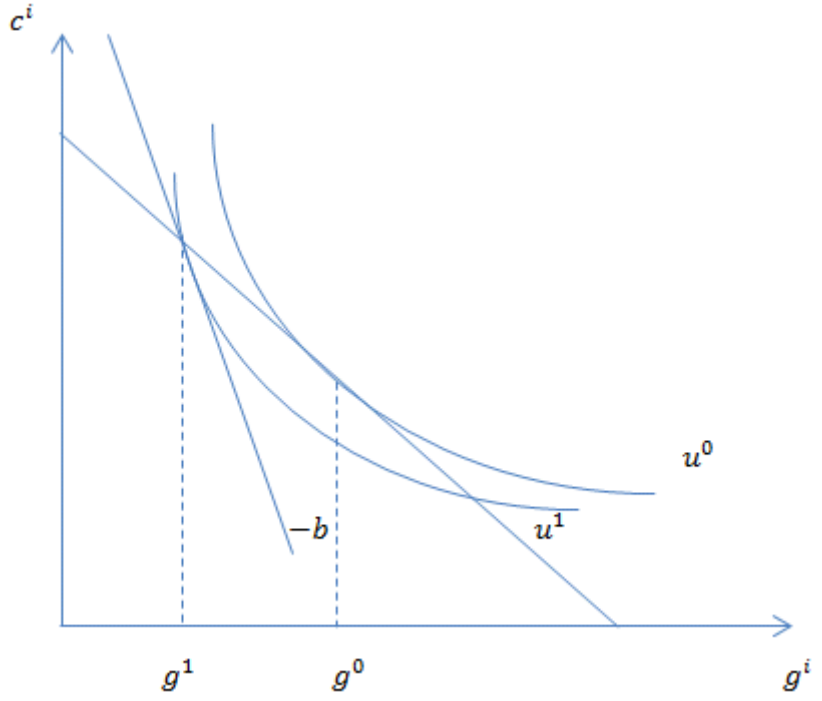
The decentralized Nash equilibrium under uncoordinated tax competition that the countries reach is inefficient. Since the amount of capital is given the total base from a collective viewpoint is inelastic and tax coordination would make the first best allocation feasible (Keen and Konrad, 2012). There are however authors who argue the potential benefits of tax competition (Wilson and Wildasin, 2004).

2.7 Country size

Hindriks and Myles (2006) has shown that the relative size of a country affects the cost of taxation. A large country will have a less elastic tax base than a small country. This is a situation where the competitive Nash equilibrium will lead to the smaller country setting a lower tax rate and achieving a higher capital labor ratio than the larger country.

The model above can show this in an example of two countries differing only in the number of residents. If I suppose country 1 is "large" with a share $s > \frac{1}{2}$ of the total population and country 2 being "small" with a share $1 - s < \frac{1}{2}$. The capital market

Figure 3: Tax competition Nash equilibrium



clearing condition would be:

$$sk_1(t_1, t_2) + [1 - s]k_2(t_1, t_2) = \bar{k} \tag{24}$$

The arbitrage condition implies equality of after tax-return on capital across the two countries.

$$\begin{aligned} f'(k_1) - t_1 = R = f'(k_2) - t_2 \\ = f'(\frac{\bar{k}}{1-s} - \frac{sk_1}{1-s}) - t_2 \end{aligned} \tag{25}$$

Differentiating this arbitrage condition gives the capital outflow in response to a domestic tax increase for the large country:

$$\frac{dk_1}{dt_1} = \frac{1-s}{[1-s]f''(k_1) + sf''(k_2)} < 0 \tag{26}$$

Analogously, for the small country I get:

$$\frac{dk_2}{dt_2} = \frac{s}{[1-s]f''(k_1) + sf''(k_2)} < 0 \tag{27}$$

From equations (26) and (27) I see that both have a negative impact on capital from an increase in their own tax rate. I also note that the outflow is less severe in the large country when $t_1 = t_2$ I have $k_1 = k_2, f''(k_1) = f''(k_2)$ and thus $\frac{dk_1}{dt_1} < \frac{dk_2}{dt_2} < 0$ for

$s > 1 - s$. The larger country has a less elastic tax base and will therefore chose a higher tax rate then the smaller country.

Hindriks and Myles (2006) shows that if the small country is sufficiently small it is possible that the country will be better off with tax competition than without, at the behest of the large country.

2.8 Neighbouring countries

From the fundamental tax model it can be seen that the perfect flow of capital equalizes marginal return of capital in all countries. However the foreign investment flows seem to be concentrated to and from countries of geographical or cultural closeness, see Table 1. Such an effect could stem from home bias as a result of information asymmetries or some other reason leading to a relative over-investment in capital close to home. In Norway the largest share of foreign owned firms originate from Sweden and Denmark with Great Britain, USA and Germany following.

Table 1: Share of total number of foreign owned corporations

	Norway	Sweden	Denmark
Norway	-	15 %	9,2 %
Sweden	29 %	-	25,6 %
Denmark	12,9 %	9,7 %	-
Great Britain	10,4 %	8,9 %	8,2 %
USA	8,5 %	9,7 %	13,2 %
Germany	5,3 %	7,8 %	11,3 %

Sources: SSB (2015), Tilväxtanalys (2014), DST (2015)

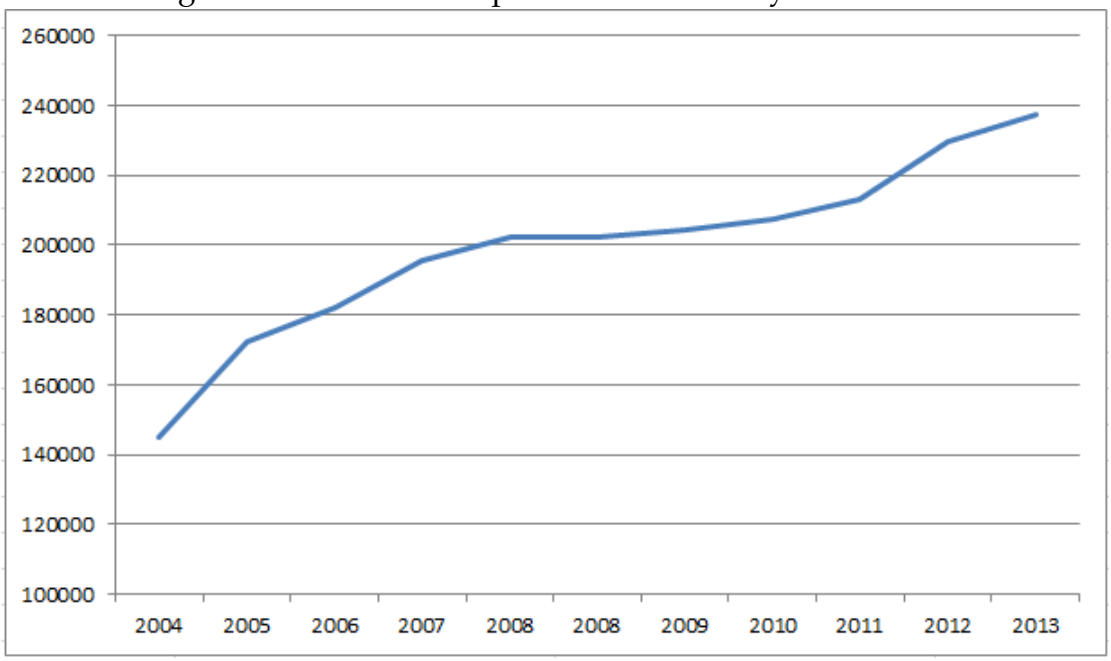
Research has shown that these countries are among those with the least home bias (Bekaert and Wang, 2009) the close ties and similarities between the Scandinavian countries makes it a natural assumption that capital is more mobile between Norway and neighbouring countries as Sweden then say Norway and Spain.

2.9 Other factors

Other factors that could influence the corporate tax base is the degree of public ownership and organizational form of public enterprises. The liberalizations reforms of the 1980's and 90's increased privatization and incorporation of public enterprises moving employees and companies from the government to corporations. From 1985 until 2002 60-70 governmental organizations have changed organizational form where most have had various forms of incorporation (Christensen, 2004).

Figure 4 shows the growth in number of corporations overall in the Norwegian economy has been substantial just from the period of 2003 to 2013 the increase has been more then a 60% growth in corporations from 140,000 to almost 240,000. If the private corporate sector grows relatively stronger then the public or non-corporate sector the tax base will grow relative to the economy as a whole. Even with falling tax rates, a sufficient growth in the corporate sector in itself could keeping or increase the economy share of tax revenues.

Figure 4: Number of corporations in Norway: 2003 - 2013



Source: SSB (2015)

It is also reasonable to argue that public ownership could alter the goals or behaviour of publicly owned firms. In the case where a company is fully or partially owned by the state the company would go against shareholder interests if exerting aggressive tax planning or profit shifting as the corporate income tax payed is also state revenue. Such a company would likely have less incentives to exert effort in order to reduce taxes. However the fully owned company Statkraft and majority owned Statoil has been uncovered to shift profits through internal debt in low tax country Belgium (Aftenposten, 2014). This could perhaps be explained by the standard managerial incentives of profit maximising rather then maximising profits, and taxes.

3 Empirical analysis

The theoretical models provide some testable hypothesises about what factors affect the corporate income tax base. This section will specify an econometric model and the data used in order to test the effects of the corporate tax rate on the corporate tax base in a panel of OECD countries. I will investigate which effects are present, and how the corporate tax base is affected by the tax rate at home, as well as the tax rate in tax competing countries. To approach this question, I will use spatial data and other weights to establish tax competing countries along with a dynamic specification to estimate the long run effects.

3.1 Empirical background

The empirical approach chosen is within a subset of a wealth of empirical research, related to tax competition, growth and investment effects of corporate taxes. For an overview of the literature and findings see Zodrow (2010) and Genschel and Schwarz (2011).

Buettner (2003) does an in country study of a dynamic panel of over 1000 German jurisdictions over 21 years and finds a strong negative impact of local tax rates on the tax base. The neighbouring negative tax rate externality was only present for jurisdictions of a relatively small size. The large, and significant, results of Büettner implies that some municipalities are on the downward sloping part of the Laffer curve with a long run elasticity of -1.40. The author explains this finding with the effect of the underlying fiscal system of redistributive intergovernmental transfers of Germany and that the estimation of the tax base using the highest statutory tax rate in a progressive tax allowance system will provide an overestimation of the tax base.

