Tax and the City –
A Theory of Local Tax Competition

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Abstract In this paper we propose a novel theoretical model of tax competition at the local level. Large jurisdictions (cities) compete both locally with smaller neighbouring communities and interregionally with more distant cities, while small jurisdictions (hinterlands) compete only with other jurisdictions in their neighbourhood. The model structure is motivated by recent empirical findings as well as survey results among German mayors: the perceived intensity of competition for firms varies considerably between jurisdictions and can mainly be explained by the size and location of the jurisdiction. Our model predicts – contrary to earlier findings for competition between countries or regions – that capital taxes of large jurisdictions fall more strongly with increasing interregional competition and may eventually lead to smaller taxes than in small jurisdictions. Hinterlands are therefore less affected from globalisation than cities. We contrast our results with a standard tax competition model in which all jurisdictions compete with all other jurisdictions.

Classification: H71, H73, H77
Keywords: local tax competition, survey, intensity of competition, asymmetric tax competition

1 Introduction

A common view in the theoretical literature on tax competition is that smaller jurisdictions have lower tax rates on mobile capital than larger jurisdictions (see, for example, Bucovetsky, 1991; Wilson, 1991; Baldwin and Krugman, 2004; Haufler and Wooton, 2010). In addition, tax rates on mobile factors should vanish eventually if competitive pressures rise further and further – for instance when the number of competing jurisdictions becomes very large – assuming that alternative tax instruments are available (Bucovetsky and Wilson, 1991). The theoretical literature thus predicts that for the local level differences in the taxation of mobile factors should be larger than for regions or countries[1], since the number of competing local jurisdictions is regularly very high. For example, there are more than 11,000 municipalities in Germany which independently choose the rates of the local business tax (*Gewerbesteuer*). Size differences are significant, ranging from less than 100 to more than 3 million inhabitants.

In this paper we argue that the above predictions do not necessarily hold in the context of local tax competition. In particular, larger jurisdictions may make less use of distortionary taxes than smaller municipalities, since they are confronted with a bigger set of competitors. The purpose of this paper is to highlight this additional channel in a novel theoretical model of interdependent tax making. Unlike most of the theoretical literature we do not assume that *every* jurisdiction competes with *every* other jurisdiction. Unlike many authors in empirical tax competition research we do not assume that for all types of municipalities the degree of fiscal competition is decreasing in distance and therefore strongest among geographic neighbours. Instead we assume that there are two levels of competition: (1) There is local competition among geographically close neighbours, and in addition (2) we assume that large/populous jurisdictions, called cities, compete with other cities of which some are geographically far.

Support for our modelling assumptions comes from recent empirical research, which will be discussed below, as well as an own survey we conducted among more than 700 mayors in the German state of Baden-Württemberg. We study the spatial structure of local tax competition by asking local politicians who they actually consider to be their main competitors for mobile capital. The size of the jurisdiction turns out to be an important determinant of

[1]Empirical support for the first statement comes from in Baldwin and Krugman (2004) as well as Haufler and Wooton (2010), among others, who report country level data.

the decision-maker's perception of the intensity of competition. Compared to non-urban municipalities, respondents from urban centres (up to population of 600,000) perceive a much higher intensity of competition for firms in general, and especially with respect to competing jurisdictions which are distant or even located in other countries. By contrast, mayors from smaller municipalities (usually with populations of 1,000 to 10,000 inhabitants) regularly state that they don't compete with distant jurisdictions for mobile firms. Moreover, we find evidence that jurisdictions in the direct neighbourhood are generally regarded as especially important competitors.

We are not the first to point out that fiscal interaction among governments is not only driven by competition among geographic neighbours. Case et al. (1993, 287) argue that "neighbourliness does not necessarily connote geographic proximity" and demonstrate that US states' expenditures do not only depend on their geographical neighbours' expenditures, but also depend on those of states which are economically (per capita income) or demographically (racial composition) similar. This finding suggests that spatial interactions do not have to be restricted to their geographic neighbourhood, but can occur over longer distances if jurisdictions are similar in an economic sense. Such considerations, however, have not explicitly been adopted by the theoretical literature. We push this idea in the context of the revenue side of the government budget and essentially ignore the role of expenditures. This reflects our view that at the local level tax differences between geographic neighbours are more important than at the country or regional level, because firms can more easily benefit from infrastructure and agglomeration advantages in neighbouring jurisdictions when these are geographically close.

Our model assumes n metropolitan regions, each of which consists of one urban centre, called *city*, and m surrounding jurisdictions called *hinterlands*. There are two levels of competition for mobile capital. First, cities simultaneously compete for mobile capital by setting their tax policies, followed by capital movements between cities. This represents the level of competition between non-neighbouring communities identified in our survey. Second, after the cities' tax choices and initial capital movements, hinterlands compete simultaneously for capital *within* their metropolitan area, taking the city's tax rate and the total metropolitan capital supply as given. This approximates the neighbourhood competition effect described above and is closely linked to the empirical literature on fiscal interactions at the local level (see Brueckner, 2003, and Revelli, 2005, for surveys).[2] One way to think about our sequential structure is to view cities as the primary competitors for large-scale investments, such as headquarters or FDI, which are often accompanied by smaller investments (for example from suppliers or subcontractors). After the large-scale investment has been located in a city, the associated suppliers and subcontractors have strong incentives to settle in a reasonable distance to their client, i.e. in the same metropolitan region.[3] We find this interpretation helpful even though in our theoretical model we do not distinguish between different types of capital or firms for tractability reasons.

We then compare the outcome of the fiscal competition game from this model, called the *sequential model*, to a traditional tax competition model, called the *simultaneous model,* in which all governments decide simultaneously in an otherwise identical setup. We are particulary interested in the effects of a rise in the number of metropolitan regions n, which approximates the increase in competition through globalisation (or in Germany's context the effects from Eastern enlargement of the EU and German unification).[4] Our first result is a limit result and demonstrates in both types of model that for a very large number of metropolitan regions ($n \to \infty$) capital tax rates in cities converge to zero, while for hinterlands the capital tax rate goes to zero in the simultaneous model, but stays bounded above zero in the sequential model. Secondly, in the sequential model an increase in n affects cities more than hinterlands in two ways: i) cities reduce capital tax rates more than hinterlands lower theirs, and ii) cities shift more from mobile capital taxation to immobile labour taxation than hinterlands. Result i) does not hold in the simultaneous model, where in cities the effect can be larger or smaller than in hinterlands and is typically close to zero when evaluated numerically. Our sequential model thus predicts that hinterlands are less affected than cities by increasing competition from entry of metropolitan regions. As

[2]Therefore two commitment assumptions are built into our model: i) A city's capital tax is fixed once its hinterlands compete (but the city rationally anticipates competition from hinterlands), and ii) after the cities' tax competition game capital is mobile only within the city's metropolitan region but not beyond.

[3]This finding gets further empirical support from van Dijk and Pellenbarg (2000), who show that the vast majority of firm relocations in the Netherlands occur in the form of short distance moves. Brueckner and Saavedra (2001) argue why capital – although theoretically completely mobile at least within a country – is supplied inelastically within a region and, thus, remains in the respective metropolitan region. For instance, investment in specialised industries is strongly tied to a region. Moreover, closeness to suppliers or selling markets as well as existing local networks are further reasons why firms may not respond elastically after they are locked in a location.

[4]In the literature globalisation is often modelled as a fall in the cost of international transactions (e.g. transportation costs), see for example, Haufler and Wooton (2010) in a tax competition context. Others use the change in the number of jurisdictions to model the degree of competition, see, for instance, Janeba and Schjelderup (2009), which seems the more appropriate approach in the current context.

empirically hinterlands are typically much smaller than urban centres, our model contrasts to research which has shown that smaller or more peripheral countries have lower corporate tax rates than large countries or regions in the core.

The rest of the paper is organised as follows. In section 2 we present motivating evidence from our survey and discuss related theoretical and empirical work. In section 3, we introduce a sequential model, present the results and compare them to a simultaneous model (shown in the appendix). Section 4 concludes.

