Discussion Paper No. 12-005

Tax and the City – A Theory of Local Tax Competition and Evidence for Germany

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Economic Research

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Non-technical summary

In this paper we use survey responses of mayors from cities and municipalities in the German state of Baden-Württemberg to study the "true" spatial structure of local tax competition. The size of the jurisdiction and, in particular, its economic function turn out to be the important determinants of the decision-maker's perception of the intensity of competition. In particular, respondents from urban centres perceive a much higher intensity of competition for firms with respect to competing jurisdictions which are distant or even located in other countries. Our empirical findings confirm the assumption of the empirical literature about the importance of neighbourhood competition, but it also shows that another important factor is missing. In particular, the assumption of the empirical literature that competition takes place only among neighbours is at odds with the theoretical approaches where all jurisdictions compete simultaneously. The existing standard models, however, are incapable of explaining the empirical particularities of local competition.

These empirical findings motivate our sequential tax competition model which considers a rich competition structure. Essentially, we assume a number of metropolitan regions which each consist of one city centre and a number of surrounding (rural) jurisdictions. The model has two levels of competition for mobile capital: first, cities simultaneously compete for mobile capital by setting their tax policies (which can be interpreted as competition for large scale investments, such as headquarters); second, rural areas compete simultaneously for capital within their metropolitan area (which corresponds to the neighbourhood competition).

We are especially interested in the effects of a rise in the number of metropolitan regions, which represents the increase in external competition, for example through globalisation, Eastern enlargement of the EU or German unification. It is shown that – similarly to standard models – the capital tax rates of the cities converge to zero, but they stay positive for the hinterlands. Moreover, cities are more affected by an increase in external competition than hinterlands, since they reduce capital tax rates more and shift more from mobile capital to immobile labour taxation. In contrast to existing models, our results imply that larger jurisdictions do not necessarily rely more on capital taxes in case they face strong competition with more distant competitors. Based on tax data from Baden-Württemberg, we show that several of the predictions from the sequential model are in line with the development of tax rates in the past 20 years.

Das Wichtigste in Kürze

Wir nutzen Daten aus einer Umfrage unter baden-württembergischen Bürgermeistern um die “reale” räumliche Struktur des lokalen Steuerwettbewerbs zu untersuchen. Die Größe und vor allem die ökonomische Funktion der Städte und Gemeinden stellen sich als wichtige Determinanten der Wahrnehmung des Wettbewerbsdrucks durch die Entscheidungsträger heraus. Vor allem Befragte aus urbanen Zentren nehmen eine wesentlich höhere Intensität des Wettbewerbs um Firmenansiedlungen mit Kommunen in größerer Entfernung oder im Ausland wahr. Unsere Befunde bestätigen zwar die Annahme der empirischen Literatur hinsichtlich der Relevanz von Nachbarschaftswettbewerb, sie zeigen aber auch, dass ein wichtiger Faktor ignoriert wird. Zudem steht die Annahme, dass Wettbewerb nur zwischen Nachbarn stattfindet, im Widerspruch zu theoretischen Arbeiten, in denen alle Gebietskörperschaften miteinander im Wettbewerb stehen. Diese Standardmodelle sind jedoch nicht in der Lage, die empirischen Besonderheiten des lokalen Wettbewerbs zu erklären.

Diese Befunde motivieren unser sequentielles Steuerwettbewerbsmodell, das eine komplexe Wettbewerbsstruktur berücksichtigt. Wir unterstellen im Wesentlichen zahlreiche Metropolregionen, die jeweils aus einer Stadt und einer Anzahl an umgebenden (ländlichen) Gemeinden bestehen. Das Modell umfasst zwei Ebenen des Wettbewerbs um Kapital: Erst konkurrieren Städte simultan miteinander über ihre Steuerpolitik (dies kann als Wettbewerb um große Investitionen, wie Unternehmenszentralen, angesehen werden). Danach konkurrieren ländliche Gebiete um den Kapitalstock ihrer Region (dies entspricht dem Nachbarschaftswettbewerb).

Uns interessiert vor allem der Effekt einer Erhöhung der Anzahl an Metropolregionen auf die Steuersetzung; dies entspricht einer Verschärfung des externen Wettbewerbs, etwa durch die Globalisierung, Osterweiterung der EU oder die deutsche Wiedervereinigung. Es zeigt sich, dass – wie im Standardmodell – die Kapitalsteuern der Städte gegen Null konvergieren; sie bleiben jedoch positiv für das Umland. Zudem sind die Städte stärker von einer Verschärfung des externen Wettbewerbs betroffen, da sie ihre Kapitalsteuern mehr absenken und stärker auf die Besteuerung des immobilen Faktors Arbeit zurückgreifen müssen. Im Gegensatz zur bestehenden Literatur implizieren unsere Ergebnisse, dass größere Gebietskörperschaften nicht notwendigerweise stärker auf Kapitalbesteuerung zurückgreifen, falls sie sich einem starkem Wettbewerb mit weiter entfernten Wettbewerbern ausgesetzt sehen. Abschließend zeigen wir, dass zahlreiche der Vorhersagen des Modells mit der Entwicklung der Steuersätze in Baden-Württemberg in den letzten 20 Jahren in Einklang stehen.