Riedl and Rocha-Akis (2012) use a method similar to Büettner for study of a panel of 17 OECD countries from 1982 to 2005. The authors use different measures of the tax rate with both effective, marginal and statutory tax rates to investigate the effects on the corporate tax base. They find that a country's aggregate reported corporate profits are significantly and, negatively affected by the CIT rate reductions in neighbouring countries. Further the authors find that a unilaterally reduction in domestic CIT rate results in a lower domestic CIT revenue. They conclude that that the tax base is inelastic with regards to the domestic tax rate, and that the long run elasticity of the tax base with regards to the domestic tax rate is -0.86. Meaning a one percent increase in domestic tax rate is associated with a -0.86% decrease in the domestic tax base. Further they find that one percent unilateral increase in the three closest neighboring countries tax rate is associated with a 1.13% increase in the tax base. Providing that the effect of only one country increasing the tax rate being third of 1.13% namely 0.38%.

The empirical findings of this literature suggest that if a country lowers it's tax rate this there is a negative externality is present with regards to neighbouring countries tax bases. As the world is arguably becoming increasingly globalised and data increasingly available these results might change. With this paper I wish to further explore these questions and test weather the results will change with adding data covering the most recent years as well as updating the previous collected data. I will build upon the existing literature and expand with new variables and adjustments to the data pertinent to the study of the Norwegian context.

3.2 Regression specification

In order to estimate the elasticity of the corporate tax base, I will use the method of Riedl and Rocha-Akis (2012) to do a cross country study with the use panel data of a subset of OECD countries. The method relies on publicly available aggregate country level data. The dependent variable is the logarithm of the corporate income tax base per capita in country i estimating the following equation:

$$lnb_{it} = \lambda_0 + \rho lnb_{it-1} + \lambda_1 ln\tau_{it} + \lambda_2 ln\overline{\tau}_{it} + \lambda_x \chi_{it} + Z_\mu + Z_\nu + Z_\theta + \varepsilon_{it} \tag{28}$$

Subscripts i, j denote country dimension $i, j = 1, 2, \ldots, N$, while t denotes time dimension $t = 1, 2, \ldots, T,$. The two explanatory variables of interest are the corporate income tax (CIT) in country i, τ_{ij} and the weighted average of CIT in neighboring countries $\overline{\tau}_{ij}$. Given the log specification the regression coefficients can be interpreted as elasticities.

The regression controls for various macro data variables (χ_{it}) such as income per capita, real unit labor cost, growth, income, export and EU membership. Further the regression includes country specific effects (Z_μ), time invariant effects (Z_ν) and individual country trends (Z_θ) and the autoregressive variable ρlnb_{it-1} of a one year lag of the dependent variable.

The data for the corporate tax base is not available therefore it has to be estimated from the corporate tax revenue. The variable b_{it} is an estimation of the corporate income tax base per capita[6]. The calculation is done by taking the CIT-revenue as percent of GDP and multiplying this with GDP per capita. This gives CIT-revenue per capita and dividing this by the statutory corporate income tax derives the estimate of the corporate income tax base.

$$b_{it} = \frac{CITRev_{it}}{\tau_{it}} \tag{29}$$

The corporate tax revenues for the time period are recorded on both an accrual and

[6]The data available only provide taxes as percent of GDP and not directly in USD.

cash basis. For the years recorded on cash basis the tax liabilities will normally be paid with a one year delay. Therefore the tax base specification for years of cash flow will be $b_{it} = \frac{CITrev_{it+1}}{\tau_{it}}$ while for the years recorded on an accrual basis the specification will be within year $b_{it} = \frac{CITrev_{it}}{\tau_{it}}$. This generates missing values on the dependent variable for the year before transition from cash based to accrual based accounting. Out of the total of 20 countries the dataset has 16 observations missing due to this change of recording system[7]. While using the first lag of the dependent variable as a regressor also means losing the lagged observations the first year.

In choosing a dynamic specification this will account for the persistence of the tax base. The firm is expected to be a rational and forward looking actor, meaning behavioural changes to tax policy are expected to be partially immediate and parts of the change will happen over time. The total accumulated effect is the most interesting when evaluating fiscal and welfare effects of tax change. The autoregressive parameter of the endogenous variable ρ captures the speed of the tax base adjustment. In order to get the long run coefficient of the tax rate τ_{it}, I apply the following calculation $\widetilde{\lambda_1} = \frac{\lambda_1}{1-\rho}$ equivalently for the coefficient on the neighbouring tax rates $\overline{\tau_{it}}$, $\widetilde{\lambda_2} = \frac{\lambda_2}{1-\rho}$ [8]. Using a dynamic model allows to account for more complicated timing of taxes such as losses carried forward, refunds and advance payments affecting the development of the tax revenue (Riedl and Rocha-Akis, 2012). Controlling for country specific time invariant and time fixed effects allows to control for unobserved heterogeneity within the sample. Including time specific effects will control for common time specific business cycle shocks such as widespread financial crisis. Country specific effects will allow to control for the wide variation in countries and unobserved effects such as differences in efficiency of tax collection or tax evasion[9]. In addition the regression includes individual country trends in order to control for long term growth in the tax base, where countries can vary in the rate of growth in the corporate sector, and other country specific developments.

3.3 Sample data selection

The countries analyzed are a subset of the OECD countries for which reliable and consistent annual data on tax revenue and tax rates for the period of 1982 to 2012 is available. The 20 countries included are Australia, Austria, Belgium, Canada, Switzerland, Germany[10], Denmark, Spain, Finland, France, United Kingdom, Greece, Japan, Italy,

[7] Years of change from cash to accrual recording of tax income: Australia 1997, Austria 1994, Canada 1998, Germany 2001, Spain 1999, Finland 1997, France 1991, UK 1989, Greece 1997, Ireland 1997, Italy 1999, Japan 1989, Netherlands 1998, Norway 1999, New Zealand 1988, Sweden 1999 and USA 1989.

[8] Assuming that the short run coefficient ρ is < 1.

[9] Such heterogeniety as the differences between tax collection in Greece and Germany for instance.

[10] Data for Germany up until 1990 refers to West Germany.

Ireland, Netherlands, Norway, New Zealand[11], Sweden and USA[12]. Within a balanced panel there is a trade off between the number of years and number of countries available. Data for Eastern Europe countries are available from 1995 on, data for Korea and Iceland are available from 1983, while data for Portugal and Luxembourg are available from respectively 1991 and 1992. The year 2013 is excluded because corporate tax revenues for three countries are not available at that time [13].

The corporate tax rate measure used is the total statutory corporate tax rate including local and federal taxes, surcharges and deductability of local taxes[14]. I could not utilize the effective and marginal corporate tax rates as there are no consistent measures calculated for the countries and period in question[15]. However the measure of EATR and the statutory rate is highly correlated as the EATR is a weighted composition of the EMTR and the statutory rate. In choosing this specification the coefficients λ_1 and λ_2 does not reflect a country's change in tax legislation such as changes in depreciation rates and debt allowances. The correlation table shows a high correlation between the statutory tax rate and the EATR, a correlation coefficient of 0.96 in Table 11 in the appendix, and Figure 9 shows and confirms that the variation in EATR is highly correlated with changes in the statutory rate.Riedl and Rocha-Akis (2012) finds that using the statutory rate does not significantly alter their results.

An overview of the data variables, measures and sources can be seen in Table 6 in the appendix. I have also compiled an alternate set of data for Norway corrected for petroleum sector revenues[16]. The data sources and calculations are shown in Table 7 in the appendix.

3.4 Neighbouring tax rate

In order to asses the impact of tax competition and the impact of competing countries tax setting some measure of the competing tax rate is needed. The baseline weighting scheme of the neighbouring tax rate variable $\bar{\tau}_{it}$ is given by a spatial component and takes the weighted average of the three closest countries. It is provided by the following equation:

$$\overline{\tau}_{it} = \sum_{j}^{t} \omega_{ij}^{geo} \tau_{jt} \tag{30}$$

[11]Data on real unit labor costs are not available before 1986.

[12]See appendix for list of country abbreviations.

[13]Netherlands, Greece and Australia.

[14]For Switzerland it is the federal tax that is deductable in the local tax.

[15]There are two databases each covering different years for different countries of the EATR and EMTR. I attempted to combine these but the calculations were done using different assumptions and quality of information available on the tax system lead to that I was unable to find a consistent measure.

[16]Abbreviated as NOR2

$$\omega_{ij}^{geo} = \begin{cases} \frac{1}{3} & \text{if j is among i's three closest neighbours and} j \neq i \\ 0 & \text{if not} \end{cases} \tag{31}$$

The spatial data used to calculate this weight is the smallest distance from capital to capital between the countries. As indicated by the discussion in Section (2.8) distance is a relevant factor to consider and a natural assumption to have a negative effect on the mobility of capital. Invoking Tobler (1970) and his formulation of the first law of geography; "Everything is related to everything else, but near things are more related than distant things". The advantage of this method compared to looking at direct neighbours is that it includes weights for island states such as the UK and Japan. Selecting only a limited number of countries, as opposed to some weight including all countries, will increase the variability of the estimator that could have a positive impact on standard errors (Riedl and Rocha-Akis, 2012). The disadvantage to this simplification is the underlying assumption that any and all of the three closest countries each have an equal effect on the tax base while disregarding actual investment flows, growth rates, institutional and cultural factors. This weighting regime gives that the three closest neighbours to the USA is Canada, UK and Ireland. For Norway it is Sweden, Denmark and Finland. While for Australia this is New Zealand, Japan and Greece. That Greece is the most likely country to compete for Australian tax base then the marginally more distant (700km) USA is an effect worth noting of this rule. As an extension and part of the robustness alternate weighting regimes including size of trading partners considering outward foreign direct investment flows (FDI) and growth rates will be explored further.

3.5 Control variables

As shown in Section 2 there are many components influencing the corporate tax base. Factors that determine a firms surplus is likely to be negatively influenced by the cost of input factors, as well as positively determined by the amount of sales in the economy. To control for these factors I use GDP per capita, denoted by *income*, and a measure of the real unit cost of labor denoted by *rulc*. The real unit cost of labor includes the total costs of labor including social contribution, income taxes, allowances, overtime and bonuses. The real unit cost of labor measure represents a direct link between the productivity, relative to the cost of labor used, in generating the output. Business cycles are also expected to affect the firms profits and therefore the tax base providing grounds for including *growth* as a variable measuring the annual change in GDP over the previous year. To control for an increased turnover as purely increases in prices inflation is tried as another control variable.

