Tax competition: dynamic policy and empirical evidence

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To Barbara and Adrian

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ABSTRACT

This thesis studies tax competition from both a theoretical and an empirical point of view. In chapter 1 we develop a dynamic two-country optimal taxation model to study tax competition. We find that tax competition is costly and that the equilibrium with tax competition differs remarkably from the first-best outcome in a fiscal union, both during transition and in the long run. In chapter 2 we empirically test the relationship between taxation and agglomeration economies. In the presence of agglomeration economies firms are less sensitive to changes in tax rates, and therefore capital tax competition has a smaller effect on investment. We find some evidence that municipalities in large agglomerations set higher tax rates than municipalities in smaller ones.

RESUMEN

Esta tesis estudia la competencia impositiva tanto desde el punto de vista teórico como empírico. En el capítulo 1, desarrollamos un modelo dinámico de imposición óptima en dos países con el objetivo de estudiar la competencia impositiva. Encontramos que la competencia impositiva es costosa y que el equilibrio con competencia impositiva difiere significativamente del mejor resultado en una unión fiscal, tanto durante la transición como en el largo plazo. En el capítulo 2, analizamos empíricamente la relación entre imposición y economias de aglomeración. En presencia de economías de aglomeración, las empresas son menos sensibles a cambios en los tipos impositivos y, por tanto, la competencia impositiva para atraer capital tiene efectos menores en la inversión. Encontramos evidencia a favor de que los municipios en grandes aglomeraciones establecen tipos impositivos más altos que los que están en pequeñas aglomeraciones.

FOREWORD

This thesis studies tax competition both from a theoretical and empirical point of view. In particular we are interested in the analysis of capital tax competition, where jurisdictions compete over investment by setting tax rates strategically. There is a rich literature on the subject. Oates (1972) already describes how jurisdictions lower tax rates to attract business investment. The first formal models following this idea were developed by Zodrow and Mieszkowski (1986) and Wilson (1986), who study the link between tax competition, public spending and welfare in a static model with many small regions. A recurring question in this literature[1] is the effect of tax competition on public expenditures and welfare. The general finding is that tax competition leads to lower tax rates, underprovision of the public good, and a reduction in welfare.

In chapter 1 we look at a model with two large economies competing over capital. In contrast to the literature outlined above we work with a dynamic model, and find that in this case the results are less clear-cut. In a dynamic model capital taxation has not only an impact on the current state of the economy but also on investment, and therefore on subsequent periods. We find that capital tax rates are too low only in the short run. Contrary to the result from the standard tax competition literature, we find that public expenditures are too high in the short run, and inefficiently low only in the long run. An extension to the tax competition literature was realised by Bucovetsky (1991) and Wilson (1991), who analyse the case of asymmetric countries. If we want to think of tax competition in the context of the European Union for instance, we have to be aware that member countries have very different characteristics. We discuss tax competition among asymmetric countries in section 1.6, where find that even a simple difference in country size can have a major impact on taxation policies.

A different stream of literature related to this work is the optimal taxation literature. We use a two-country version of a standard optimal taxation

[1] Surveys on the standard tax competition literature were realised by Wilson (1999) and more recently by Wilson and Wildasin (2004).

model[2] to analyse tax competition. Optimal taxation models discuss taxation in a dynamic framework. Although tax competition is not frequently discussed in this literature, we are not the first ones to study taxation in an open economy. Razin and Sadka (1995), Atkeson et al. (1999), Correia (1996a) and Wildasin (2003) look at optimal taxation in a small open economy. The small open economy approach simplifies the analysis, because no strategic interactions among the countries arise. The strategic interactions in our model in turn allow us to look at tax competition. Governments set tax rates strategically, taking the other countries' taxation policy as given. The solution is a Cournot type equilibrium. Mendoza and Tesar (2005) and Klein et al. (2005) consider strategic tax setting among large countries, but within a restricted set of taxation policies. To assess the cost of tax competition we extend the analysis and compare the outcome of the model with tax competition to the first-best case of a fiscal union, where governments cooperate in tax setting. The benefits of monetary policy cooperation have been discussed extensively in the literature, see Benigno and Benigno (2003, 2006), Corsetti and Pesenti (2005) and Obstfeld and Rogoff (2002) among others. We contribute to the literature on fiscal policy coordination, which in comparison is relatively scarce. Kehoe (1987) studies cooperative and non-cooperative policies in a world where all countries are small. Kehoe (1989) discusses fiscal policy coordination in a two-period model.

There exists ample empirical evidence of the importance of tax competition. Griffith and Klemm (2004) for instance have a close look at the evolution of corporate tax rates over the last two decades and show that the corporate tax rates in the OECD decreased steadily over this time period.[3] Decreasing statutory tax rates are not per se an evidence of tax competition. But a look at the empirical literature confirms the intuition of interdependent taxation policies behind the fact of decreasing statutory tax rates. Tax competition is not just an issue at the OECD or EU level but also within many countries, as regions try to attract labour and capital

[2]Standard models are discussed in Chamley (1986), Chari and Kehoe (1999) or Ljungqvist and Sargent (2004) among others.

[3]Other authors found similar evidence. See for example European Comission (2007), Krogstrup (2004), Randolph (2005) or Bond et al. (2000).

by setting tax rates strategically.[4]

The new economic geography literature (NEG) looks at tax competition from a different perspective. Whereas the optimal taxation literature mentioned above predicts a race-to-the-bottom in capital tax rates (the so-called Chamley (1986) and Judd (1985) result), the NEG literature offers a theoretical explanation why this extreme result needs not take place. Firms have an incentive to stay in a place because they can profit from the existence of agglomeration economies (market access, supplier proximity and spill-over effects), even if elsewhere the tax rates would be lower. The existence of agglomeration effects can therefore mitigate the effect of tax competition, as local governments can set higher tax rates according to the intensity of agglomeration effects at the local level. In chapter 2 we want to test empirically if local governments take agglomeration economies into account in their taxation policy. Charlot and Paty (2007), Jofre-Monseny and Solé-Ollé (2009) and Koh and Riedel (2010) are the first attempts to directly test whether agglomeration rents are taxed, by showing that local taxes are positively correlated with local agglomeration economies. However, all three attempts suffer from severe identification problems, which we address in this chapter.

[4] See for example Bordignon et al. (2003), who do an analysis for Italian municipalities; Heyndels and Vuchelen (1998) use data on Belgian municipalities; Feld and Reulier (2005) have a closer look at tax competition inside Switzerland; Brett and Pinkse (2000) look at taxation in British Columbia; Solé-Ollé (2003) at Spanish municipalities; Buettner (2001) at competing German jurisdictions and Brueckner and Saavedra (2001) at the Boston metropolitan area.

CONTENTS

1 THE DYNAMICS OF TAX COMPETITION. INSIGHTS FROM A TWO-COUNTRY OPTIMAL TAXATION MODEL

1.1 INTRODUCTION

In a globalised world of highly integrated financial markets it is impracticable for tax authorities to conduct an independent fiscal policy. Capital is particularly mobile as a tax base, and therefore very responsive to taxation policy. As a consequence tax authorities can not ignore taxation policies conducted by other countries, as long as they intend to attract investment or ensure investment does not leave the country towards more advantageous tax regimes. Tax competition emerges as a consequence. Being aware of the challenge faced by tax authorities, the OECD as well as the European Commission intensely discuss taxation policies, harmful tax competition and cooperation among governments to exchange information (see Ruding Report (1992), European Comission (2001, 2003), OECD (1998, 2007)).

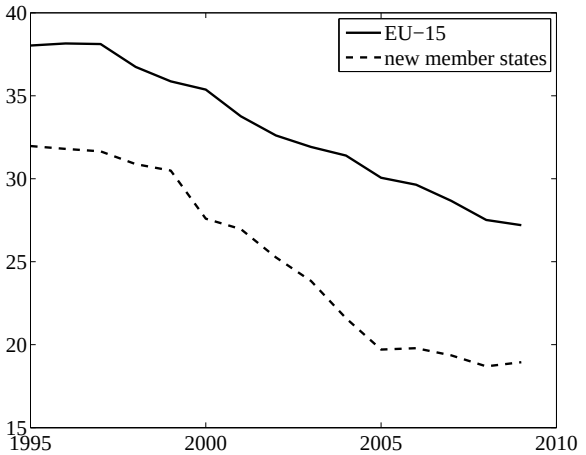

Figure 1.1: Adjusted top statutory corporate tax rates in the EU

Figure 1.1[1] illustrates the evolution of tax rates in the EU over the last 15 years and highlights why institutions take so much interest in tax competition. There are two patterns evident from this graph. The significant decrease in corporate tax rates points to the presence of tax competition.[2] The huge difference in taxation in the EU-15 and the new member countries suggests different characteristics of the new and old member states as a possible source of tax competition.[3] The model we build in this paper illustrates the decreasing pattern of corporate tax rates over time. An asymmetric version of the model gives an explanation for the difference in taxation between the EU-15 and the new member states. In that case we assume, that one country starts off with a lower initial capital stock. We find that the initially poorer country has lower capital tax rates over transition. This serves as an explanation of the pattern observed in Figure 1.1, as the new member states are on average much poorer than the EU-15.[4]

We use a two-country version of a standard optimal taxation model[5] to analyse tax competition. In each country the governments behave as Ramsey planners and set the tax rates for their country optimally, given that they are in a world of tax competition. Because the countries are assumed being large strategic interactions arise. Capital is perfectly mobile, and as a consequence governments set tax rates strategically in order to attract capital. Governments can fully commit to their policy, and play a Cournot game. They take the sequence of tax rates of the other govern-

[1] Data from the European Communities (2009)

[2] Note that decreasing statutory tax rates are not per se an evidence of tax competition. But a look at the empirical literature confirms the intuition of interdependent taxation policies behind the fact of decreasing statutory tax rates. See Griffith and Klemm (2004) for a discussion of the empirical literature on tax competition.

[3] It is worth noting that tax competition is not just an issue at the OECD or EU level but also within many countries, as regions try to attract labour and capital by setting taxes strategically. See studies by Solé-Ollé (2003), Buettner (2001), and Brueckner and Saavedra (2001) among others.

[4] According to data from International Monetary Fund (2009) average GDP per capita in the new member states during the period from 1995 to 2008 evolved from 14% to 32% of the GDP in the EU-15.

[5] Standard models are discussed in Chamley (1986), Chari and Kehoe (1999) or Ljungqvist and Sargent (2004) among others.

ment as given, and decide on a sequence of tax rates in response, to which they can commit. To asses the costs of tax competition we compare the model with tax competition with the first-best case of a fiscal union. We find that in the long run capital tax rates converge to zero, both in a fiscal union and with tax competition. This is a standard result in the optimal taxation literature, first established by Chamley (1986) and Judd (1985), which we can proof as well in the present context. Nevertheless, there are long-run effects of tax competition. We find that in the long-run labour tax rates are inefficiently high. As well, the public good is under-provisioned and the governments are indebted in all periods, whereas in the fiscal union governments save. We find that capital, labour and consumption are inefficiently low in the long run. This contrasts remarkably with the short-run results, where capital tax rates are inefficiently low for several periods, and because of a smoother convergence to the steady state, too high for some time. Labour tax rates are inefficiently low in the short run and therefore labour supply is too high. We find as well an over-supply of the public good and over-accumlation of capital in the short run. Given that in the fiscal union it is optimal to have zero capital tax rates in the long, one could think that tax competition was a good thing, as it leads governments to reduce capital tax rates earlier. But this is not true. Summarising the cost of tax competition, we find that the consumption equivalent welfare cost of tax competition is 4%.

Extending the analysis to asymmetric countries, we assume that the two countries differ in the initial capital stock. We endogenously define the tax haven as the country with the lower capital tax rates during transition. With this model we can explain the existence of lower tax countries and how they attract capital from abroad by setting lower capital tax rates. Although the foreign country owns more capital than what we call the tax haven in any period, the tax haven manages to attract enough capital from abroad, such that in the end more capital is invested in the tax haven than in the foreign country. From the welfare analysis we find that tax havens are better off in an open economy than in autarky. The tax haven prefers even tax competition to autarky. But the contrary is true for the other country. The initially richer country would be better off staying in autarky than to

being in either an open economy with tax competition or a fiscal union. In other words, as soon as countries differ in the initial capital stock the initially richer country would prefer to impose capital controls and remain in a state of complete autarky. What does this imply for the EU countries in Figure 1.1? Countries in the EU can hardly isolate themselves from the international financial markets or avoid tax competition. Following our analysis a fiscal union would be preferable to the current state of tax competition in the EU. But the richer countries would still be better off in autarky.

We are not the first ones to study taxation in an open economy. Razin and Sadka (1995), Atkeson et al. (1999) and Correia (1996a) look at optimal taxation in a small open economy. The small open economy approach simplifies the analysis, because no strategic interactions among the countries arise. The strategic interactions in our model in turn allow us to look at tax competition. Governments set tax rates strategically, taking the other countries' taxation policy as given. The solution is a Cournot equilibrium. Mendoza and Tesar (2005) and Klein et al. (2005) consider strategic tax setting among large countries, but within a restricted set of taxation policies. Mendoza and Tesar (2005) assume that the governments of the two countries meet once to decide on invariant capital tax rates forever. We in contrast examine a Ramsey plan of optimal taxation, where tax rates are allowed to change over time. Klein et al. (2005) employ a model of optimal time-consistent taxation with international mobility of capital. In this framework they limit the analysis to time-consistent taxation policies. They focus on the long run results of their model, where the results explain the heavy reliance on capital taxation of the US compared to Europe. In contrast to their paper we do an optimal taxation analysis, where the governments can commit to their fiscal policies. Our analysis allows us to discuss the evolution of tax rates and the other variables of the model over time and to discuss the optimal policy as well in the short run as in the long run. It turns out, that the policy recommendations during transition are very different from the long run. To assess the cost of tax competition we extend the analysis and compare the outcome of the model with tax competition to the first-best case of a fiscal union, where governments

collaborate on setting tax rates. The benefits of monetary policy cooperation have been discussed extensively in the literature, see Benigno and Benigno (2003, 2006), Corsetti and Pesenti (2005) and Obstfeld and Rogoff (2002) among others. The literature on coordination of fiscal policies is in comparison relatively scarce. Kehoe (1987) studies cooperative and non-cooperative policies in a world where all countries are small. Kehoe (1989) discusses fiscal policy coordination in a two-period model.

Another stream of literature related to this paper is the standard tax competition literature which has its roots back to Tiebout (1956) and Oates (1972). Surveys on the tax competition literature can be found by Wilson (1999) and more recently by Wilson and Wildasin (2004). This literature generally studies tax competition in static models. Two exceptions are the dynamic studies by Razin and Sadka (1995) and Wildasin (2003), where optimal taxation in a small open economy is discussed. This approach contrasts with the Nash equilibria discussed in Klein et al. (2005), Mendoza and Tesar (2005) and the model employed in this paper. As far as we know this is the first paper to consider optimal taxation with commitment in a two-country model where countries are considered being large. We add with this paper the dynamic aspect to the standard tax competition literature, and extend the optimal taxation literature to the analysis of tax competition. Using a dynamic taxation model allows us to discern optimal long run taxation policies from optimal policies during transition, which are remarkably different.

The remainder of this chapter is structured as follows. In Section 1.2 we explain the features of the model and define the equilibrium. In Section 1.3 we discuss the setup of the fiscal union and the model with tax competition. The long run results are to be found in Section 1.4. The transitional results comparing tax competition with the case of a fiscal union can be found in Section 1.5. The results from competition with a tax haven are discussed in Section 1.6. Results from a model with exogenous government spending and a model with balanced budget are discussed in Sections A.10 and A.11 in the Appendix. Section 1.7 concludes.

1.2 MODEL

Our model is a two-country version of a standard dynamic optimal taxation model. In each country there are households and a production firm. Households decide on consumption, labour supply, capital accumulation and the amount of government debt they want to hold. Households can only hold debt of their own government. Each household decides every period in which country to invest the current capital. The decision on investment depends on capital returns and capital taxation in each country. Capital is perfectly mobile between the two countries, whereas labour is immobile. Firms rent capital internationally and labour from the households of their own country. Governments finance endogenous government expenditures by labour and capital taxation and can get indebted. Capital taxation is source based. A source based tax regimes implies that all the income on capital accruing inside a country are taxed. This contrasts with a residence based regime, where the worldwide income of a resident is taxed. In reality most countries apply a mix of both systems. The US for example have a residence based tax systems. But corporate income is taxed only on repatriation, which approximates again the source based tax model. European countries in contrast are closer to the source based taxation system.[6]

There are two countries in the model, $i = 1, 2$. The world is governed by the following aggregate resource constraint:

$$\sum_{i=1,2} (G_{i,t} + c_{i,t} + k_{i,t} - (1-\delta)k_{i,t-1}) = \sum_{i=1,2} F(k_{i,t-1}, (1-\ell_{i,t})) \qquad (1.1)$$

which assures that the amounts consumed by governments ($G_{i,t}$) and households ($c_{i,t}$) plus investment are not higher than overall production. $k_{i,t}$ denotes the total capital invested in country i and δ is the depreciation rate of capital. $\ell_{i,t}$ is leisure and total time available to the households is normalized to 1. Therefore $1 - \ell_{i,t}$ denotes labour. $F(k_{i,t-1}, (1-\ell_{i,t}))$ is the production technology of the final good.

[6] Razin and Sadka (1995) discuss theoretically source vs. resident based taxation.

a Governments

The governments finance endogenous government expenditures $G_{i,t}$ by taxing labour and capital income of households, and decide on the amount of government debt to issue each period. The government budget constraint looks as follows:

$$G_{i,t} = \tau^k_{i,t}(r_{i,t} - \delta)k_{i,t-1} + \tau^l_{i,t} w_{i,t}(1 - \ell_{i,t}) + p_{i,t} b_{i,t} - b_{i,t-1}. \tag{1.2}$$

Government debt issued at time t is denoted by $b_{i,t}$ and can be positive or negative. $p_{i,t}$ is the price of debt. $\tau^k_{i,t}$ is the tax rate on household capital income net of depreciation and $r_{i,t}$ the rental rate of capital paid by the firms located in country i. $\tau^l_{i,t}$ denotes the tax rate on labour income charged by the government, and $w_{i,t}$ is the wage rate paid by the firms in i to the households in i.

b Households

Households maximise discounted lifetime utility deciding on consumption, labour supply, capital accumulation and the amount of government debt they want to hold. Government expenditures are to the benefit of the households and enter the utility function. We can write the households' problem as

$$\max_{c_{i,t}, \ell_{i,t}, G_{i,t}, a^n_{i,t}, b_{i,t}} \sum_{t=0}^{\infty} \beta^t u(c_{i,t}, \ell_{i,t}, G_{i,t}) \tag{1.3}$$

s.t.

$$\begin{aligned} &c_{i,t} + \sum_{n=1,2} a^n_{i,t} + b_{i,t} p_{i,t} = \\ &\sum_{n=1,2} \left[1 + (r_{n,t} - \delta)(1 - \tau^k_{n,t})\right] a^n_{i,t-1} + (1 - \tau^l_{i,t}) w_{i,t}(1 - \ell_{i,t}) + b_{i,t-1} \end{aligned} \tag{1.4}$$

where β is the rate at which households discount the future and $a^n_{i,t}$ the capital households of country i invest in country n, $i = 1, 2$ and $n = 1, 2$.

$k_{i,t}$ as used in equations (1.1) and (1.12) is the sum of the capital invested in country i by the households of the two countries:

$$k_{i,t} = \sum_{n=1,2} a^i_{n,t}. \tag{1.5}$$

From the first-order conditions with respect to capital and consumption we find the Euler equations, which describe the way in which current consumption relates to future consumption. Because households can decide on investing capital at home ($a^i_{i,t}$) or abroad ($a^j_{i,t}$, $i \neq j$), there exist two Euler equations for country i,

$$u_{c_{i,t}} = \beta u_{c_{i,t+1}} \left[1 + (r_{i,t+1} - \delta)(1 - \tau^k_{i,t+1})\right] \tag{1.6}$$

$$u_{c_{i,t}} = \beta u_{c_{i,t+1}} \left[1 + (r_{j,t+1} - \delta)(1 - \tau^k_{j,t+1})\right]. \tag{1.7}$$

From equations (1.6) and (1.7) we find the no-arbitrage condition (1.8), implying that the after-tax return on capital in the two countries has to be equal at equilibrium,

$$(r_{i,t+1} - \delta)(1 - \tau^k_{i,t+1}) = (r_{j,t+1} - \delta)(1 - \tau^k_{j,t+1}). \tag{1.8}$$

It follows from equation (1.8) that at the equilibrium the households are indifferent about where to invest their capital. From the first-order conditions with respect to consumption and leisure we find that

$$\frac{u_{\ell_{i,t}}}{u_{c_{i,t}}} = (1 - \tau^l_{i,t}) w_{i,t}. \tag{1.9}$$

Hence labour taxes introduce a wedge between the marginal rate of substitution between leisure and consumption and the wage rate.

From the first-order conditions with respect to government debt and consumption it follows that

$$u_{c_{i,t}} p_{i,t} = \beta u_{c_{i,t+1}}. \tag{1.10}$$

Equation (1.10) combined with the Euler equation (1.6) implies that the price of government debt has to be related to the after-tax return on capital in the following way:

$$\frac{1}{p_{i,t}} = \left[1 + (r_{i,t+1} - \delta)(1 - \tau^k_{i,t+1})\right]. \tag{1.11}$$

c Firms

Firms maximise profits. Because of perfect competition equilibrium profits are zero after paying out wages and the rental price of capital.

$$\max_{k_{i,t-1},(1-\ell_{i,t})} F(k_{i,t-1}, (1 - \ell_{i,t})) - r_{i,t}k_{i,t-1} - w_{i,t}(1 - \ell_{i,t}) \tag{1.12}$$

The good produced by firms is the same in the two countries, so there is be no trade in goods with the aim of increasing the variety of goods at disposal of consumers. First-order conditions from the firms' problem imply that the capital and the wage rental rate equal marginal productivities of capital and labour respectively:

$$r_{i,t} = F_{k_{i,t-1}}(k_{i,t-1}, (1 - \ell_{i,t})) \tag{1.13}$$

$$w_{i,t} = F_{(1-\ell_{i,t})}(k_{i,t-1}, (1 - \ell_{i,t})). \tag{1.14}$$

d Equilibrium

A competitive equilibrium with taxes in this two-country model is a sequence of allocations $\{c_{i,t}, \ell_{i,t}, a^n_{i,t}, k_{i,t}\}_{i=1,2,\ n=1,2}$, prices $\{p_{i,t}, w_{i,t}, r_{i,t}\}_{i=1,2}$, and government policies $\{b_{i,t}, \tau^l_{i,t}, \tau^k_{i,t}, G_{i,t}\}_{i=1,2}$ for $t = 0, \ldots, \infty$ such that given prices and government policies, households maximise utility (1.3) under the budget constraint (1.4), production firms maximise profits (1.12), the government budget constraints (1.2) hold and markets clear: $k_{i,t} = \sum_{n=1,2} a^i_{n,t}$, for $i = 1, 2$.