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This version: January 2012

Abstract Despite the well-developed empirical literature on local tax competition, little is known about the actual spatial structure of inter-municipal competition. Assuming that competition takes place only among neighbours (as in the empirical literature) is at odds with the theoretical approaches where all jurisdictions compete simultaneously. In this paper we use a survey conducted among mayors in the German state of Baden-Württemberg to show that the perceived intensity of competition for firms varies considerably between jurisdictions and can mainly be explained by the size and location of the jurisdiction. Based on these findings, we develop a sequential tax competition model in which urban centres compete with other urban centres and rural jurisdictions in their own neighbourhood. This model predicts that larger jurisdictions do not necessarily rely more on capital taxes; in case they face strong competition with more distant competitors, larger cities even have lower capital taxes. In addition, we discuss how the model compares to a standard simultaneous approach and show that results from our sequential model are in line with trends in local taxation in Baden-Württemberg.

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

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1 Introduction

The governments of local jurisdictions compete for mobile resources, yet we know little about the spatial structure of this competition. For example, the empirical literature has focused on the analysis of spatial interactions. When these originate from inter-municipal tax competition for mobile capital, researchers typically assume that the competitors of a local community are mainly those jurisdictions in its close neighbourhood. Thus intensity of competition is approximated by neighbourhood matrices (see Brueckner, 2003, and Revelli, 2005, for surveys). If true, this assumption implies for theoretical modelling that the tax reaction function of a community depends directly only on the tax rates of its neighbouring jurisdictions. This, however, is incompatible with standard models of capital tax competition where complete capital mobility is assumed and *all* jurisdictions compete with each other in a simultaneous game (see, Wilson, 1999, for a survey; exceptions discussed below).

The discrepancy between the empirical and theoretical literatures has important consequences for our thinking about the effects of market integration or globalisation. According to the theoretical literature an increase in the number of jurisdictions or metropolitan areas should lead to declining or even zero capital tax rates everywhere (assuming other tax instruments with finite supply elasticities are available), while in the context of the empirical model at most a rather small indirect effect should be found. Whether in the long run tax rates on mobile factors become small or not has important long run consequences for the distribution of income across factors of production and thus for the political acceptance of market integration. Moreover, the viability of local government finances is at stake, which is important as decentralised government decision making is often considered desirable.

In this paper we make two novel contributions, one empirical and one theoretical, which relate to the above discrepancy between theoretical and empirical models. First, based on survey evidence from more than 700 mayors in the German state of Baden-Württemberg, we study the "true" spatial structure of local tax competition by asking local politicians who they actually consider to be their main competitors for mobile capital. This allows us to identify empirically the reference group for local business tax policy decisions. The size of the jurisdiction and in particular its economic function (based on categories from spatial planning) turn out to be the important determinants of 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. On the one hand, these findings confirm the assumption of the empirical literature about the importance of neighbourhood competition; but, on the other hand, it also shows that an important effect is left out.

Second, based on these empirical findings, we build a multi-stage tax competition model with a rich competition structure. Our model assumes n metropolitan regions, each of which consists of one urban centre 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 to a particular city. This represents the level of competition between non-neighbouring communities identified in our survey. Second, after the cities' tax choices, hinterlands compete simultaneously for capital within their metropolitan area, taking the urban centre's tax rate and the total metropolitan capital supply as given (which is their own supply plus the capital attracted by the city beforehand). This approximates the neighbourhood competition effect described above.[1] One way to think about our sequential structure is to view large cities as the primary competitors for large-scale investments, such as headquarters, 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.[2]

[1] 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.

[2] This finding gets further empirical support from van Dijk and Pellenbarg (2000), who show that the vast majority of firm relocations in the Netherlands occurs in 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.

We then compare the outcome of the fiscal competition game from this model, called the *sequential model*, to a traditional tax competition model in which all governments decide simultaneously in an otherwise identical setup; this second model is called the *simultaneous model*. 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; more on this below). Our first result is a limit result and demonstrates that in both types of models 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 empirically hinterlands are typically much smaller than urban centres, our model contrasts 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 (Baldwin and Krugman, 2004; Haufler et al., 2009; Haufler and Wooton, 2010). We then show, however, that several of our predictions coming from the sequential model are in line with stylised facts about local business tax rates in the German state of Baden-Württemberg, the same state on which our survey draws. Local business tax rates in small jurisdictions are clearly not low and sometimes even higher than in city centres. In addition, in recent years tax rates in small jurisdictions in Baden-Württemberg have increased, whereas they have stagnated in urban centres. Cities in turn have shifted tax burden much more to a less distortionary property tax than small communities have. Our preferred explanation for the difference in predictions and stylised facts is that competition between geographically close jurisdictions at the local level is qualitatively different from competition among countries or states. At the local level, but not at the country or state level, it is relatively easy for a firm to profit from the agglomeration benefits and infrastructure of an urban centre, while enjoying the same legal and cultural context, and still be located just outside that jurisdiction for tax reasons.