Fryges and Wagner (2010) uses a high quality panel of German firms to show a positive statistically significant causal relationship of exporters compared to non-exporters. Although the authors say the effect is small $exports$, as share of GDP, will be included to capture this effect. Finally inclusion in the single European market is argued to lower barriers of trade and therefore might positively affects firms profits within these countries. Therefore I have added dummy variables for years of EU-membership, including the year before accession to account for the effect of forward looking firms, denoted euf. As an extension to the model by Riedl and Rocha-Akis (2012) I also experiment with adding an additional dummy EU including EFTA. As a further extension of the analysis I experiment with including a dummy variable for the years of having an explicit thin capitalization rules. Thin capitalization rules regulate the amount of debt a firm can get deductions for to reduce profit shifting through internal loans between firms in different countries. Using data on thin capitalization rules of 54 countries, Blouin et al. (2014) finds that the rules affect firm capitalization structure, and leverage. OECD (2013) places such interest deduction rules as action point 4 out of 15 in their plan to limit Base Erosion and Profit Shifting (BEPS). To capture this effect I include thin capitalization (tcr) as a dummy variable which is expected to positively influence the tax base in the countries introducing this rule. I also experimented with including the difference between the CIT and the personal income tax (PIT) to capture the effects of income shifting between organizational form.

3.6 Estimation technique, instrumentation and standard errors

The theoretical model described in equation (28) shows that issues regarding potential endogeneity, serial and spatial correlation will be addressed in this section. With the use of the lagged dependent variable as an explanatory variable partial adjustment mechanism can be modeled. The autoregressive b_{it-1} is potentially endogenous if there are first order serial correlation in the error terms, then ε_{t-1} is correlated with ε_t and the lagged regressor is by effect correlated with the error term (Murray, 2006). Roodman (2006) points to the use of Generalized Method of Moments (GMM) estimators in dynamic panel data regressions where there is a large number of entities (N) and a small number of periods (T), while if the T is large the panel data bias is negligible. Riedl and Rocha-Akis (2012) considers this and performs a Monte Carlo simulation finding that the bias of their estimates using Least Squares Dummy Variables (LSDV) are extremely small. I will, with the increase of periods in my dataset assume that the LSDV estimator is still a suitable choice.

A further complication is that since the two regressors of main interest τ_{it} and $\overline{\tau_{it}}$ are determined simultaneously the variables are expected to be correlated with the error term. In order to deal with this possible endogeneity the use of instrumental variables

is considered. Riedl and Rocha-Akis (2012) compare results both including and excluding instrumenting for both the statutory as well as the EATR. The authors conclude that their preferred regression using the statutory tax rate includes instrumentation while with the EATR measure of the tax rate their preferred method is without instrumentation. However these results may change with a larger set of countries and more observations therefore I will extend the analysis with the same basis of comparing with and without instrumentation.

The instruments Riedl and Rocha-Akis (2012) choose are motivated by theoretical and empirical studies in the literature concerning the determinants of CIT rates. The instruments validity is considered by the use of J-statistic, F-test and the Durbin-Wu-Hausmann test. The authors refer to Swank (1998) who finds that openness to trade leads to a downward pressure in tax rates this is also confirmed by Slemrod (2004). The assumptions is that policymakers have an increased incentive to improve competitiveness and terms of trade of firms the more open the economy is. Following this argument the share of imports and exports in the economy as share of GDP as an potential instrument to the tax rates, denoted as *openness* which is also interacted with the year variable to capture change of trend over the period. Another possible instrument is weather the country has the status of being an offshore financial centre, often described as tax havens, as defined by IMF (2000). This dummy variable is interacted with the country's population [17]

The next instrument to consider is the personal income tax. Slemrod (2004) look at the determinants of the CIT rate and finds that there is evidence of a strong association between the top personal tax rate and the top statutory tax rate. As discussed in Section 2.4 the corporate income tax can work as a backstop from the PIT in order to avoid distortions in organiasational form, also known as income shifting. Slemrod (2004) shows that all else equal the CIT is higher in countries with a high top PIT making the PIT-rate a potential instrument. Further the question of the relative sizes of a country and how it affects their tax setting is addressed.

As shown in the theoretical discussion with the model of Hindriks and Myles (2006) in Section 2.8 a larger country will want to set a higher tax rate then a comparatively small country making population a potential instrument for the tax rate. However Riedl and Rocha-Akis (2012) also points out that in the case of economies of scale a large country might attract more multinational corporations despite higher tax rates, whereas if this is the case the instrument's exogeniety is questionable. In addition the authors include unemployment under the assumption that policymakers might want to alleviate the tax burden of firms in times of high unemployment, but also points out that this might be correlated with the business cycle.

The two requirements of an instrument is that it is both relevant and exogenous

[17] Countries in the sample identified as OFC's are USA, Japan, UK, the Netherlands and Switzerland.

(Stock and Watson, 2012). They are relevant if they are determinants of the endogenous regressors namely the domestic and neighbouring tax rates. In order to mitigate issues of reverse causality, namely that the instruments themselves might be endogenous, Riedl and Rocha-Akis (2012) applies the instruments in both their spatial and domestically first lagged form. This is however not a straight forward assumption. Angrist and Krueger (2001) warns about using lagged endogenous variables as instruments in the presence of serial correlations in omitted variables or the error term.

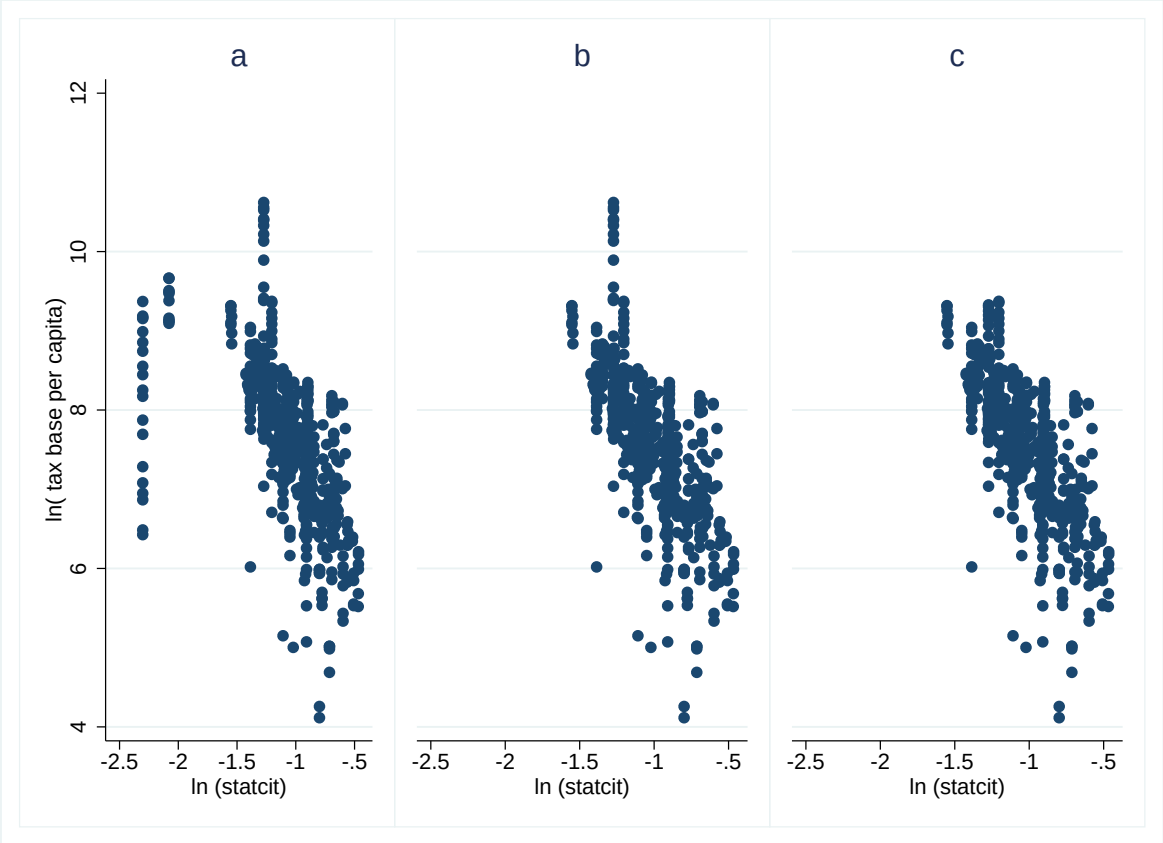
Lastly using spatially lagged variables could introduce cross-sectional dependent errors where the disturbances are likely to follow a spatial pattern stemming from similar geographical conditions in adjacent countries (Riedl and Rocha-Akis, 2012). The authors approaches this issue of contemporaneous correlation of arbitrary form with the use of bootstrapping. Anselin (1990) describes the use of bootstrapping to obtain robust standard errors in spatial econometrics. The method relies on re sampling observations the data set with a number of random draws with replacement. Drawing from the underlying observations with equal probability ($1/N$ where N is number of observations) mean that some observations can be included more then once, or not at all in the pseudo data set. I follow Riedl and Rocha-Akis (2012) with performing 200 replications in both the short- and long run estimates.

3.7 Data description

In visual plotted inspections of the data it is apparent that the statutory tax rates have declined in almost all countries in the period. The exception is Ireland which has only increased the tax rate. The rate of decline seem to have slowed in the recent years. Tracing the development of the corporate income tax base, see Figure 8 in the appendix, it can be seen that most countries reaches a top in 2007 before the financial crisis. Inspecting the base per country it is apparent that Norway is an outlier with around four times the tax base per capita as most countries starting mid 1990's. When controlling Norway for the petroleum sector I note that revenues align more with the trend. Ireland is also an outlier with the second highest tax base per capita in the top year.

To see how this might influence the regression I did a scatter plot of the domestic tax rate and the tax base in Figure 5. Ireland is an obvious outlier with the potential of making the regression unstable as it is the only country which has consistently held a low tax rate and only increased it in the period. Removing Ireland from the plot as shown in the difference from a to b in Figure 5. Further comparing the dataset with Norway corrected for petroleum sector in b to c shows that doing this correction further aligns the data. I will come back to Norway as an extension but for the baseline estimations follow Riedl and Rocha-Akis (2012) in excluding Ireland from the sample but including it in calculating the neighbouring tax rates.

Figure 5: Scatterplot, tax base and domestic tax rate.



b: without Ireland, c: Norway corrected for petroleum revenues (NOR2)

4 Estimation

In the process of exploring this topic I wanted to compare my methods and results with that of Riedl and Rocha-Akis (2012), in order to check that I am able to replicate the results using the same methodology on the same time period, specifically 1982 to 2005, before extending the analysis. Upon request I received the data and do-file of the authors. In order to ensure consistency and use of the most recent, and assumably, most correct data I retrieved my own data from the sources as described in Table 6 in the appendix. However as shown in Table 2 and Table 3 below running the regression provided some different results. The long run coefficients on the variables of interest τ and $\bar{\tau}$ are of a considerably higher value and the significance of the neighbouring country variable has decreased as well as an increased standard error. For the sake of robustness this warrants closer inspection.

The different results could stem from one or more of the following; i) difference in estimation techniques, ii) change or difference in data sources, iii) error(s) in compiled data sets, iv) measurement errors or v) undocumented transformation of variables by Riedl and Rocha-Akis (2012). I will address these in turn.