Because at equilibrium the no-arbitrage condition (1.8) holds, the households are indifferent about where to invest their capital. For this reason only the total amount of capital invested ($k_{i,t}$) and accumulated ($a_{i,t} = \sum_{i=1,2} a^i_{n,t}$) in each country are defined at equilibrium, but not the proportion $a^n_{i,t}$ of capital the households in country i invest in country n. There exist many different competitive equilibria, depending on the government policy. The Ramsey problems we discuss in the following section help to choose one of them, in which the household's utility is maximised.

1.3 optimal fiscal policy

In this part of the paper we study the policy objective of the governments and the interaction of the countries under tax competition. To assess the cost of tax competition we compare an economy with tax competition with the first-best case of a fiscal union. In the fiscal union, a central fiscal authority sets tax rates for both countries, maximising the overall welfare of the two countries. With tax competition in contrast governments maximise only the welfare of their own households, and take foreign tax rates as given. We assume the two countries to be large, and therefore to take into account the effect of their own taxation policy on the foreign economy. Governments can commit to their future policies at the beginning of time. Solving a Ramsey plan, the governments solve for a stream of tax rates in order to maximise the objective function, taking into account how the private sectors in each country respond to these tax rates.

a Fiscal union

We assume that a central fiscal authority decides on fiscal policy maximising the weighted sum of the utility of consumers in the two countries, and taking into account all the equilibrium conditions of the two countries. The fiscal authority has at disposal the full array of tax instruments $\{\tau^l_{i,t}, \tau^k_{i,t}\}_{i=1,2}$ for each country, and for periods $t = 0, \ldots, \infty$. We can write the Ramsey plan

for the fiscal union as maximising

$$\sum_{t=0}^{\infty} \beta^t \sum_{i=1,2} \varphi_i u(c_{i,t}, \ell_{i,t}, G_{i,t}) \tag{1.15}$$

subject to equations (1.2), (1.4), (1.6), (1.9), (1.10), (1.13), (1.14) for each country, $i = 1, 2$ and equation (1.8). The aggregate resource constraint (1.1) can be found by adding up the household and government budget constraints of the two countries. Hence, we can use as well the aggregate resource constraint instead of one of the government budget constraints (1.2). φ_i is the weight the central fiscal authority attaches to the utility of the households in i.

For the first period capital is given, and hence inelastically supplied. Taxing initial capital is lump sum and therefore very attractive for governments, as it is non-distortionnary. To avoid unrealistically high capital tax rates in any period we set an upper bound on capital tax rates: $\tau^k_{i,t} \leq \bar{\tau}^k$, $t = 0, \ldots, \infty$.

The dual approach to the Ramsey plan as characterized above can be rewritten in a more concise form. In a standard one-country model the so-called primal approach helps to reduce the dual Ramsey plan to a problem with two constraints only, the inter-temporal implementability condition and a period-by-period aggregate resource constraint. The implementability condition is an inter-temporal version of the household budget constraint, where prices and tax rates have been substituted out using the first-order conditions of the households. The government therefore chooses quantities directly. In the present model we have two countries, but only one aggregate resource constraint. Therefore the simplified Ramsey plan we use (as proposed in Proposition 1) differs from the standard one-country version in that we have two implementability constraints, i.e., one for each country, the aggregate resource constraint and a version of a government budget constraint where we substituted out all prices and tax rates. For details on defining a Ramsey equilibria and more generally on the primal approach to solving a Ramsey plan see Chari and Kehoe (1999) and Ljungqvist and Sargent (2004).

Proposition 1. A solution to the following simplified Ramsey problem is equivalent to a solution to the dual problem. The dual problem as outlined above is to maximise (1.15) subject to (1.2), (1.4), (1.6), (1.9), (1.10), (1.13), (1.14) for each country, $i = 1, 2$ equation (1.8) and the transversality conditions (1.16), (1.17) and (1.18), $n = i, j$:

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})p_{n,T}b_{n,T} = 0 \tag{1.16}$$

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})a^{i}_{n,T} = 0 \tag{1.17}$$

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})a^{j}_{n,T} = 0. \tag{1.18}$$

The simplified Ramsey plan can be written as maximising:

$$\sum_{t=0}^{\infty}\beta^{t}\sum_{i=1,2}\varphi_{i}u(c_{i,t},\ell_{i,t},G_{i,t}) \tag{1.19}$$

subject to

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c_{i,t}} c_{i,t} - u_{\ell_{i,t}} (1 - \ell_{i,t}) \right] = A_{i,0} \tag{1.20}$$

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c_{j,t}} c_{j,t} - u_{\ell_{j,t}} (1 - \ell_{j,t}) \right] = A_{j,0} \tag{1.21}$$

$$\frac{u_{c_{i,t}}}{\beta u_{c_{i,t+1}}} = \frac{u_{c_{j,t}}}{\beta u_{c_{j,t+1}}} \tag{1.22}$$

$$\begin{aligned} G_{i,t} = & \left[(F_{k_{i,t-1}} - \delta) - \frac{u_{c_{i,t-1}}}{\beta u_{c_{i,t}}} + 1 \right] k_{i,t-1} \\ & + \left[F_{1-\ell_{i,t}} - \frac{u_{\ell_{i,t}}}{u_{c_{i,t}}} \right] (1 - \ell_{i,t}) + \frac{\beta u_{c_{i,t+1}}}{u_{c_{i,t}}} b_{i,t} - b_{i,t-1} \end{aligned} \tag{1.23}$$

$$\sum_{i=1,2} (G_{i,t} + c_{i,t} + k_{i,t} - (1 - \delta) k_{i,t-1}) = \sum_{i=1,2} F(k_{i,t-1}, (1 - \ell_{i,t})) \tag{1.24}$$

where $k_{i,t} = \sum_{n=1,2} a^i_{n,t}$ and

$$A_{i,0} = u_{c_{i,0}} \left(b_{i,-1} + \sum_{n=1,2} \left[1 + (1 - \tau^k_{n,0})(F_{k_{n,-1}} - \delta) \right] a^n_{i,-1} \right) \tag{1.25}$$

$$A_{j,0} = u_{c_{j,0}} \left(b_{j,-1} + \sum_{n=1,2} \left[1 + (1 - \tau^k_{n,0})(F_{k_{n,-1}} - \delta) \right] a^n_{j,-1} \right) \tag{1.26}$$

The proof to Proposition 1 can be found in Appendix A.1.

b Tax competition

With tax competition the governments take only the welfare of their own households into account, in contrast to the fiscal union where the overall welfare is maximised. We assume that both economies are large. Therefore each country takes the effect of its taxation policy on the other country into account, and hence strategic issues arise. The government of country i sets a sequence of tax rates $\{\tau^l_{i,t}, \tau^k_{i,t}\}_{t=0}^{\infty}$ taking the foreign sequence of tax rates

$\{\tau^l_{j,t}, \tau^k_{j,t}\}_{t=0}^{\infty}$ as given, $i \neq j$. The solution is a Cournot equilbrium. For the Ramsey plan this implies that each government maximises the utility of its own households, subject to the first-order conditions of the households' and firms' problem of each country, and the household and government budget constraints of both countries. To know the effect of their taxation policies, the governments take first-order conditions with respect to all the variables, except the foreign tax rates, which are taken as given. The solution to the constraints and first-order conditions of the Ramsey plan then represents the best response tax sequence of the respective government.[7] We can write the tax competition Ramsey plan for the government of country i as maximising

$$\sum_{t=0}^{\infty} \beta^t u(c_{i,t}, \ell_{i,t}, G_{i,t}) \tag{1.27}$$

subject to equations (1.2), (1.4), (1.6), (1.9), (1.10), (1.13), (1.14) for each country, and equation (1.8).

As in the fiscal union, we apply an upper bound on capital tax rates in all periods: $\tau^k_{i,t} \leq \bar{\tau}^k$, $t = 0, \ldots, \infty$.

Again, we reduce the dual problem above to a simplified Ramsey plan. Remember that in our model with tax competition the government of country i takes tax rates of country j as given, and therefore the problem can not be reduced for the planner to choose quantities only. But we can go a step into the same direction, by reducing the problem such that governments choose quantities for the home country, given foreign tax rates.

Proposition 2. A solution to the simplified Ramsey plan below is equivalent to maximising (1.27) subject to equations (1.2), (1.4), (1.6), (1.9), (1.10), (1.13), (1.14) for each country, equation (1.8) and the transversality

[7] This equilibrium concept is very similar to Benigno and Benigno (2006), who use it in context of international monetary policy.

conditions (1.28), (1.29) and (1.30), $n = i, j$:

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})p_{n,T}b_{n,T} = 0 \tag{1.28}$$

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})a^i_{n,T} = 0 \tag{1.29}$$

$$\lim_{T\to\infty}(\prod_{s=0}^{T-1} p_{n,s})a^j_{n,T} = 0. \tag{1.30}$$

We write the simplified Ramsey plan as maximising:

$$\sum_{t=0}^{\infty}\beta^t u(c_{i,t}, \ell_{i,t}, G_{i,t}) \tag{1.31}$$

subject to

$$\sum_{t=0}^{\infty}\beta^t[u_{c_{i,t}}c_{i,t} - u_{\ell_{i,t}}(1-\ell_{i,t}) + (u_{c_{i,t}} - \tilde{R}_{j,t+1}\beta u_{c_{i,t+1}})a^j_{i,t}] = A_{i,0} \tag{1.32}$$

$$\sum_{t=0}^{\infty}\beta^t[u_{c_{j,t}}c_{j,t} - u_{c_{j,t}}\tilde{w}_{j,t}(1-\ell_{j,t}) + (u_{c_{j,t}} - \tilde{R}_{j,t+1}\beta u_{c_{j,t+1}})a^j_{j,t}] = A_{j,0} \tag{1.33}$$

$$u_{c_{j,t}} = \beta u_{c_{j,t+1}}\tilde{R}_{j,t+1} \tag{1.34}$$

$$u_{\ell_{j,t}} = u_{c_{j,t}}\tilde{w}_{j,t} \tag{1.35}$$

$$\frac{u_{c_{i,t}}}{\beta u_{c_{i,t+1}}} = \tilde{R}_{j,t+1} \tag{1.36}$$

$$G_{j,t} = \tau^k_{j,t}(F_{k_{j,t-1}} - \delta)k_{j,t-1} + \tau^l_{j,t}F_{1-\ell_{j,t}}(1-\ell_{j,t}) + \frac{\beta u_{c_{j,t+1}}}{u_{c_{j,t}}}b_{j,t} - b_{j,t-1} \tag{1.37}$$

$$\sum_{i=1,2}(G_{i,t} + c_{i,t} + k_{i,t} - (1-\delta)k_{i,t-1}) = \sum_{i=1,2}F(k_{i,t-1}, (1-\ell_{i,t})) \tag{1.38}$$

where $k_{i,t} = \sum_{n=1,2} a^i_{n,t}$ and

$$A_{i,0} = u_{c_{i,0}}[b_{i,-1} + \sum_{n=1,2} \tilde{R}_{n,0} a^n_{i,-1}] \tag{1.39}$$

$$A_{j,0} = u_{c_{j,0}}[b_{j,-1} + \sum_{n=1,2} \tilde{R}_{n,0} a^n_{j,-1}] \tag{1.40}$$

and for $n = i, j$:

$$\tilde{R}_{n,t} = 1 + (1 - \tau^k_{n,t}) \left[F_{k_{n,t-1}} - \delta\right] \tag{1.41}$$

$$\tilde{w}_{n,t} = (1 - \tau^l_{n,t}) F_{1-\ell_{n,t}} \tag{1.42}$$

The proof to Proposition 2 can be found in Appendix A.2.

1.4 Long-run results

Chamley (1986) and Judd (1985) first found what we call the Chamley/Judd result, that in the long run capital tax rates are optimally equal to zero. The intuition behind this result is that to finance government spending, the government would optimally use non-distortionary lump-sum taxes. Having only access to distortionary taxation, i.e., capital and labour taxation, the government chooses the combination of the two which is best for the economy. It turns out that capital taxation distorts the economy more than labour taxation by biasing future investment. Therefore it is optimal to set the capital tax rate to zero in the long run and rely only on labour taxation to finance government spending. We find that the Chamley/Judd result holds as well in an open economy with tax competition and in a fiscal union.

Proposition 3. In a fiscal union as described in Section a capital tax rates are equal to zero in the long run.

The proof to Proposition 3 can be found in Appendix A.3.

Proposition 4. In an open economy the model with tax competition as outlined in Section b capital tax rates are equal to zero in the long run.

The proof to Proposition 4 can be found in Appendix A.4.

In the data we observe positive capital tax rates. Therefore, the Chamley/Judd resultis often regarded as a not very realistic outcome. There are several possible ways of extending our model to get non-zero capital tax rates in the long run. One way would be to introduce incomplete taxation as in Correia (1996b). Looking at the fully time-consistent model as Klein et al. (2005) or introducing loose commitment à la Debortoli and Nunes (2009) would be other possibilities. Abel (2007) develops a model with depreciation allowances and finds that capital tax rates are optimally positive, in all periods. The zero capital tax rate in the long run is a standard result in infinitely-lived agent models. In overlapping generations models in contrast this is an outcome only under certain conditions. Optimal taxation in overlapping generations models is studied by Escolano (1992), Erosa and Gervais (2001), Erosa (2002) and Abel (2005) among others.

We find zero capital tax rates in the long run are optimal both with tax competition and in the fiscal union. Therefore this result is not due to capital tax competition. But tax competition is nevertheless costly, both in the short and in the long run. We find that in steady state government expenditures, consumption, labour, production and the capital stock are lower and labour taxation and government debt are higher in an economy with tax competition than in a fiscal union.

1.5 FISCAL UNION VS. TAX COMPETITION

The long-run analysis shows us some of the costs of tax competition, but it is the transitional results which explain the origin of these costs. The transitional results allow us to explain the patterns observed in Figure 1.1. In this section we look at two symmetric countries, comparing the tax competition outcome with the first-best results of a fiscal union. An overview of the parameters used for calibration is provided in Table 1.1.

The period length is one year. The discount rate of households β and the depreciation of capital δ are set accordingly. Households have a log utility function of the form $u(c_{i,t}, \ell_{i,t}, G_{i,t}) = \log(c_{i,t}) + \varepsilon \log(\ell_{i,t}) + \log(G_{i,t})$. ε is chosen such that labour in steady state is equal to about 1/3, which corresponds to a working day of 8 hours. The production function is Cobb-Douglas with a capital income share of $\alpha = 0.3$. Government spending does not vary over time and is assumed to be around 40% of GDP in steady state. To avoid unreasonably high capital tax rates we set an upper bound on capital tax rates of 38%. This is the top statutory capital tax rate observed in the European Union over the last decade (compare with Figure 1.1).

Parameter	Value	Interpretation
α	0.3	Share of capital in production
β	0.96	Discount factor of households
δ	0.1	Depreciation rate of capital
ε	1.5	Utility parameter
$a^n_{i,-1}$	0.3	Initial capital stock
$b_{i,-1}$	0	Initial government debt
$\bar{\tau}^k_i$	0.38	Upper bound on capital tax rate

Table 1.1: Parameter values

Initial capital is inelastically supplied. Therefore taxing initial capital is lump sum and hence non-distortionary. A common feature of this type of models is that the governments therefore have the incentive of raising the tax revenues needed for all periods in the first period. To avoid this scenario an upper bound on capital tax rates is imposed. Imposing this upper bound only in the first period leads to a hike in capital tax rates in the second period, as depicted in Figure 1.2. In the fiscal union this hike is particularly extreme: the optimal capital tax rate in period is over 460% in period 2 and then drops to zero in period 3. Why does this happen? On the one hand, taxing capital in period 2 is distortionary, therefore the

capital tax rate is not as high as it would be in the first period. On the other hand, the capital stock in period 2 still consists to some extent of the initial capital stock, plus the new savings and minus the depreciation of capital. As it is best to tax initial capital, very high tax rates in period 2 are optimal. The same happens with tax competition, but to a lesser extent. Tax competition drives the capital tax rates down, although we still observe implausible high capital tax rates reaching a maximum of 86%.

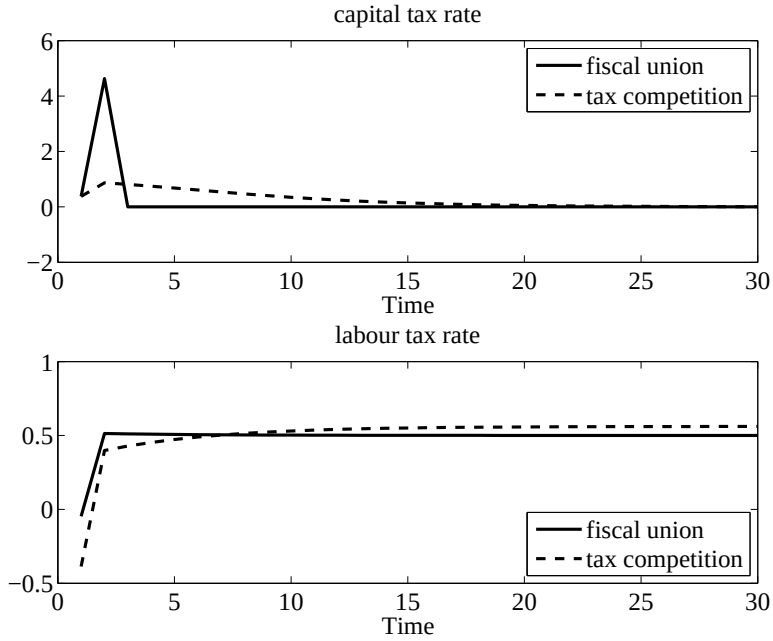

Figure 1.2: Capital and labour tax rates with upper bound in period 0 only

This hike in capital tax rates especially in the fiscal union, is very unrealistic. Such a hike in capital tax rates in period 1 could have a devastating effect on investment in the real world. As well, we can hardly imagine a government being able to implement such a taxation policy without causing political unsettlement. We therefore prefer imposing an upper bound on

capital tax rates in all periods. The results with upper bound are shown in Figure 1.3. We find that capital tax rates stay at the upper bound for several periods, both with tax competition and in the fiscal union. Tax rates then drop from the upper bound much earlier with tax competition than in the fiscal union and smoothly converge to zero. In the fiscal union capital tax rates converge to zero over just two periods. This result has been found before in the literature. Chamley (1986) showed in a continuous time framework that capital tax rates are constant at the upper bound for a finite number of periods, and zero thereafter. Atkeson et al. (1999) show this result in a discrete time environment and for a more general class of utility functions. They find that the capital tax rate stays at the upper bound for a finite number of periods, takes an intermediate value for one period and is zero thereafter.

Comparing the results for tax competition with the fiscal union, we find that under tax competition capital tax rates are inefficiently low for several periods (see Figure 1.3). But because of a smoother convergence to steady state, this is true only for a certain amount of time. The intuition for the smoother convergence is the following. Governments would still prefer reducing the capital tax rates as fast as in the fiscal union, but can not afford doing so, because they already suffer a huge loss in tax revenues compared to the fiscal union. Governments suffer this loss because they start reducing capital tax rates much earlier. This smooth convergence to zero of capital tax rates in an open economy with tax competition contrasts with findings from Atkeson et al. (1999) who find that in an open economy capital tax rates are equal to zero in all periods. The difference with our analysis is that Atkeson et al. (1999) abstract from any strategic issues by taking a small-open-economy approach. The intuition behind their result is, that the government in the small open economy faces a perfectly elastic supply of capital, and therefore optimally sets capital tax rates equal to zero. Considering two large economies as in the present paper breaks this result. Capital supply is no more perfectly elastic, and governments compete over capital by strategically setting capital tax rates. The inefficiently low capital tax rates we find are a direct effect of tax competition: governments want to attract the mobile resource, capital, from the other country and

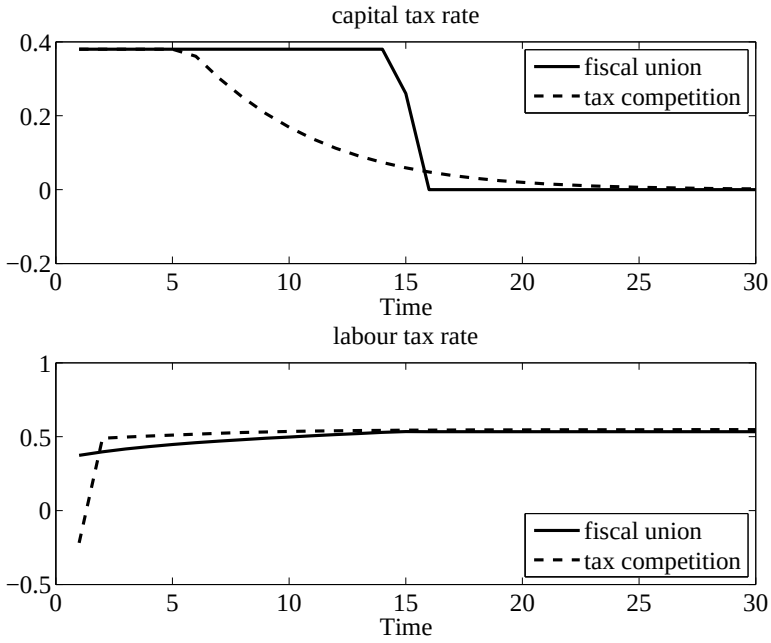

Figure 1.3: Capital and labour tax rates

therefore set capital tax rates lower than they would in a fiscal union for some periods. Countries want to attract foreign capital for two reasons. Firstly, they want to increase the home capital stock, which contributes to the growth of the country. And secondly, the presence of foreign capital implies as well that foreigners pay a part of the home government spending, as taxation is source based.

Because of tax competition capital tax rates are inefficiently low for some periods, and government revenues from capital taxation as a consequence diminished. Governments therefore have to or raise revenues from a different source, or decrease spending. We find that governments use a combination of both measures. On the one hand they decrease government expenditures (see Figure 1.4) and on the other hand they increase govern-

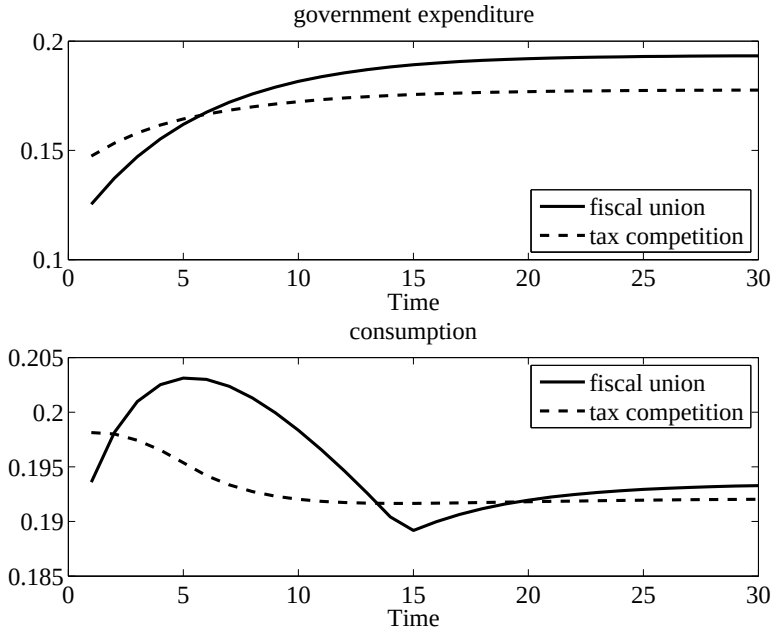

Figure 1.4: Government expenditure and private consumption

ment debt (Figure 1.5) and labour tax rates (Figure 1.3).[8] The shift from capital taxation to labour taxation is one manifestation of capital tax competition. Because labour is in contrast to capital not mobile, a bigger part of the tax burden is shifted to labour.