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) enrich the empirical analyses with explicit theoretical considerations. These contributions are based on standard tax competition models in the tradition of the workhorse model by Zodrow and Mieszkowski (1986) and are modified by restricting the number of competing jurisdictions. Capital is then 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 at least for larger cities.

Comparable to our results is the finding that not all jurisdictions compete for capital to the same degree, which appears in few theoretical papers that endogenise the number of jurisdictions competing for mobile capital. The approaches by Jayet and Paty (2006) and Matsumoto (2010) assume that local jurisdictions have to pay a development cost before entering the competition for a mobile firm. Therefore, in equilibrium not all jurisdictions enter competition for outside investment. The main focus of these papers is, thus, on the overall number and not the type of jurisdictions that compete for an investment.

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.[3] Yet, these works 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 and are hence faced with a different competitive pressure 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. They justify the structure with the reasoning that in the real world the large region is likely to move first and

[3]Most recently, Bucovetsky (2009) shows that this result can be generalised for federations consisting of more than two jurisdictions.

the small region moves second. This assumption gets support from empirical evidence on international corporate tax reforms (see e.g., Altshuler and Goodspeed, 2002, and Redoano, 2007). 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 region might have incentives to move first.

The rest of the paper is organised as follows. In section 2 we present the findings from our survey of local decision-makers in Baden-Württemberg which motivate our theoretical model. In section 3, we introduce a sequential model, present the results and compare them to a simultaneous model (shown in the appendix). Finally, in section 4 we discuss the implications of the model for local tax setting and compare them with local business tax rates in the German state of Baden-Württemberg.

2 The Spatial Structure of Competition – Perceptions of Local Decision-Makers

The existing empirical literature on spatial interactions suggests that capital mobility is highest between neighbouring jurisdictions. Spatial tax interaction is, for instance, demonstrated for the local business tax for cities and municipalities in the German state of Baden-Württemberg by Buettner (2001). Similar evidence for inter-municipal interactions has been found 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. The observed patterns may also have other causes, such as yardstick competition (see Revelli, 2005, for different explanations of spatial interactions). In fact, the direct evidence for tax base mobility is mixed. 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 for a sample of municipalities in the Canadian province of British Columbia. Some positive evidence comes from Buettner (2003), who studies the tax base effect for the local business tax in the state of Baden-Württemberg.

He only finds evidence for relatively small municipalities whose tax bases are positively affected by the tax rates of their neighbours.

A survey therefore helps in finding out whether capital mobility between jurisdictions is high. Decision-makers can only be expected to be responsive to taxes in other jurisdictions if they believe that capital is mobile to these jurisdictions. We assume that these beliefs can be regarded as proxies for the true mobility of firms as decision-makers are likely to be well-informed about one of their most important revenue sources.[4] Our survey approach is similar to that of Heinemann and Janeba (2011) in focussing on political decision makers. They study individual perceptions of members of the German parliament (Bundestag) with respect to the intensity of international tax competition and find, inter alia, a strong ideological bias.[5] In this work, we shift the focus to the study of the municipality characteristics to explain differences in the competitive pressures which are perceived by politicians. We control for a possible ideological bias in the regressions.

2.1 Survey description and results

In this section, we examine the determinants of the competitive pressures which are actually perceived by real world decision-makers at the local level. We focus on German cities and municipalities in the state of Baden-Württemberg. The institutional setting in this state is relevant because, as in all German states, the local level has autonomy over the rates of two main tax instruments: (i) the local business tax ("Gewerbesteuer") and (ii) the land tax ("Grundsteuer B"). The former is levied directly on business earnings, so that it can be regarded as a tax on capital and, as such, a highly mobile tax base.[6] These characteristics have already been exploited by empirical works which find strong evidence for interactions between neighbouring jurisdictions in this state (see Buettner, 2001, and Hauptmeier et al., 2012).

[4] We realise that beliefs about mobility do not necessarily have to be identical with real mobility, and therefore decision-makers might build their decisions on wrong perceptions of the reality. Evidence for this view comes from Brülhart and Parchet (2010), who demonstrate what they call "alleged" tax competition for inheritance taxes in Swiss municipalities.

[5] A survey-based approach with respect to lower-tier decision-makers has until now only be applied by Ashworth and Heyndels for Belgium municipalities. In contrast to our work, however, they focus on the stated preferences for tax reforms (see Ashworth and Heyndels 1997, 2000), and not on the perceptions and spatial structure of competitive pressures.

[6] Buettner (2003) argues that the business tax can be regarded as a capital income tax since the definition of taxable business earnings does not only include profits but also a major part of interest payments.

For our purpose, we conducted a survey which we sent to the mayors of all 1108 cities and municipalities of the state of Baden-Württemberg in May 2008 (see figure 5 in the appendix for a map showing the location of the jurisdictions). Mayors are of particular importance in the political system of this state due to the characteristics of the "South German Council Constitution" (see Wehling, 2003, for an overview). They are elected directly by the citizens and head the administration of the jurisdiction. Moreover, they preside over the local council, for which they enjoy voting rights. The combination of executive authority and agenda setting power in the legislative generates a quasi-presidential system with a strong position of the mayor and a rather weak council.