2 Motivation and Related Literature

2.1 Motivating Evidence

Our model structure is motivated by empirical findings from studies of local tax competition and results taken from an own survey conducted among decision-makers in (southwestern) German municipalities. The existing empirical literature on spatial interactions suggests that capital mobility is highest between neighbouring jurisdictions. Spatial tax interaction is demonstrated for the local business tax in the German state of Baden-Württemberg by Buettner (2001), for local business property taxes in the metropolitan area of Boston (Brueckner and Saavedra, 2001), and the Canadian province of British Columbia (Brett and Pinkse, 2000). Yet, evidence for spatial fiscal interaction is by itself not a sufficient proof for the existence of capital tax competition that is induced by high capital mobility between neighbouring jurisdictions. In fact, the direct evidence for tax base mobility is mixed.[5]

Moreover, recent empirical evidence suggests that cities from different metropolitan areas compete with each other, without the participation of smaller municipalities. Strauss-Kahn and Vives (2009) show for the USA that headquarters are highly concentrated in urban areas due to agglomeration externalities and the need for infrastructure. They also find that headquarters are quite mobile and are attracted by low corporate taxes. The importance of local taxation is also shown for the location decision of foreign multinational enterprizes'

[5] The observed patterns may also have other causes, such as yardstick competition (see Revelli, 2005). Brett and Pinkse (2000) as well as Brett and Tardif (2008) do not find any effect of neighbours' levels of business property tax rates on the tax base in the Canadian province of British Columbia. Positive evidence comes from Buettner (2003), who finds evidence only for relatively small municipalities in Baden-Württemberg whose tax bases are positively affected by the local business tax rates of their neighbours.

(MNEs) within Germany, see Becker at al. (2012). The vast majority of municipalities does not attract any foreign affiliate since these have to meet further conditions – such as appropriate infrastructure, skill level and abundance of the work force – in order to be able to compete for MNE investment; these are usually only fulfilled by urban centres (further evidence comes from Guimarães, Figueiredo, and Woodward (2000) and is summarised by Dembour (2008)).

These two different strands of literature thus suggest that cities compete with their neighbouring (rural) communities as well as more distant cities for mobile capital, while rural communities should predominantly regard neighbouring jurisdictions as their competitors. Further support for this hypothesis comes from a survey of political decision-makers, which we conducted among the mayors of all 1108 cities and municipalities in the German state of Baden-Württemberg in May 2008.[6] Mayors are elected directly by citizens, head the administration, and preside over the local council (see Wehling, 2003, for an overview of the institutional structure). Our survey question of interest is: "With which cities and municipalities do you perceive yourself to be in competition for businesses?" Respondents were asked to assess the strength of competitive pressures on a discrete scale from -4 (not at all regarded as competitors) to +4 (very strongly regarded as competitors) regarding three types of jurisdictions: (Q1) cities and municipalities in Baden-Württemberg, (Q2) cities and municipalities in other German states and (Q3) cities and municipalities in other countries. The high response number of 714 (64.4% of all municipalities) provides us with a sizeable sample for our empirical investigation.

We are primarily interested in the effect of jurisdiction size on the perceived competitive pressure. Figure 1 shows the distributions of responses to the three survey questions conditional on the size of the jurisdictions. Jurisdictions are partitioned into deciles plus the twenty biggest jurisdictions of the state. All three diagrams indicate that larger cities perceive the highest degree of competitive pressures; however, this effect varies strongly depending on the reference group. Perception depends strongly on size when competition with more distant competitors in other German states or different countries is considered (Q2 and Q3): it is mostly the biggest municipalities which regard these as their competitors. The interpretation of the perceptions for competition with local competitors within the

[6]Surveys of political decision have been used by Heinemann and Janeba (2011) to study perceptions of German politicians with respect to the constraints on tax policy arising from globalisation, and by Ashworth and Heyndels (1997, 2000) for tax reform preferences of local politicians in Belgium.

state (Q1) is more difficult because the survey question does not allow us to disentangle the perceived intensity of competition with urban centres and rural areas within the state. The responses confound the two channels discussed above, i.e. competition with neighbouring municipalities as well as with more distant jurisdictions within the same state. If we expect the answers to this question to be driven by the same factors as for questions Q2 and Q3, this should bias the results upwards for bigger cities. However, we observe that the scores on Q1 are similar in size – despite the potentially boosting effect for bigger cities – and very high for all jurisdiction size categories. This observation is in line with our view that smaller and bigger jurisdictions are both affected by competition with their geographic neighbours.[7]

[Figure 1 about here]

2.2 Related Literature

Our theoretical approach is related to several strands of literature. Few of the empirical contributions on local tax competition (e.g. Buettner, 2001; Brueckner and Saavedra, 2001; Hauptmeier et al., 2012) base their empirical analyses on explicit theoretical considerations other than standard tax competition models in the tradition of Zodrow and Mieszkowski (1986), and are modified only by restricting the number of competing jurisdictions. Capital is completely mobile within one region, but not at all mobile with respect to jurisdictions in other regions, so that jurisdictions only compete for capital with jurisdictions from the same region. This assumption, however, is refuted by our survey results for larger cities. Consistent with our approach is the finding that not all jurisdictions compete for capital to the same degree. Jayet and Paty (2006) and Matsumoto (2010) endogenise the number of jurisdictions competing for mobile capital. Local jurisdictions have to pay a development

[7] In the discussion paper version of this paper (Janeba and Osterloh, 2013), we demonstrate the robustness of the descriptive findings from figure 1 in a seemingly unrelated regressions (SUR) ordered probit model. In order to test the statistical significance of the effect of municipal size, we use the jurisdiction's number of inhabitants and dummies for district types (coming from the state's spatial planning programme) as independent variables, respectively. The regression results confirm that the size effect turns out to be statistically significant after controlling for socio-economic and political municipal characteristics. For the identification of neighbourhood effects we use the proximity to subnational and international borders as reference points. We find that the perceived intensity of competition with municipalities from other German states is statistically significantly higher for those municipalities located adjacent to a state border – and consequently for those jurisdictions that are direct neighbours of jurisdictions in other states – than for non-border municipalities (see also Geys and Osterloh (forthcoming) for more details). Similar but weaker effects can be found for jurisdictions adjacent to a country border relating to international competition perceptions.

cost before entering the competition for a mobile firm. In equilibrium not all jurisdictions enter competition for outside investment. The main focus of these papers is on the overall number and not the type of jurisdictions that compete.

The theoretical tax competition literature has identified size differences (expressed as differences in labour endowments) as a factor for explaining why different jurisdictions are affected asymmetrically by tax competition (see Bucovetsky, 1991, and Wilson, 1991). In these two-jurisdiction models, the small jurisdiction suffers a bigger outflow of capital after an increase of its capital tax rate than the bigger competitor, so that the smaller jurisdiction sets the lower tax rates than the bigger one.[8] Kächelein (forthcoming) explains tax rate differences among jurisdictions of different size even when they are small in the global capital market by introducing asymmetries in the symmetric model of Braid (1996). In a model with three production factors he allows for capital mobility across and labour mobility within a metro region. When labour income is taxed at source, larger jurisdictions choose higher tax rates on capital due to a second fiscal externality arising from commuting.

The standard asymmetric tax competition model bears important implications for empirical work on spatial interaction patterns. A size effect interacts with the neighbourhood effect, since tax rates can be expected to react – ceteris paribus – stronger to bigger neighbours than to smaller ones. This is considered in many empirical papers by applying a combined weighting matrix which considers distance and size (measured as population or GDP, see e.g. Brueckner and Saavedra, 2001). Yet, these models focus only on the pure size effects and do not consider that larger urban centres might compete with a different set of competitors for mobile capital than smaller rural areas.

Concerning the model structure, Gordon (1992) and Wang (1999) assume similar to us a sequential timing with the bigger region moving first. This assumption gets support from empirical evidence on international corporate tax reforms (see e.g. Kumar and Quinn, 2012). Sequential game structures are also common in new economic geography models for tax competition, such as in Baldwin and Krugman (2004) and Borck and Pflüger (2006). A new approach has been presented by Kempf and Rota-Graziosi (2010) who endogenise the moves in a simple two-region tax competition model and find that in their model the smaller

[8] Most recently, Bucovetsky (2009) shows that this result can be generalised for federations consisting of more than two jurisdictions. Zissimos and Wooders (2008) advance the literature by endogenizing the size of countries through the endogenous choice of public input goods.

region might have incentives to move first.

3 The Model

In this section we develop a multi-stage model of fiscal competition between many metropolitan regions, each consisting of a city and several surrounding jurisdictions called hinterlands. Important assumptions of the model are motivated by the discussed findings from the empirical literature on local tax competition as well as the survey results reported above: First, capital has to be regarded as particularly mobile between directly neighbouring jurisdictions. Second, larger cities, and in particular regional and secondary centres, additionally perceive a high intensity of competition with more distant jurisdictions.

The model builds on Borck (2003), who examines the choice of tax policy in a political economy context with heterogeneous agents. He considers only one level of competition and there is no distinction between cities and hinterlands. We extend his work in a substantial way by considering the interaction between different types of jurisdictions in a multi-stage game. The economy consists of n symmetric metropolitan regions indexed by i, each comprising one city and m symmetric hinterland municipalities indexed by j. Hence, there are $n(1+m)$ jurisdictions in the economy. This structure is illustrated in figure 2 for the case of 3 regions with each containing 3 hinterlands, i.e. $n = 3$, $m = 3$. Our main interest is in determining how increases in n, interpreted as globalisation (for example via German unification or integration of Eastern Europe into the EU), affect equilibrium tax policy. Our model allows us to analyse changes in the number of hinterlands m, perhaps resulting from the merger of small localities, even though this is not the focus of our work in this paper.