In Figure 1.3 we can see that with tax competition labour tax rates are much lower, even negative in the first period. The subsidies to labour in the first period are as well a consequence of tax competition. Governments want to attract capital from abroad, and therefore aim to increase the post-tax return to capital, which is composed of the capital tax rate and the (pre-tax) return to capital. Governments achieve this by setting lower

[8] Compare Figures A.3 and A.4 in Appendix A.5

capital tax rates on the one hand, and by subsidising labour on the other hand. Labour subsidies have the effect of increasing labour (compare Figure 1.6). Because labour and capital are complements in the (Cobb-Douglas) production function, higher labour increases the need and therefore return to capital. From the second period onwards the labour tax rates are higher with tax competition than in the fiscal union. Governments now want to drive capital tax rates down as fast as possible and therefore shift a part of the tax burden from capital to labour.

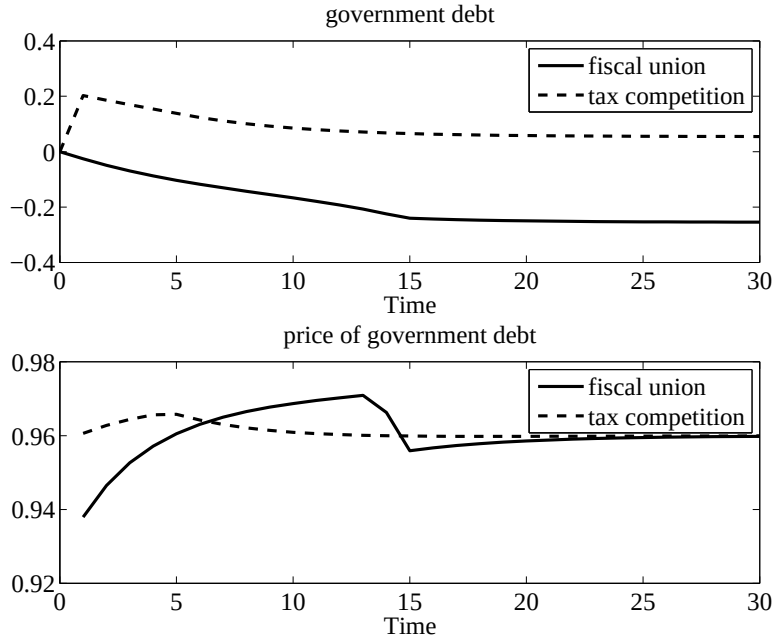

Figure 1.5: Government debt and price of debt

Another effect of tax competition is the underprovision of the public good. Figure 1.4 illustrates how tax competition drives down government spending in the long run. But in the short run government spending is higher with tax competition than in a fiscal union, because from period 2

to 8 the total tax revenue is higher with tax competition than in the fiscal union.[9] Governments can not only raise income through taxation, but have as well the possibility of issuing debt (Figure 1.5). In the fiscal union getting indebted does not appear to be a desirable alternative to labour taxation, on the contrary, governments in the fiscal union are saving in all periods. The case for tax competition is different. Because the capital tax rates are much lower than in the fiscal union for several periods, governments rely not only heavier on labour taxation, but increase as well government debt in compensation. Those few periods of inefficiently low capital tax rates are very costly and therefore governments under tax competition can not afford to decrease debt enough to start saving as the governments do in the fiscal union. As a consequence government debt stays at a positive level even in the long run.

The price of government debt ($p_{i,t}$ in the government budget constraint (1.2)) is shown in Figure 1.5. We know from equation (1.11), that the price of debt in period t is inversely related to the evolution of capital tax rates and the capital rental rate in period $t+1$. The drop of the price of debt in the fiscal union in period 13 can be explained by the drop in capital tax rates one period later. The increase in the price of debt before and after this moment can be explained by the decline of the capital rental rate.[10] With tax competition we observe a similar, although less pronounced pattern. Again, the kink in the evolution indicates where the upper bound on the capital tax rate is no more binding. In the long run the price of debt is the same as in the fiscal union. From the steady-state version of equation (1.11) it follows that in the long run the price of debt is equal to β, the discount rate of households, which is the same in both models.

In Figure 1.6 we can see that the lower capital tax rates with tax competition have initially the effect of an over-accumulation of capital. But after an initial jump in the capital stock capital accumulation slows down, converging to a steady-state level which is lower than in the fiscal union. Note that apart from the first period capital accumulation is faster in the

[9] Compare Figure A.4 in Appendix A.5

[10] For capital rental rates and wage rates see Figure A.1 in Appendix A.6.

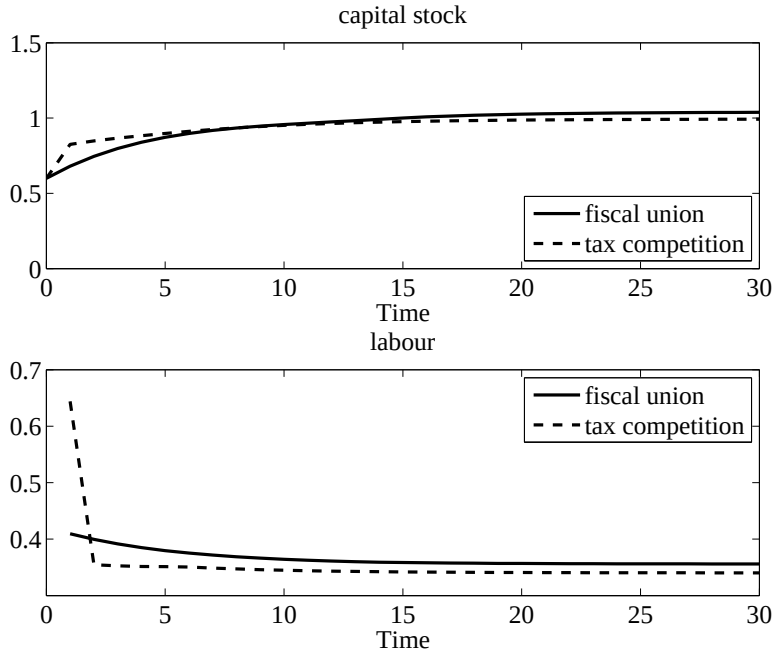

Figure 1.6: Capital stock and labour

fiscal union than with tax competition. In the fiscal union the capital stock increases smoothly from the exogenously given initial level to the steady state.

Consumption in the fiscal union (see Figure 1.4) increases over the first few periods and then decreases again. The drop of the capital tax rates from the upper bound has as an immediate effect an increase in the after-tax return of capital, with which consumption starts growing again, and then continues growing until it reaches the steady state. With tax competition consumption starts off at a slightly higher level, and then decreases over time to the steady state. Consumption decreases over time, because initially the capital tax rates are at the upper bound, and therefore accumulating

capital is very costly. As a consequence households prefer consuming some of their capital right away instead of saving it. The steady-state level of consumption is somewhat lower than in the fiscal union.

The evolution of labour, as depicted in Figure 1.6 can be explained by labour tax rates. In the fiscal union labour tax rates start out by being relatively low and then increase over time. Therefore households work more in the fiscal union during the first periods, because their salary is taxed less. As labour tax rates increase, households prefer taking more time off instead of working, and therefore labour participation decreases. With tax competition the mechanism is similar. Because labour tax rates are extremely low, even negative in the first period, working is very rewarding and labour participation therefore very high. With the jump in labour tax rates in period 2 working becomes much less interesting and labour drops almost to the steady-state level.

In the fiscal union production[11] increases over time, converging smoothly to the steady-state level. With tax competition production is very high in the first period, reflecting the correspondingly high labour participation in the same period. Production drops jointly with labour participation in the second period. After this production starts growing again with the accumulation of capital.

a Welfare analysis

In the model we are using here it is optimal for the countries to be in a fiscal union. A fiscal union means that capital tax rates are set in a way to improve overall welfare, in contrast to two countries competing with the aim of maximising only the welfare of its own households. Above we have analysed the cost of tax competition during transition, illustrated by Figures 1.3 to 1.6. We found that in the long run labour tax rates are inefficiently high. As well, the public good is under-provisioned and the governments are indebted in all periods, whereas in the fiscal union governments save. We find that capital, labour and consumption are inefficiently low in the

[11] See Figure A.2 in Appendix A.5

long run. This contrasts with the short-run results, where capital tax rates are inefficiently low for several periods, and because of a smoother convergence to the steady state, too high for some time. Labour tax rates are inefficiently low in the short run and therefore labour supply is too high. We find as well an over-supply of the public good and over-accumlation of capital in the short run. In this section we want to find a number measuring the overall cost of tax competition. Consumption equivalent welfare costs measure the consumption households would have to give up in the fiscal union to obtain the same welfare as in with tax competition. We find with the present parametrisation that consumption equivalent welfare costs of tax competition are 4%. This appears to be a rather large cost, considering that both in a fiscal union and with tax competition it is optimal to decrease capital tax rates from the upper bound to zero in the long run. A fiscal union does not mean, that the capital tax rates have to be the same across the countries. In the next section we look at tax competition with a tax haven. An illustration comparing the optimal taxation with a tax haven under tax competition and in a fiscal union can be found in Appendix A.7.

1.6 ASYMMETRIC COUNTRIES

In the previous section we analysed the cost of tax competition compared to the fiscal union. Here we move away from the fiscal union analysis and focus on tax competition, comparing the optimal fiscal policy in two asymmetric countries. As the only source of asymmetry we introduce a difference in initial capital stock. We assume that $a^1_{1,-1} = 0.4$ instead of 0.3, i.e., country 1 starts off richer than country 2. The rest the parameters are the same as in Table 1.1. This analysis allows us to explain difference in taxation observed between the EU-15 and the new member states, which are much poorer than the EU-15. In the following we discuss how in our model the fiscal policy in the two countries compares. An illustration of the comparison of the optimal policy under tax competition with the fiscal union can be found in Appendix A.7. The welfare costs of competing with a tax haven are analysed in Section 1.6 a.

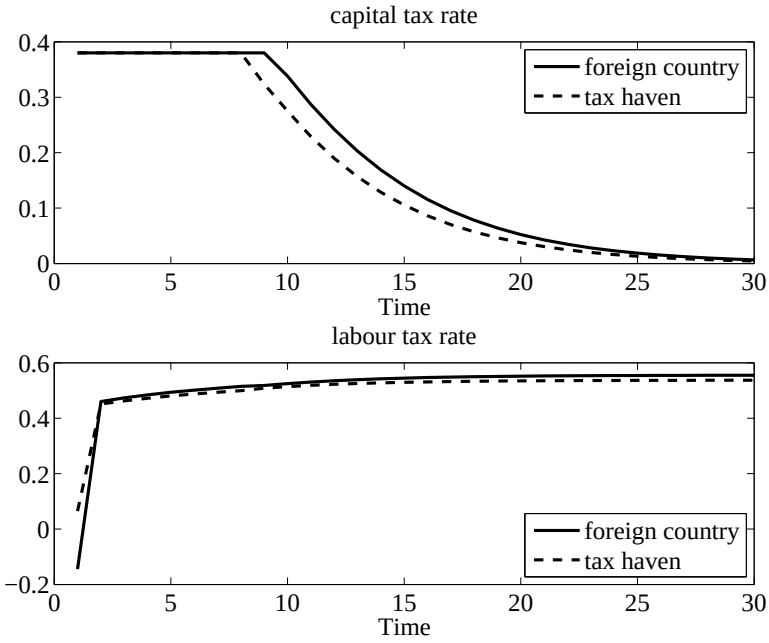

Figure 1.7: Capital and labour tax rates

We endogenously define the tax haven as the country with lower capital tax rates during transition. It turns out that the initially poorer country sets lower capital tax rates and therefore manages to attract capital from the richer country (see Figure 1.7). We will therefore call the poorer country tax haven in what follows, and the richer country simply foreign country. But why is it that the tax haven has lower capital tax rates? Intuitively, we can say that the elasticity of capital with respect to the capital tax rate must be higher in the country with the lower capital stock, simply because of decreasing returns to scale. With higher returns to scale an increase in the capital tax rate is costlier, and therefore the tax haven sets lower tax rates to retain the capital at home, and attracting some from the foreign country. Lower capital tax rates in the tax haven do not

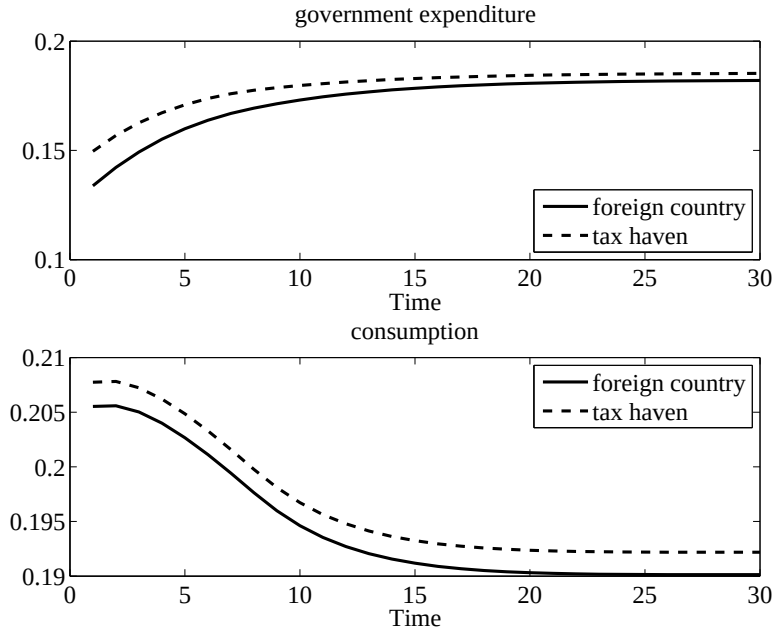

Figure 1.8: Government expenditure and private consumption

necessarily imply higher labour tax rates. We find that the foreign country has higher labour tax rates, higher capital tax rates and at the same time lower government spending (see Figure 1.8) than the tax haven. It sounds counter-intuitive that a country can have lower labour and capital tax rates but at the same time can afford higher government spending. On the one hand this is because the tax haven relies more on government debt in the long run (see Figure A.7 in Appendix A.6). On the other hand we find that the tax haven has higher tax revenues. We find that due to higher labour participation (Figure A.7 in Appendix A.6) the tax haven has higher labour tax income than the foreign country (Figure A.8 in Appendix A.6) for all periods but periods 2 to 5. Revenues from capital taxation are almost the same. It turns out that households in the tax haven prefer higher

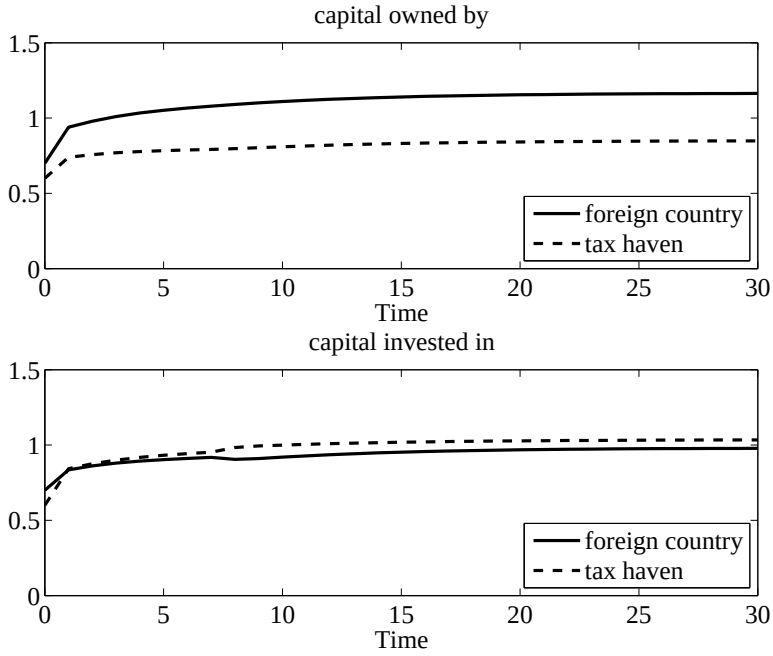

Figure 1.9: Capital stock

consumption (both private consumption and government expenditure, see Figure 1.8), but work harder for it. The households in the foreign country on the other hand prefer free-time over consumption. What is the effect of competing with a tax haven? It is true that through setting lower capital tax rates the tax haven can attract foreign capital, as shown in Figure 1.9. The foreign country, which is the initially richer country, always owns more capital, even in the long run. But the capital flees the country and is invested in the tax haven, where tax rates are lower and the return to capital is higher. The difference is huge. Whereas the initially richer country owns almost 60% of the world capital, less than half (48%) is invested there.

a Welfare analysis

In this section we have looked at the optimal fiscal policy in an asymmetric world. We found that the tax haven manages to attract a lot of capital from abroad by setting lower capital tax rates. But not only is there more capital invested in the tax haven, but as well private consumption and government consumption are higher in the tax haven than in the foreign country. The tax haven raises more revenues from labour, as we find that labour participation is higher in the fiscal union. Although the households in the foreign country enjoy more free-time, it looks as if the tax haven profits from tax competition at the expense of the foreign country. To find out something about the costs of competing with a tax haven, we do the following exercise. First, we compare the consumption equivalent welfare cost for each country from moving from a fiscal union to autarky. Then we consider the cost of moving from tax competition to autarky and the cost of moving from tax competition to the fiscal union. Finally, we compare the welfare in the tax haven with the welfare in the foreign country.

Welfare gain of moving to:	Autarky	Fiscal union
Fiscal union	-0.0075	–
Tax competition	-0.0015	0.0061

Table 1.2: Welfare cost asymmetric countries: tax haven

As we can see in Table 1.2, the tax haven is better off in an open economy than in autarky. This is true both for an open economy with tax competition and a fiscal union. Not surprisingly, the tax haven is better off in a fiscal union than with tax competition, although the welfare gain of moving to a fiscal union is only of 0.6%.

The picture looks very different for the foreign country, as shown in Table 1.3. We are not surprised to see that as well the foreign country is better off in a fiscal union than with tax competition. Surprisingly though, the foreign country would prefer being in autarky than either in a fiscal union or an open economy with tax competition. The cost of moving from

Welfare gain of moving to:	Autarky	Fiscal union
Fiscal union	0.0079	–
Tax competition	0.0451	0.0369

Table 1.3: Welfare cost asymmetric countries: foreign country

autarky to tax competition is of 4.5%, higher than the gain of moving from tax competition to a fiscal union (3.6%). This measure depends on the weight governments in the fiscal union put on the welfare of the households in each countries. Certainly optimal policy and the implied welfare gains of a fiscal union would be greatly influenced by the political weight of each country in the union, i.e. the country's power of negotiation and ability of influencing the fiscal policy in its own interest. Here, we abstract from these issues and assume that the central fiscal governments puts a weight of 0.5 on each country. Applying this insight to the real world, we have to say that it is not obvious that richer countries profit from being in a globalised world with high capital mobility. As capital flees the richer country for being invested in a poorer country the richer country would actually prefer being able to set barriers on capital flows, and remain in a state of autarky. The reverse is true for the (poorer) tax haven, which prefers being in an open economy with tax competition or even better in a fiscal union, than being in autarky.

Above we have seen that the tax haven profits from opening up, compared to the foreign country. Now we wonder how the welfare in the tax haven compares to the welfare in the foreign country.

Fiscal union	0.0046
Tax competition	-0.0253

Table 1.4: Difference in welfare tax haven vs. foreign country

What we find from Table 1.4 is that in a fiscal union, the initially richer country is better off than the tax haven by 0.46%. With tax competition

on the other hand the tax haven is better off than the foreign country by 2.53%. In other words, starting off poorer is better. Does this imply that the foreign country would be better destroy its capital in the first period for being as poor as the tax haven? Comparing the welfare in the symmetric model with the welfare in the asymmetric model answers this question. We find that it would not be a good idea for the foreign country to destroy its capital, as in a world with more capital (i.e. the asymmetric case) both countries are better off. The welfare cost of destroying its initial capital to be at the same level as the tax haven is of 1.53%.

1.7 CONCLUSION

We employ a dynamic two-country optimal taxation model to discuss tax competition. This approach contrasts with the standard tax competition literature, which analyses tax competition in a static setup. As well we add to the optimal taxation literature by extending the analysis to optimal taxation when countries compete over capital by strategically setting tax rates. We first compare tax competition between two symmetric countries with the first-best outcome of a fiscal union to assess the costs of tax competition. We find that during transition capital tax rates are inefficiently low with tax competition for several periods. But because of a much smoother transition than in the fiscal union, capital tax rates are actually higher than in the fiscal union for some periods. In the long run capital tax rates converge to zero both in the fiscal union and with tax competition. Nevertheless, tax competition is costly as well in the long run. Government expenditures, consumption, labour, production and the capital stock are lower and labour taxation and government debt are higher in the long run with tax competition. Given that in the fiscal union it is optimal to have zero capital tax rates in the long, one could think that tax competition was a good thing, as it leads governments to reduce capital tax rates earlier. But this is not true. We find in contrast that tax competition is very costly, leading to consumption equivalent welfare costs of 4%.

An asymmetric version of our model can explain the difference in tax-

ation observed between the EU-15 and the new member states. The only source of asymmetry in our model is a difference in initial capital stock. We endogenously define the country with lower capital tax rates during transition as a tax haven. We find that the initially poorer country emerges as a tax haven, attracting so much capital from abroad with its taxation policy, that in the long run more capital is invested in the tax haven than in the foreign country although the foreign country still owns more capital than the tax haven. But the tax haven exhibits not only lower capital tax rates, but as well lower labour tax rates and higher government spending. This is possible because the tax haven relies more on government debt, and has higher overall tax revenues because of higher labour participation. It follows that the households in the foreign country prefer more free time to consumption, whereas households in the tax haven work harder but consume more. From the welfare analysis we find that the tax haven is better off in an open economy than in autarky. Not surprisingly, we find that the tax haven prefers being in a fiscal union than in an open economy with tax competition. The initially richer country on the contrary would be better off staying in autarky than being in either an open economy with tax competition or a fiscal union. Countries in the EU can not isolate themselves from the international financial markets or avoid tax competition. Following our analysis a fiscal union would be preferable to the current state of tax competition in the EU. But as capital flees the richer countries towards more advantageous tax regimes in poorer countries, the richer countries would be better of in autarky than in an open economy. The reverse is true for the (initially poorer) tax havens, which are better off in an open economy with tax competition or a fiscal union, than in autarky.