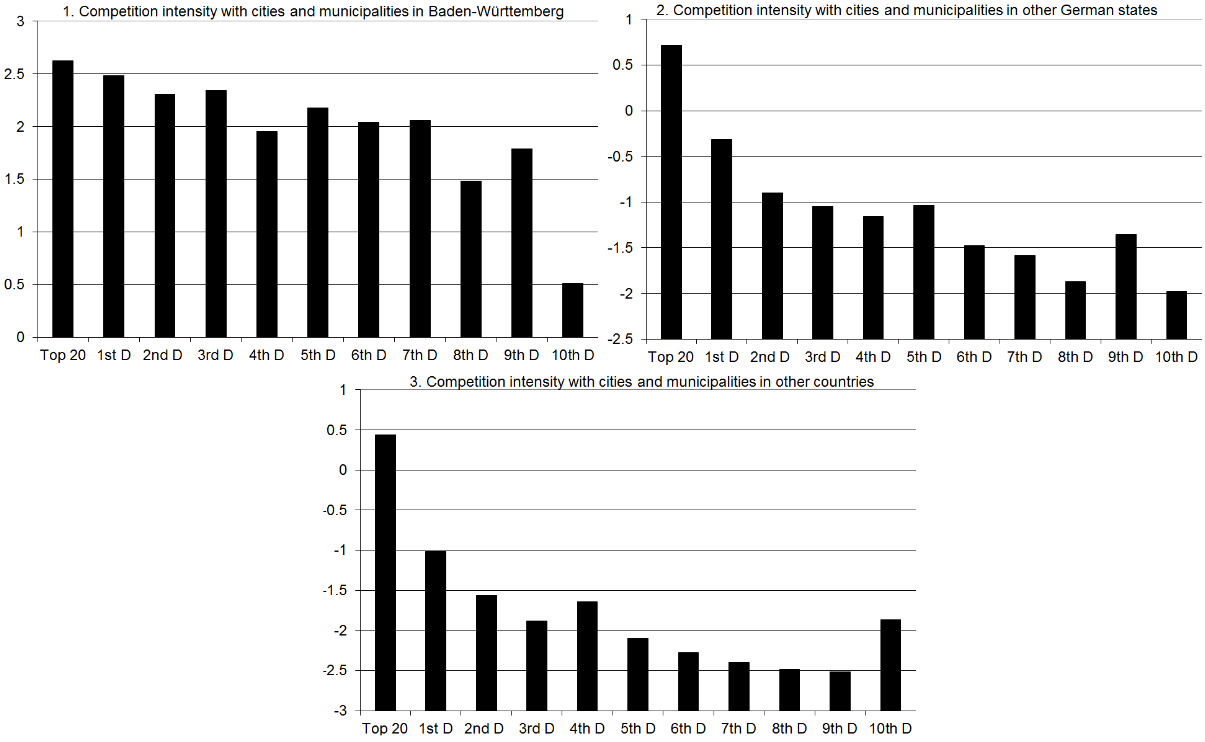
Our survey question of interest is the following: "With which cities and municipalities do you perceive yourself to be in competition for businesses?"[7] Respondents were asked to assess the strength of competitive pressures on a discrete scale from -4 (not at all regarded as competitors) to +4 (very 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. Unfortunately, the survey questions do not allow us to disentangle the perceived intensity of competition with urban centres and rural areas within the state of Baden-Württemberg. The responses given to the first question confound the two channels discussed above, i.e. competition with neighbouring municipalities as well as with more distant jurisdictions within the same state.[8]

First, we are interested in the effect of the jurisdiction size on the perceived competitive pressure. The illustrations in figure 1 show the distributions of the responses to the three survey questions conditional on the size of the jurisdictions. Jurisdiction sizes 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. Whereas the perception of the intensity of competition with local competitors (within the state of Baden-Württemberg) does not differ strongly for all size deciles, the perception depends

[7] The exact wording of this question in German is: "Mit welchen anderen Städten und Gemeinden sehen Sie sich besonders im Wettbewerb um Unternehmensansiedlungen?".

[8] We would have liked to ask for the exact identity of a jurisdiction's competitors rather than using this indirect question. In order to obtain a high response rate, however, we enlisted the support of the cities' joint representation organisation who did not allow us to ask such a direct question.

Figure 1: Survey: distribution of responses



strongly on size when competition with more distant competitors is considered, that is jurisdictions located in other German states or different countries (Q2 and Q3).