[Figure 2 about here]

Output of a numeraire consumption good is produced using interjurisdictionally mobile capital and immobile labour. In each region i, the population share of all hinterlands together is denoted as s, so that the population share of a city is $1 - s$. Each hinterland thus has a population share of s/m. The parameter s is the size parameter known from the literature on asymmetric tax competition: Larger jurisdictions tend to have higer tax rates. In our context a larger s should induce higher (lower) tax rates in hinterlands (cities). Capital (expressed in per capita terms) is equally distributed between all jurisdictions in the sense that cities and hinterlands in all regions have the same capital-labour endowment $\bar{k}^{c,i} = \bar{k}^{h,ij} = \bar{k}$. Capital use k in any particular jurisdiction may differ from this value due to fiscal policy differences.

We assume that the production function is quadratic in order to keep the analysis tractable, which in intensive form reads (we leave out city and hinterland subscripts when no confusion is possible):

$$f(k) = ak - b\frac{k^2}{2}. \tag{1}$$

Some but not all of our qualitative results should hold for more general production functions and we will point this out where applicable.

Each jurisdiction is populated by many consumers who differ in their capital and labour endowment (which is explained in more detail below). Each individual consumes the numeraire consumption good and a public good which is provided by its local government. Preferences are assumed to be quasi-linear:

$$U(c, g) = c + u(g) \tag{2}$$

where c is the private consumption good, g the publicly provided private good – called the public good in the following – and the partial derivatives obey $u' > 0$ and $u'' < 0$. We assume that one unit of the private good can be transformed into one unit of the public good. The public good is provided by the government and financed through two taxes: (i) a distortionary tax per unit of capital levied at source t and (ii) a non-distortionary labour tax τ. Given that labour is immobile and fixed in supply, the labour tax is effectively an efficient lump sum tax.

Finally, we introduce an unequal endowment of labour and capital among individuals. In every region, the factor e determines the individual per capita endowment of labour, $(1+e)$, and capital, $(1-e)\bar{k}$. The factor e has a zero mean but a non-zero median and is restricted to the interval $[-1, 1]$. The heterogenous distribution of endowments ensures – equivalently to Borck (2003) – that both tax instruments are used in equilibrium.[9] We are now in a position

[9]This intentionally contrasts with much of the earlier literature (such as Bucovetsky and Wilson, 1991) which predicts no use of the distortionary tax in small jurisdictions as soon as a non-distortionary tax becomes available.

to pin down an individual's private consumption c, which is financed from the return to the fixed factor labour plus the profits from the capital endowment. The return to labour equals the residual output after payment for capital use minus the labour tax:

$$c = (1+e)[f(k) - (\rho + t)k - \tau] + (1-e)\rho\bar{k}, \tag{3}$$

where $\rho = f'(k) - t$ is the net return to capital.

The public good is financed by taxing capital and labour:

$$g = tk + \tau, \tag{4}$$

which represents the government budget constraint.

The game structure can be summarised as follows:

In the *first stage*, all n cities determine simultaneously their capital and labour tax rates $\{t^{c,i}, \tau^{c,i}\}_{i=1,\ldots,n}$. Each city takes the tax rates in all other cities as given. In addition, in each city the tax policy tuple must be the outcome of a majority rule voting process where voters take into account how the city's tax policy affects subsequent play.

In the *second stage*, capital is completely mobile between cities. A city i obtains a per capita capital stock of $\tilde{k}^i$, which depends on the tax policy vector from stage 1. The net return on capital is equalised across metropolitan regions, where the net return captures correctly the outcome of the game among hinterlands in region i. Together with the capital endowments of the hinterlands this determines the overall capital stock available in a metropolitan region in stages 3 and 4.

In the *third stage*, all hinterlands of metropolitan region i choose simultaneously their tax policies, $\{t^{h,ij}, \tau^{h,ij}\}_{j=1,\ldots,m}$. Each hinterland takes the city's tax rates $\{t^{c,i}, \tau^{c,i}\}$ and the tax policy of all other hinterlands in the *same* metropolitan region as given. In each hinterland tax policy forms a majority rule voting equilibrium, taking subsequent choices into account.

In the *fourth and final stage*, capital within a metropolitan region i is allocated between the city and its hinterlands, so that $k^{c,i}$ and $\{k^{h,ij}\}_j$ result, based on $t^{c,i}$ and $\{t^{h,ij}\}_j$. The net returns to capital between the city and its hinterlands in the same region are equalised. At this stage, capital can only flow within a metropolitan area by assumption. Production and consumption take place, and the government provides the public good in all jurisdictions.

The model is solved via backward induction.

Before solving the model it is useful to discuss briefly the nature of capital mobility. In our model capital is assumed to be homogenous and rates of return are equalised. At the same time capital supply from hinterlands is de facto constrained to stay within the metropolitan region. One way of rationalizing this structure is to think of the capital supply in hinterlands as savings from local citizens who channel it to local savings banks, who in turn primarily invest in local and regional firms. By contrast, large mobile firms often finance their investment from internationally integrated equity markets or borrow from national and international banks who obtain deposits from savers around the world. These are the firms that make investment decisions in stage 2 of our model.

3.1 Solving the model

3.1.1 Stage 4

We consider a typical metropolitan region i and drop the index whenever possible to simplify notation. In the final stage, capital use of a city and its hinterlands depends on the capital tax rates of those jurisdictions $(t^c, t^{h,j})$. The overall supply of capital which is available in any given metropolitan region consists of the initial endowment of the hinterlands, which is $\bar{k}$ per jurisdiction, and the capital stock that is available in the city, $\tilde{k}^i$ (which comes out of stage 2). The capital market equilibrium condition can be written

$$(1-s)k^c + \frac{s}{m}\sum_{j=1}^{m} k^{h,j} \leq (1-s)\tilde{k} + s\bar{k}, \tag{5}$$

which means that capital use cannot exceed capital supply. When the net return to capital ρ is positive, condition (5) holds with equality. Recall that s is the population share of all hinterlands in a metro region.

Assume for now that the equilibrium is characterised by positive ρ and thus (5) holds with equality. Then in equilibrium, the net return to capital, $\rho = f'(k) - t$, has to be identical in the city and every municipality in the hinterland:

$$\rho = a - bk^c - t^c = a - bk^{h,j} - t^{h,j} \tag{6}$$

Combining (5) and (6) gives the capital stock in a city

$$\begin{aligned} k^c(\{t^{h,j}\}_j, t^c, \tilde{k}) &= s\bar{k} + (1-s)\tilde{k} + \frac{s}{b}\left(\frac{\sum_{j=1}^m t^{h,j}}{m} - t^c\right) \\ &= \widehat{k} + \frac{s}{b}(\overline{t^h} - t^c), \end{aligned} \tag{7}$$

and its hinterlands

$$\begin{aligned} k^{h,j}(\{t^{h,j}\}_j, t^c, \tilde{k}) &= s\bar{k} + (1-s)\tilde{k} + \frac{(1-s)t^c}{b} + \frac{s\sum_{l\neq j} t^{h,l} - (m-s)t^{h,j}}{mb} \\ &= \widehat{k} + \frac{(1-s)t^c + s\overline{t^h} - t^{h,j}}{b}, \end{aligned} \tag{8}$$

as functions of capital tax rates, the capital supply in the metro area and exogenous parameters, where $\widehat{k} = s\bar{k} + (1-s)\tilde{k}$ is the metropolitan region's capital supply and $\overline{t^h}$ is the average tax rate of hinterlands in that region. Note that in both expressions the first two terms denote the capital supply within the metropolitan region and the last two terms capture the adjustment due to tax differentials between the city and the municipalities in the hinterland. For both (7) and (8), an increase in the own tax rate lowers the amount of capital employed, while an increase in another jurisdiction's tax rate increases capital use; in particular, we obtain

$$\frac{\partial k^{h,j}}{\partial t^{h,j}} = \frac{s-m}{mb} < 0.$$

It is easy to see that after inserting (7) and (8) into (6) the net return to capital is declining in any jurisdiction's tax rate. For example, we get $\partial\rho/\partial t^{h,j} = -s/m < 0$.