2 DO LOCAL JURISDICTIONS REALLY TAX AGGLOMERATION RENTS? with Kurt Schmidheiny

2.1 INTRODUCTION

Looking at the geographical distribution of economic activity, we find that firms are not uniformly distributed across regions but tend to form agglomerations. The new economic geography literatures (NEG) discusses this pattern and finds that economic activity tends to agglomerate depending on the strength of agglomeration economies such as market access, supplier proximity or knowledge spillover. Because of increasing returns to scale in production, concentration of economic activity enhances further concentration. In other words, agglomeration of the mobile factor increases its reward. This has an impact not only on location, but as well on taxation. Core regions are able to set positive tax rates without fearing to loose firms to peripheral regions as the firms would loose the benefits from agglomeration economies. It therefore becomes possible for jurisdictions with larger agglomerations to set higher capital tax rates than similar jurisdictions with smaller agglomerations. This contrasts with the prediction by the optimal taxation literature of a race to the bottom in capital tax rates.[1] In this paper we study whether local policy makers effectively tax agglomeration rents, and whether this effect is strong enough to have a noticeable impact on the evolution of statutory corporate tax rates across Swiss municipalities between 1985 and 2005.

The NEG prediction can be tested by showing that small regions exhibit lower tax rates than bigger ones. Although this test seems straightforward to implement there are a series of challenges. First, the standard tax competition model with asymmetric jurisdiction size also predicts that small locations (tax havens) have lower tax rates than large ones, but the economic implications are very different. To separate the two predictions we make a clear difference between the jurisdictional (i.e. political) and eco-

[1] See Chamley (1986) and Judd (1985)

nomic size (i.e. the agglomeration) of a location by developing a measure for each definition of size. To identify the two effects separately, we take advantage of the fact that small and medium sized municipalities can be found both in metropolitan and rural areas. Second, unobserved and unobservable local characteristics could have an important effect on local tax rates. We control for unobserved local characteristics by including municipality fixed effects. Third, the size of local jurisdictions is likely affected by local tax rates and therefore endogenous. We instrument for both measures of location size with a set of variables based on initially available land reserves and initial sector composition.

Further challenges arise from bridging the gap between theoretical model and empirical evaluation. While the theoretical literature assumes that agglomerations are economically and politically independent from each other, we find that in reality the majority of agglomerations are composed of several jurisdictions. We address this issue by carrying out an analysis at the metropolitan level, focussing on economically independent agglomerations; and the municipality level, where locations are politically independent and can therefore set tax rates independently. Another aspect ignored by the theoretical literature is the industry composition of agglomeration. Because different industries can exhibit different degrees of agglomeration economies, the industry composition at the local level could have an important effect on taxation. We construct a cluster intensity measure to deal with this problem.

The rest of this chapter is structured as follows. In section 2.2 we discuss the related literature and in sections 2.3 and 2.4 we describe the data and the variables used for the estimations. Section 2.5 explains our empirical strategy, section 2.6 the results and section 2.7 concludes.

2.2 Related literature

The implications of agglomeration economies for strategic tax setting have been studied in a number of theoretical contributions, including Ludema and Wooton (2000), Kind et al. (2000), Andersson and Forslid (2003), Bald-

win and Krugman (2004), and Borck and Pflüger (2006). See Baldwin et al. (2003, ch. 15 and 16) for a comprehensive overview. The key insight of this literature is that agglomeration forces make the world 'lumpy': when capital (or any other relevant production factor) is mobile and trade costs are sufficiently low, agglomeration forces lead to spatial concentrations of firms which cannot easily be dislodged by tax differentials. Ottaviano and van Ypersele (2005) have shown that in the presence of agglomeration economies tax competition can be second-best welfare-enhancing, as it may mitigate a tendency towards excessive spatial concentration of firms. In fact, agglomeration externalities create rents that can in principle be taxed by the jurisdiction hosting the agglomeration. This prediction contrasts with results from the standard tax competition literature, where mobile factors such as capital lead to inefficiently low tax rates because of competition among local governments. The standard tax competition literature goes back to Oates (1972), who already describes how jurisdictions lower tax rates to attract business investment. The first formalised models were developed by Zodrow and Mieszkowski (1986) and Wilson (1986). These papers find that because of tax competition local governments set capital tax rates and the level of public spending inefficiently low. In an extension to the standard tax competition literature, Bucovetsky (1991) and Wilson (1991) deal with the existence of tax havens. As an important difference between countries they introduce asymmetric country size. They find that because the marginal product of capital is higher in the smaller country, the elasticity of capital with respect to the capital tax rate must be higher. This results in lower tax rates in the smaller country, which therefore will be a tax haven.

There is yet only preliminary evidence of the NEG prediction. Charlot and Paty (2007), Jofre-Monseny and Solé-Ollé (2009) and Koh and Riedel (2010) are the first attempts to directly test whether agglomeration rents are taxed, by showing that local taxes are positively correlated with local agglomeration economies. Charlot and Paty (2007) assess the effect of agglomeration (measured as market access) on local taxation. They use panel data for French municipalities and find a positive effect of market access on taxation, and mimic behaviour in tax setting across municipali-

ties. Jofre-Monseny and Solé-Ollé (2009) focus on the effect of urbanisation economies, localisation economies and market potential on the Spanish municipal business tax rate. Using a cross-section of Spanish municipality level data, they find that all of the above factors have a positive effect on tax rates. Koh and Riedel (2010) determine the tax effect of urbanisation and localisation economies, and investigate whether differentiation from neighboring economies has an effect on business tax rates. Using panel data for local business tax rates in Germany, they find a positive impact of agglomeration and differentiation on tax rates. Our paper is complementary to these three studies and seeks to overcome their shortcomings in several dimensions. First, we analyze data for Switzerland which is the only country studied so far where local business taxes are of a magnitude so they can matter for business location. Second, we study the evolution of local tax rates over a much longer time horizon (20 years) than previous research. Our paper has therefore the potential to cover substantial changes in the size of local jurisdictions. Third, we propose new and in our opinion more convincing instruments for the employment growth rate of locations. Fourth, we explicitly address and operationalise the important distinction between the political and economic size of local jurisdictions, which has been ignored in previous studies.

2.3 DATA

We use panel data on local business taxation in Swiss cantons and municipalities for the years 1985 and 2005. Using Swiss data offers a big advantage compared to other countries. The Swiss federal system embeds a highly decentralized tax system, where corporations are taxed on three different government levels, the federal, cantonal and municipal level. Swiss cantons and municipalities enjoy more fiscal independence than the sub-national units of any other OECD country. Therefore it offers a great opportunity to study sub-national taxation issues. Because Swiss tax law differs across cantons, the tax systems becomes very complex. At the federal level a proportional profit tax rate of 8.5% is currently applied. But at the cantonal

level profit tax rates are either proportional or progressive. As well a capital tax is applied. Municipalities apply an additional profit and capital tax on top the cantonal and federal tax rates. H.U. Bacher, M. Brülhart and M. Jametti have constructed a comprehensive database with tax rates from 1985 to 2005. We use data for the years 1985 and 2005, for which we respectively observe the 213 and 845 largest municipalities.

We further use firm-level data from the Swiss business census provided by the Swiss Federal Statistical Office. This dataset contains information on location, sector of activity and number of employees for over 300,000 firms located across Switzerland. Additionally we use municipality specific geographical and population data as well provided by the Federal Statistical Office. We get sector level data for the German economy from the EU KLEMS Growth and Productivity Account[2] for constructing our instrumental variables.

2.4 VARIABLES

a Local tax rate

Our dependent variable is the local tax rate for firms.

tax_i is the corporate profit tax rate in location i as percentage of a firm's profit. We use the tax rate for a firm with median profits (9 % of turnover in our sample). In the municipality level analysis, tax_i is the tax rate in municipality i plus the respective cantonal tax rate. In the metro level analysis, tax_i corresponds to the employment-weighted average of the local tax rates in all municipalities that belong to the corresponding metropolitan area. We use the definition of metro area elaborated by the Swiss Federal Statistical Office.

[2]See Groningen Growth and Development Centre (2008)

b Location Size

The main explanatory variable is the 'size' of the location. We measure the size of the location by its employment and as a robustness check by its population. An important contribution of this paper is to make a clear distinction between the political and the economic definition of the location. The political definition refers to the legal borders of the local jurisdiction whereas the economic definition includes the relevant neighboring jurisdictions. We use the following variables:

$empl_i$ is the number of full-time jobs in the location. Part-time jobs are added as full-time equivalent. In the municipality level analysis, $empl_i$ counts the jobs within the legal borders of the municipality. In the metro level analysis, $empl_i$ is the number of jobs in all municipalities that belong to the corresponding metro area.

$emplagglo_i$ is the number of full-time jobs in the economically relevant area in and around the location. It is the sum of the municipality's own employment and the employment of all other municipalities weighted by the inverse distance:

$$emplagglo_i = \sum_{j=1}^{J} \frac{empl_j}{dist_{ij}}$$

where $empl_i$ is employment in municipality i and J is the number of municipalities in the country. $dist_{ij}$ is the Euclidean distance between two municipalities, and if $j \neq i$ measured as:

$$dist_{ij} = \sqrt{(xcoord_i - xcoord_j)^2 + (ycoord_i - ycoord_j)^2}$$

where the x and y coordinates determine the geographical location of municipalities i and j. The so-called 'own distance' of municipality i is calculated as

$$dist_{ii} = \frac{2}{3}\sqrt{\frac{area_i}{\pi}}$$

where $area_i$ is the amount of overbuilt land in the municipality. The own distance is the average distance from the city center in a circular city of

the same size. The own distance acknowledges that firms are on average further away from each other in large municipalities than in small ones. It also guarantees that our variable $emplagglo_i$ is invariant to the units in which distance is measured.

c Specialisation and diversification

Two important factors characterising the economic activity of a municipality are the degree to which they are specialised and diversified. We use in our analysis the specialisation and diversification indices employed by Duranton and Puga (2000).

As a specialisation measure we use employment in the most important industry s of municipality i

$$special_i = \max_s \left(\frac{empl_{is}}{empl_i} \right)$$

where $empl_{is}$ is the number of employees in municipality i working in sector s and $empl_i$ is as defined above. This index measures the importance of the largest sector in a municipality, and allows for a comparison across municipalities.

As a *diversity* measure we use the inverse of the Hirschman-Herfindahl index,

$$diverse_i = \frac{1}{\sum_s (empl_{is}/empl_i)^2}$$

This index increases with increasing diversity of the local economy, equalling 1 if the activity of a sector is entirely concentrated in one municipality.

Note that using these specifications, diversification and specialisation are not exactly opposites. A municipality with one very important sector but many less important ones can be both specialised and diversified.

d Cluster intensity

Different industrial sectors exhibit different degrees of agglomeration rents. In our setting, local jurisdiction can not exploit this heterogeneity as statutory tax rates apply identically to all sectors. Local jurisdiction can potentially tax agglomeration rents if three conditions are met (1) it hosts an industrial cluster of a sector (2) this sector is an important fraction of the local economy and (3) this sector is characterized by important agglomeration economies. This applies for example to the watch-making industry in Le Locle, a rural town in the Jura. Le Locle hosts one of the largest concentrations of watch manufacturers in Switzerland, accounting for the majority of local employment (over 45% in 2005). Geneva hosts another large cluster of the watch-making industry, yet it does not account for a significant part of the local economy (only 1.5% of local employment in 2005), and therefore does not satisfy condition (2) above.

We propose the following index to measure the importance of industrial clusters in the local economy:

$$cluster_i = \sum_{s=1}^{S} \frac{empl_{is}}{empl_s} \cdot \frac{empl_{is}}{empl_i} \cdot \gamma_s$$

where $empl_s$ is total employment in sector s. $empl_{is}/empl_s$ is the fraction of employment in sector s located in municipality i; a high number indicates that the municipality hosts an important industrial cluster. The second multiplier $empl_{is}/empl_i$ is the fraction of employment in municipality i belonging to sector s; a high number indicating that the sector is important for the local economy. The third multiplier γ_s is a measure of the agglomeration economies in sector s.

To measure agglomeration economies we use the Ellison and Glaeser (1997) index:

$$\gamma_s = \frac{\frac{\sum_i (z_{is} - x_i)^2}{1 - \sum_i x_i^2} - H_s}{1 - H_s}$$

where $z_{is} = empl_{is}/empl_s$ and $x_i = empl_i/empl_{tot}$, $empl_{tot}$ denoting total national employment. H_s is an index measuring the concentration of an

industry as $H_s = \sum_k^K \psi_k^2$, where ψ_k is the share of each plant in industry employment, and K the total number of industry plants. The Ellison and Glaeser (1997) index is constructed to take into account the possibility of an industry agglomeration by pure chance, unrelated to any agglomeration economies. This so-called 'dart-board approach', assesses by how far the actual spatial distribution of an industry is different from a random distribution, arising from simply throwing darts at a board.

e Further location characteristics

$latin_i$ is a dummy variable which equals 1 if the municipality or metropolitan area belongs to the French or Italian speaking part of Switzerland.

$centre_i$ is a dummy variable which equals 1 if the municipality is the central place of a metropolitan area.

$capital_i$ is a dummy variable which equals 1 if the municipality is the capital of a canton.

f Instruments for location size

We use the following variables to instrument the growth rate of location size between 1985 and 2005.

$landreserve_i$ is the fraction of land that has not been overbuilt by 1985 but could potentially be overbuilt in the following 20 years. It is calculated as

$$landreserve_i = 1 - \frac{built\ area_i}{total\ area_i}$$

where $total\ area_i$ excludes rivers, lakes, mountains, etc. We expect that this variable is positively correlated with future growth in locations close to the centre of metropolitan areas where space constraints are most severe.

$\triangle emplhat_i$ is the predicted growth rate of employment in location i based on its initial 1985 sector composition and the sectoral growth rates

from 1985 to 2005 in Germany:

$$\triangle emplhat_i = \sum_{s=1}^{S} \frac{empl_{is,1985}}{empl_{i,1985}} \triangle empl_s^D$$

where $empl_{is,1985}$ is employment in location i and sector s in 1985 and $\triangle empl_s^D$ is the growth rate of employment is sector s in Germany between 1985 and 2005. We expect higher growth potential in locations with a large initial share of employment in sectors that turned out to grow fast over the next 20 years.

$\triangle emplagglohat_i$ is the predicted growth rate of the agglomeration of location i. We find this measure by summing over the location's own predicted employment and the predicted employment of all other municipalities:

$$\triangle emplagglohat_i = \frac{\sum_{j=1}^{J} (emplhat_j / dist_{ij})}{emplagglo_{i,1985}}$$

where

$$emplhat_i = \sum_{s=1}^{S} empl_{is,1985} \triangle empl_s^D$$

$distcentre_i$ is the distance of each municipality to the metropolitan centre.

$landreserves_i \,\mathrm{x}\, distcentre_i$ is an interaction variable of $landreserve_i$ and $distcentre_i$. This measure serves as an additional instrument for municipal growth, as a municipality closer to the centre will potentially grow faster than further away municipalities.

g Descriptive statistics

Tables 2.1 and 2.2 summarise the statistics of the variables described above. Large sample corresponds to the large cross-section in 2005 and small sample to the data from the smaller cross-section. The panel section describes the change in the $\triangle$-variables over the 20 years from 1985 to 2005. Whereas the within variance of the dependent variable tax_i is roughly the same as

the between variance, we find that the within variances of the explanatory variables $empl_i$ and $emplagglo_i$ are between a tenth and a fifth of the respective between variances.

Table 2.1: Descriptive statistics, metro level

	Obs.[1]	Mean	Std. Dev.	Min	Max
Large sample 2005					
tax	55	0.170	0.028	0.129	0.231
log(empl)	55	10.041	1.044	8.234	13.227
latin	55	0.327	0.474	0.000	1.000
Small sample 2005					
tax	53	0.172	0.029	0.129	0.231
log(empl)	53	10.075	1.048	8.234	13.227
latin	53	0.340	0.478	0.000	1.000
Small sample 1985					
tax	53	0.153	0.025	0.101	0.240
log(empl)	53	10.027	1.049	8.253	13.159
latin	53	0.340	0.478	0.000	1.000
Panel 1985-2005					
$\triangle$ tax	53	0.019	0.027	-0.031	0.089
$\triangle$ log(empl)	53	0.049	0.102	-0.115	0.393
$\triangle$ log(emplhat)	53	0.145	0.051	0.033	0.257
landreserves	53	0.723	0.124	0.311	0.966

[1] Number of observations

Table 2.2: Descriptive statistics, municipality level

	Obs[1]	Mean	Std. Dev.	Min	Max
Large sample 2005					
tax	845	0.177	0.028	0.115	0.234
log(empl)	845	7.250	1.066	3.950	12.528
log(emplagglo)	845	10.978	0.319	9.917	12.028
latin	845	0.269	0.444	0.000	1.000
centre	845	0.065	0.247	0.000	1.000
capital	845	0.031	0.173	0.000	1.000
Small sample 2005					
tax	207	0.179	0.029	0.117	0.233
log(empl)	207	8.588	0.904	7.071	12.528
log(emplagglo)	207	11.125	0.332	10.288	12.028
latin	207	0.237	0.426	0.000	1.000
centre	207	0.256	0.438	0.000	1.000
capital	207	0.126	0.332	0.000	1.000
special	207	0.188	0.083	0.098	0.660
diverse	207	12.038	3.222	2.241	18.060
cluster	207	0.000	0.001	0.000	0.017
Small sample 1985					
tax	207	0.152	0.021	0.101	0.244
log(empl)	207	8.523	0.905	7.018	12.590
log(emplagglo)	207	11.077	0.327	10.283	12.026
latin	207	0.237	0.426	0.000	1.000
centre	207	0.256	0.438	0.000	1.000
capital	207	0.126	0.332	0.000	1.000
special	207	0.205	0.101	0.097	0.622
diverse	207	11.659	3.659	2.506	18.931
cluster	207	0.001	0.005	0.000	0.077
Panel 1985-2005					
$\triangle$ tax	207	0.026	0.028	-0.031	0.090
$\triangle$ log(empl)	207	0.065	0.228	-0.647	0.950
$\triangle$ log(emplagglo)	207	0.047	0.037	-0.124	0.142
$\triangle$ log(emplhat)	207	0.148	0.079	-0.101	0.466
$\triangle$ log(emplagglohat)	207	0.162	0.027	0.100	0.262
landreserves	207	0.680	0.210	0.024	0.973
distcentre	207	6.475	6.474	0.000	32.769
landreserves x distcentre	207	4.858	5.513	0.000	31.884

[1] Number of observations

2.5 THE ECONOMETRIC MODEL

There are several challenges arising from bridging the gap between theoretical model and empirical evaluation. While the theoretical literature assumes that agglomerations are politically and economically independent from each other, we find that in reality the majority of agglomerations are composed of several jurisdictions. We develop two strategies to address this issue. First, we do an analysis at the metropolitan level (the level of the agglomeration), treating each metro area as an independent entity. By testing if economically independent entities tax agglomeration rents we do a literal test of the mechanism described in the theoretical literature. The drawback of this approach is an inaccurate representation of the political decision making structure. Metro areas are composed of several politically independent municipalities, which therefore can set tax rates independently. We estimate the following relationship:

$$tax_i = \beta_0 + \beta_1 \log(empl_i) + \beta_2 latin_i + u_i \tag{2.1}$$

Where the tax rate (tax_i) is an employment-weighted average of the municipalities in the metro area, and size is measured as employment ($empl_i$) in this area. $latin_i$ captures cultural differences between regions in Switzerland, and is a dummy variable indicating if an area is French or Italian speaking. Historically, latin cantons have higher tax rates than German speaking cantons. A more detailed description of these variables can be found in section 2.4.

In our second approach we do a municipality level analysis. This is a more accurate representation of the political decision making structure and the tax setting mechanism. The downside of this approach is that we do not deal with economically independent entities anymore, and therefore is not in line with the theoretical models. To tackle this issue we draw a clear distinction between the political ($empl_i$) and economic ($emplagglo_i$) size of the location (see the description in section 2.4 b). We estimate the following augmented relationship at the municipal level:

$$tax_i = \beta_0 + \beta_1 \log(empl_i) + \beta_2 \log(emplagglo_i) + \beta_3 x_i + u_i \tag{2.2}$$

where x_i is a vector of control variables, including $latin_i$ and several indices capturing the structure of the economy at the local level, which is another aspect ignored in theoretical models. The NEG literature considers only urbanisation economies, and neglects varying intensities in agglomeration economies across sectors. We construct a cluster intensity measure (described in section 2.4 d) which takes into account the structure of the economy at the local level. This variable is included in the control variables in equation (2.2), as well as indices describing the degree of specialisation and diversification of the economy (see section 2.4 c).

Although we use a wide range of control variables, it is still possible that there are unobserved and unobservable local characteristics with an important effect on taxation. We use the long difference (20 years) between 1985 and 2005 to control for omitted factors with a difference-in-difference strategy. As well we include time fixed effects, which capture time trends in the data:

$$tax_{it} = \beta_0 + \beta_1 \log(empl_{it}) + \beta_2 \log(emplagglo_{it}) + \beta_3 x_{it} + \delta_t + c_i + u_{it} \quad (2.3)$$

where c_i are location fixed effects and δ_t time fixes effects.

The size of local jurisdictions is likely affected by local tax rates and therefore endogenous. We instrument for both measures of location size with a set of variables based on initially available land reserves and initial sector composition, as described in section 2.4 f.

2.6 Results

We analyze the data on two different levels of aggregation. In the metro level analysis, data on tax rates and location size are aggregated to the level of metropolitan areas. In the municipality level analysis, tax rates of individual municipalities and their size are used. Section 2.5 discusses these two approaches.

The results of the metro level analysis are summarized in Table 2.3. Column [1] shows the result of a regression of profit tax rates (tax_i) on the log of total employment ($empl_i$) across 55 Swiss metropolitan areas in 2005.

Table 2.3: Tax rates and location size (metro level)

	2005		1985	1985-2005		
Sample	Large	Small	Small	Small	Small	Small
Estimator[1]	OLS	OLS	OLS	RE	FE/FD	FD-IV
	[1]	[2]	[3]	[4]	[5]	[6]
log(empl)	0.0098***	0.0095***	0.0022	0.0058***	0.0035	0.0596
	(0.0033)	(0.0035)	(0.0032)	(0.0023)	(0.0330)	(0.0926)
latin	0.0167**	0.0168**	0.0145**	0.0157**		
	(0.0074)	(0.0076)	(0.0070)	(0.0069)		
Constant	0.0663*	0.0702*	0.1268***	0.0895***		
	(0.0337)	(0.0354)	(0.0323)	(0.0234)		
Year fixed effects				yes	yes	yes
Metro fixed effects					yes	yes
Instruments						2
C-D F-statistic[2]						4.752
R-squared	0.2167	0.2011	0.0869		0.3292	
N	55	53	53	106	106	106
N Metro Areas	55	53	53	53	53	53
N Municipalities	553	179	179	179	179	179

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax, 9% profit level, employed-weighted average across municipalities. Tax rates are based on sample of largest municipalities (N municipalities) within metro area; metro area employment is based on all municipalities. Standard errors in parentheses, clustered for metro areas (except IV). Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] OLS: ordinarly least squares, RE: random effects, FE: fixed effects, FD: first difference, IV: instrumental variables.