We proceed by studying the statistical significance of our descriptive findings in a SUR (seemingly unrelated regressions) ordered probit model. The responses to the three survey questions presented above serve as dependent variables. We choose a system estimator because the individual error terms for all three questions are expected to be correlated with each other. We control for a number of further municipal characteristics, in particular for the possible impact of the state's fiscal equalisation system[9] and an ideological bias. The discussion of these control variables and the descriptive statistics of all variables can be found in table 3 in the appendix. We apply two different measures to highlight the differences between urban and rural areas. First, we insert the logarithm of a jurisdiction's number of inhabitants as explanatory variable. Second, we insert dummies for district types, which are provided by the spatial planning programme of the state of Baden-Württemberg (see LEP 2002, Wirtschaftsministerium Baden-Württemberg (2002)). This categorisation classifies jurisdictions into three categories according to a number of specific characteristics and the functions they provide, such as infrastructure or education

[9]Theoretical considerations (e.g., Köthenbürger, 2003) and empirical evidence (e.g., Buettner, 2006) suggest that transfers tend to alleviate the pressure from tax competition, so that municipalities which receive a high share of transfers should generally be less concerned about inter-municipal competition.

institutions. We insert dummies for the two highest groups of urban jurisdictions, i.e. regional centres ("Oberzentrum": the highest level, 16 cities) and secondary centres ("Mittelzentrum": intermediate level, 95 cities); the baseline category is rural area (the location of the regional and secondary centres is depicted in figure 5 in the appendix).

For the identification of neighbourhood effects, we use the proximity to subnational (and international) borders as reference points. We insert dummies for those municipalities which share a border with another German state (Bavaria, Hesse or Rhineland-Palatinate) or another country (France or Switzerland). We are especially interested in the former group since there are no formal barriers to capital mobility between German states.[10] We are now in position to investigate whether border municipalities take neighbourhood (to competitors in other states) into account in their perceptions of competitive pressures.

Table 1: Results: perception of competition intensity – Seemingly unrelated ordered probit regressions

	Perception of competition intensity with jurisdictions: (a) in Baden-Württemberg, (b) in other states, (c) in other countries					
	System (1)			**System (2)**		
	(a)	**(b)**	**(c)**	**(a)**	**(b)**	**(c)**
Inhabitants (log)$_{t-1}$	0.280***	0.264***	0.237***	–	–	–
	(4.52)	(4.51)	(3.77)			
Regional centre ("Oberzentrum")	–	–	–	0.050	0.547***	0.569***
				(0.26)	(2.71)	(2.98)
Secondary centre ("Mittelzentrum")	–	–	–	0.253*	0.468***	0.414***
				(1.90)	(3.64)	(2.98)
State border	-0.021	1.016***	0.205	0.003	1.013***	0.208
	(-0.14)	(5.61)	(1.43)	(0.02)	(5.58)	(1.43)
Country border	-0.187	-0.050	0.400**	-0.189	-0.061	0.389**
	(-1.29)	(-0.31)	(2.17)	(-1.28)	(-0.37)	(2.09)
Mayor	0.097	0.133	0.124	0.026	0.093	0.093
	(1.14)	(1.61)	(1.37)	(0.32)	(1.16)	(1.06)
Share left$_t$	-0.594	0.002	-0.331	-0.152	0.355	-0.023
	(-1.34)	(0.00)	(-0.77)	(-0.35)	(0.88)	(-0.06)
Share free voters$_t$	0.125	0.133	-0.266	-0.038	-0.011	-0.395*
	(0.56)	(0.61)	(-1.16)	(-0.17)	(-0.05)	(-1.75)
High contribution rate$_t$	0.058	-0.367***	-0.479***	-0.040	-0.447***	-0.549***
	(0.39)	(-2.63)	(-3.00)	(-0.28)	(-3.27)	(-3.48)
Medium contribution rate$_t$	0.100	-0.176	-0.155	0.067	-0.207	-0.185
	(0.72)	(-1.33)	(-1.05)	(0.48)	(-1.60)	(-1.26)
Population working age$_{t-1}$	-1.826*	-0.486	-0.873*	-1.348	-0.123	-0.592
	(-1.79)	(-0.56)	(-1.84)	(-1.23)	(-0.13)	(-1.20)
Unemployment rate$_{t-1}$	2.589	5.129	5.224	13.946*	9.930	9.153
	(0.34)	(0.67)	(0.62)	(1.83)	(1.36)	(1.12)
Observations	716	715	716	716	715	716
Pseudo R-squared	0.013	0.034	0.028	0.006	0.032	0.027

z-values in parentheses: * Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

[10] The scale and scope of the mayors' perceptions of cross-border competitive threat is studied in greater detail in Geys and Osterloh (2011).

The results are presented in table 1. First, the size effect which is apparent from figure 1 turns out to be statistically significant. Decision-makers in larger jurisdictions assess the competition with more distant jurisdictions as much more intense than decision-makers from smaller ones. This becomes even more evident in the second system of regressions in which the district type dummies are used. Decision-makers in regional and secondary centres perceive a much higher intensity of competition with respect to more distant competitors (in other states or countries) than decision-makers in rural areas. Second, we note that the perceived intensity of competition with municipalities from other German states is 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. With respect to international competition, a neighbourhood effect can also be observed for those jurisdictions adjacent to a country border, but this effect is much lower. These results confirm that nearest municipalities perceive each other as very important competitors.

Out of the control variables, the only variables which show a strong impact are the dummies which reflect the impact of the fiscal equalisation system (see the appendix for more information on the control variables). This reflects that municipalities which benefit from fiscal equalisation transfers are less concerned about competition. The political variables, however, fail to show significant effects.