4.1 Comparing results to Riedl and Rocha-Akis

Using the dataset provided by Riedl and Rocha-Akis (2012) I have successfully replicated their results using my own adapted do-file indicating that the applied estimation technique is the same but that the observations in the panels are different. In order to assess the data I have merged the data sets performing both visual inspections as well as comparing total and by country summary statistics. I have done this to check where there are deviations and to check if these are originating from change of sources or errors. I also generated variables taking the difference between individual observations in both panels. The results show that there are overall variations in almost all of the variables, and more in some countries. Data variation is not entirely unexpected as the methodology and definition of macro data indicators are subject to change and adjustments (OECD, 2014). However if changes are coming purely from adjustments to indexes or a unilateral transformations of unit of measurement, such that the provided values are different but without real changes the main results should hold. In the case of real unit cost of labor where the index value in the dataset used by Riedl and Rocha-Akis (2012) is 100 in 2005, while in my dataset the index is 100 in 2010. If only this is the case, significantly change of results raises concerns for the internal validity and robustness of the methodology applied.

By the nature of the model differences to GDP and the statutory tax rate variable are of importance as it is used estimation of both the dependent variable, as well as the

neighbouring and domestic tax rate variable. A visual inspection of differences in observations of the tax base and domestic tax rate country, see Figure 7 in the appendix for a percentage change comparison between panels, shows that there are a several variations in the dependent variable tax base per capita (b_{it}) as well as in the statutory tax rate (τ_{it}). The largest variations seem to stem from different observations in statutory tax rate which directly impacts the tax base estimate. Switzerland has a much steeper increase in the corporate tax base in my estimations due to an increasingly declining corporate tax rate, the same is the case in a lesser extent for Canada, Spain, Greece and Sweden. In the US the tax base has a positive deviation between the data sets, without this being driven by changes in the tax rate measure. Given the dependencies between the two variables potential measurement errors in the tax rate would provide an incorrect measure of the tax base potentially over- or underestimating the endogenous variable.

The database I have used to retrieve the tax rates is annually maintained by the Oxford University Centre for Business Taxation which builds upon the tax rates used by Riedl and Rocha-Akis (2012) from the Institute for Fiscal Studies [18]. Finland is excluded from the overview as it is an outlier as a consequence of a different recording of when Finland switched from cash to accrual based accounting where Riedl and Rocha-Akis (2012) has recorded this to be 1997. According to the OECD revenue statistics [19] this happened in 1987 resulting in different years of missing data and a lagged difference between the recorded years.

Some other differences discovered between the data sets are that Riedl and Rocha-Akis (2012) have not included Germany, France, Belgium and Spain in their EU- membership dummy. Further for five countries I have not been able to recreate the neighbouring tax rate based upon the weighting scheme and the statutory tax rates in their data set[20]. The result of this process is that I can confirm that my methodology is consistent and correct with the methodology as described by Riedl and Rocha-Akis (2012) and that change of results stem from differences in the generated data sets and sources. Through this process I have also been able to double check deviations and differences making me confident that my panel is correctly assembled. For a summary statistics on the difference between variables see Table 9 and Table 8 in the appendix.

From Table 2 compares two regressions. Column (1) is the regression run on own data and (2) regression run on the data used and provided by Riedl and Rocha-Akis (2012). The results of (1) show that the tax base in the long run estimate is elastic with

[18] www.sbs.ox.ac.uk/sites/default/files/Business_Taxation/Docs/Publications/Data/tax-data-description-13-14.doc

[19] http://stats.oecd.org/BrandedView.aspx?oecd_bv_id=tax-data-en&doi=data-00235-en

[20] I double checked which countries were used as the three closest neighbouring weights to create the weighted tax rate $\overline{\tau_{it}}$. Using a solver trying the combination of any three tax rates for that year came up with no matching combination for USA, Norway, Australia, Germany and Ireland.

Table 2: Regression comparison mine and Riedl and Rocha-Akis' (2011) data

VARIABLES	(1) CIT-base (mine)	(2) CIT-base (RR)
ln τ	-1.328***	-0.805**
	(0.381)	(0.382)
ln $\overline{\tau}$	1.046	0.752**
	(0.882)	(0.349)
ln income	1.636***	1.154***
	(0.558)	(0.304)
ln rulc	-3.738***	-4.387***
	(1.069)	(1.005)
growth	-0.00256	0.0138*
	(0.0181)	(0.00877)
ln export	0.943***	0.723***
	(0.379)	(0.247)
euf	0.529*	0.257**
	(0.370)	(0.144)
Constant	12.04**	8.174***
	(6.497)	(2.091)
Observations	361	361
Country-FE, χ^2_{16}	174.4***	262.9***
Time-FE, χ^2_{21}	39.70***	47.56***
Time-trend, χ^2_{17}	95.27***	164.5***
Wald-F	31.71	29.86
Hansen J, χ^2_8	11.65	2.768
Hansen p-value	0.167	0.948
Endogeneity test χ^2_2	0.971	5.207
Endogeneity, p-value	0.615	0.0740*

Notes: Both regressions show long run elasticities for the years 1982 - 2005. I use Riedl and Rocha-Akis' (RR) preferred regression specification with the statutory tax rate as the tax rate variable regressor. Standard errors in parentheses. One-tailed significance levels: * (10%), ** (5%), *** (1%)

regards to both domestic and neighbouring countries tax rate with a long run elasticity of -1.328 significant at the 1% level. Comparing to (2) the effect is significantly greater where Riedl and Rocha-Akis (2012) finds the elasticity with regards to domestic tax rate being inelastic at a long run coefficient of -0.805 significant at the 5% level. The increased elasticity can also be viewed with regards to the neighbouring country tax rate, however in my own results the neighbouring country tax rate is not significant.

The Hansen-J test over-identifying restrictions test the joint null hypothesis that the instruments are valid and uncorrelated with the error term (see related first stage

regression Table 3). The test cannot reject the null indicating that the instruments might be valid. However it is worth noting that it is of a much lower p-value (0.168) then in the compared dataset (0.948).

The endogeneity tests[21] the null hypthesis is that the regressors τ and $\overline{\tau}$ may be considered exogenous. The null hypothesis cannot be rejected in my own dataset (p-value of 0.615), while RR dataset can reject the null a confidence of 10% (p-value of 0.0740). This indicates that the instruments are correlated with the error term and, if so, invalid. Riedl and Rocha-Akis (2012) concludes in their regression that the LSDV-IV is the preferred specification using the statutory rate because of these findings. However my own data is not as clear in this regard. To closer examine this question turns us to the first stage regression in Table 3. There are several instruments that seem to have a weak explanation power of the regressors. Unemployment in my own dataset is not statistically significant, population has a significance level lower on both domestic and neighbouring countries tax rate. The personal income tax in neighbouring countries is significant at the 5% level in the panel of Riedl and Rocha-Akis (2012) with regards to both domestic and neighbouring tax rates while it is only significant at the 10% level with regards to the domestic tax rate in my own panel.

One important note is that Riedl and Rocha-Akis (2012) mainly focused their instrumentation of the effective average tax rate and not the statutory. The choice of instruments is done with the regards to the EATR where the significance level is increased in some cases.

4.2 Full dataset regression

Extending the analysis and taking advantage of my full dataset I will in this section derive my baseline estimates of the data spanning from 1982 to 2012 of all 19 countries. The results are shown in Table 4. Regressions (1) to (9) includes instrumentation (LSDV-IV) while regression (10) and (11) is done without instruments (LSDV), regression (11) is the short run estimates. In regressions (1) to (8) i use the same instrumentation and vary the use of regressors. Adding inflation and a dummy for thin capitalization rules (7) are insignificant and does not change the results. Replacing EU-membership with EFTA membership in column (8) also makes the dummy variable insignificant. Regression (9) removes the two lagged endogenous regressors as instruments, see first stage regression in Table 6.4 in the appendix comparing the alternative instruments between, the otherwise equal, regressions (5) and (9). The results is that the F-test[22] value falls to the point where it is well below the thumb rule of 10 implying

[21] A variant of the Durbin-Wu-Hausmann test called by the use of endogtest() option with ivreg2 in Stata.

[22] Specifically the rk. Wald F-statistic as is the robust analog of the Cragg-Donald statistic (Baum et al., 2007).

Table 3: First stage of regressions in Table 2.

	My datatset		RR dataset	
	(1)	(2)	(1)	(2)
	ln τ	ln $\overline{\tau}$	ln τ	ln $\overline{\tau}$
L1.ln τ	0.638***	0.0165	0.702***	0.00341
	(0.100)	(0.0350)	(0.0841)	(0.0351)
L1.ln $\overline{\tau}$	0.0320	0.644***	0.0784	0.0624***
	(0.0832)	(0.0566)	(0.0880)	(0.0519)
L1.ln pit	0.111**	-0.00274	0.111**	-0.00672
	(0.0642)	(0.0239)	(0.0494)	(0.0248)
L1. ln $\overline{pit}$	0.148*	0.0573	0.150**	0.0934**
	(0.103)	(0.0665)	(0.0782)	(0.0537)
L1. ln unemp	-0.0172	-0.00364	-0.0224	-0.0222**
	(0.0218)	(0.0113)	(0.0205)	(0.0106)
L1. ln $\overline{unemp}$	-0.0895**	-0.0769**	-0.0535*	-0.0844***
	(0.0532)	(0.0389)	(0.0367)	(0.0206)
pop	0.0217*	-0.0199**	0.0128***	-0.0136***
	(0.0138)	(0.00691)	(0.00454)	(0.00433)
offshore*pop	-0.00972	-0.0195*	-0.00641	0.0108**
	(0.0169)	(0.0122)	(0.00647)	(0.00518)
openness	-28.83	20.00	-5.628	2.579
	(40.73)	(17.87)	(10.33)	(6.155)
openness*year	0.0145	-0.0100*	0.00282	-0.00129
	(0.0204)	(0.00867)	(0.00517)	(0.00308)
Constant	-3.605**	4.394***	-1.597**	0.364
	(2.019)	(1.410)	(0.734)	(0.406)
Exogenous regressors	Included		Included	
R^2	0.936	0.976	0.938	0.973
N	361	361	361	361

Standard errors in parentheses
One-tailed significance levels: * (10%), ** (5%), *** (1%)