[2] Cragg-Donald F-statistic

The tax rates are based on the 553 largest municipalities in the country. The estimated effect of employment is positive and highly significant ($t = 2.97$). The point estimate of 0.0098 means that a doubling in the size of the metro area leads to an increase in tax rates of $\log(2) \cdot 0.01 = 0.7\%$ points. This is a substantial effect given that tax rates are on average 17% and that the largest metro area is 150 times larger than the smallest metro area. Figure 2.1 visualizes this relationship.

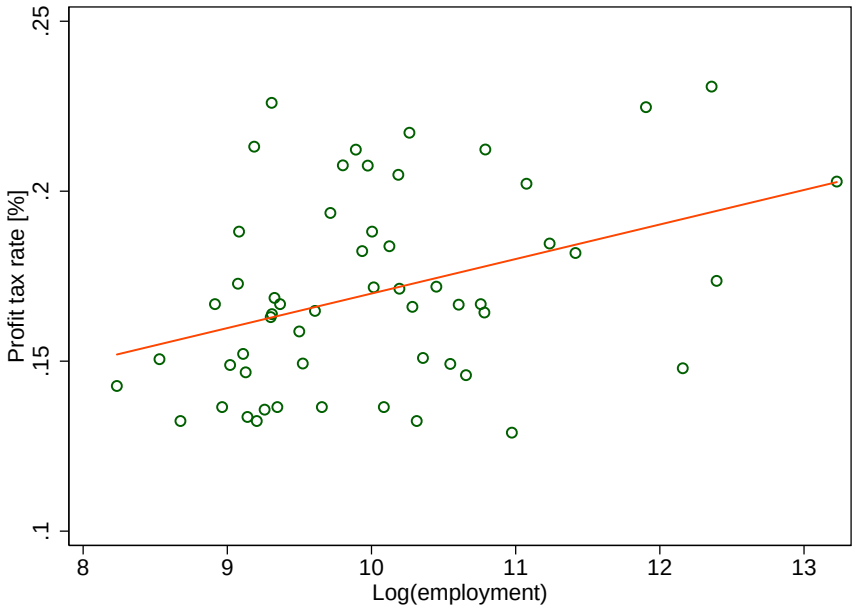

Figure 2.1: Profit tax rates and employment across 55 Swiss metro areas in 2005.

Column [2] repeats the same exercise but based on a smaller sample of the 179 largest municipalities. The results are virtually unchanged and show that focusing on this smaller sample is not a limitation. Column [3] estimates the tax-size relationship for the 1985 cross-section. The point estimate is still positive though considerably smaller and not significantly

different from zero anymore.

The significant positive relationship reported in column [1] could likely be confounded with other factors that differ across metropolitan areas. We seek to control for such omitted factors with a difference-in-difference strategy using the long (20 years) difference between 1985 to 2005. Column [5] reports the results of this fixed effect (FE) or equivalently first-difference (FD) estimation. Even controlling for all time-constant factors, we find a positive but insignificant effect. Note, however, that despite the 20 year distance, the within-variance of log(empl) is only a tenth of the between variance. This reflects the enormous stability of the urban system generally observed. It is therefore not unexpected that we do not find a significant effect with that little identifying variation. The large confidence bounds include the significant results from the 2005 cross-section and do not contradict them.

In the last column [6] of Table 2.3 we seek to control for the potential reverse causality of tax rates and size with instrumental variables. We use 1985 land reserves and employment growth based on 1985 sector composition as instruments for the actual 1985 to 2008 employment growth. Our instruments are highly significant in the first stage (See Table B.1 in the appendix). Not unexpectedly with a sample size of 53, the Cragg and Donald (1993) F-statistic reveals that our instruments are nevertheless rather weak. The estimated confidence bounds of the parameter is again non-informative: while we cannot detect a significant relationship we can also not rule out the results from the cross-section.

The results of the municipality level analysis are given in Table 2.4. Column [1] reports the results from a regression of the local profit tax rate on local employment within municipal borders (jurisdiction size, $empl_i$) and on employment within the wider agglomeration (agglomeration size, $emplagglo_i$) across 845 Swiss municipalities in 2005. The estimated effect of the agglomeration size on tax rates is positive and highly significant while the effect of the jurisdiction size is virtually zero and insignificant. The point estimate of agglomeration size almost perfectly matches our findings in the metro level analysis in Table 2.3. Column [2] includes in addition dummy variables for whether the municipality belongs to the French or

Table 2.4: Tax rates and location size (municipality level)

	2005			2005		
Sample	Large	Large	Large	Small	Small	Small
Estimator[1]	OLS	OLS	LSDV	OLS	OLS	LSDV
	[1]	[2]	[3]	[4]	[5]	[6]
log(empl)[2]	-0.0002	-0.0002	0.0007	0.0014	0.0018	0.0023*
	(0.0010)	(0.0010)	(0.0006)	(0.0023)	(0.0028)	(0.0012)
log(emplagglo)[3]	0.0109***	0.0317***	0.0014	0.0122*	0.0259***	-0.0002
	(0.0033)	(0.0028)	(0.0053)	(0.0068)	(0.0057)	(0.0084)
latin		0.0330***	0.0162		0.0367***	0.0313**
		(0.0024)	(0.0100)		(0.0047)	(0.0148)
centre		-0.0096**	-0.0040*		-0.0123**	-0.0073*
		(0.0046)	(0.0023)		(0.0056)	(0.0039)
capital		-0.0026	0.0012		-0.0042	0.0029
		(0.0055)	(0.0024)		(0.0059)	(0.0056)
Constant	0.0581	-0.1779***	0.1522***	0.0304	-0.1301**	0.1557*
	(0.0358)	(0.0295)	(0.0553)	(0.0723)	(0.0557)	(0.0883)
Metro effects			yes			yes
Year effects						
Municipality effects						
Metro x year effects						
Instruments						
K-P rank F[4]						
R-squared[5]	0.0149	0.2363	0.0227	0.0269	0.3169	0.0748
N municipalities	845	845	845	207	207	207
N municipalities - year						

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax rate, 9% profit level. Standard errors in parentheses, heteroscedasticity robust. Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
[1] OLS: ordinarly least squares, LSDV: least squares dummy variable estimator.
[2] employment in municipality
[3] sum of employment in municipality and all other municipalities weighted by inverse distance
[4] Kleinbergen-Paap rank F
[5] Within R-squared (excludes explanatory power of metro effects)

Table 2.4: Tax rates and location size (municipality level) continued

	1985			1985-2005			
Sample	Small	Small	Small	Small	Small	Small	Small
Estimator[1]	OLS	OLS	LSDV	RE	FE/FD	FE/FD	FD-IV
	[7]	[8]	[9]	[10]	[11]	[12]	[13]
log(empl)[2]	0.0010	-0.0007	0.0017	0.0015	0.0145	-0.0038	0.002
	(0.0015)	(0.0027)	(0.0018)	(0.0022)	(0.0125)	(0.0065)	(0.0135)
log(emplagglo)[3]	-0.0052	0.0005	-0.0123*	0.0125**	0.0282	-0.0267	-0.0337
	(0.0054)	(0.0062)	(0.0064)	(0.0050)	(0.0801)	(0.0391)	(0.0580)
latin		0.0091**	0.0259	0.0227***			
		(0.0044)	(0.0308)	(0.0037)			
centre		0.0019	-0.0046	-0.0065			
		(0.0050)	(0.0035)	(0.0043)			
capital		-0.0003	0.0067	-0.0031			
		(0.0071)	(0.0064)	(0.0056)			
Constant	0.2018***	0.1503**	0.2676***	-0.0029	-0.2838	0.4802	
	(0.0549)	(0.0589)	(0.0612)	(0.0481)	(0.8162)	(0.3928)	
Metro effects			yes				
Year effects				yes	yes	yes	yes
Municipality effects					yes	yes	yes
Metro x year effects						yes	yes
Instruments							5
K-P rank F[4]							2.896
R-squared[5]	0.0062	0.0356	0.0777	0.3339	0.4835		
N municipalities	207	207	207	207	207	207	207
N municipalities - year				414	414	414	414

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax rate, 9% profit level. Standard errors in parentheses, heteroscedasticity robust. Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] OLS: ordinarly least squares, LSDV: least squares dummy variable estimator.

[2] employment in municipality

[3] sum of employment in municipality and all other municipalities weighted by inverse distance

[4] Kleinbergen-Paap rank F

[5] Within R-squared (excludes explanatory power of metro effects)

Italian part of Switzerland ($latin_i$), whether it is the central place of a metropolitan area ($centre_i$) and whether it is a cantonal capital ($capital_i$). Controlling for these additional variables, the effect of agglomeration size is reinforced while the effect of jurisdictional size remains zero. We see this as evidence that, if at all, the NEG mechanism rather than the tax haven mechanism is at work.

Column [3] in Table 2.4 includes a fixed effect for each metropolitan area.[3] This analysis ignores the differences across metro areas and relies fully on the variation of location sizes within metro areas. This dramatically changes our results: both jurisdiction and agglomeration size have no significant effect anymore. This is not the consequence of a lack of identifying variation as the point estimates in column [3] are close to zero with small confidence bounds that rule out effects of the magnitude reported in column [2].

Columns [4] to [5] in Table 2.4 repeat the first 3 columns for the 207 largest municipalities. The smaller sample alters the point estimates only marginally but increases the standard errors. Again, focusing on the smaller sample does not change our results substantially. Columns [7] to [9] estimate the same relationship across 207 municipalities 20 years earlier. As in the metro level analysis we do not find a systematic relationship between size and tax rates in 1985.

Table 2.4 columns [10] to [13] report the results using a panel with 2005 and 1985 data. Column [11] controls for municipality fixed effects, i.e. for all time-invariant characteristics including metro fixed effect. This fixed effects (FE) estimator is equivalent to the first difference estimator (FD) which regresses 20-year changes in tax rates on the growth rate of local employment. As in the metro level analysis, there is very little time variation that we can exploit and the large confidence intervals neither detect significant effects nor rule out effects as estimated in the cross-section. Column [12] additionally includes year specific metro area effects leading to negative though insignificant size effects. Finally, column [13] tackles the

[3] Municipalities not belonging to a metropolitan area were assigned to the metropolitan area whose central place is closest to them.

potential reversed causality of changes in tax rates on employment growth by instrumenting both employment growth of the jurisdiction and of the agglomeration. Our instruments are highly significant in both first stage regressions (see Table B.1 in the appendix) though a joint analysis with the Kleibergen and Paap (2006) F-statistics shows that they are rather weak. The estimates in column [13] are therefore only indicative.

Summing up Table 2.4, we find that municipalities in large agglomerations set higher tax rates than municipalities in small agglomerations. This provides evidence that agglomeration rents are indeed taxed in the competition among large metropolitan areas. Within metropolitan areas, however, municipality size does not explain tax rates or is even negatively associated. Within metropolitan areas, municipalities can therefore exploit the advantage of agglomeration rents as they are competing against a multitude of other jurisdictions with equivalent access to the employment cluster. Controlling for municipality fixed effects and reversed causality is non-informative and neither supports nor contradicts these findings.

Table 2.5 extends our municipality level analysis to allow for agglomeration effects to differ across sectors. We use a new index $cluster_i$ (described in detail in section 2.4 d) that measures the existence of important sectoral clusters in a municipality i. $cluster_i$ takes a high value in municipalities which host one or more sectoral clusters of national importance and where these sectors account for a large fraction of the local economy. Column [1] reports the estimates for the large 2005 cross-section. Both total employment in the agglomeration ($emplagglo_i$) and the cluster intensity ($cluster_i$) are significantly and positively associated with local tax rates. Total employment, however, is more important: a one standard deviation increase in $emplagglo_i$ leads to a $0.332 \cdot 0.0313 = 1\%$ point increase of tax rates whereas a one standard deviation increase in $cluster_i$ leads to a $0.00124 \cdot 1.0778 = 0.1\%$ point increase. Column [2] controls for metro area wide fixed effects. As in Table 2.4, total size of the agglomeration has no significant effect anymore and its point estimate is small. Our new measure of cluster intensity, however, stays significantly positive, although the size of the effect is halved. Based on the evidence from the large 2005 cross-section, we conclude that the presence of important sector clusters

Table 2.5: Using industry specific concentration (municipality level)

	2005		2005	
Sample	Large	Large	Small	Small
Estimator[1]	OLS	LSDV	OLS	LSDV
	[1]	[2]	[3]	[4]
log(empl)[2]	-0.0012	0.0005	0.0000	0.0011
	(0.0011)	(0.0006)	(0.0029)	(0.0015)
log(emplagglo)[3]	0.0313***	0.0016	0.0273***	0.0016
	(0.0028)	(0.0054)	(0.0057)	(0.0105)
special	0.0337**	0.011	0.0384***	0.0285*
	(0.0167)	(0.0086)	(0.0046)	(0.0153)
diverse	0.0015***	0.0004	-0.0125**	-0.0075*
	(0.0006)	(0.0003)	(0.0055)	(0.0039)
cluster	1.0778**	0.4364**	-0.0036	0.0035
	(0.4443)	(0.2134)	(0.0058)	(0.0057)
latin	0.0336***	0.016	0.0791**	0.0238
	(0.0024)	(0.0100)	(0.0388)	(0.0257)
centre	-0.0106**	-0.0041*	0.0028***	0.0013
	(0.0046)	(0.0023)	(0.0010)	(0.0009)
capital	-0.0026	0.0012	1.2206***	0.5578***
	(0.0054)	(0.0025)	(0.4525)	(0.1770)
Constant	-0.1893***	0.1454**	-0.1792***	0.1253
	(0.0308)	(0.0579)	(0.0595)	(0.1174)
Year effects				
Municipality effects				
Metro effects		yes		yes
Metro x year effects				
R-squared[4]	0.2424	0.0244	0.3378	0.0998
N municipalities - year				
N municipalities	845	845	207	207

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax rate, 9% profit level. Standard errors in parentheses, clustered for municipalities. Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] RE: random effects, FE: fixed effects, FD: first difference, IV: instrumental variables.

[2] employment in municipality

[3] sum of employment in municipality and all other municipalities weighted by inverse distance

[4] Within R-squared (excludes explanatory power of municipality fixed effects and metro effects)

Table 2.5: Using industry specific concentration (municipality level) continued

	1985		1985-2005	
Sample	Small	Small	Small	Small
Estimator[1]	OLS	LSDV	FE/FD	FE/FD
	[5]	[6]	[7]	[8]
log(empl)[2]	-0.0008	0.0014	0.0126	-0.0037
	(0.0028)	(0.0018)	(0.0122)	(0.0068)
log(emplagglo)[3]	0.0002	-0.0105	0.0253	-0.0384
	(0.0060)	(0.0070)	(0.0782)	(0.0389)
special	0.0095**	0.0246	0.036	0.0415*
	(0.0046)	(0.0304)	(0.0549)	(0.0241)
diverse	0.0009	-0.0058	0.0006	0.0013**
	(0.0052)	(0.0035)	(0.0014)	(0.0006)
cluster	-0.001	0.0055	-0.7662***	-0.2806**
	(0.0070)	(0.0066)	(0.2680)	(0.1134)
latin	0.0273	0.0274		
	(0.0434)	(0.0206)		
centre	0.001	0.0011*		
	(0.0012)	(0.0007)		
capital	-0.1078	-0.0559		
	(0.1155)	(0.0562)		
Constant	0.1365**	0.2325***	-0.2502	0.5846
	(0.0629)	(0.0761)	(0.7990)	(0.3888)
Year effects			yes	yes
Municipality effects			yes	yes
Metro effects		yes		
Metro x year effects				yes
R-squared[4]	0.0414	0.0937	0.4896	
N municipalities - year			414	414
N municipalities	207	207	207	207

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax rate, 9% profit level. Standard errors in parentheses, clustered for municipalities. Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] RE: random effects, FE: fixed effects, FD: first difference, IV: instrumental variables.

[2] employment in municipality

[3] sum of employment in municipality and all other municipalities weighted by inverse distance

[4] Within R-squared (excludes explanatory power of municipality fixed effects and metro effects)

can explain some of the variation in tax rates *within* metro areas while the total employment size can mainly explain variation in tax rates *across* metro areas.

Colums [3] and [4] repeat the same empirical exercise for the small 2005 cross-section. Unfortunately, the smaller sample is not able to detect the above findings. We conclude from this, that the effects of our new cluster measure can only be identified by observing enough smaller and more peripheral municipalities within metropolitan areas. This very much limits the results of our estimations with the 1985 cross-section in columns [5]-[6] and the 1985-2005 panel in columns [7]-[8] as only data for the small sample is available. The fixed effects estimates in columns [7]-[8] suggest that an increase in the cluster index over 20 years is associated with a decrease in local tax rates over the same period. We do not yet take this as evidence of a negative causal effect. First, as discussed above, we would want to repeat these estimates with a larger sample of municipalities. Second, the negative effect could stem from inverse causality when tax cuts attract new clusters. Unfortunately, we could not yet find credible instruments for our cluster index.

2.7 Conclusion

In this paper we study whether local policy makers tax agglomeration rents, as predicted by the NEG literature. To test this mechanism we use a panel of Swiss municipality level data. We face several challenges bridging the gap between theoretical model and empirical evaluation. First, the standard tax competition model with asymmetric jurisdiction size also predicts that small locations (tax havens) have lower tax rates than large ones, but the economic implications are very different. To separate the two effects we make a clear difference between the jurisdictional (i.e. political) and economic size (i.e. the agglomeration) of a location by developing a measure for each definition of size. From our estimates we find some evidence confirming the NEG prediction, but not the tax haven story. Second, there could be important unobserved and unobservable local characteristics. We

address this problem by including municipality fixed effects to control for omitted variables. Despite the 20 year distance in the data there is very little time variation we can exploit, and the large confidence intervals neither detect signicant effects nor rule out the positive effects estimated in the cross-section. Third, the size of local jurisdictions is likely affected by local tax rates and therefore endogenous. We instrument for both measures of location size with a set of variables based on initially available land reserves and initial sector composition. Our instruments turn out to be highly significant in the first stage, but rather weak. Summing up, we find that municipalities in large agglomerations set higher tax rates than municipalities in smaller agglomerations. This evidence is neither supported nor contradicted controlling for omitted variables and instrumenting for endogeneity.

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A APPENDIX TO CHAPTER 1

A.1 PROOF OF PROPOSITION 1

Proof. We claim that the restrictions imposed on the equilibrium by the dual problem (1.15) as outlined in Section a of the fiscal union are summarised by the simplified Ramsey plan (1.19) described in Proposition 1. To demonstrate this we first show that the restrictions from the dual problem (1.15) imply equations (1.20) to (1.24). To see this, note that we can get equation (1.24) by adding up equations (1.2) and (1.4) for both countries, $i = 1, 2$. Equation (1.23) is obtained by using (1.2) and substituting out prices and tax rates by using (1.6), (1.9), (1.10), (1.13) and (1.14).

We claim that any allocation satisfying the restrictions to the dual problem (1.15) and the transversality conditions (1.16), (1.17) and (1.18) for each country must satisfy as well equations (1.20) to (1.22). To see this, we start by iterating forward the household budget constraint (1.4) by adding up the period-by-period constraints and successively substituting out debt. Using equation (1.6), (1.9), (1.10), (1.13) and (1.14) and imposing the transversality conditions (1.16) to (1.18) we find the implementability conditions (1.20) and (1.21) for each country:

$$\sum_{t=0}^{\infty} \beta^t \left[u_{c_{i,t}} c_{i,t} - u_{\ell_{i,t}} (1 - \ell_{i,t}) \right] = A_{i,0}$$
$$\sum_{t=0}^{\infty} \beta^t \left[u_{c_{j,t}} c_{j,t} - u_{\ell_{j,t}} (1 - \ell_{j,t}) \right] = A_{j,0}$$

where

$$A_{i,0} = u_{c_{i,0}}\left(b_{i,-1} + \sum_{n=1,2}\left[1 + (1-\tau^k_{n,0})(F_{k_{n,-1}} - \delta)\right] a^n_{i,-1}\right)$$

$$A_{j,0} = u_{c_{j,0}}\left(b_{j,-1} + \sum_{n=1,2}\left[1 + (1-\tau^k_{n,0})(F_{k_{n,-1}} - \delta)\right] a^n_{j,-1}\right).$$

Equations (1.6) for each country and (1.8) imply (1.22). Thus equations (1.20) to (1.24) are satisfied by the dual problem.

Next, we claim that given any allocation satisfying the simplified Ramsey plan as well the restrictions to the dual problem are satisfied. We show that equations (1.20) to (1.24) satisfy as well equations (1.4), (1.6), (1.9), and (1.10) from the households' problem for each country, equation (1.8), the government budget constraint (1.2) for each country, the firms' first order conditions (1.13) and (1.14) and the transversality conditions (1.16) to (1.18) for both countries. To see this we construct sequences of bonds and government policies $\{\tau^k_{i,t}, \tau^l_{i,t}\}$ for each country, such that the household budget constraints (1.4), and first order conditions (1.6) and (1.9) are satisfied for each country. We can find series of prices to satisfy equations (1.10), (1.13) and (1.14). The no-arbitrage condition (1.8) is satisfied by the fact that (1.6) holds for both countries and by (1.22). The government budget constraint (1.2) for country i is satisfied by (1.23), and because equations (1.6), (1.9) and (1.10) hold. The government budget constraint (1.2) for country j is satisfied because (1.2) holds for country i, equation (1.4) holds for both countries and by (1.24). Therefore the restrictions on the set of allocations achievable by the Ramsey planner in the dual problem (1.15) are the same as in the simplified Ramsey plan (1.19). □

A.2 Proof of Proposition 2

Proof. We claim that the restrictions imposed on the equilibrium by the dual problem (1.27) of country i are summarised by the simplified Ramsey plan (1.31) of country i. To demonstrate this we first show that the restrictions from problem (1.27) imply equations (1.32) to (1.38). To see this,

note that we can get equation (1.38) by adding equations (1.2) and (1.4) for each country. Equation (1.37) is obtained by using (1.2) for country j and substituting out prices by using (1.10), (1.13) and (1.14).