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. Several important features of the model are consistent with the survey results reported above: First, the findings for border regions support the assumption that capital has to be regarded as particularly mobile between directly neighbouring jurisdictions. Second, larger cities, and in particular regional and secondary centres, also perceive a high intensity of competition with more distant jurisdictions. This corroborates with recent empirical evidence from the literature on competition for headquarters (see Strauss-Kahn and Vives (2009) on the US and Becker et al. (2009) on Germany). While it is shown for Germany that the vast majority of municipalities does not attract any headquarters, the literature also finds that headquarters are very mobile and that they are, inter alia, attracted by low corporate taxes at the local level.[11]

We therefore assume two levels of competition: (1) competition among urban centres for investments and (2) competition within a metropolitan region. We choose a sequential structure of the tax-setting game. Initially, all urban areas or 'cities' – superscripted by c – decide simultaneously on their tax rates, and the capital is allocated among cities. Capital is thereafter bound to a city's metropolitan region. Then, the hinterlands – superscripted by h – follow in their tax setting, and the fixed supply of capital stock in a metropolitan region i is allocated between the city in i and the hinterlands in i. We believe that this sequencing captures best the two levels of competition. Any reversal of the decision of cities and hinterlands would lead to a different competition structure. In particular, hinterlands would then indirectly compete with all cities because hinterlands would rationally have to anticipate how their tax policy decision affects all cities' tax choices, which is in contrast to our empirical findings.

One way to think about our sequential structure is as follows: Large cities are the primary competitors for large-scale investment, such as headquarters, which are often accompanied by smaller investment, such as those from suppliers or subcontractors. After the large-scale investment has been located in a city and has thus committed to a certain metropolitan region, the associated suppliers and subcontractors have strong incentives to settle in a reasonable distance to their client, i.e. in the same metropolitan region.[12]

3.1 Model structure

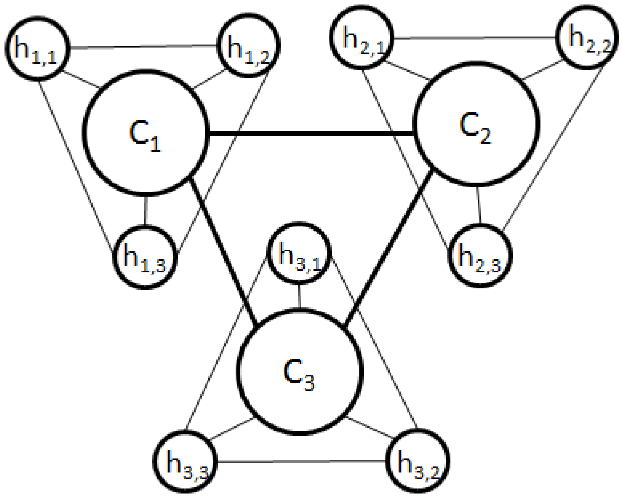
The model builds on Borck (2003), who examines the choice of tax policy in a political economy context with heterogeneous agents. He considers only one level of competition and there is no distinction between cities and hinterlands. We extend his work in a substantial way by considering the interaction between different types of jurisdictions in a multi-stage game. The economy consists of n symmetric metropolitan regions indexed

[11] Similar evidence exists for different kinds of foreign investment. Evidence that mainly highly agglomerated centres compete for foreign investment comes, e.g., from Guimarães et al. (2000) and is summarised by Dembour (2008).

[12] And even the headquarter itself is sometimes mobile within a metropolitan region, perhaps due to tax advantages. One example for such a behaviour is the German stock exchange (Deutsche Börse AG) which, due to low local business tax, outsourced half of its staff to Eschborn, a small city (20,000 inhabitants) only 7 kilometers away from its traditional headquarter in the financial centre of Frankfurt, in 2008.

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 European union), affect equilibrium tax policy. Our model also 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 main focus of our work in this paper.

Figure 2: Model structure



Output of a numeraire consumption good is produced using interjurisdictionally mobile capital and immobile labour. In section 4, we apply our model in the context of Germany's localities and with some adjustments reinterpret the factor labour as land. For now, it is easier to follow the standard tax competition approach and label the factors as capital and 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 thus the size parameter known from the literature on asymmetric tax competition: Bigger 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. The heterogenous distribution of endowments ensures – equivalently to Borck (2003) – that both tax instruments are used in equilibrium.[13]

We are now in a position 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:

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

[13]This intentionally contrasts with much of the earlier literature (such as Bucovetsky and Wilson, 1991) which predicts the complete disuse of the distortionary tax in small jurisdictions as soon as a non-distortionary tax becomes available.

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 marginal rate of transformation between public and private good is assumed to be one.

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 $k^{h,ij}$ result, based on $t^{c,i}$ and $t^{h,ij}$. 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. Since labour taxes do not distort the capital allocation, their levels are determined by the difference between the public good demand and the funds provided from the taxation of capital via (4). Production and consumption take place, and the government provides the public good in all jurisdictions.

In the following, the model is solved via backward induction, starting with the final stage of the game.

3.2 Solving the model

3.2.1 Stage 4

We now solve the final stage for a typical metropolitan region i and drop the index whenever possible to simplify notation. In the final stage, capital used in a city and its hinterland areas depend on the respective 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

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

Recall that s is the population share of all hinterlands in a metro region.