3.1.2 Stage 3

We now solve for the tax policy equilibrium within a metropolitan region, given the tax policy of the city (from stage 1) and capital stocks determined in stage 2 for that city (t^c and $\tilde{k}$, omitting city index i). Since fiscal policy in each hinterland must be a political equilibrium, we follow Persson and Tabellini (2000) and (omitting hinterland indices) rewrite the utility function of a voter with endowment e after substituting (3) and (4) into (2) as

$$U((t,\tau);e) = J(t,\tau) + eH(t,\tau),$$

where

$$\begin{aligned} J(t,\tau) &= f(k) - (\rho+t)k - \tau + \rho\bar{k} + u(tk+\tau), \\ H(t,\tau) &= f(k) - (\rho+t)k - \tau - \rho\bar{k}, \end{aligned}$$

and k is the capital stock of the hinterland community as given by (8), which in turn depends on t and τ. The intermediate preferences condition (see Grandmont, 1978) can be applied if voter utility can be written as a function of the idiosyncratic term e, where the constant $J(t,\tau)$ and the slope parameter $H(t,\tau)$ are common to all voters and the term involving e is monotonic in e. Consequently, the equilibrium tax rates depend on the capital endowment of the median voter, $\hat{e}$. In the standard case of equal endowments of all citizens within each jurisdiction, i.e. $\hat{e} = 0$, the median voter would only use the non-distortionary labour tax and set the rate of the distortionary capital tax to zero (assuming no terms of trade argument). We will show below that in our model an equilibrium with positive tax rates for both tax instruments occurs only if we assume that the distribution of the capital endowment is skewed to the right, so that $\hat{e} > 0$. This seems empirically reasonable. Furthermore, it is assumed that $\hat{e}$ is identical in all cities and hinterlands.

Before we proceed, we need to make sure that private consumption c is nonnegative. The constraint could become binding if the level of public good provision is high and the funding is coming (mainly) from the labour tax. The problem is not aggravated by heterogeneous endowments: Consumption (3) is nonnegative for everyone if the average labour income net of tax, $f(k) - (\rho+t)k - \tau$, is nonnegative because $e \in [-1, 1]$. Using the definition of ρ and inserting the production function (1), the expression is nonnegative if the labour tax satisfies $\tau \leq bk^2/2$. The capital allocation does not directly depend on the labour tax. Hence by assuming a low enough value for the value of the public good, consumption is nonnegative.[10]

[10] An alternative way of guaranteeing the same is to assume that all consumers have a strictly positive endowment of the private good. This does not change the maximisation problem subsequently as wealth enters the utility function linearly in private consumption and the price of the consumption good is the numeraire. The assumption makes sense economically if we think of this endowment as own or inherited

We now focus first on a Nash equilibrium in which total capital supply is actually used (no excess capital supply). In Appendix A.4 we demonstrate under weak assumptions the existence and uniqueness of the Nash equilibrium in stage 3, similar to Bucovetsky (2009). The preferred policy of the median person in hinterland j of metropolitan region i is derived by maximising utility function (2) with respect to $t^{h,ij}$ and $\tau^{h,ij}$, subject to individual budget constraint (3), government budget constraint (4), and the capital stock functions (7) and (8). The two first order conditions are (index i is omitted):

$$-(1+\hat{e})f''(k^{h,j})\frac{\partial k^{h,j}}{\partial t^{h,j}}k^{h,j} + (1-\hat{e})\frac{\partial \rho}{\partial t^{h,j}}\bar{k} + u'(g^{h,j}) \cdot \left(k^{h,j} + t^{h,j}\frac{\partial k^{h,j}}{\partial t^{h,j}}\right) = 0 \tag{9}$$

and

$$u'(g^{h,j}) - (1+\hat{e}) = 0. \tag{10}$$

Equation (10), the first order condition from optimising over the labour tax, fixes the supply of the public good as function of the median's endowment parameter $\hat{e}$.[11] The number of hinterlands or their joint population share s does not matter. The provision is efficient if the distribution of capital-labour endowments is not skewed (i.e., $\hat{e} = 0$).

After inserting the comparative-static results reported at the end of stage 4, as well as (8) into (9), and assuming a symmetric equilibrium for all hinterlands, we obtain a reaction function $t^{h,j}(t^c, \tilde{k})$ for a typical hinterland jurisdiction with respect to the city's capital tax:

$$t^h(t^c, \tilde{k}) = \left(\frac{s}{m-s^2}\right)\left[(1-s)\left(b\tilde{k} + t^c\right) + \frac{b\bar{k}[\hat{e} - 1 + s(1+\hat{e})]}{(1+\hat{e})}\right]. \tag{11}$$

Note that a hinterland's capital tax is increasing in the city's tax rate and capital stock: $\frac{\partial t^h}{\partial t^c} > 0$ and $\frac{\partial t^h}{\partial \tilde{k}} > 0$. In addition, for given $\tilde{k}$ and t^c, the hinterland's capital tax rate goes

wealth that is not taxed by local jurisdictions.

[11] The second order conditions are fulfilled. More specifically, the second derivative with respect to the capital tax rate, the labour tax and the cross derivative can be written as

$$\begin{aligned}(1+\widehat{e})\left(\frac{s^2-m^2}{m^2 b}\right) + u''\left(\frac{dg^{h,j}}{dt^{h,j}}\right)^2 &< 0,\\ u'' &< 0\\ u''\frac{dg^{h,j}}{dt^{h,j}} &< 0,\end{aligned}$$

assuming the government is on a upward sloping part of its revenue curve. It is then easily verified that the product of the first two conditions is larger than the square of the third condition, thus indicating a maximum.

to zero as the number of hinterland communities m converges to infinity. In that situation, hinterlands use only the nondistortionary labour tax.[12]

Next, we insert the reaction function (11) into $k^c(\{t^{h,j}\}, t^c, \tilde{k})$ and $k^{h,j}(\{t^{h,j}\}, t^c, \tilde{k})$ from stage 4 to obtain the capital allocations k^c and k^h (now the same in all hinterlands):

$$k^h(t^c, \tilde{k}) = \frac{(1-s)(m-s)}{(m-s^2)}\left[\frac{t^c}{b} + \tilde{k}\right] + \frac{\bar{k}s\,[m(1+\hat{e}) - 2s + 1 - \hat{e}]}{(1+\hat{e})(m-s^2)} \tag{12}$$

and

$$k^c(t^c, \tilde{k}) = \frac{m(1-s)}{(m-s^2)}\tilde{k} - \frac{s(m-s)}{b(m-s^2)}t^c + \frac{\bar{k}s[m(1+\hat{e}) + (\hat{e}-1)s]}{(1+\hat{e})(m-s^2)}. \tag{13}$$

As expected, a higher capital tax rate in the city increases capital use in hinterlands and lowers it in the city ($\frac{\partial k^h}{\partial t^c} > 0$, $\frac{\partial k^c}{\partial t^c} < 0$). In addition, a bigger capital supply increases capital employed everywhere ($\frac{\partial k^h}{\partial \tilde{k}} > 0$, $\frac{\partial k^c}{\partial \tilde{k}} > 0$).

The labour tax follows from the government budget constraint $\tau^h = g^h - t^h k^h$, where g^h is determined by (10), as argued above. The net return to capital in metropolitan region i can be determined by substituting (11) and (12) into (6):

$$\rho(t^{c,i}, \tilde{k}^i) = a - \frac{m(1-s)[b\tilde{k}^i + t^{c,i}]}{(m-s^2)} - \frac{\bar{k}sb[m(\hat{e}+1) + s(\hat{e}-1)]}{(1+\hat{e})(m-s^2)}. \tag{14}$$

This net return incorporates the strategic interaction of hinterlands for a given capital supply and city capital tax rate in region i.