Table 4: Baseline estimates 1982 - 2012

VARIABLES	(1)	(2)	(3)	(4)	(5)	(7) [a]	(8)	(9)	**(10)**	(11)
ln τ	-1.152***	-1.346***	-1.179***	-0.995***	-1.051***	-1.049***	-1.153***	-0.944*	**-1.167*** **	-0.558***
	(0.461)	(0.413)	(0.356)	(0.349)	(0.351)	(0.351)	(0.374)	(0.621)	**(0.226)**	(0.119)
ln $\overline{\tau}$	1.024	0.945	0.907*	0.739	0.744	0.716	0.493	0.173	**0.590***	0.282*
	(0.939)	(0.767)	(0.634)	(0.623)	(0.617)	(0.621)	(0.534)	(0.841)	**(0.396)**	(0.189)
euf / efta	1.016**	0.876***	0.654**	0.584**	0.548**	0.539**	0.203 [b]	0.486*	**0.504***	0.241*
	(0.456)	(0.356)	(0.339)	(0.332)	(0.322)	(0.323)	(0.382)	(0.354)	**(0.313)**	(0.159)
ln income		0.936***	1.020***	0.930***	1.231***	1.241***	1.267***	1.221***	**1.266*** **	0.604***
		(0.326)	(0.286)	(0.277)	(0.345)	(0.346)	(0.380)	(0.339)	**(0.311)**	(0.176)
ln rulc			-4.083***	-2.853***	-2.613***	-2.535***	-2.812***	-2.575***	**-2.566*** **	-1.223***
			(0.766)	(0.748)	(0.736)	(0.746)	(0.741)	(0.726)	**(0.727)**	(0.325)
growth				0.0510***	0.0462***	0.0455***	0.0489***	0.0479***	**0.0454*** **	0.0216***
				(0.0156)	(0.0159)	(0.0159)	(0.0161)	(0.0170)	**(0.0152)**	(0.006)
ln export					0.484**	0.487**	0.562**	0.471**	**0.500** **	0.239**
					(0.258)	(0.257)	(0.272)	(0.264)	**(0.237)**	(0.117)
L1.ln tax base										0.522***
										(0.0639)
Constant	7.400***	-1.598	17.35***	12.08***	9.170**	8.694**	9.758**	8.775**	**8.506** **	4.064
	(0.564)	(2.935)	(4.654)	(4.598)	(4.830)	(4.940)	(4.895)	(4.705)	**(4.597)**	(2.069)
Observations	538	538	535	535	535	535	535	535	**535**	535
Country-FE, χ^2_{18}	182.9***	141.2***	317.7***	252***	211.6***	209.4***	235***	198.5***	**214.5*** **	214.5***
Time-FE, χ^2_{27}	97.74***	86.17***	57.95***	50.99***	42.60***	42.41***	45.68***	41.36***	**46.49*** **	46.49***
Time-trend, χ^2_{19}	142.3***	71.82***	128.7***	103.3***	103.3***	89.16***	100.3***	99.60***	**109.2*** **	109.2***
WaldF	37.94	36.73	35.06	32.78	32.06	31.75	32.28	5.313		
Hansen J, χ^2_8	7.010	14.58	14.28	12.82	13.02	13.11	12.77	11.82		
Hansen p-value	0.536	0.0679*	0.0748*	0.118	0.111	0.108	0.120	0.0662*		
Endogeneity test, χ^2_2	4.378	7.064	7.227	7.224	4.054	3.768	3.389	0.471		
Endogeneity, p-value	0.112	0.0292**	0.0270**	0.0270**	0.132	0.152	0.184	0.790		
adj. R^2									**0.973**	0.973

Standard errors in parentheses. One-tailed significance levels: * (10%), ** (5%), *** (1%)

[a] Includes control variable for thin capitalization rules (tcr) and inflation which is not significant alone or combined.

[b] EFTA

a weak instrument problem. The findings are, similar to the earlier regression comparing the sub-sample. Including the lagged tax rate variables are significant at the one percent level and adding it removes some of the significance of the other variables and overall lifts the explanatory power of the variables quite a bit. However the Hansen J over-identifying test is close to significant in most regressions indicating that the instruments themselves might be endogenous. Comparing the Durbin-Wu-Hausman endogeneity test I can see that the differences to the results running on regular LSDV is not large. The test is not able to reject the joint null hypothesis that the tax rate variables can be considered exogenous. The two tests are not proving to give any clear answers. Comparing to the regression without instrumentation the results are not significantly changed and as the LSDV estimator is more efficient I will follow Riedl and Rocha-Akis (2012) and not rely on instrumentation as my preferred regression. Column (10) is the preferred regression with an R^2 of 0.973 implying the regression fits the data well.

Regression (11) show the short run estimates. The tax base coefficient ρ is provided in the regressor "L1.ln tax base" and shows the rate of adjustment of the tax base where half the adjustment happens already in the immediate year of change. Comparing my short run results to those of Riedl and Rocha-Akis (2012) it shows that the rate of adjustment is larger while the short run effect of the domestic tax rate is the same. However the neighbouring tax rate follows the earlier results where the coefficient is only significant at the 10 % level and has a quite low effect and only half of Riedl and Rocha-Akis (2012) estimates.

Comparing my results to those of the sub-sample which was comparable to Riedl and Rocha-Akis (2012) estimates the sample differ in the number of years and countries. The results indicate that including these additional countries, New Zealand and Denmark, in addition to the 7 additional years provide an estimate of a slightly less elastic tax base. My findings show lower estimates from the initial comparison of my own subset regression with respects to the effect of the domestic tax rate, as well as a a lower, but more significant, effect of the neighbouring tax rate. In order to find the semi-elasticity of the corporate tax rate I can re-specify the preferred regression (10) with using the tax rates without log transformation. The resulting semi-elasticity is -2.93 with respect to the domestic tax rate and 1.57 with respect to a unilateral increase in the tax rate, of one percentage point, of the three closest neighbours. In the case of a change in a single neighbour country the effect would be a third of this, namely 0.52.

4.3 Robustness

In this section I will investigate the robustness of the baseline estimates reported in Table 4. I will follow the same procedure and alternative specifications as Riedl and Rocha-Akis (2012) with a few addition and changes that will be noted. First I will test

the results with two alternate weighting regimes, weighting in foreign direct investments and a simplified weighting regime of Riedl and Rocha-Akis (2012) with regards to similarities in growth rates. Further I will extend the analysis and look at the effects of adjusting Norway and exclude petroleum revenues. I will also look at a sub sample of Northern European countries, alternative specification of the tax base, tax rates, spillover effects and excluding dynamics and the influence of neighbours.

The baseline weighting scheme of the neighbouring tax rate variable $\overline{\tau}_{it}$ is given purely by a spatial component taking the average tax rate of the three closest neighbours. As noted in Section 3.4 this can provide some strange results. Considering which countries compete for the common tax base, through utilizing the flow of foreign investments, could be a good indicator. This is done by constructing an additional weight composed the previous geographical weight and with equal weight a similarly constructed variable composed of the three countries receiving the largest amount of outwards flowing FDI. This creates the weighting regime $\omega_{Geo}^{FDI} = 0.5\omega_{ij}^{FDI} + 0.5\omega_{ij}^{Geo}$

The weighting for FDI is provided in the following way:

$$\omega_{ij}^{FDI} = \begin{cases} \frac{1}{3} & \text{if j is among i's three largest receivers of FDI} \\ 0 & \text{if not} \end{cases} \tag{32}$$

One thing to notice is that a few recurring countries are the top trading partners of most of the dataset. USA is among the top three in 17 of the 20 countries. In Figure 6 the number of times a country has position 1 and 3 of outgoing FDI in the dataset is presented graphically.

Riedl and Rocha-Akis (2012) also apply bilateral growth weighting matrix by considering countries in the dataset with the most similar average growth rates in addition to proximity. The authors created a weighting scheme based upon the relative closeness of average growth rates of all other countries'. Their result was both increased significance and doubling of the impact of the neighbouring/competing countries tax rate coefficient showing that the weighting regime has a big impact on the coefficient of the neighbouring country tax rate. I experimented with constructing a simplified variant of their weighting matrix consisting of the average of the three countries with the most similar growth rates. Given equal weights I combined the geographical component and the growth component [23]. The results of this decreased the significance and size of of the effect of the neighbouring tax rate and I chose to omit the results from the table as the weighting regime proved inferior of the two previously described, and it is not directly comparable or a sufficient alternative to the similar specification by Riedl and Rocha-Akis (2012). In Table 5 the baseline weighting regime ω_{ij}^{Geo} is used in all but Column (1).

[23] Denoted ω_{Geo}^{Growth}

Table 5: Robustness analysis of preferred regression

VARIABLES	(1) ω_{Geo}^{FDI}	(2) NOR2	(3) τ diff	(4) N.Europe	(5) Endog	(6) Spillover	(7) Static
ln τ	-1.168***	-1.240***		-1.322***	-1.095***	-1.086***	0.689***
	(0.220)	(0.204)		(0.415)	(0.194)	(0.226)	(0.126)
ln $\overline{\tau}$	0.774*	0.506*		1.246	0.376	0.801**	0.100
	(0.471)	(0.352)		(1.094)	(0.357)	(0.414)	(0.216)
$\tau - \overline{\tau}$ [a]			-2.655***				
			(0.499)				
ln income	1.240***	1.070***	1.204***	1.316***		0.991***	1.139***
	(0.304)	(0.322)	(0.323)	(0.211)		(0.266)	(0.151)
ln rulc	-2.566***	-1.518**	-2.702***	-3.607***		-3.038***	-1.972***
	(0.730)	(0.713)	(0.712)	(1.263)		(0.786)	(0.515)
growth	0.0461***	0.0549***	0.0470***	0.0239		0.0475***	0.0282***
	(0.0153)	(0.0161)	(0.0152)	(0.0225)		(0.0152)	(0.00876)
ln export	0.491**	0.343*	0.436**	0.00568			0.386***
	(0.237)	(0.247)	(0.241)	(0.656)			(0.145)
euf	0.488*	0.489*	0.584**	0.610	0.444**	0.525*	0.231*
	(0.302)	(0.306)	(0.283)	(0.652)	(0.236)	(0.325)	(0.162)
L1.ln rulc					-3.820***		
					(0.790)		
L1.ln export					0.379**		
					(0.183)		
$\overline{growth}$						0.0283	
						(0.0233)	
ln $\overline{income}$						-0.286	
						(0.335)	
ln $\overline{rulc}$						-1.040	
						(1.484)	
Constant	8.868**	4.745	9.960**	10.98**	21.24***	19.86**	6.519***
	(4.604)	(4.310)	(4.732)	(5.708)	(3.887)	(10.82)	(2.669)
Observations	535	535	535	311	564	535	551
Country-FE, χ^2_{18}	226.86***	196***	209.7***	73.23***[b]	365.3***	228***	578.9***
Time-FE, χ^2_{27}	46.00***	54.58***	39.47***	37.92**	86.02***	47.98***	113.9***
Time-trend, χ^2_{19}	107.88***	89.87***	111.4***	55.64***[c]	199.3***	105.7***	303.3***
R^2	0.973	0.971	0.973	0.970	0.931	0.973	0.960