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

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

and its hinterlands

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

as functions of capital tax rates, the capital supply in the metro area and exogenous parameters. 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

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

3.2.2 Stage 3

We now solve for the tax policy equilibrium within a metropolitan region, given the tax policy of the city 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.

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), where (8) is substituted into (3) and (4). The two first order conditions are (index i is omitted):

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

and

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

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 $\hat{e}$. 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:

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

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 to zero as the number of hinterland communities m converges to infinity. In that situation, hinterlands use only the nondistortionary labour tax.[14]

Next, we insert the reaction function (11) into $k^c(\{t^{h,j}\}, t^c, \tilde{k})$ and $k^{h,j}(\{t^{h,j}\}, t^c, \tilde{k})$

[14] 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.

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 labor 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.

3.2.3 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 the net returns to capital

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

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 cities' tax policies. 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, which now applies to the capital stocks determined at stage 2:

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

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

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

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):

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

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

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

where $T = \sum_{i=1}^{n} t^{c,i}$ is the sum of all cities' capital tax rates and $T^{-i} = \sum_{v \neq i} t^{c,v}$ is the sum of all cities' tax rates without city i. 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.

3.2.4 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. 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 are positive, that is $n(m-s^2)^2 > m^2(1-s)^2$. This condition holds for $m = 1$ regardless of the value of n (assuming $n > 1$). 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 hinterlands m and 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) (omitted here). In a symmetric city equilibrium, the overall capital stock is identical in all metropolitan regions, so that $\tilde{k}^i = \bar{k}$.

The tax rate conditions (24) and (25) make 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. All equilibrium tax rates are zero in this case. Taking limits with 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.

This completes the solution of the multi-stage game. We now turn to further characterising the equilibrium.

3.3 Equilibrium Properties

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 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 is called the simultaneous model and is summarised in the 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 and converges to $\frac{2\hat{e}b\bar{k}s}{(1+\hat{e})(m-s^2)} > 0$. 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 the value provided in the Proposition. 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 (evidence on local tax rates is provided in section 4). 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 whether capital tax rates are monotonic in the number of metropolitan regions. Our result show that an increase in n affects cities and hinterlands 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; that is,

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

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. The tax differential (26) also shows that it is not a priori determined whether a city or hinterland has the higher tax. 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. More on this aspect is discussed in section 3.4 when we analyse the model numerically.

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 other words, an increase in n has a similar effect on capital tax rates in cities and hinterlands in the simultaneous model, while hinterlands are somewhat more sheltered than cities in the sequential model. In section 4, we argue on the basis of actual tax data that the sequential model seems to better fit the trend in local business tax rates in Germany.

We have seen that our sequential model behaves differently from the simultaneous model when it comes to the relationship between capital tax rates and number of metropolitan regions. At the same time, the sequential model reproduces important results from the earlier literature. In particular, 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. This follows from differentiation of (24) with respect to s.[15] The effect on the capital tax rate of hinterlands is theoretically ambiguous due to the nonlinear structure, but in all numerical simulations the hinterland tax rates rise with s.

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 results demonstrate.

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.

Proof: See appendix (A.3).

Proposition 3 demonstrates that both cities and hinterlands shift from capital tax rates to land tax rates when external competition increases. In the next section 3.4, we

[15] 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.

go beyond the qualitative effect and analyse numerically for which type of jurisdiction the shift is larger. This will be important for our comparison to real world tax data from the German state of Baden-Württemberg considered in section 4.

We now ask a related question: Do governments rely more on labour taxes in terms of revenues? We therefore define the following revenue gap:

$$\Gamma^r = t^r k^r - \tau^r, r = c, h \tag{27}$$

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

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

based on the arguments provided in the proof of Proposition 3. For hinterlands, the result is less straightforward. Notice that we can write the hinterland's capital stock based on (20) in a symmetric equilibrium as

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

where t^c 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:

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

because all capital tax rates decline in n. We summarise in the following proposition:

Proposition 4. In the sequential model, an increase in n leads to more tax revenue collected from the immobile factor (labour) and less from the mobile factor (capital) in both cities and hinterlands.

Propositions 3 and 4 are consistent with results from standard tax competition models. Yet, the mechanism differs due to the sequential structure, which gives rise to indirect effects as in the proof of Proposition 4.

3.4 Numerical Example

In the following, we present a numerical example to illustrate and complement our analytical results, in particular Propositions 2 and 3. Comparative static results from the numerical example can also be compared to real world tax data as done in section 4.

We assign 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, $\Delta = t - \tau$.