3.1.3 Stage 2

We now consider the interaction of tax setting and investment decisions across metropolitan regions. In stage 2, equilibrium in the capital market across cities is considered for a given vector of cities' tax policies. In the location decision, capital owners correctly anticipate how subsequently competition among hinterlands affects the net return in a region. Since capital is perfectly mobile between all cities, the capital allocation has to entail the equalisation of

[12] It is true that the hinterland tax rate on capital is not zero when the capital distribution is not skewed due to terms of trade considerations in the capital market. This result holds for a given tax rate of the city, which is, however, endogenous and itself depends on e.

the net returns

$$\rho = a - bk^{c,i} - t^{c,i} = a - bk^{c,v} - t^{c,v} \tag{15}$$

for any pair of cities $v \neq i$. In equation (15), the capital stock as derived in (13) enters as this is the amount of capital a city obtains given the all cities' tax policies and forseeing the subsequent adjustment in hinterland tax policies and capital allocation.. Condition (15) implies for any two cities that

$$k^{c,v} = \frac{bk^{c,i} + t^{c,i} - t^{c,v}}{b}. \tag{16}$$

In addition, the capital market of the cities has to be in equilibrium:

$$\tilde{k}^i + \sum_{v \neq i} \tilde{k}^v = n\bar{k} \tag{17}$$

Combining (13), (16) and (17), we can solve for $\tilde{k}^i$:

$$\tilde{k}^i(t^{c,1}, ..., t^{c,n}) = \bar{k} + \frac{\sum_{v \neq i} t^{c,v} - (n-1)t^{c,i}}{nb}. \tag{18}$$

We may now determine the capital stocks in cities and hinterlands as a function of cities' capital tax rates only by inserting (18) into (11)-(13):

$$k^{c,i} = \frac{(1-s)mT - n(m-s^2)t^{c,i}}{bn(m-s^2)} + \frac{\bar{k}[m(1+\hat{e}) + (\hat{e}-1)s^2]}{(1+\hat{e})(m-s^2)}, \tag{19}$$

$$k^h = \frac{(m-s)(1-s)T}{bn(m-s^2)} + \frac{\bar{k}[m(1+\hat{e}) + s^2(\hat{e}-1) - 2\hat{e}s]}{(m-s^2)(1+\hat{e})}, \tag{20}$$

$$t^h = \frac{s(1-s)T}{n(m-s^2)} + \frac{2b\hat{e}\bar{k}s}{(1+\hat{e})(m-s^2)}, \tag{21}$$

where $T = \sum_{i=1}^{n} t^{c,i}$ is the sum of all cities' capital tax rates. In addition, the net return to capital is found by substituting (18) into (14) and rearranging terms:

$$\rho(t^{c,1}, ..., t^{c,n}) = a - \frac{m(1-s)T}{n(m-s^2)} - \frac{b\bar{k}[m(1+\hat{e}) + (\hat{e}-1)s^2]}{(1+\hat{e})(m-s^2)}. \tag{22}$$

Note that hinterland variables and the net return to capital depend only on the sum of the cities' tax rates (and exogenous parameters). A city's capital stock is negatively affected by a raise in its capital tax but increases with tax increases in other cities.

3.1.4 Stage 1

In the first stage, all n cities determine simultaneously their tax policies $\{t^{c,i}, \tau^{c,i}\}_i$. Each city takes in its decision the tax policy of all other cities as given, but rationally anticipates the effects of its tax policy on its capital stock and hinterland policies in subsequent stages as shown in (19)-(21). A city's tax policy must also be a majority voting equilibrium. We use the same approach as under stage 3 to argue that the preferred policy of the median endowment person prevails.[13] To find this policy, we maximise the utility of the median voter with respect to tax rates, given the vector of all other cities' tax rates. Therefore, we have to solve

$$\max_{t^{c,i},\tau^{c,i}} (1+\hat{e}) \left[f(k^{c,i}) - f'(k^{c,i})k^{c,i} - \tau^{c,i} \right] + (1-\hat{e})\rho\bar{k} + u((t^{c,i}k^{c,i}) + \tau^{c,i}), \tag{23}$$

where $k^{c,i} = k(t^{c,i}, \{t^{c,v}\})$ and $\rho = \rho(t^{c,i}, \{t^{c,v}\})$ come from (19) and (22), respectively. Similar to (10), the derivative with respect to $\tau^{c,i}$, after setting equal to zero, delivers $u'(g^{c,i}) - (1 + \hat{e}) = 0$ and, thus, determines the public good level g. The public good level in cities and hinterlands is the same when the endowment distribution is the same, which we assume.

We then differentiate the utility function with respect to $t^{c,i}$, replace u' by $(1+\hat{e})$ and make use of the symmetric equilibrium property $t^{c,i} = t^c$ for all i. This gives us the equilibrium capital tax rate in a symmetric city equilibrium

$$t^c = \frac{2m^2\hat{e}b\bar{k}(1-s)}{(1+\hat{e})\left[n(m-s^2)^2 - m^2(1-s)^2\right]} \geq 0, \tag{24}$$

and after inserting into (21) the equilibrium capital tax rate for each hinterland

$$t^h = \frac{2\hat{e}b\bar{k}sn(m-s^2)}{(1+\hat{e})\left[n(m-s^2)^2 - m^2(1-s)^2\right]} \geq 0. \tag{25}$$

To see that capital tax rates are nonnegative, it is sufficient to show that the denominators

[13] Existence and uniqueness of equilibrium follow from the same line of reasoning as in Appendix A.4 for stage 3. The structure of the problem is comparable to (7) and (8), as capital demand functions (19)-(21) are linear in tax rates.

are positive, that is $n(m-s^2)^2 > m^2(1-s)^2$. This condition holds for $m=1$ when $n>1$. Moreover, the left hand side of the inequality is rising faster in m than the right hand side because $2n(m-s^2) > 2m(1-s)^2$, thus proving the claim.

Conditions (24) and (25) are the key expressions for our further analysis as they capture the equilibrium capital tax rates as a function of exogenous parameters, in particular the number of metropolitan regions n. All other equilibrium variables now follow from simple substitution. In particular, the equilibrium capital stocks are found by inserting the equilibrium capital tax rates into (19) and (20). In a symmetric city equilibrium, the overall capital stock is identical in all metropolitan regions, so that $\tilde{k}^i = \bar{k}$. Conditions (24) and (25) make also intuitively sense. For example, when the parameter of the production function b is zero, production is linear in the capital-labour ratio and thus jurisdictions compete in a Bertrand fashion, leading to zero equilibrium tax rates on capital. Taking limits with respect to the size of jurisdictions gives also clear results: Capital tax rates of cities (hinterlands) go toward zero when the population share of hinterlands (cities) goes to 1. Moreover, changes in the size of jurisdictions have the following effects: An increase in the population size of all hinterlands in a region, s, lowers the tax rate of cities.[14] The effect on the capital tax rate of hinterlands is theoretically ambiguous due to the nonlinear structure (but in numerical simulations we conducted the hinterland tax rates rise with s).

3.2 Equilibrium Properties

We now turn to further characterising the equilibrium. We are particularly interested in how capital tax rates in cities and hinterlands, and the difference of the two, change with n. We also examine the extent of the shift of taxation from mobile to immobile factors in both types of jurisdictions. A change in n can be interpreted as globalisation or market integration such as the fall of communism that brought Eastern European countries into the European Union or German unification which extended the number of metro regions

[14]This follows from differentiation of (24) with respect to s. The derivative is

$$\frac{dt^c}{ds} = \frac{n(m-s^2)[4s(1-s)-(m-s^2)] - m^2(1-s)^2}{[n(m-s^2)^2 - m^2(1-s)^2]^2},$$

which is negative if the term in square brackets in the numerator is negative. This is the case, as it is negative for $s = 2/3$, which is the value that maximises the square bracket.

that compete for similar investment under the same political and legal system. In addition, we compare those findings to a model where all tax policy decisions, both by cities and hinterlands, are made simultaneously while maintaining all other assumptions. This model is called the simultaneous model, and its derivation is summarised in Appendix A.2.

We start with a limit result to demonstrate the difference between our sequential model and a standard tax competition model in which all governments make simultaneous choices.

Proposition 1. In the *sequential* model, the equilibrium capital tax rate of a city t^c converges to zero for $n \to \infty$, while the tax rate of a hinterland jurisdiction is bounded above zero. In the *simultaneous* model, capital tax rates of all jurisdictions converge to zero when the number of metropolitan regions becomes very large.

Proof: The convergence to zero of the city tax rate follows immediately from (24). Using l'Hôpital's rule, the hinterland's tax rate converges to $\frac{2\hat{e}b\bar{k}s}{(1+\hat{e})(m-s^2)^2} > 0$. The results for the simultaneous model are proven in the appendix.

The limit result should not be interpreted literally because in practice the number of metropolitan areas is not infinite. Still, local business tax rates even in small localities in Germany are clearly positive, although the number of potential competitors can be fairly large. This points to the usefulness of the sequential model, in which hinterland communities compete only in the geographic neighbourhood.

In addition to the limit result, we study the monotonicity of capital tax rates in the number of metropolitan regions n, and show that cities and hinterlands are affected differentially.

Proposition 2. In the sequential model, all capital tax rates in a symmetric equilibrium fall with n, but the capital tax rates of hinterlands fall less than the city's capital tax:

$$0 > \frac{dt^h}{dn} > \frac{dt^c}{dn}.$$

The proof for falling capital tax rates follows from differentiation of (24) and (25). To see that the city's tax rate falls more, combine (24) and (25) to obtain

$$t^c - t^h = \frac{2\hat{e}b\bar{k}[m^2(1-s) - sn(m-s^2)]}{(1+\hat{e})\left[n(m-s^2)^2 - m^2(1-s)^2\right]}, \tag{26}$$

which is decreasing in n as the numerator falls and the denominator rises in n. In the appendix, we show that in the simultaneous model the derivative $d(t^c - t^h)/dn$ can be positive or negative, and with the help of numerical simulations often close to zero in absolute value and small in comparison to the derivative in the sequential model with the same parameter values. In the simultaneous model, an increase in n has a similar effect on capital tax rates in cities and hinterlands, while in the sequential model hinterlands are somewhat more sheltered than cities. The tax differential (26) shows also that the ranking of tax rates of city and hinterland is ambiguous. For small m and high n a hinterland has the higher capital tax, while the reverse is true when n is small relative to m and s takes on a low value.