We claim that any allocation satisfying the restrictions to the dual problem (1.31) plus transversality conditions (1.28), (1.29) and (1.30) must satisfy as well equations (1.32) to (1.36). To see this, we start by iterating forward the household budget constraint (1.4) for country i by adding up the period-by-period constraints and successively substituting out debt. We get an inter-temporal household budget constraint of the following form

$$\sum_{t=0}^{\infty}\left(\prod_{s=0}^{t-1}p_{i,s}\right)\Big[c_{i,t}+\sum_{n=1,2}a^n_{i,t}-\sum_{n=1,2}(1+(1-\tau^k_{n,t})(r_{n,t}-\delta))a^n_{i,t-1}- (1-\tau^l_{i,t})w_{i,t}(1-\ell_{i,t})\Big]=b_{i,-1}. \tag{A.1}$$

Using equations (1.6) and (1.10) for country i and imposing transversality condition (1.29) we find that $a^i_{i,t}$ vanishes from the equation. This is not true for $a^j_{i,t}$ as we can not substitute out foreign (i.e., country j) tax rates from the equation. Using (1.9) to substitute out labour tax rates of country i and (1.10), (1.13) and (1.14) we can rewrite (A.1) and find equation (1.32)

$$\sum_{t=0}^{\infty}\beta^t[u_{c_{i,t}}c_{i,t}-u_{\ell_{i,t}}(1-\ell_{i,t})+(u_{c_{i,t}}-\tilde{R}_{j,t+1}\beta u_{c_{i,t+1}})a^j_{i,t}]=A_{i,0}$$

where

$$A_{i,0}=u_{c_{i,0}}[b_{i,-1}+\sum_{n=1,2}\tilde{R}_{n,0}a^n_{i,-1}]$$
$$\tilde{R}_{j,t}=1+(1-\tau^k_{j,t})\left[F_{k_{j,t-1}}-\delta\right].$$

Similarly, we now iterate forward the household budget constraint (1.4) for country j, by adding up the period-by-period constraints and successively substituting out debt, and get

$$\sum_{t=0}^{\infty}\left(\prod_{s=0}^{t-1}p_{j,s}\right)\Big[c_{j,t}+\sum_{n=1,2}a^n_{j,t}-\sum_{n=1,2}(1+(1-\tau^k_{n,t})(r_{n,t}-\delta))a^n_{j,t-1}-$$
$$(1-\tau^l_{j,t})w_{j,t}(1-\ell_{j,t})\Big]=b_{j,-1}. \tag{A.2}$$

Using equations (1.6) and (1.10) for country j, equation (1.8) and the transversality condition (1.29) we find that $a^i_{j,t}$ vanishes from the equation. Again, this is not true for $a^j_{j,t}$ as we can not substitute out foreign tax rates from the equation. Using (1.10) and (1.13) for country j and impose transversality condition (1.30) we can rewrite (A.2) and find equation (1.33)

$$\sum_{t=0}^{\infty}\beta^t[u_{c_{j,t}}c_{j,t}-u_{c_{j,t}}\tilde{w}_{j,t}(1-\ell_{j,t})+(u_{c_{j,t}}-\tilde{R}_{j,t+1}\beta u_{c_{j,t+1}})a^j_{j,t}]=A_{j,0}$$

where

$$A_{j,0}=u_{c_{j,0}}[b_{j,-1}+\sum_{n=1,2}\tilde{R}_{n,0}a^n_{j,-1}]$$
$$\tilde{R}_{j,t}=1+(1-\tau^k_{j,t})\left[F_{k_{j,t-1}}-\delta\right]$$
$$\tilde{w}_{j,t}=(1-\tau^l_{j,t})F_{1-\ell_{j,t}}.$$

By using (1.6) and (1.9) for country j and equations (1.41) and (1.42) we find equations (1.34) and (1.35). Combining Euler equation (1.6) and equation (1.8) we get equation (1.36). Thus equations (1.32) to (1.38) are satisfied by the dual approach to the Ramsey plan.

Next we claim that given any allocation satisfying equations (1.32) to (1.38) from the simplified Ramsey plan, as well the restrictions from the dual problem (1.27) are satisfied. To see this, we can construct sequences of bonds and government policies $\{\tau^k_{i,t},\tau^l_{i,t}\}$ for country i, such that (1.4), (1.6) and (1.9) are satisfied for country i. We can construct a sequence of bonds $\{b_{j,t}\}$ to satisfy (1.4) for country j. We can find series of prices to

satisfy equations (1.10), (1.13) and (1.14) for each country. The government budget constraint (1.2) for country j is satisfied by equation (1.37) and because (1.10), (1.13) and (1.14) hold. The government budget constraint for country i is satisfied because the aggregate resource constraint (1.38), the government budget constraint (1.2) for country j and the household budget constraints (1.4) for each country are satisfied. Equations (1.9) for country j and equation (1.7) are satisfied by (1.34), (1.35), (1.41), (1.42) and given the foreign country's taxation policies $\{\tau^k_{j,t}, \tau^l_{j,t}\}$. Equations (1.8) is satisfied by (1.36) and (1.41) and because (1.6) holds for country i.

Therefore the restrictions on the set of allocations achievable by the governments in the dual problem (1.27) are the same as in the simplified Ramsey plan (1.31). □

A.3 PROOF OF PROPOSITION 3

Proof. The first order condition of the simplified Ramsey plan of the fiscal union (1.19), with respect to $a^j_{j,t}$ is

$$-\lambda^5_{t+1}\beta\left[1 + F_{k_{j,t}} - \delta\right] + \lambda^5_t = 0 \tag{A.3}$$

where λ^5_t is the Lagrange multiplier on the aggregate resource constraint. In the long run all variables are invariant. We can therefore rewrite the long-run version of (A.3) as

$$\beta\left[1 + F_{k_j} - \delta\right] = 1 \tag{A.4}$$

Now we go back to the household problem in Section b. Using the steady-state version of the first-order condition with respect to capital (1.6) and equation (1.13) we find that

$$\beta\left[1 + (1 - \tau^k_j)(F_{k_j} - \delta)\right] = 1. \tag{A.5}$$

As equations (A.4) and (A.5) both have to hold at equilibrium, it follows that in the long-run the capital tax rate of country j (τ^k_j) has to be equal to zero.

This result is less obvious to get for the capital tax rate of country i. Maximizing (1.19) with respect to $a^i_{i,t}$ we find

$$\lambda^4_{t+1}\beta\left[F_{kk_{i,t}}k_{i,t} + (F_{k_{i,t}} - \delta) - \frac{u_{c_{i,t}}}{\beta u_{c_{i,t+1}}} + 1 + F_{(1-\ell_{i,t+1})k_{i,t}}(1-\ell_{i,t+1})\right] \\ -\lambda^5_{t+1}\beta\left[F_{k_{i,t}} + 1 - \delta\right] + \lambda^5_t = 0 \tag{A.6}$$

where λ^4_t is the Lagrange multiplier on the government budget constraint of country i and λ^5_t the Lagrange multiplier on the aggregate resource constraint. In the long run this equation looks as follows

$$\lambda^4\beta\left[F_{kk_i}k_i + (F_{k_i} - \delta) - \frac{1}{\beta} + 1 + F_{(1-\ell_i)k_i}(1-\ell_i)\right] \\ -\lambda^5\beta\left[F_{k_i} + 1 - \delta\right] + \lambda^5 = 0. \tag{A.7}$$

Using the properties of the production function[1] we find that $F_{kk_i}k_i + F_{(1-\ell_i)k_i}(1-\ell_i) = 0$ and can rewrite (A.7) as

$$\beta(\lambda^4 - \lambda^5)\left[1 + (F_{k_i} - \delta) - \frac{1}{\beta}\right] = 0. \tag{A.8}$$

We rewrite equation (A.5) for country i

$$1 + (1 - \tau^k_i)(F_{k_i} - \delta) - \frac{1}{\beta} = 0. \tag{A.9}$$

Unless $\lambda^4 = \lambda^5$, equations (A.7) and (A.5) for country i imply that τ^k_i must be equal to zero in the long run. □

[1] We use a Cobb-Douglas production function: $F(k_{i,t-1}, (1 - \ell_{i,t})) = A_i k^{\alpha}_{i,t-1}(-\ell_{i,t})^{1-\alpha}$

A.4 PROOF OF PROPOSITION 4

Proof. The first order condition of the simplified Ramsey problem of country i (1.31) with respect to $a^i_{i,t}$ is

$$-\lambda^7_{t+1}\beta\left[1 + F_{k_{i,t}} - \delta\right] + \lambda^7_t = 0 \tag{A.10}$$

where λ^7_t is the Lagrange multiplier on the aggregate resource constraint. In the long run all variables are invariant. We can therefore rewrite the long-run version of (A.10) as follows:

$$\beta\left[1 + F_{k_i} - \delta\right] = 1 \tag{A.11}$$

Going back to the household problem of Section b, we use the steady-state version of the first-order condition with respect to capital (1.6) and equation (1.13) and find that

$$\beta\left[1 + (1 - \tau^k_i)(F_{k_i} - \delta)\right] = 1. \tag{A.12}$$

As both equations (A.11) and (A.12) have to hold at equilibrium, it follows that in the long run the capital tax rate (τ^k_i) has to be equal to zero. Rewriting the Ramsey plan (1.31) for country j it is easy to see that it must as well be true that in the long run τ^k_j is equal to zero. □

A.5 appendix to section 1.5, fiscal union vs. tax competition

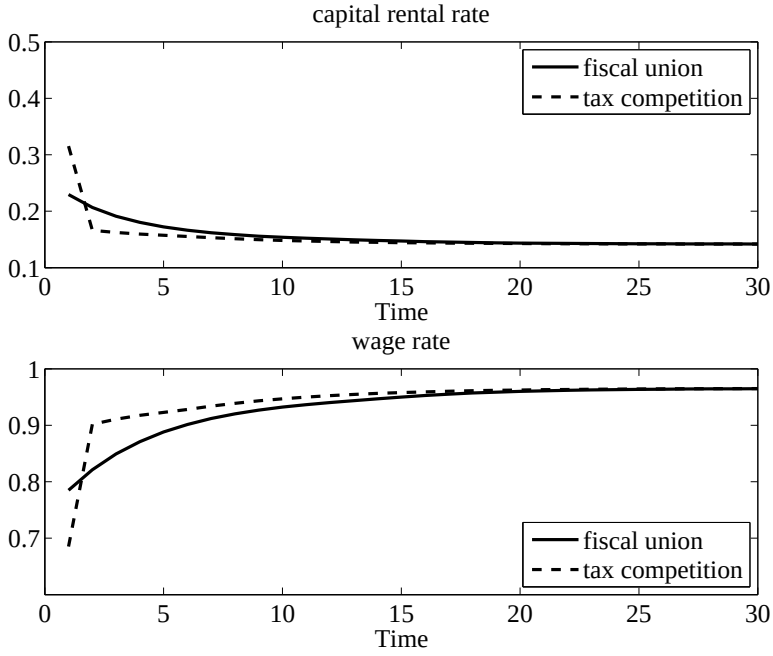

Figure A.1: Capital rental rate and wage rate

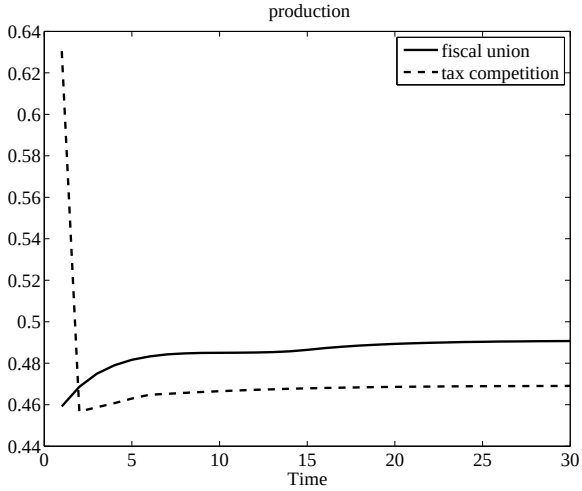

Figure A.2: Production

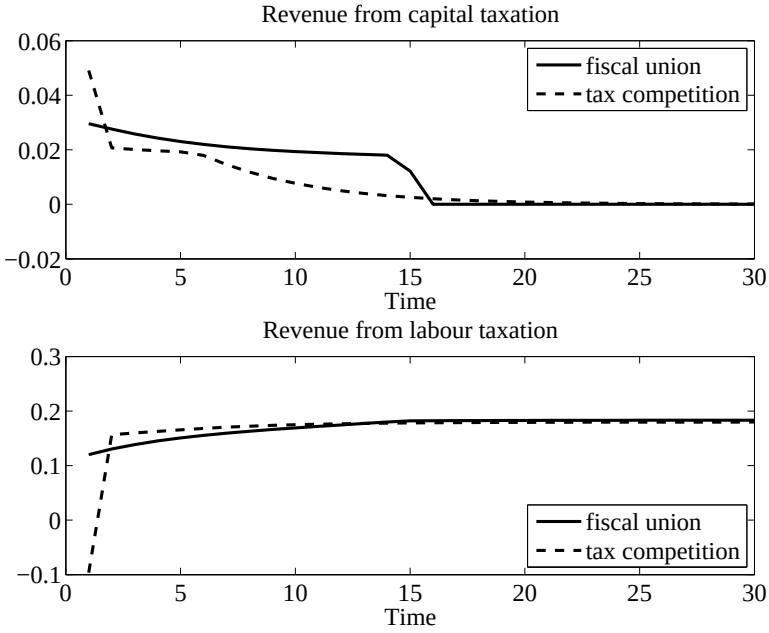

Figure A.3: Revenue from capital and labour taxation

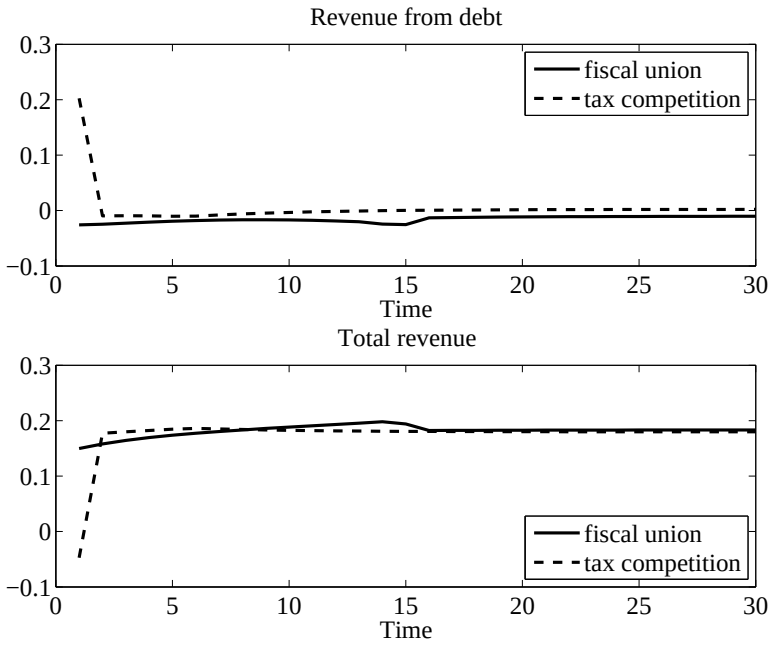

Figure A.4: Total revenue from taxation and from debt

A.6 appendix to section 1.6, asymmetric countries

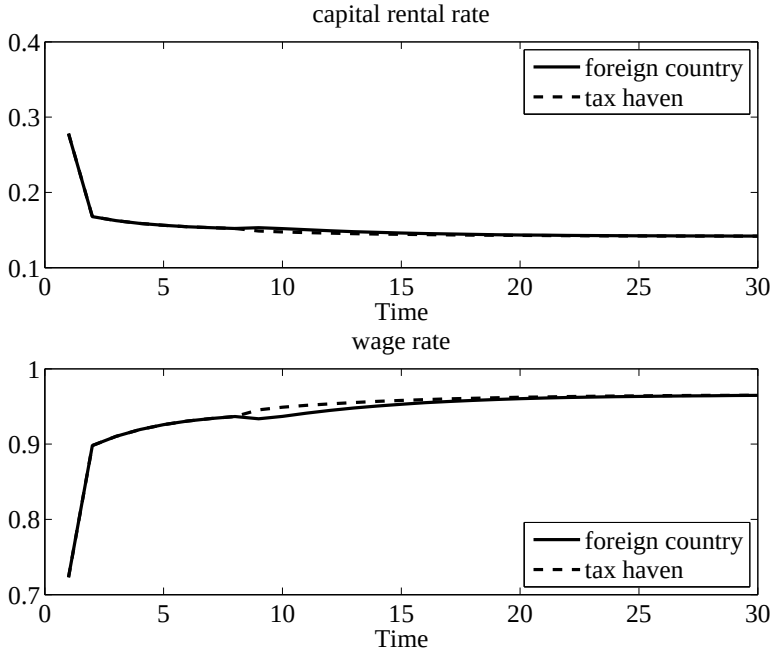

Figure A.5: Wage and capital rental rates

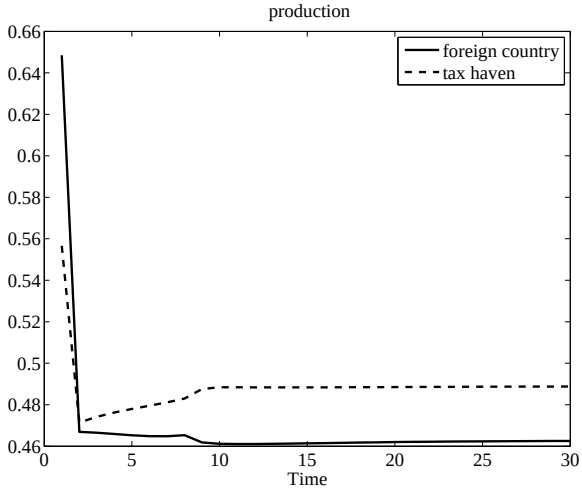

Figure A.6: Production

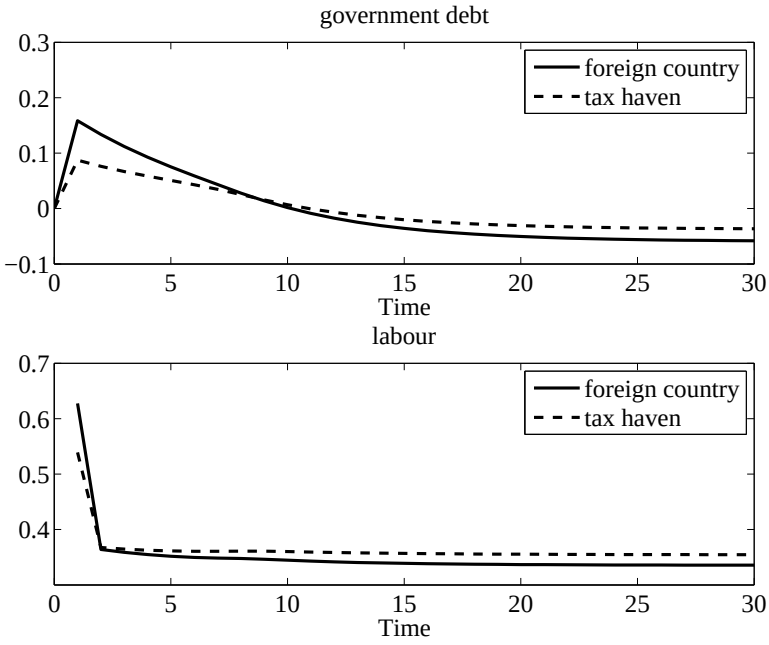

Figure A.7: Government debt and labour

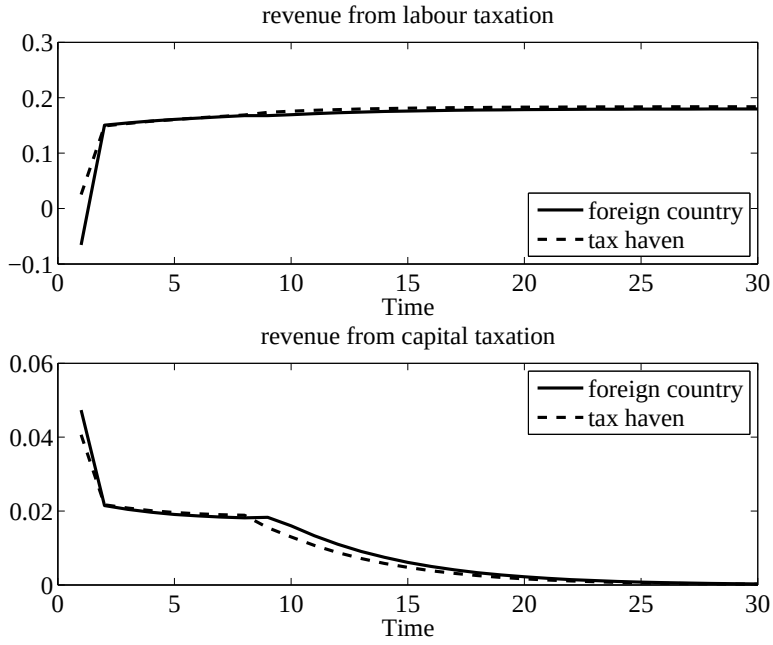

Figure A.8: Revenue from taxation

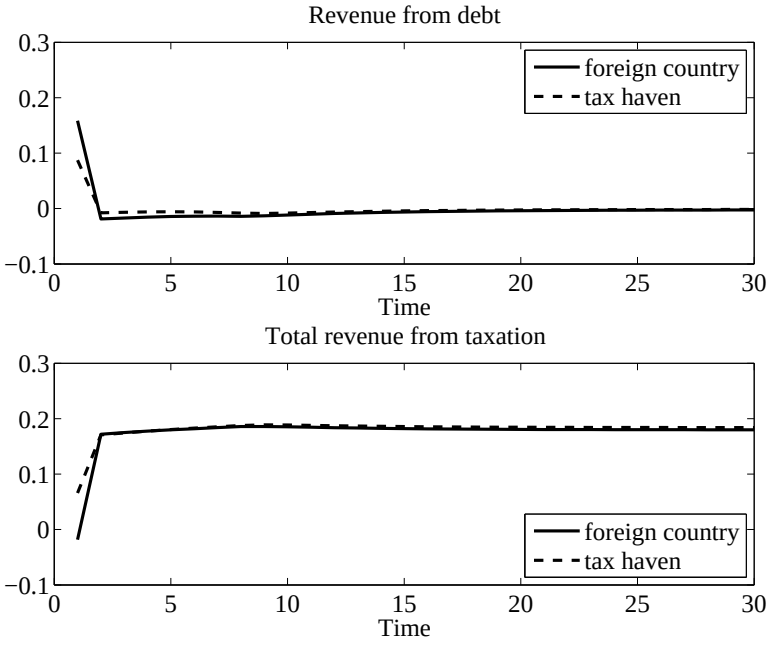

Figure A.9: Total revenue from taxation and from debt

A.7 ASYMMETRIC COUNTRIES IN A FISCAL UNION

Here we first look at asymmetric countries in a fiscal union, and then compare the optimal fiscal policy in a world with asymmetric countries under tax competition with the optimal outcome in a fiscal union. The aim of this section is to determine which results are due to tax competition and which are due to the asymmetries among the countries.