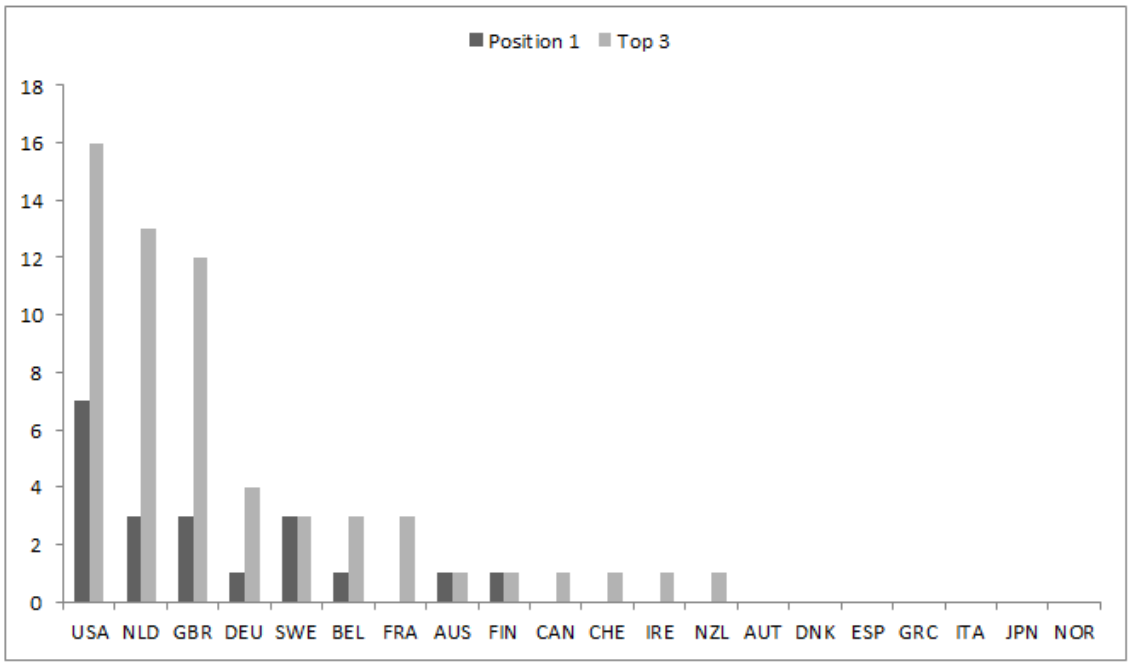
Standard errors in parentheses. One-tailed significance levels: * (10%), ** (5%), *** (1%)

[a] Interpreted as the semi-eliasticity namely the percentage change in tax base from a one percentage point increase in the difference between domestic and foreign tax rate.

[b] χ^2_{10}

[c] χ^2_{10}

Figure 6: FDI number of top 1 and top 3 position by receiving countries



Source: United Nations Conferance on Trade and Development (UNCTAD, 2015)

As shown in Figures 1 and 5 Norway stands out with a very high corporate tax revenue per capita as a result of a special petroleum tax[24] of highly profitable natural resources (Lund, 2014). Natural resources and the rents procured can be assumed to be country specific and therefore not competed over internationally. Other countries, such as Canada and the USA, also have revenues stemming from natural resources as well with rich deposits of oil and gas, but not in the same proportions per capita. The panel data regression corrects for country specific effects in order to mitigate bias stemming from fixed country specific factors, however the estimates with the alternate specification for Norway (2) indicates that excluding Norway's petroleum sector has a noticeable increase on the average elasticity of the tax base.

In the regression specification in column (3) the tax rate variable is redefined to be the difference between domestic and foreign tax rate. The variable is interpreted as a semi-elasticity. Different specification such as the differences between the logarithm of the tax rates, or the ratio between them, provide similar results. Riedl and Rocha-Akis (2012) comments that this specification seem to be driven primarily by the domestic tax rate and that the results hold even with a foreign tax rate is constructed of random weights. I applied the different weighting regimes previously described and found that the coefficient on the difference increased, along with the significance, of the neighbouring tax rate in the baseline regression. The variations in terms of semi-

[24] And up until 1992 use of royalty taxes.

elasticities were quite large [25].

The sample data includes countries in four different continents. In order to see if there might be variations within sub-samples where closeness of markets and cultural differences are perhaps more similar I have taken a sub sample of Northern and Western European countries[26]. The results shown in column (4) are largely unaltered. The increase in the tax rate coefficients could indicate that these countries have a more elastic tax bases and that tax competition is fiercer. However this could also be likely due to excluding the two largest economies in the sample, Japan and USA, which are expected to have a less elastic tax base then the smaller European countries. For this sub-sample I also experimented with including a dummy variable for the years when Norway, Finland and Sweden were under the dual income tax. The dummy was not significant and including it did not alter the results.

One potential concern for endogeneity is that the firms profits might be endogenous and correlated with the income per capita and real unit cost of labor regressors. This is an increasing source of concern as income per capita is utilized to estimate the tax base variable[27] and therefore has a direct mechanical link in the model. In order to see if the results hold while excluding the income measure from both sides of the equation, I performed the following analysis. The endogenous variable in regression given in column (5) is the natural logarithm of corporate tax base as percent of GDP. The lagged variables of labor cost and exports are included as well as excluding the directly related GDP measures of growth and income per capita and the main results are consistent under this specification. In specification (6) the baseline model is extended to include the spatially lagged macro variables that determine a country's tax base. In the baseline model it is assumed that the neighbouring countries only effect the domestic tax base through the tax rate externality. However there might be effects working through other parts of the economy. The spatially lagged variables are denoted with overlines, namely $\overline{growth}$, $\overline{income}$ and $\overline{rulc}$. In this case, the effect of the domestic tax rate is slightly lower while the neighbouring tax rate coefficient is increased in size and significance level. This suggests that an economy's tax base is influenced by these macroeconomic determinants of the neighbouring countries in addition to the tax rate. Further I tested including a variable for the difference between the CIT and the PIT, the effect was not significant and did also not alter the results.

Lastly an alternative specification provided in column (7) excludes dynamics. It shows that the impact of domestic taxes are significantly lower without the dynamic

[25] -2.87 with the use of ω_{Geo}^{FDI} to -1.95 with the use of the least significant weighting regime ω_{Geo}^{Growth}

[26] Specifically Norway, Sweden, Denmark, Finland, Germany, United Kingdom, Belgium, Netherlands, France and Switzerland.

[27] The OECD database only provides corporate tax revenue as a percentage of GDP, therefore the estimation required a transformation through the income per capita variable to find the corporate tax revenue in USD.

effect regarding the persistence of the tax base. My coefficient is only slightly altered when excluding neighbouring countries (-0.704 instead of -0.689) indicating that the domestic tax and dynamic effects are the main contributors. Riedl and Rocha-Akis (2012) compares the static specification and their own results of -0.4 to two single country estimates where the static elasticities are -0.5 for the German panel of Dwenger and Steiner (2008) and -0.2 for the US data of Gruber and Rauh (2007).

5 Conclusion

The effects of international tax competition is a field subjected to a plethora of research and attention. The ongoing reform proposals in both Norway and Sweden make this still a highly current topic. This paper has investigated the effects of the domestic and neighbouring country tax rates on the tax base. Utilizing the methodology of Riedl and Rocha-Akis (2012), I have explored the tax base sensitivity to the tax setting, while controlling for international fiscal leakages. I have found that the tax base is elastic with regards to changes in the domestic tax rate. Furthermore, with regards to fiscal competition, the effects on the tax base of changes in neighbouring countries tax rate is small. The estimated model does not distinguish between the different channels through which the tax base moves. The changes in tax rate affects how much and where the firm invests, the amount of profit it shifts as well as its legal and financial structure. The estimated effect is a combination of these. Relocated investments and shifted profits will have a considerably larger revenue and welfare consequence than spillover effects between a country's personal and corporate tax. The estimated semi-elasticity of the tax base with regards to changes in the domestic tax rate is found to be -2.9. This comes close to the total estimate of -3.1 provided in the meta-study by De Mooij and Ederveen (2008). The large estimate of the tax base elasticity indicates that there is a large excess cost of taxing corporate income. The finding of an elastic tax base in the long run reveal that a one point reduction in the tax rate provides a more then proportional increase in the tax base. About half of this effect is in the immediate short run.

Being granted access to Riedl and Rocha-Akis's (2012) dataset and do-file, I have been able to directly compare my results, estimation technique and dataset to theirs. The results of a detailed comparison showed that the differences were in the data observations and not methodology. For the equivalent period and countries in 1982 to 2005 I found an elasticity of -1.328 compared to -0.805 using the dataset of Riedl and Rocha-Akis (2012), in addition to a larger and insignificant neighbouring tax rate. Introducing the most recent data and two more countries lowered the domestic tax rate elasticity. This could be interpreted as a development in the sensitivity of the tax base or as a result of a larger sample, and improvements in data quality of more recent years. The estimated elasticity is also likely to be high as lowering of the statutory tax rate is often done in combination with base-broadening measures, such as lowering depreciation allowances (Devereux et al., 2002). Calculating a consistent measure of average effective tax rates over this period would be an interesting next step in understanding these effects.

The low impact and elasticity of the neighbouring tax rate does not convincingly explain why countries would engage in fierce tax competition. However as firms are

forward looking and governments are arguably more so. The governments are reacting to the competing countries tax-setting making the domestic tax rate endogenous with the neighbouring tax setting. Such a behavioural response in governments could mitigate the effect captured on tax rates in neighbouring countries. In the case of Norway this is exemplified by the strong indication to follow suit on the Swedish tax setting in both the previous and coming reform proposal.

One of the econometric challenges in this macro data model are the inter-dependencies with estimating the tax base from the tax rate. Any measurement errors in the tax rate variable would feed back into measurement error in the dependent tax base variable and potentially provide noticeable bias. In replicating the results of Riedl and Rocha-Akis (2012) over the same period potentially small changes, adjustments or variations to the data sources seem to have provided relatively large impacts on the results. With the use of detailed firm level data between countries, one could be able to distinguish the different channels influencing the tax base and in particular profit shifting and would be a very interesting way forward to see the effects of coming reform changes.