We now consider the shift in taxation from mobile to immobile factors, that is, the difference between the capital and labour tax rate $\Delta = t - \tau$, both for a typical city and a hinterland. In standard tax competition models more competition leads to a shift from taxation of mobile factors to immobile factors. This is also the case in the sequential model as the following result demonstrates.

Proposition 3. In the sequential model, for both cities and hinterlands the tax rate gap between the tax on mobile capital and immobile labour, $\Delta^r = t^r - \tau^r, r = c, h$, is falling in the number of metropolitan areas n.

The proof is given in Appendix A.3, where we also show that the result concerning tax rates extends to tax revenues.

We now go beyond the qualitative effect of Proposition 3 and analyse numerically for which type of jurisdiction (city, hinterland) the shift from mobile to immobile tax base is larger. We choose a specific subutility function for the public good, $u(g) = ln(g)$, in order to calculate the public good provision level and the tax rates on labour, τ^c and τ^h. From a hinterland's first order condition (10), and similar for a city from stage 2, we obtain the per capita provision level of the public good in c and h: $g = \frac{1}{1+\hat{e}}$. Substituting this value back into the government budget constraint, the labour tax rates are found to be $\tau^c = \frac{1}{1+\hat{e}} - t^c k^c$ and $\tau^h = \frac{1}{1+\hat{e}} - t^h k^h$, where the capital tax rates are taken from (24) and (25), respectively, and the capital stocks follow from (19) and (20) after appropriate substitutions. Together, these values allow us to calculate the tax rate gap between the capital and labour tax rate in cities *relative* to hinterlands, that is $d\Delta^c/dn$ and $d\Delta^h/dn$. In addition, we compare the absolute level of capital taxes in the two types of jurisdictions, i.e. we evaluate the sign of (26) as function of n.

[Figure 3 about here]

The dependency of capital tax rates and tax rate gaps in cities and hinterlands on the number of metropolitan regions n is visualised in figure 3. We plot the capital tax rates and the tax rate gaps as functions of the number of metropolitan regions, n, for the case of a small city (s=0.4) and a large city (s=0.1), respectively (other parameter values are $\overline{k} = 1, b = 1, \widehat{e} = 0.5$). The steeper line belongs to a city and is steeper than the one for the hinterland (as in other simulations that we did). Moreover, the two lines intersect, which means that for a low number of external competitors, the cities have the higher capital tax rate and the higher tax rate gap than the hinterlands, while the opposite is true for a high number of n, as then hinterlands rely more strongly on capital taxation. However, when the city gets bigger relative to the hinterlands (s=0.1), the city's curve is shifted upwards and the hinterland's curve is shifted downwards. This reflects the size effect discussed before and leads to a shift of the intersection to the right; i.e., in this case, the city undercuts the hinterlands' capital tax rates only for a very high number of metro regions n.

4 Discussion and Conclusion

In our theoretical analysis we have demonstrated that two different effects interact in our model of local tax competition. First, we have observed a pure size effect, which is well-known from the literature on asymmetric tax competition. Smaller jurisdictions rely less on capital taxation than bigger ones. Second, this effect is offset through external competition from cities in other metropolitan regions. Since cities react stronger to external competition than hinterlands, an increase in the number of metropolitan regions n implies a stronger shift to the use of immobile tax bases in cities than in hinterlands. For a sufficiently large number of competitors, the cities might make less use of capital taxation than their hinterlands.

Recent empirical evidence by Foremny and Riedel (2012) supports some of our predictions. They study the local business tax policy of German municipalities between 2000 and 2008; the local business tax (Gewerbesteuer) is levied directly on business earnings and can be regarded as a tax on mobile capital. They find that larger communities tend to have lower growth rates of their tax rates than bigger ones. Similarly, in the discussion paper version of this paper (Janeba and Osterloh, 2013) we additionally present descriptive evidence on the development of the local property tax in the state of Baden-Württemberg. The property tax is the second main tax instrument of German municipalities; it is likely to be less distortionary than the local business tax and approximates a tax on an immobile factor. We note that between 1990 and 2008 – a period in which external competition increased due to globalisation in general and the Eastern enlargement of the EU and German unification in particular – the municipalities tended to increase the rates of the land tax relative to the rates of the business tax. This suggests that bigger cities tended to shift their tax burden more to the property tax than small communities. These results should be viewed as preliminary since the development of both taxes is simultaneously affected by other influences, such as the mandated shifts of responsibilities for social welfare policies from higher level governments to local communities (which lead to an upward trend of both taxes) or different developments of property value in the municipalities (which misbalanced the real relative burden of the two taxes); moreover, the municipal fiscal equalisation scheme affects the local tax setting in Germany. Therefore further empirical work is needed to disentangle these effects.

Our predictions are, however, in contrast to research which has shown that smaller countries and countries on the periphery have lower corporate tax rates than large countries or regions in the core (e.g. Baldwin and Krugman, 2004; Haufler and Wooton, 2010). In our view, competition between geographically close jurisdictions is qualitatively different from competition among countries or states. At the local level, but not the country or state level, it is relatively easy for a firm to benefit from agglomeration benefits and infrastructure of an urban centre even in smaller jurisdictions, as long as they are located within a reasonable close to the urban centre.

In this paper we have argued that in local tax competition 'economic distance' typically does not coincide with geographical distance; this view is also adopted explicitly or implicitly in some applied work on spatial interactions (e.g. Case et al., 1993, or Baicker, 2005; see section 1). A second contribution of our paper therefore lies in the formal representation of this view. Our results suggest that for a given geographical distance the 'economic distance' between bigger cities is smaller than between smaller municipalities. Economic distance is imperfectly measured if the simplifying assumption is made that spatial interactions depend only on geographical distance (and hence economic distance would be equally strong between all types of jurisdictions in our model). Building on an approach with geographic distance only creates problems for the estimation of a spatial dependence model.

Our findings thus provide auxiliary information on economic distance, which can be exploited by means of nonparametric estimation methods, such as Conley (1999).[15] In the applied literature it is common practice to use interaction terms in order to differentiate the intensity of spatial interactions between different types of jurisdictions and to incorporate information about economic distance which goes beyond geographic distance. For instance, Devereux et al. (2003) show that the strength of exchange controls between countries affects the intensity of their strategic interactions, and Gérard et al. (2010) find that spatial interactions between Belgian municipalities can only be observed for those which have the same language.

Our model structure implies that jurisdictions should also be differentiated by size: for larger cities, one should consider other larger cities in the sample as part of their reference group. Their tax rates should enter the weighting in addition to those of the 'spatial' neighbours, which correspond to the hinterlands in our model. For larger cities it could even become necessary to consider the taxes of cities from beyond national borders, for instance, in the form of a weighted average of tax rates from foreign competitors. For smaller jurisdictions, however, only their geographical neighbours should be part of the reference group, since these seem to compete merely at the local level.

We conclude by emphasising the importance of considering asymmetries. Not all jurisdictions are identical and the perceived pressures from competition differ between jurisdictions. This has important implications for the theoretical and empirical modelling of tax competition. We believe that our approach is a first step in the right direction, but clearly much work needs to be done to better understand the spatial structure of tax competition.

[15] However, this method requires that the measure of neighbourhood is symmetric (Baicker, 2005); this prerequisite is not compatible with our theoretical model, since we find that a bigger city has a stronger impact on a smaller municipality than the other way around.