A.8 FISCAL UNION

Looking at two asymmetric countries in a fiscal union, we find that the taxation policy among the two countries is very similar. As in the symmetric case, we find that capital tax rates are at the upper bound for several periods, and then abruptly drop to zero. In contrast to the symmetric case capital taxes do not go to zero over 2 periods, but over 3 periods. It can hardly be seen from Figure A.10, but capital tax rates drop from the upper bound to an intermediate level of 11.56% and then to -.0780% in the initially richer country, and to 11.74% and -.0794% in the initially poorer country. We therefore find that the capital tax rate in the intermediate periods is slightly higher in the initially richer country in one period, and slightly lower in the other. To speak of a tax haven in a fiscal union is not really appropriate, as tax rates are set optimally in this case and are not an outcome of competition. Nevertheless, we will continue calling the initially poorer country tax haven for being consistent in the presentation of the results. Similar to the case of tax competition is labour taxation. We find as well here that labour tax rates are higher in the initially poorer country ('tax haven') in the beginning, but then are lower in the long run. We observe a remarkable difference between the models in Figure A.11. Whereas with tax competition the initially poorer country has not only lower capital and labour tax rates, but as well higher government spending and consumption, we find here in contrast that the initially poorer country has higher government expenditure, but lower consumption than the other country. For the ownership of capital we find again similar patterns as be-

fore. The initially poorer country will always remain poorer, measured by the capital stock owned by the countries' residents. But this is not true, taking the investment in the country as a measure: in the long run more capital will be invested in the initially poorer country than in the richer one.

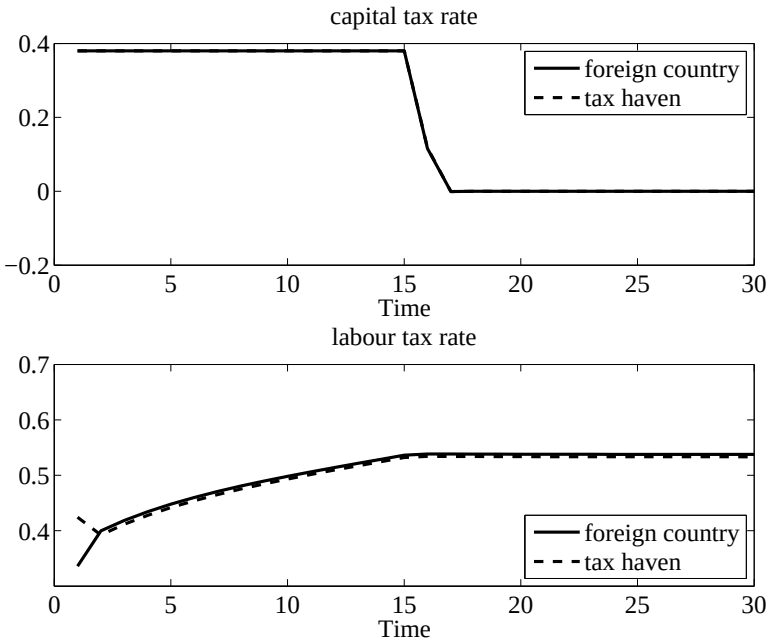

Figure A.10: Capital and labour tax rates

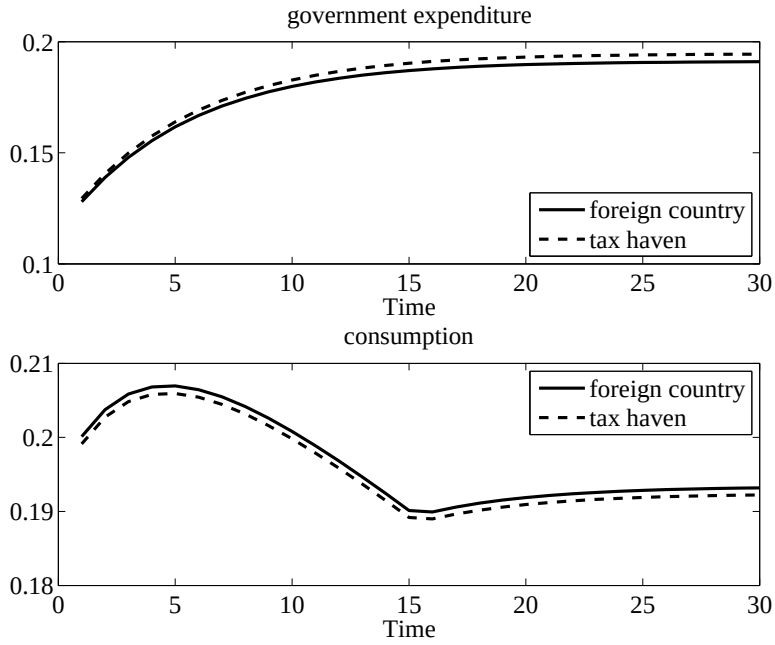

Figure A.11: Government expenditure and consumption

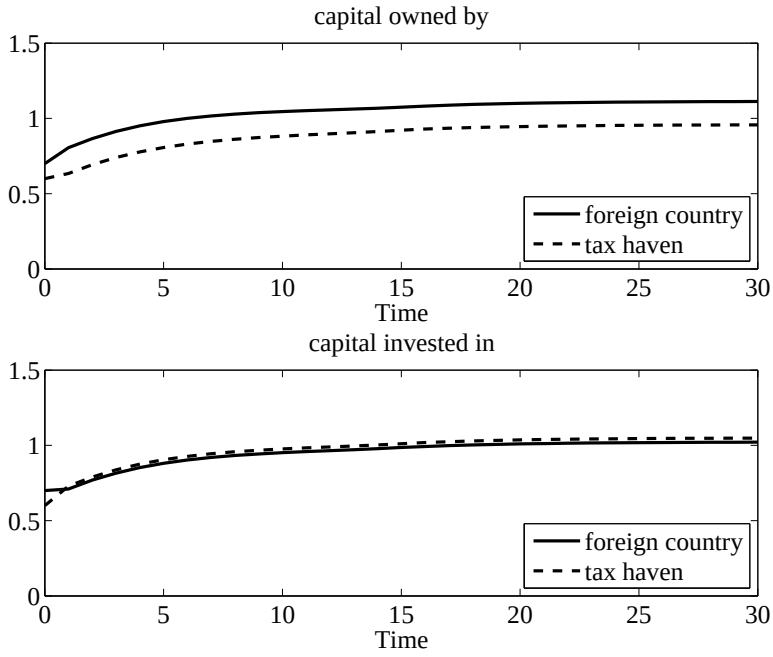

Figure A.12: Capital stock

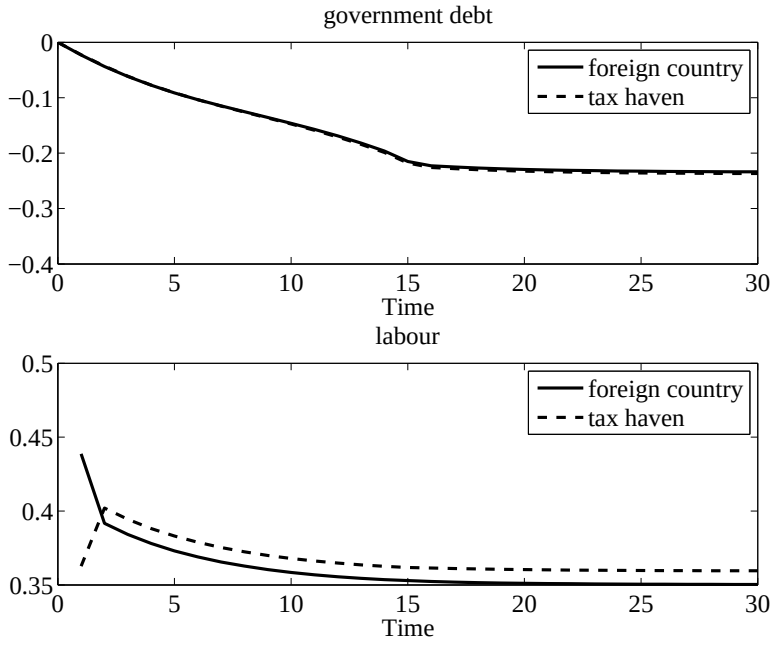

Figure A.13: Government debt and labour

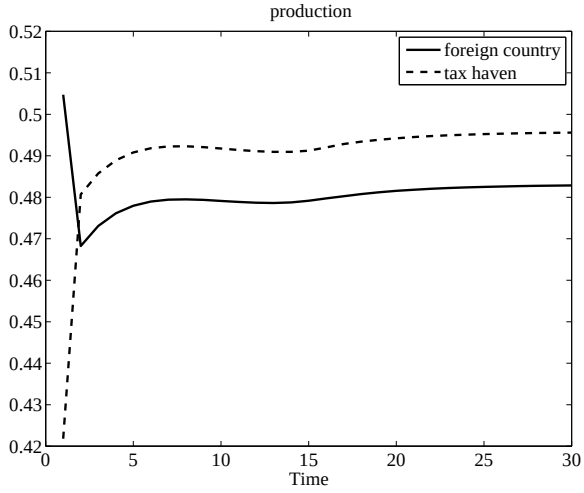

Figure A.14: Production

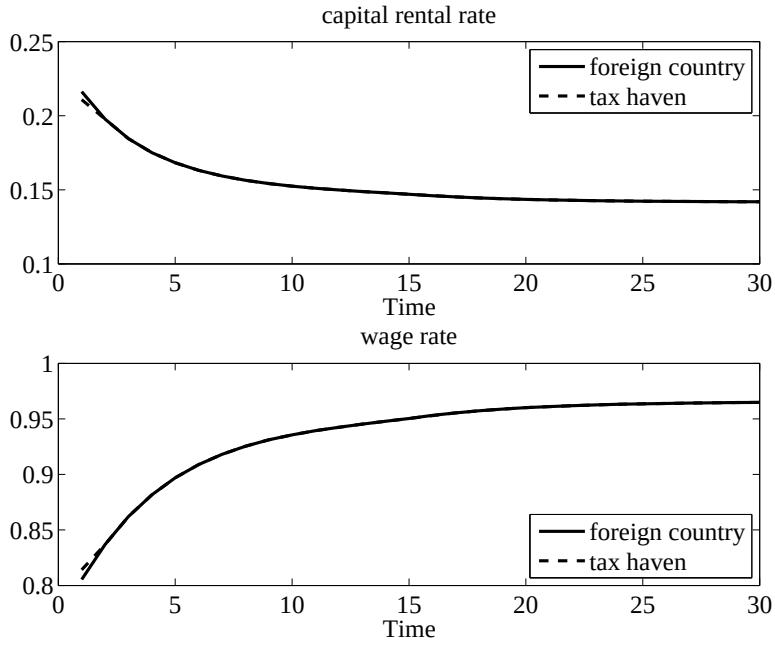

Figure A.15: Capital rental and wage rate

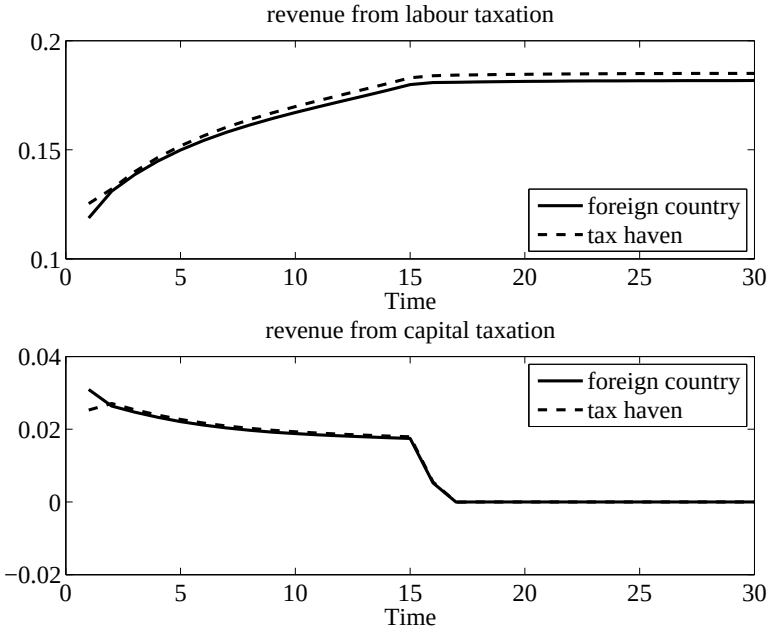

Figure A.16: Revenue from capital and labour taxation

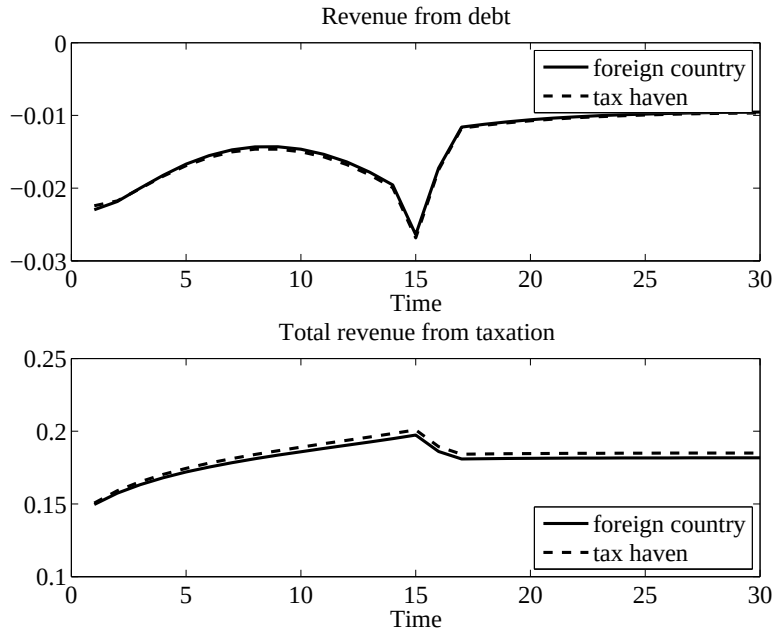

Figure A.17: Total revenue from taxation and from debt

A.9 Tax competition vs. fiscal union

In this section we compare the asymmetric countries in a fiscal union with the outcome under tax competition. From Figure A.18 we find that in the tax haven the capital tax rate is much lower than the first-best outcome in the fiscal union, than in the foreign country. We find that the labour tax rate in the first period is higher in the fiscal union, both in the tax haven and the foreign country. What happens with tax competition is that both countries want to attract capital. As the capital tax rate is equal and at the upper bound for both countries, they want to increase the return to capital by increasing labour supply. By lowering labour taxation the government can increase the return to labour and therefore the labour supply. This in turn increases the return to capital because we have a Cobb-Douglas production function, where capital and labour are complements. After this the labour tax rate is higher with tax competition in both countries, as the governments want to decrease the capital tax rates as fast as possible, and therefore have to raise income from a different source.

In Section A.8 we saw that the initially poorer country accumulates less capital than the initially richer country as well in a fiscal union. Here we find that although it is true that the initially poorer country accumulates less capital than the richer one, it does accumulate much more in the fiscal union. Whereas the tax haven with tax competition over-accumulates capital during the first period, similar to the symmetric case studied in Section 1.5, we find that in the long run the capital stock is only about 80% of the fiscal union level. This happens because with tax competition the tax haven can attract much more capital from the foreign country, than in the fiscal union. Instead of accumulating capital, the tax haven can then consume the capital, and ends up with higher consumption than the foreign country. Due to tax competition the foreign country over-accumulates capital in all periods. We find that with tax competition government spending is inefficiently low in the long run in both countries. In the short run government spending is too high with tax competition. This way the governments want to compensate their households for the higher labour tax rates from period 2 onwards.