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6 Appendix

6.1 Data variables and sources

Table 6: Data variables, measures and sources

Variable	Measure	Source
STAT	Total corporate tax rate. Sum of federal tax rate, local tax rate taking into account surcharge and deductability of local taxes	CBT Tax Database www.sbs.ox.ac.uk/ideas-impact/tax/publications/data
CIT rev.	Total CIT revenues as % of GDP	OECD (2015) Revenue Statistics (online database) https://data.oecd.org/
CIT base	Own calculation: CIT revenues % multiplied with GDP per capita divided by STAT.	
income	Gross domestic product in current USD per capita	International Monetary Fund (IMF), World Economic Outlook Database (WEO), October 2014
rulc	Real unit cost of labor. Ratio of compensation per employee to nominal GDP per person employed. 2010 = 100	European Commission AMECO database.
export	Own calculation: Export of goods and services divided by GDP	AMECO database.
openness	Own calculation: Exports plus imports of goods and services as share of GDP.	AMECO database
growth	Percentage change in real GDP over the previous year	WEO
unemp	Unemployment in percentage of total labor force.	WEO
pop	Population of country in millions.	WEO
inf	Annual percentage change of average consumer prices.	WEO
PIT	Top personal income tax rate, central and representative sub-central rate.	OECD http://www.oecd.org/tax/tax-policy/tax-database.htm
EUF	Dummy = 1 for years of EU membership including year before accession.	http://europa.eu/
offshore	Dummy = 1 if country listed as an Offshore Financial Centre (OFC).	IMF (2000)
distance	Distances between capitals in kilometres measured of latitudes and longitudes	CEPII www.cepii.fr/distance/geo_cepii.dta
FDI	Foreign direct investments outward positions in USD by country, averaged over the period 1982 - 2012.	UNCTAD (2015) Foreign Direct Investment Database
tcr	Countries introducing explicit thin capitalization rules 1982-2004.	IMF working paper Blouin et al. (2014)

Table 7: Data variables, measures and sources (Norway corrected for petroleum sector)

Variable	Measure	Source
income	Own calculation: Gross domestic product excl. petroleum sector as percentage of GDP multiplied with WEO income data.	SSB and WEO
CIT base	Own calculation 1981-1984 and 2013. CIT revenues excl. petroleum sector as percentage of GDP excl. petroleum sector.	Ministry of Finance, SSB and SSB Tax Statistics 1981, 1982, 1983 and 1984 www.ssb.no/a/histstat/nos/
export	Own calculation: Export excl petroleum sector as share of GDP excl. petroleum sector.	SSB
openness	Sum of imports and exports excl. petroleum sector as share of GDP excl. petroleum sector.	SSB
growth	Own calculation: percentage change in real GDP excl. petroleum sector over previous year.	SSB

Country abbreviations: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Switzerland (CHE), Germany (DEU), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), United Kingdom (GBR), Greece (GRC), Japan (JPN), Italy (ITA), Ireland (IRL), Netherlands (NLD), Norway (NOR), New Zealand (NZL), Sweden (SWE) and USA (USA). Norway corrected for petroleum revenues is abbreviated (NOR2).

6.2 Tables comparing my own and Riedl and Rocha-Akis (2012)'s data

Table 8: Descriptive statistics. Differences between own and compared dataset.

	mean	sd	min	max	count
D_CITbase	-10.47871	265.9531	-1956.633	2570.231	414
D_STAT	.0029114	.0307929	-.123407	.11	432
D_income	392.5895	501.322	-572.4761	2397.737	432
D_growth	.0602106	.3267787	-1.892	1.607	432
D_export	-.0183831	.0383624	-.2267378	.0930452	432
D_infl	-.0088912	.2376278	-3.056	3.071	432
D_eu	.2152778	.4114914	0	1	432
D_pit	.0002255	.001876	-2.86e-08	.03	432
D_pop	-.0009677	.0790753	-.394	.3779988	432
D_offshore	0	0	0	0	432
D_pop*offshore	-.0011111	.0199365	-.1440125	.1409998	432
D_$\overline{STAT}$	-.0315803	.0473293	-.1816667	.1481467	432
N	432				

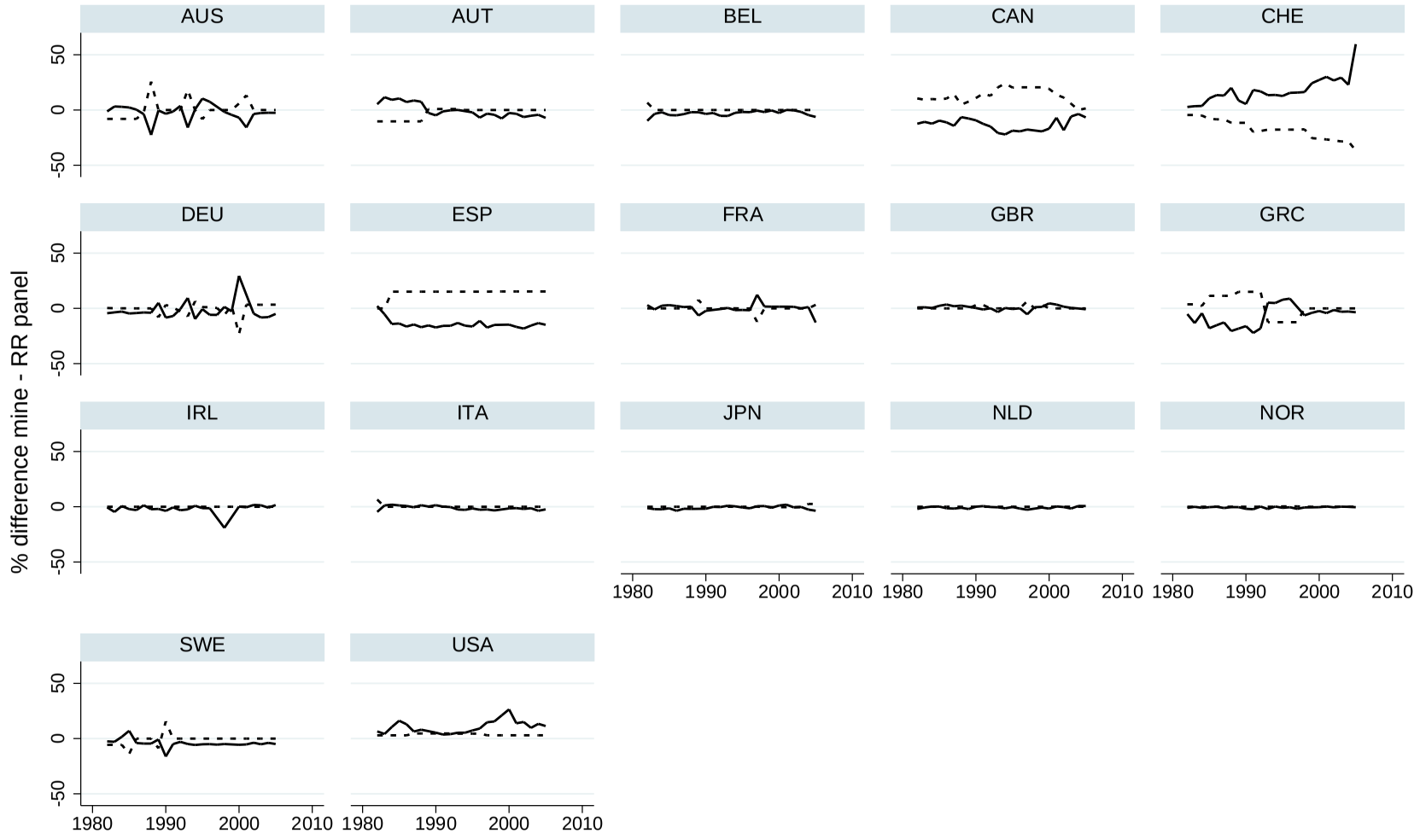
Notes: The variables show difference $(D\_)$ in values $Var_{it}^{Mine} - Var_{it}^{RR}$ between mine and Riedl and Rocha-Akis (2012)'s dataset for key variables.

Table 9: Correlation table. Differences between own and compared dataset.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) D_CITbase	1.00									
(2) D_STAT	-0.48	1.00								
(3) D_$\overline{STAT}$	0.09	-0.26	1.00							
(4) D_income	0.22	-0.11	0.09	1.00						
(5) D_growth	0.05	0.02	0.12	0.09	1.00					
(6) D_export	0.34	-0.22	-0.04	0.12	0.13	1.00				
(7) D_infl	0.03	0.02	0.02	0.01	-0.03	0.01	1.00			
(8) D_eu	0.09	-0.14	-0.25	0.23	0.11	0.15	-0.03	1.00		
(9) D_PIT	0.02	0.07	-0.05	0.12	-0.02	0.01	0.01	-0.03	1.00	
(10) D_pop	-0.02	0.04	-0.19	-0.22	-0.03	0.02	-0.02	-0.05	-0.07	1.00
(11) D_popoffshore	0.07	0.01	-0.02	-0.16	-0.07	-0.10	-0.01	-0.03	-0.22	0.25

Notes: The variables show difference in values between my own and Riedl and Rocha-Akis (2012)'s dataset for key variables. Dummy "offshore" omitted because of no difference between sets.

Figure 7: Percentage difference between mine and RR panel observations on b_{it} and τ_{it}



Finland is excluded as being an outlier because of different years recorded in changing from cash to accroul based accounting.

6.3 Visual and descriptive data of own dataset 1982–2012

Table 10: Summary statistics

	mean	sd	min	max	count
STAT	.3774544	.0908186	.211729	.627434	570
$\overline{STAT}$	.3582597	.078386	.2175	.59948	570
EATR	.2984407	.0671593	.161032	.495927	377
$\overline{EATR}$	.2911936	.0624953	.182683	.495927	443
Tax base per capita	2987.115	4341.406	61.29987	40973.99	554
income	28462.68	15033.93	4379.138	99249	570
$\overline{income}$	29776.34	13582.03	7322.645	71745.32	570
growth	2.2211	2.177394	-8.269	7.259	570
rulc	102.3999	5.401929	90.01939	124.034	567
export	.3265352	.1577865	.0697541	.8223139	570
inf	3.198863	3.108286	-1.342	23.113	570
PIT	.5042369	.1053152	.235	.93	570
$\overline{PIT}$	.5134805	.0706884	.4055667	.73	570
euf	.5701754	.4954857	0	1	570
efta	.7263158	.4462404	0	1	570
pop	43.35986	63.3329	3.184	314.154	570
unemp	7.282444	3.811774	.501	24.8	570
openness	.6378002	.2908444	.1592399	1.640057	570
offshore	.2631579	.4407342	0	1	570
offshore*pop	25.30975	66.14117	0	314.154	570
tcr	.4947368	.5004114	0	1	570