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A Appendix

A.1 The Simultaneous Game

The simultaneous game consists of two stages only. In the first stage, governments from cities and hinterlands simultaneously choose their tax policy, where in each jurisdiction tax policy must be a majority voting equilibrium for a given fiscal policy in all other regions. In the second stage, capital is allocated between all cities and all hinterlands depending on capital tax rates of all jurisdictions $\{t^{c,i},\ t^{h,ij}\}$. We use the same notation as in section 3. The capital market equilibrium condition is

$$(1-s)\sum_i k^{c,i} + \frac{s}{m}\sum_i \sum_j k^{h,ij} = n\bar{k}. \tag{A1}$$

In equilibrium the net return to capital, $\rho = f'(k) - t$, has to be the same across all cities, and across any city and its hinterlands:

$$\rho = a - bk^{c,i} - t^{c,i} = a - bk^{c,l} - t^{c,l} = a - bk^{h,ij} - t^{h,ij}, \tag{A2}$$

for all $i, l = 1, ..., n$ and $j = 1, ..., m$. Solving (A2) for $k^{c,l}$ and $k^{h,ij}$, respectively, and then substituting in the capital market equilibrium condition (A1) gives

$$\begin{aligned} k^{c,i} &= \bar{k} - \frac{(n-1+s)t^{ci}}{nb} + \frac{(1-s)T^{-i}}{nb} + \frac{s}{nmb}\left(\sum_{j=1}^{m} t^{hi_j}\right) \\ k^{h,ij} &= \bar{k} + \frac{(1-s)T}{nb} + \frac{s\sum_{l=1}^{n}\sum_{v=1}^{m} t^{h,lv}}{nmb} - \frac{t^{h,ij}}{b}, \end{aligned} \tag{A3}$$

where T is the sum of all cities' capital tax rates and $T^{-i} = T - t^{c,i}$. It is easy to see that a jurisdiction's capital stock is declining in its own tax rate:

$$\frac{dk^{c,i}}{dt^{c,i}} = -\frac{(n-1+s)}{nb} < 0 \tag{A4}$$

$$\frac{dk^{h,ij}}{dt^{h,ij}} = \frac{(s-nm)}{bnm} < 0. \tag{A5}$$

Furthermore, $d\rho/dt^{c,i} = -b \cdot dk^{c,i}/dt^{c,i} - 1$ and similar for a change in a hinterland's capital tax rate.

In a symmetric equilibrium where all hinterlands choose the same tax and all cities choose the same tax, (A3) simplifies to

$$k^c = \bar{k} + \frac{s(t^h - t^c)}{b} \tag{A6}$$

$$k^h = \bar{k} + \frac{(1-s)(t^c - t^h)}{b}. \tag{A7}$$

We now move to the analysis of the first stage. The reaction function of a typical hinterland jurisdiction and a typical city can be determined in a similar fashion as in stages 1 and 3 of the sequential game. For example, the two first order conditions for the utility maximisation of the median voter in hinterland j in region i are:

$$(1+\widehat{e})\left(-f''(k^{h,ij})\frac{\partial k^{h,ij}}{\partial t^{h,ij}}k^{h,ij}\right) + (1-\widehat{e})\left(\frac{\partial \rho}{\partial t^{h,ij}}\bar{k}\right) + u'(g^{h,ij}) \cdot \left(k^{h,ij} + t^{h,ij}\frac{\partial k^{h,ij}}{\partial t^{h,ij}}\right) = 0 \tag{A8}$$

$$u'(g^{h,ij}) - (1+\widehat{e}) = 0$$

The same qualitative conditions hold for a city.

Substituting (A3) into (A8), imposing symmetry among hinterlands as well as among cities (so that (A6) and (A7) apply), and using comparative statics reported in (A4) and (A5), we obtain the equilibrium tax rates as

$$t^c = \frac{2nm\widehat{e}b\bar{k}(1-s)}{(1+\widehat{e})\left[(nm-s^2)(n-1+s(2-s)) - (1-s^2)^2\right]} \tag{A9}$$

$$t^h = \left(\frac{1}{nm-s^2}\right)\left[\frac{2\widehat{e}b\bar{k}s}{(1+\widehat{e})} + s(1-s)t^c\right], \tag{A10}$$

where t^h contains t^c to write the hinterland's tax more compactly.

The equilibrium tax policy has the following properties in the simultaneous game. First, the city tax rate converges towards zero when n goes to infinity because the numerator in

(A9) is linear in n, while the denominator is quadratic in n. This is in line with Prop. 1. A difference arises for hinterland communities. When n goes to infinity, t^h converges to zero because t^c goes to zero and the denominator in round brackets goes to infinity.

We next consider how the difference in capital tax rates, $t^c - t^h$, responds to changes in n. In the sequential game, we know from Prop. 2 that this derivative is negative. In the simultaneous game, however, this derivative can be positive or negative. To obtain more insights, write the city and hinterland capital tax rates more compactly as $t^c = A_1 \geq 0$ and $t^h = A_2 + A_3 t^c \geq 0$, where $A_2 \equiv 2\widehat{e}b\bar{k}s/((1+\widehat{e})(nm-s^2) \geq 0$ and $A_3 \equiv s(1-s)/(nm-s^2) \geq 0$, so that $t^c - t^h = A_1(1-A_3) - A_2$ and, thus,

$$\frac{d(t^c - t^h)}{dn} = (1 - A_3)\frac{dA_1}{dn} - A_1\frac{dA_3}{dn} - \frac{dA_2}{dn}. \tag{A11}$$

Note that the derivatives in the second and third term of (A11) are negative, so that the sum of these two effects is positive. By contrast, the city's tax rate is typically declining in n, and $1 - A_3 = (nm - s)/(nm - s^2) > 0$, so that the first effect is negative. Numerical simulations (not reported) show that the net effect can be positive or negative. The case of a positive derivative is most easily seen when s converges towards 1 as dA_1/dn and dA_3/dn then go to zero, while dA_2/dn is bounded above zero. While such a high value of the hinterlands' population share may seem unrealistic, it nevertheless points to an important difference to the sequential model. Moreover, numerical simulations (not reported) also show that regardless of the sign of (A11) the derivative is small in absolute value and in comparison to the sequential model. This becomes clear when examining the terms A_1, A_2, A_3 and their derivatives with respect to n, which all have a higher order of n (or a product of n and m) in the denominator than in the numerator, so that even for "reasonable" parameter values of m and n the derivative (A11) becomes small in absolute value.

A.2 Proof of Proposition 3

Consider first the tax gap in a hinterland jurisdiction

$$\Delta^h = t^h - \tau^h = t^h - (g^h - t^h k^h) = t^h(1 + k^h) - g^h, \tag{A12}$$

where we made use of the government budget constraint to substitute for the labour tax. Recall that the public good level g^h is independent of the number of jurisdictions and depends only on the median's endowment position. This allows us to focus on the first term in (A12). Because t^h falls, Δ^h is decreasing in n if k^h is declining in n. Condition (20) shows that k^h equals a constant plus a term that is proportional in the sum of cities' capital tax rates. The direct effect of n in the first term of (20) vanishes after realising that in a symmetric city equilibrium $T = nt^c$. As the city tax rate falls in n, and k^h depends positively on t^c, the capital use in hinterlands must fall with competition. Hence, $d\Delta^h/dn < 0$.

Next consider a city's tax gap $\Delta^c = t^c - \tau^c = t^c(1 + k^c) - g^c$. Because g^c is not changing with n, we get

$$\frac{d\Delta^c}{dn} = \left[1 + k^c + t^c \frac{dk^c}{dt^c}\right] \frac{dt^c}{dn} + t^c \frac{\partial k^c}{\partial n}. \tag{A13}$$

From Proposition 2 we know that t^c is falling in n. Hence, the tax difference in cities is declining if the term in square brackets is positive and the last term in (A13) is non-positive. Consider first the direct effect of n on a city's capital stock (the last term in (A13)). Imposing symmetry among cities, the capital stock of a city (19) can be written as

$$k^c = \frac{s(s-m)t^c}{b(m-s^2)} + \frac{\bar{k}(m(1+\hat{e}) + (\hat{e}-1)s^2)}{(1+\hat{e})(m-s^2)},$$

which does not depend on n directly, i.e. $\partial k^c/\partial n = 0$. We are thus left with the first term in (A13). The square bracket is positive for n toward infinity as t^c converges to zero (Prop. 1) as long as the derivative dk^c/dt^c is finite. The latter derivative represents the change of a city's capital stock when *all* cities are changing their capital tax rates.

To examine the square bracket more generally, consider the sum of the second and third term in square brackets, $k^c + t^c \cdot dk^c/dt^c$, which looks like the slope of a government revenue curve. The difference to the typical Laffer curve of a city is that here the total effect of a change in capital tax rates of all cities is considered when n increases. If we assume for now that each city is on the left side of its own Laffer curve, so that $k^{c,i} + t^{c,i} \cdot (\partial k^{c,i}/\partial t^{c,i}) > 0$, then the sum of the second and third term of the square bracket in (A13) must be positive as well when all cities change their tax rate ($dk^c/dt^c = \sum_i \partial k^{c,i}/\partial t^{c,i}$), as now the loss in tax base for an individual city is smaller if all cities increase their taxes. This becomes evident from (A13), where the derivative of the city's capital stock with respect to all other cities' capital tax rates is positive, i.e. $dk^{c,i}/dT^{-i} = \sum_{v \neq i} \partial k^{c,i}/\partial t^{c,v} > 0$ and, hence, $k^{c,i} + t^{c,i} \frac{dk^c}{dt^c} =$

$k^{c,i} + t^{c,i}(\frac{dk^{c,i}}{dT^{-i}} + \partial k^{c,i}/\partial t^{c,i}) > k^{c,i} + t^{c,i}(\partial k^{c,i}/\partial t^{c,i}) > 0.$

We assumed above that a city is on the left-hand side of its Laffer curve, which must hold because otherwise the city could choose a lower tax rate that would generate the same public good level, lead to a higher net return to capital and higher private consumption. This completes the proof.