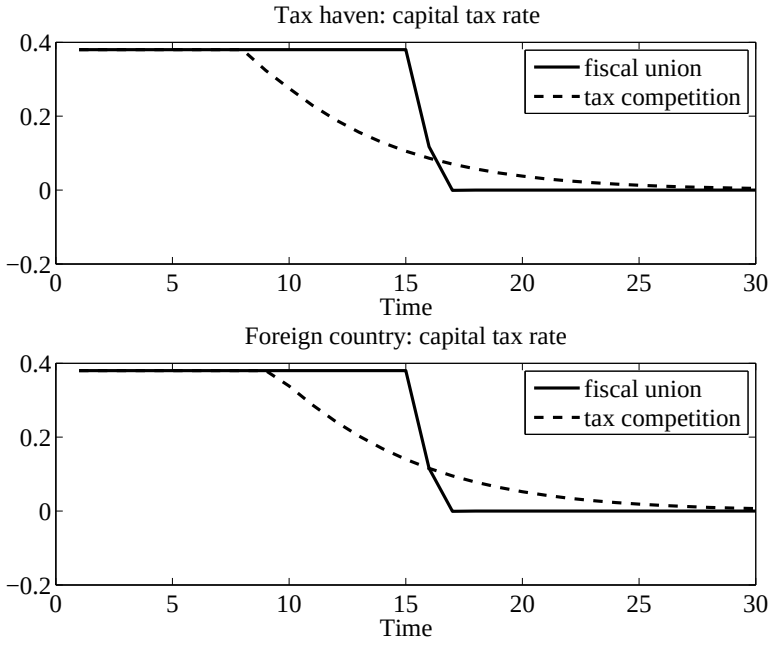

Figure A.18: Capital tax rates

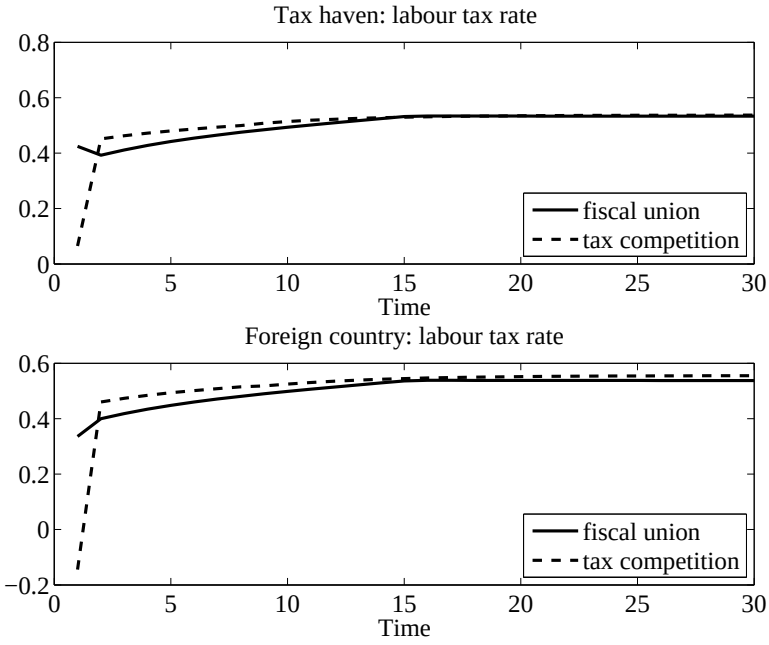

Figure A.19: Labour tax rates

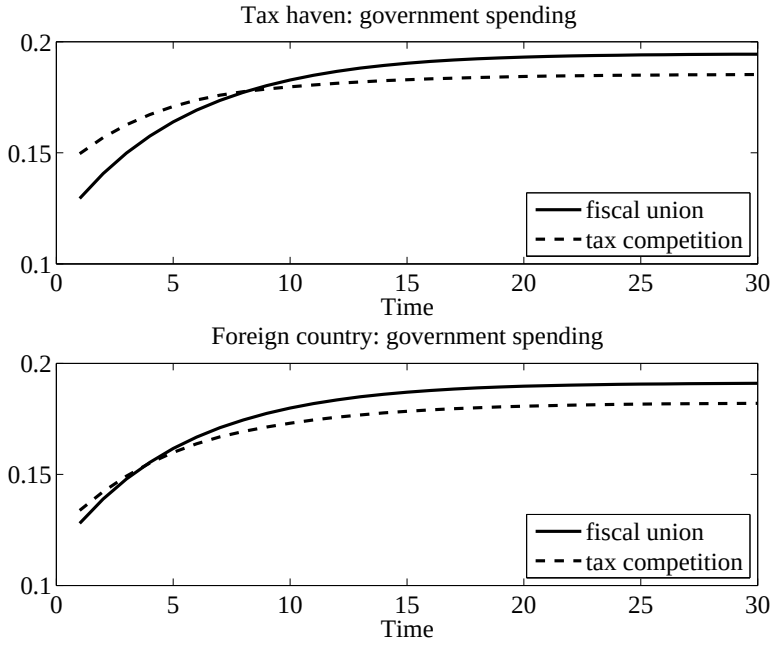

Figure A.20: Government expenditure

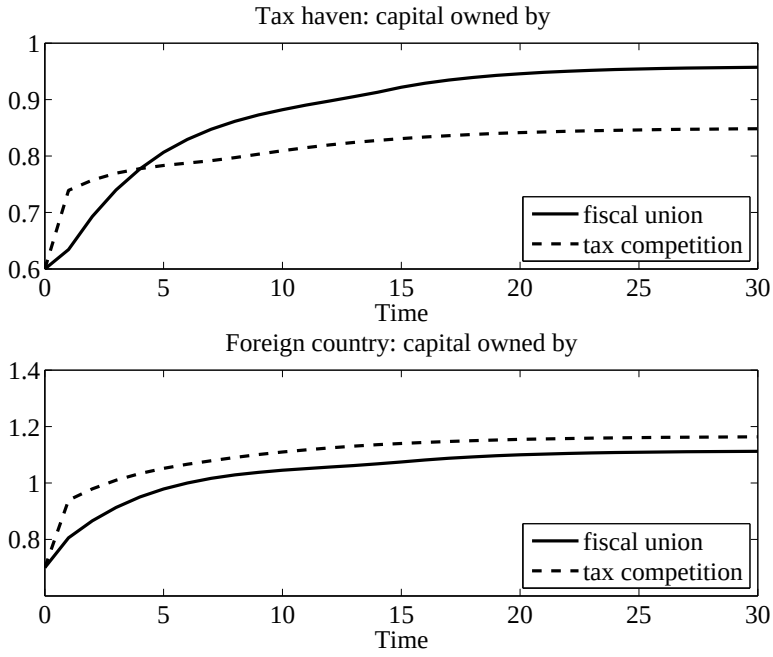

Figure A.21: Capital owned by the country

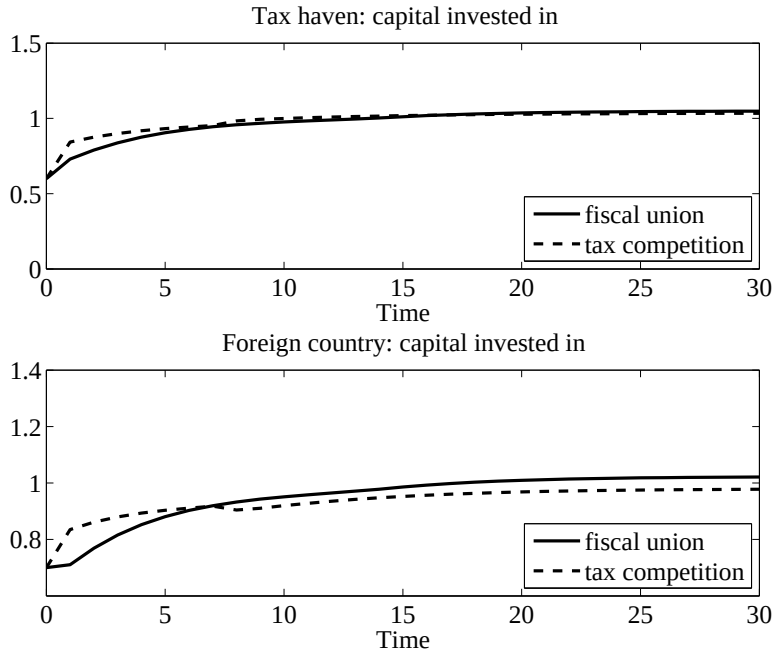

Figure A.22: Capital invested in the country

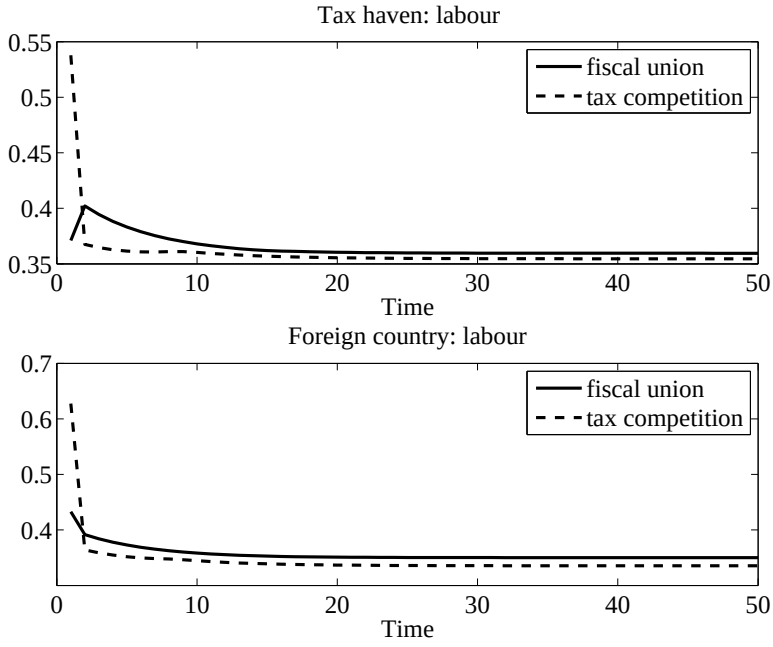

Figure A.23: Labour

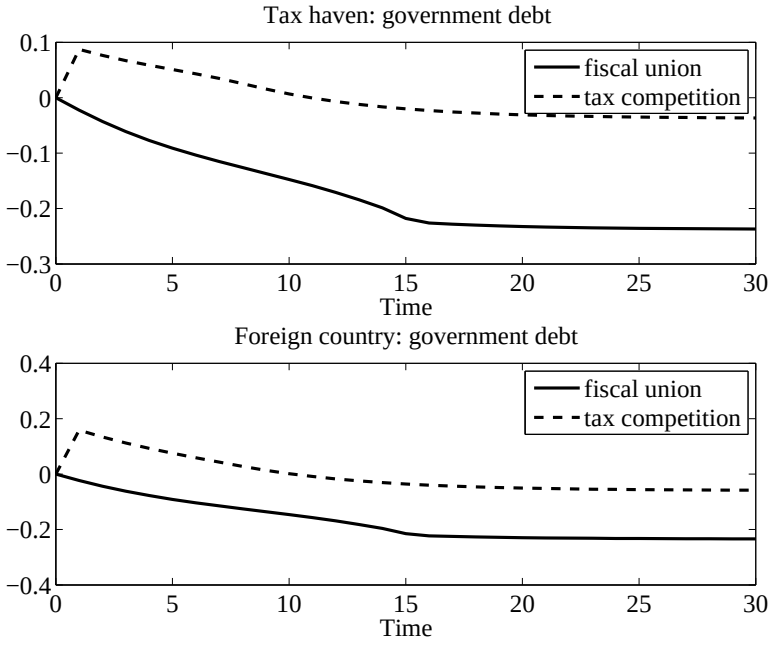

Figure A.24: Government debt

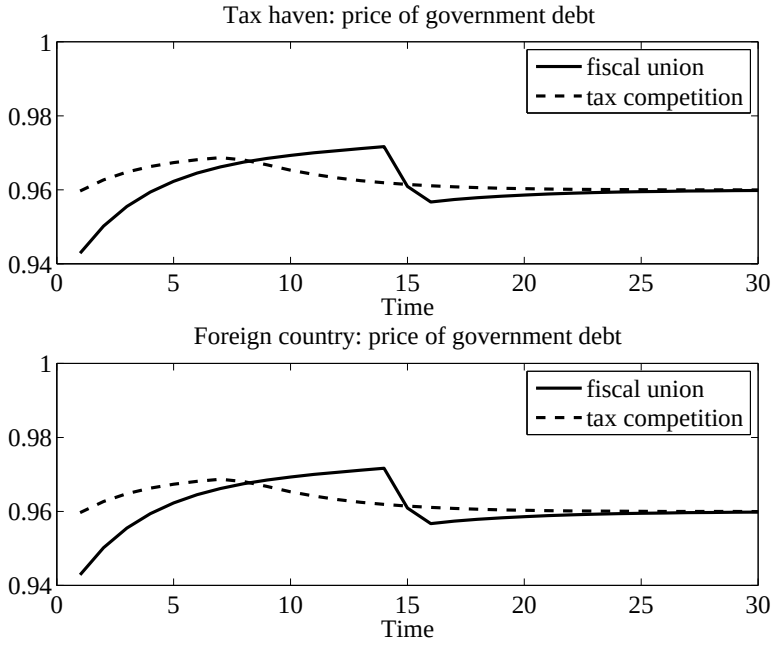

Figure A.25: Price of debt

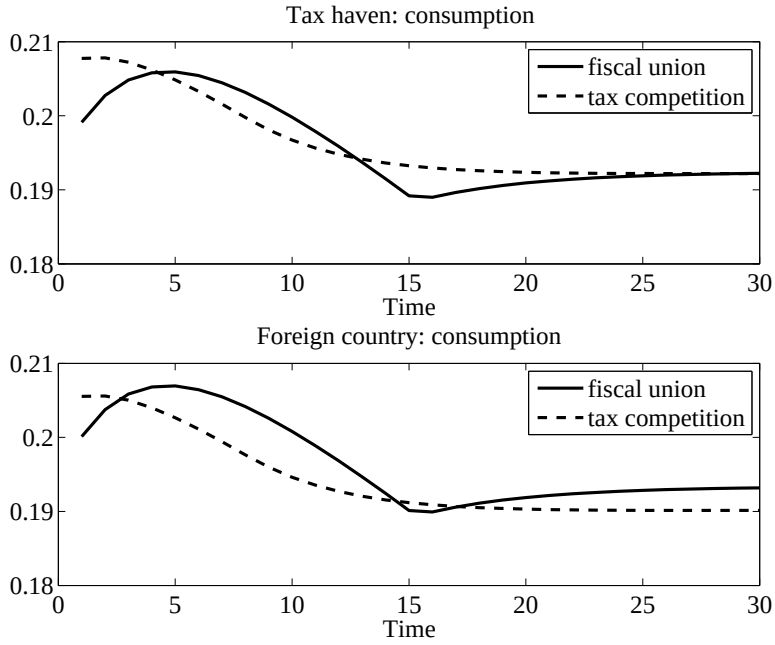

Figure A.26: Consumption

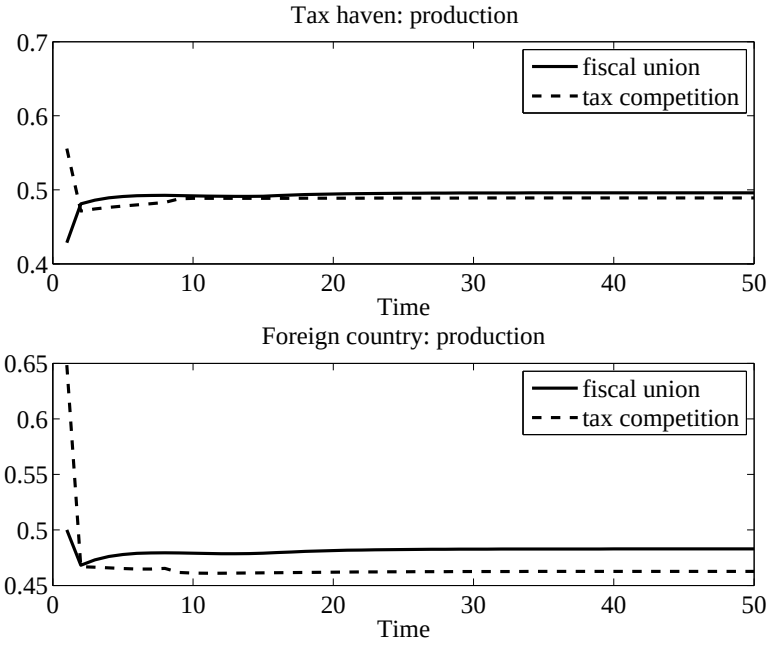

Figure A.27: Production

A.10 RESULTS WITH EXOGENOUS GOVERNMENT SPENDING

In the main body of this paper we have looked at the case of endogenous government spending. The following graphs show what happens if government expenditures are exogenously given. Here government expenditures are constant and equal to 0.2 for all periods. We found that endogenous government spending optimally increases over time. Constant government expenditures are therefore relatively costlier at the beginning than later on. This show is in the evolution of government debt among other, which is even in the fiscal union positive during the first few periods.

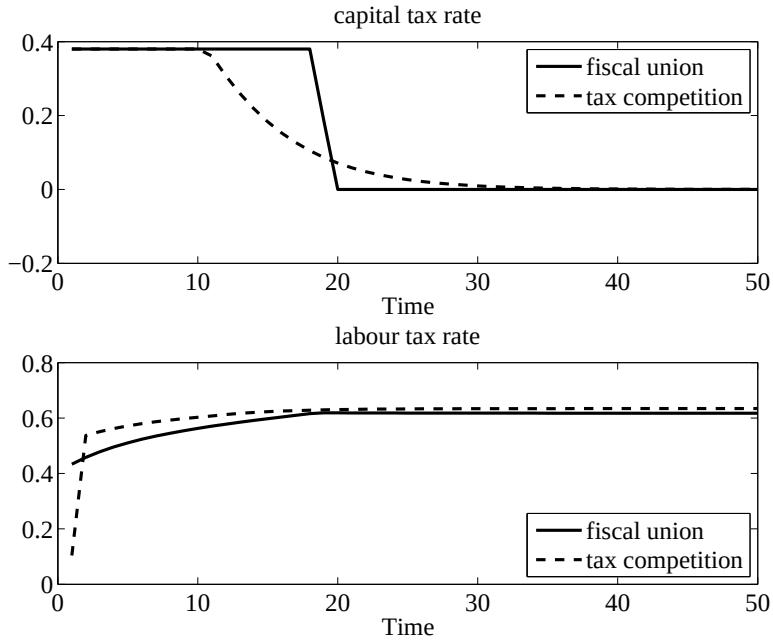

Figure A.28: Capital and labour tax rates

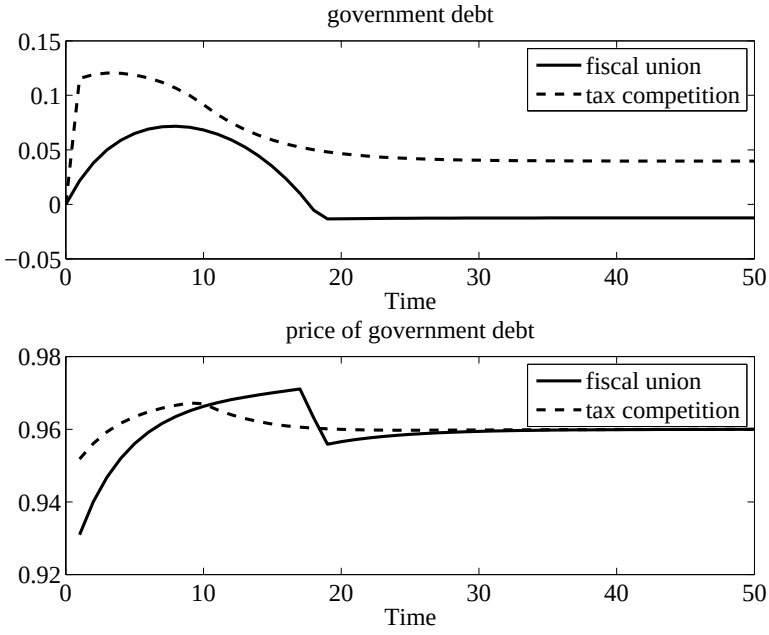

Figure A.29: Government debt and price of debt

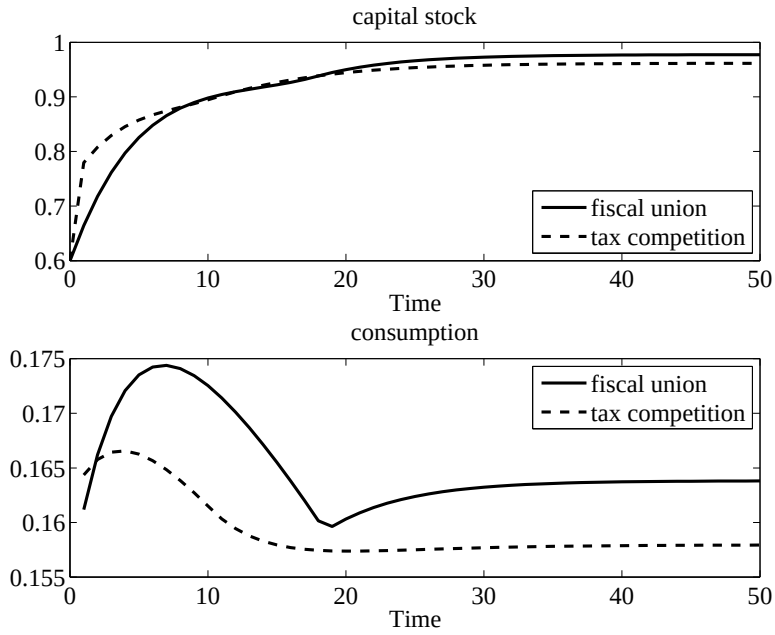

Figure A.30: Consumption and capital

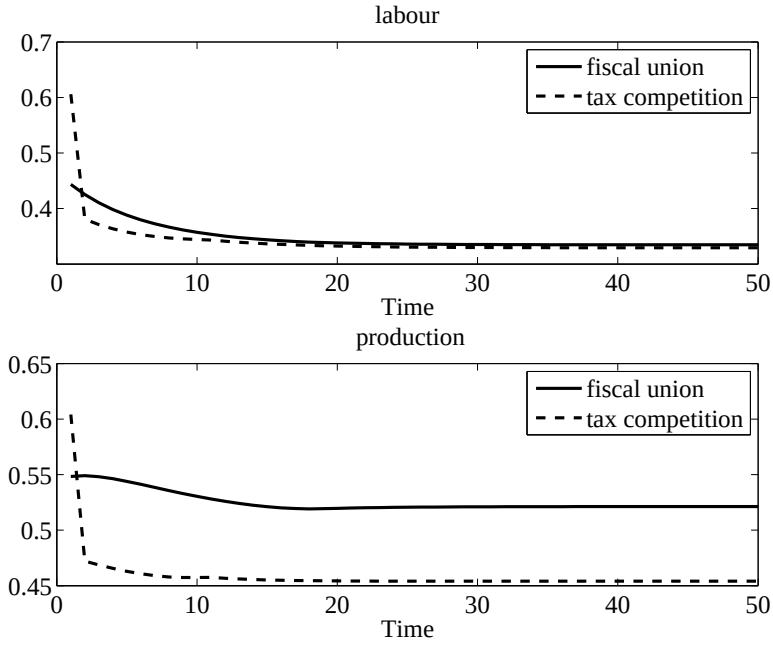

Figure A.31: Labour and production

A.11 RESULTS WITH BALANCED BUDGET

In this section we discuss a special case of the model discussed in the main part of this paper, where government debt is set to zero for all periods. Setting $b_{it} = 0$ for all t, all the equations from section 1.2 and section 1.3 are still true. We can neglect equations (1.10) and (1.11), the conditions concerning government debt and the price of debt. A common assumption in the optimal taxation literature is that governments can get indebted. But we think balanced budget is an important case to consider, as in reality many governments face some kind of budget constraint. The European Union for instance established in the Maastricht Treaty that the ratio of

government deficit to GDP should not exceed 3%. The balanced budget case makes as well a good robustness test to the results obtained in Section 1.5.

With balanced budgets we do not observe any differences in the long-run results for the fiscal union and tax competition. Hence tax competition is costly only during transition.

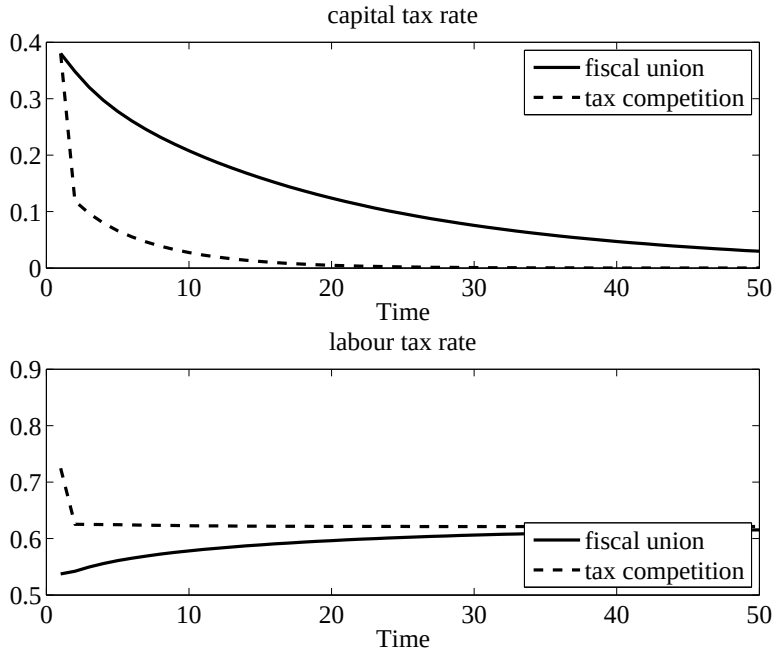

Figure A.32: Capital and labour tax rates

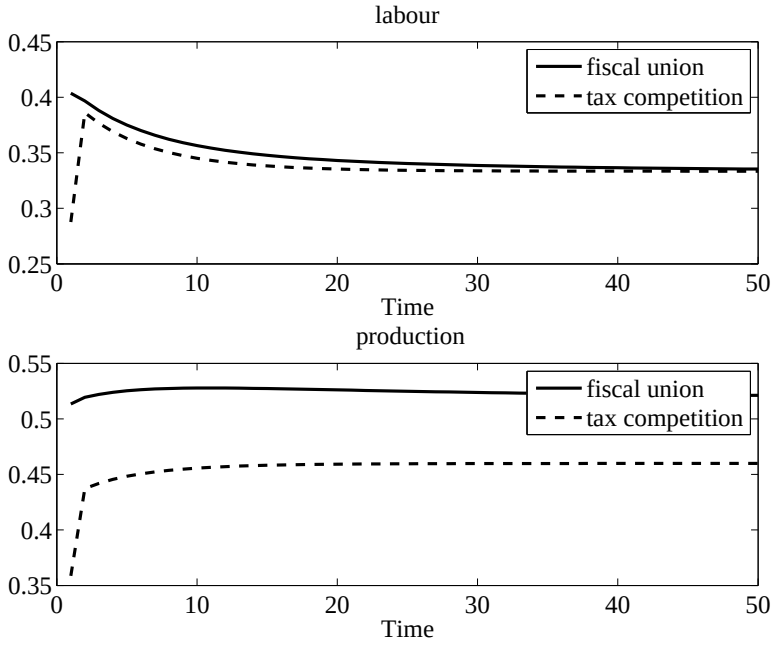

Figure A.33: Labour and production

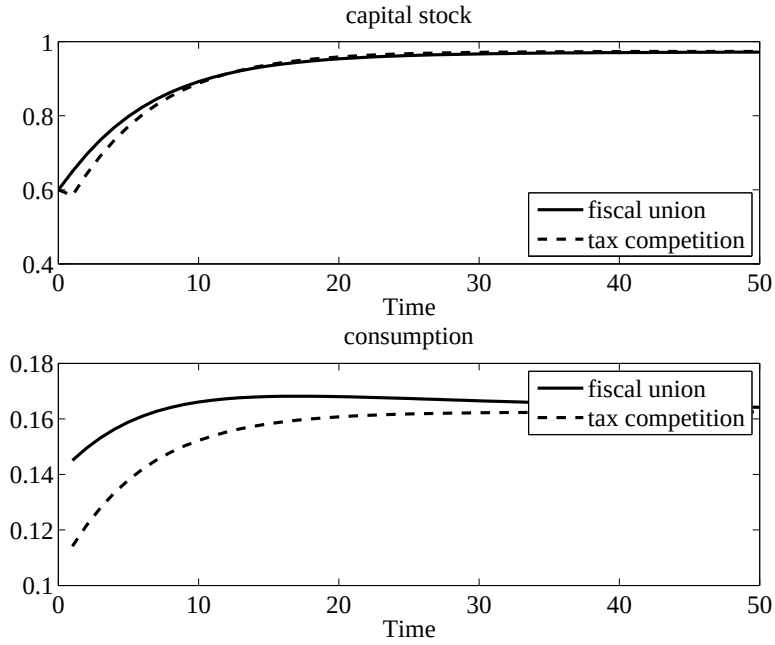

Figure A.34: Consumption and capital stock

B appendix to chapter 2

Table B.1: First-stage regressions for Tables 2.3 and 2.4

	Table 2.3	Table 2.4	
Dependent Variable	△ log(empl)	△ log(empl)	△ log(emplagglo)
	[1]	[2]	[3]
△ log(emplhat)	0.7468***	0.0071	-0.1209**
	(0.2630)	(0.2452)	(0.0493)
△ log(emplagglohat)		-0.5697	0.4638
		(1.1278)	(0.3328)
landreserves	0.1784	0.4007***	0.0648***
	(0.1079)	(0.1364)	(0.0205)
Distcentre		0.0155	0.0089***
		(0.0147)	(0.0021)
landreserves x		-0.0252	-0.0097***
distcentre		(0.0185)	(0.0027)
Constant	-0.1886**	-0.1215	-0.0646
	(0.0932)	(0.2113)	(0.0468)
Municipality effects	yes	yes	yes
Year effects	yes	yes	yes
Metro x year effects		no	no
F-stat excl iv[1]	4.752	2.67	8.78
K-P rank F-statistic[2]		2.896	2.896
R-squared[3]	0.1597	0.4102	0.6049
N	53	207	207

Dep. Variable: Corporate profit tax rate, sum of municipal and cantonal tax rate, 9% profit level. Standard errors in parentheses, clustered for municipalities. Coefficient significant at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[1] F-statistic excluded instruments

[2] Kleibergen-Paap F-statistic

[3] Within R-squared (excludes explanatory power of municipality fixed effects and metro effects)