Table 11: Correlation table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) ln STAT	1.00												
(2) ln $\overline{STAT}$	0.48	1.00											
(3) ln EATR	0.96	0.28	1.00										
(4) ln $\overline{EATR}$	0.23	0.93	0.21	1.00									
(5) ln gdpcap	-0.62	-0.63	-0.50	-0.53	1.00								
(6) ln rulc	0.52	0.44	0.40	0.29	-0.27	1.00							
(7) growth	0.14	0.23	0.17	0.21	-0.21	-0.04	1.00						
(8) ln export	-0.45	-0.01	-0.61	-0.06	0.26	-0.27	-0.06	1.00					
(9) inf	0.33	0.40	0.13	0.38	-0.60	0.13	-0.02	-0.23	1.00				
(10) ln PIT	0.39	0.35	0.25	0.08	-0.32	0.35	0.07	0.09	0.14	1.00			
(11) ln $\overline{PIT}$	0.33	0.60	0.06	0.40	-0.47	0.27	0.12	0.06	0.22	0.34	1.00		
(12) efta	-0.21	0.06	-0.41	-0.16	0.06	-0.23	-0.13	0.54	0.02	0.10	0.20	1.00	
(13) euf	-0.10	-0.15	-0.12	-0.22	-0.08	-0.37	-0.09	0.30	0.03	0.23	0.03	0.70	1.00
(14) tcr	-0.13	-0.36	0.16	-0.20	0.31	-0.11	-0.08	-0.13	-0.28	-0.32	-0.18	-0.32	-0.19

Figure 8: Corporate income tax base, per capita 1982- 2012

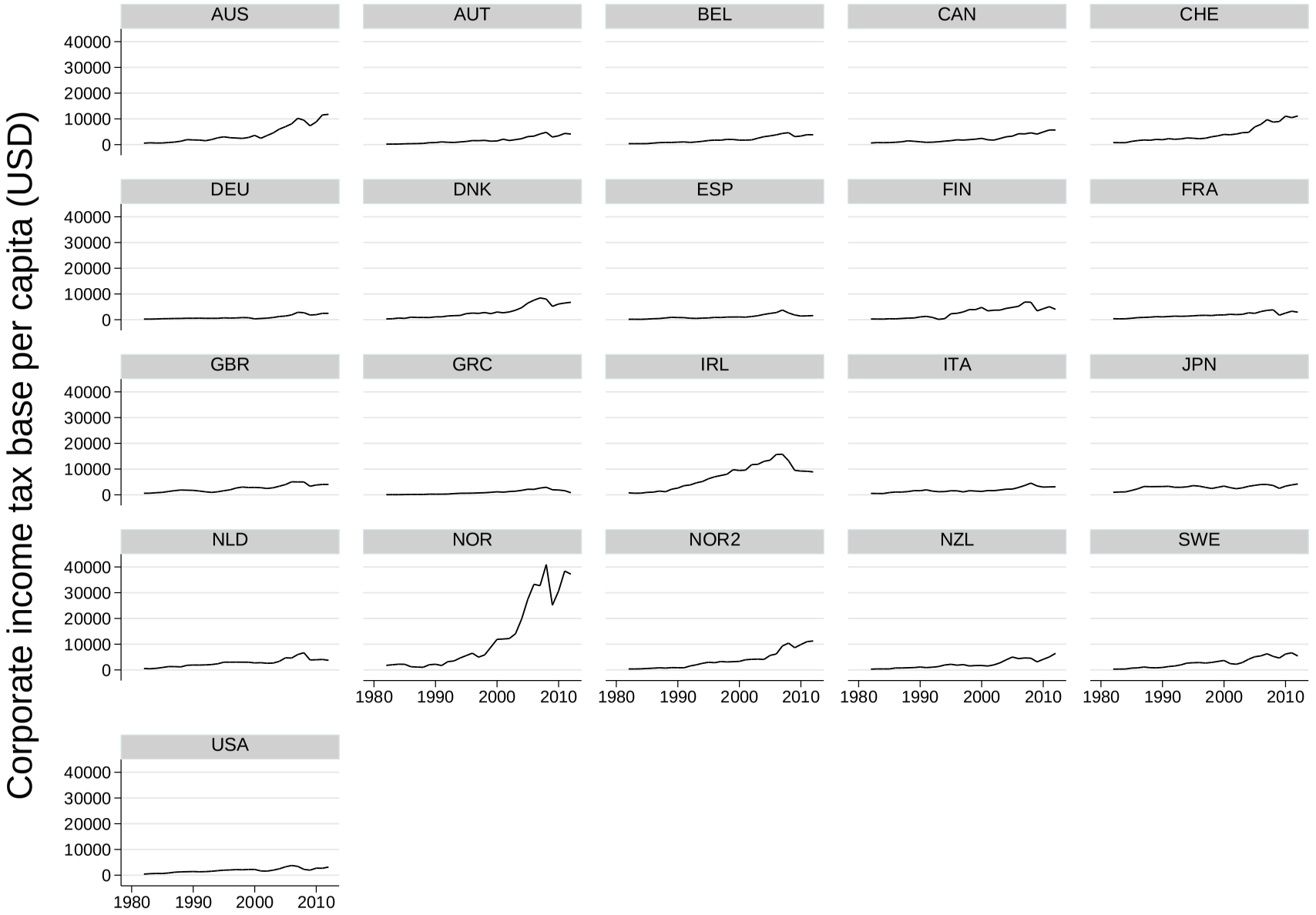
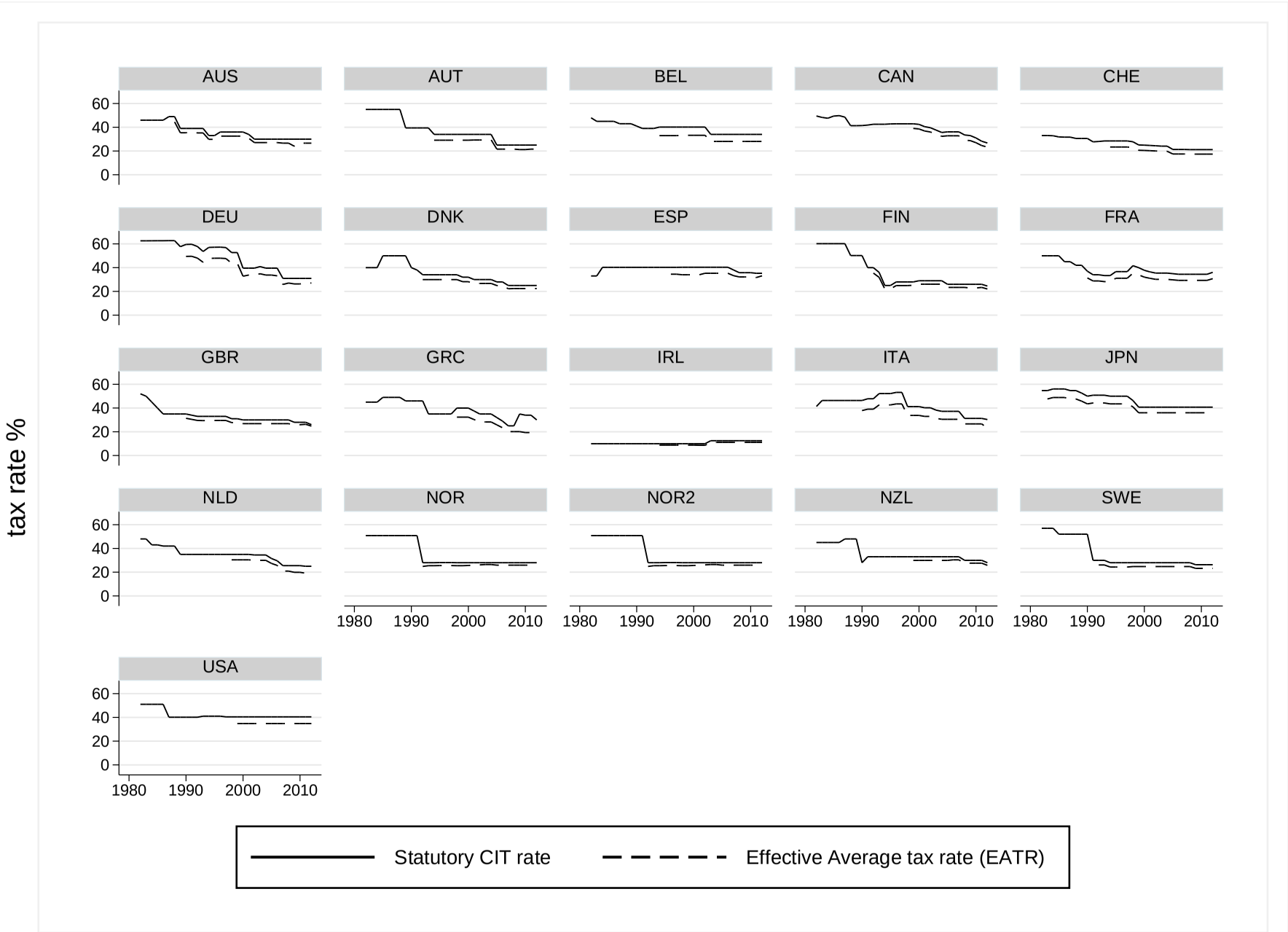


Figure 9: Statutory, and average corporate income tax rate 1982- 2012



6.4 First stage regression for full sample 1982 - 2012

Table 12: First stage regression comparing instruments (5) and (9) in Table 4.

	(5) $\ln \tau$	(5) $\ln \overline{\tau}$	(9) $\ln \tau$	(9) $\ln \overline{\tau}$
L1.ln τ	0.646***	0.0345*		
	(0.0728)	(0.0267)		
L1.ln $\overline{\tau}$	0.0745	0.699***		
	(0.0595)	(0.0411)		
L1ln pit	0.106**	-0.00190	0.278***	-0.00689
	(0.0489)	(0.0162)	(0.0423)	(0.0212)
L1ln $\overline{pit}$	0.0705	0.0354	0.154**	0.187***
	(0.0744)	(0.0444)	(0.0924)	(0.0614)
L1.ln unemp	-0.0265*	-0.00229	-0.0590***	-0.0161
	(0.0189)	(0.00886)	(0.0215)	(0.0128)
L1.ln $\overline{unemp}$	-0.0655***	-0.0742***	-0.156***	-0.164***
	(0.0257)	(0.0174)	(0.0325)	(0.0212)
pop	0.00604	-0.00531*	0.00101	-0.0146***
	(0.00613)	(0.00340)	(0.00840)	(0.00507)
offshore*pop	-0.00752	-0.00591	-0.00481	-0.0102
	(0.0107)	(0.00632)	(0.0143)	(0.00969)
openness	4.203	6.098	40.88**	34.53***
	(15.38)	(6.805)	(18.14)	(12.51)
openness*year	-0.00205	-0.00305	-0.0203**	-0.0173***
	(0.00765)	(0.00339)	(0.00904)	(0.00624)
Constant	-1.130	1.575**	-0.546	3.115***
	(1.192)	(0.740)	(1.614)	(1.219)
Exogenous regressors	Included		Included	
N	535	535	535	535
adj. R^2	0.933	0.973	0.886	0.938

Standard errors in parentheses

One-tailed significance levels: * (10%), ** (5%), *** (1%)