In the following we briefly go beyond Proposition 3, which is concerned with tax rates, by asking whether the result holds also in terms of revenues? We therefore define the following revenue gap: $\Gamma^r = t^r k^r - \tau^r, r = c, h$, and notice that τ is both the labour tax rate as well as labour tax revenue in per capita terms. Using again the government budget constraint, we can write $\Gamma^r = 2t^r k^r - g$. For a city, this term is declining in n as

$$\frac{d\Gamma^c}{dn} = 2\left(k^c + t^c \frac{dk^c}{dt^c}\right)\frac{dt^c}{dn} < 0, \tag{A14}$$

based on the arguments provided in the proof of Proposition 3. For hinterlands, we can appeal to (20), which allows us to write the hinterland's capital stock based as function of a city's tax rate t^c (in a symmetric equilibrium), which is given by (24). Hence, k^h increases with the cities' capital tax rates ($dk^h/dt^c > 0$) and we can write the derivative with respect to n as follows:

$$\frac{d\Gamma^h}{dn} = 2\left(k^h \frac{dt^h}{dn} + t^c \frac{dk^h}{dt^c}\frac{dt^c}{dn}\right) < 0, \tag{A15}$$

because all capital tax rates decline in n.

Figure 1: Survey: distribution of responses (size)

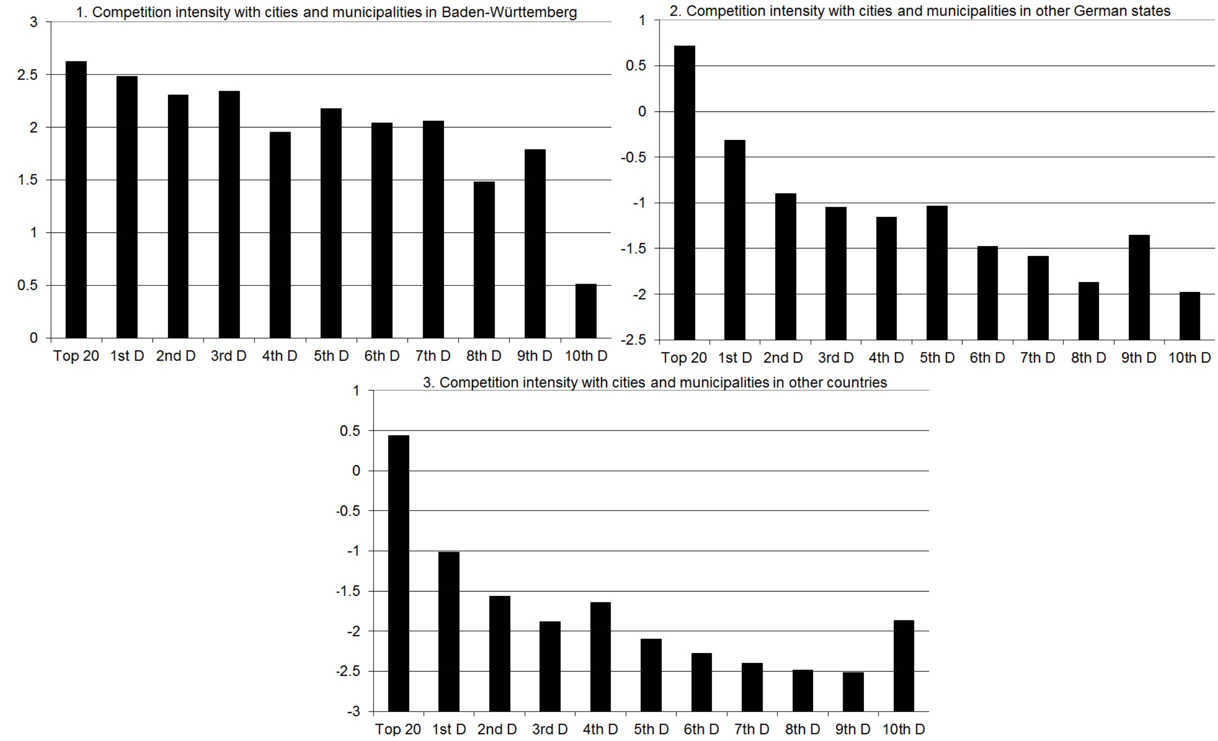


Figure 2: Model structure

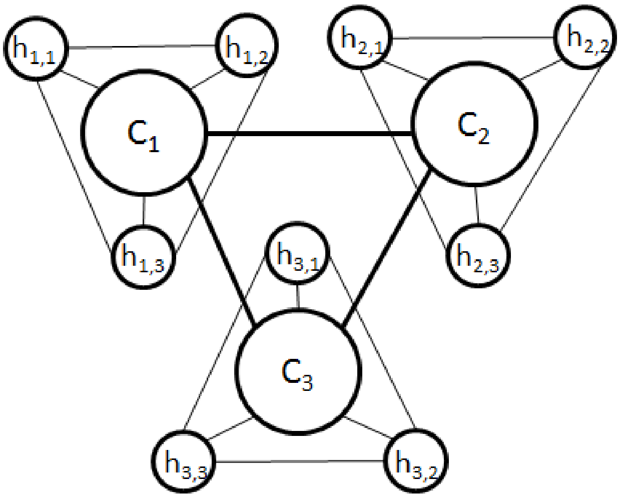
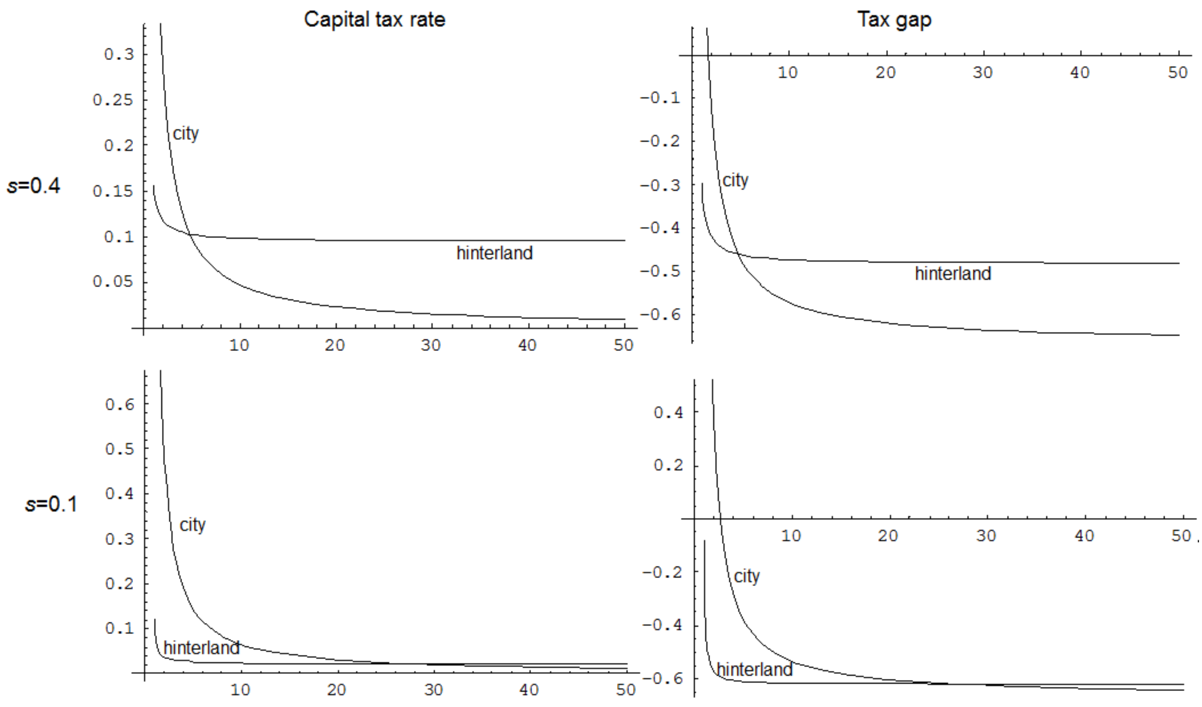


Figure 3: Simulation results



n is displayed on the x-axis. Parameters: $\bar{k}$=1, b=1, $\hat{e}$=0.5, m=3