Table 2: Numerical example

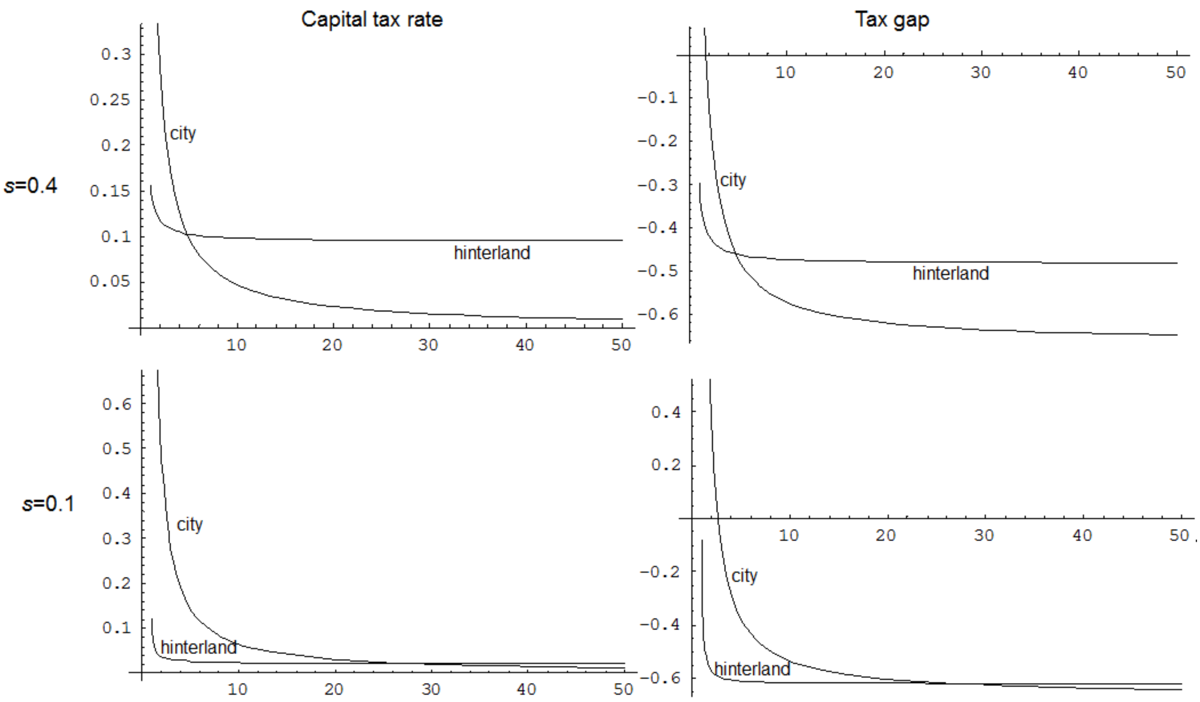
	t^c	t^h	τ^c	τ^h	Δ^c	Δ^h
1. s=0.05, m=10, n=2	0.5776	0.0061	0.1056	0.6573	0.4720	-0.6512
2. s=0.05, m=10, n=50	0.0129	0.0034	0.6538	0.6632	-0.6409	-0.6598
3. s=0.3, m=10, n=50	0.0096	0.0204	0.6570	0.6464	-0.6474	-0.6261
4. s=0.05, m=2, n=50	0.0129	0.01700	0.6537	0.6497	-0.6408	-0.6327
5. s=0.3, m=2, n=50	0.0103	0.1058	0.6560	0.5679	-0.6457	-0.4620

Other parameters: $\bar{k}$=1, b=1, $\hat{e}$=0.5

We now go beyond Proposition 3 by analysing how the tax rate gap changes in cities *relative* to hinterlands, that is $d\Delta^c/dn$ and $d\Delta^h/dn$. In addition, we also compare the absolute level of capital tax rates in the two types of jurisdictions, i.e. we evaluate the sign of (26) as function of n. We vary the values for the overall population size of the hinterlands relative to the city, s, the number of hinterlands in a metropolitan area, m, and the number of metropolitan regions, n. All other parameter values are held constant and chosen as reported in the table below. Table 2 shows that the tax rate gap in a city Δ^c can be higher or lower than the gap in a hinterland Δ^h. The gap in the city is smaller (higher in absolute terms) when s and n are sufficiently high (lines 3 and 5) and/or m is sufficiently low (line 4). Furthermore, a decrease in the size of each hinterland relative to the city – either through a smaller overall population size of the hinterlands s for a given number of hinterlands, or an increasing number of hinterlands m for given population size – leads in the hinterland to a shift from distortionary capital taxation to non-distortionary labour taxation. The corresponding effect for cities, however, differs (the city's capital tax decreases for increasing m – compare lines 4 and 3 – while for decreasing s the city's tax may increase – see lines 3 and 2).

Obviously, doing the reverse exercise, namely making a city smaller in population size (i.e. s increases) leads to the same qualitative outcome: a shift from capital taxation to non-distortionary labour taxation in a city. Yet, this does not imply that the smaller jurisdiction *always* makes less use of capital taxation than the bigger ones as lines 3 to 5 in table 2 demonstrate. This result contrasts with the finding of the model by Bucovetsky (2009), in which smaller jurisdictions always make less use of the distortionary taxation than larger ones.

Figure 3: Simulation results



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

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. After making use of the same parameter values as before in the table notes, we plot the capital tax rates and the tax rate gaps in city and hinterland as function 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. The steeper line belongs to a city and is in all of our simulations steeper than the one for the hinterland. 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. Figure 3 is important for our comparison with real world tax data in Germany, which we will discuss next.

4 Discussion and Conclusion

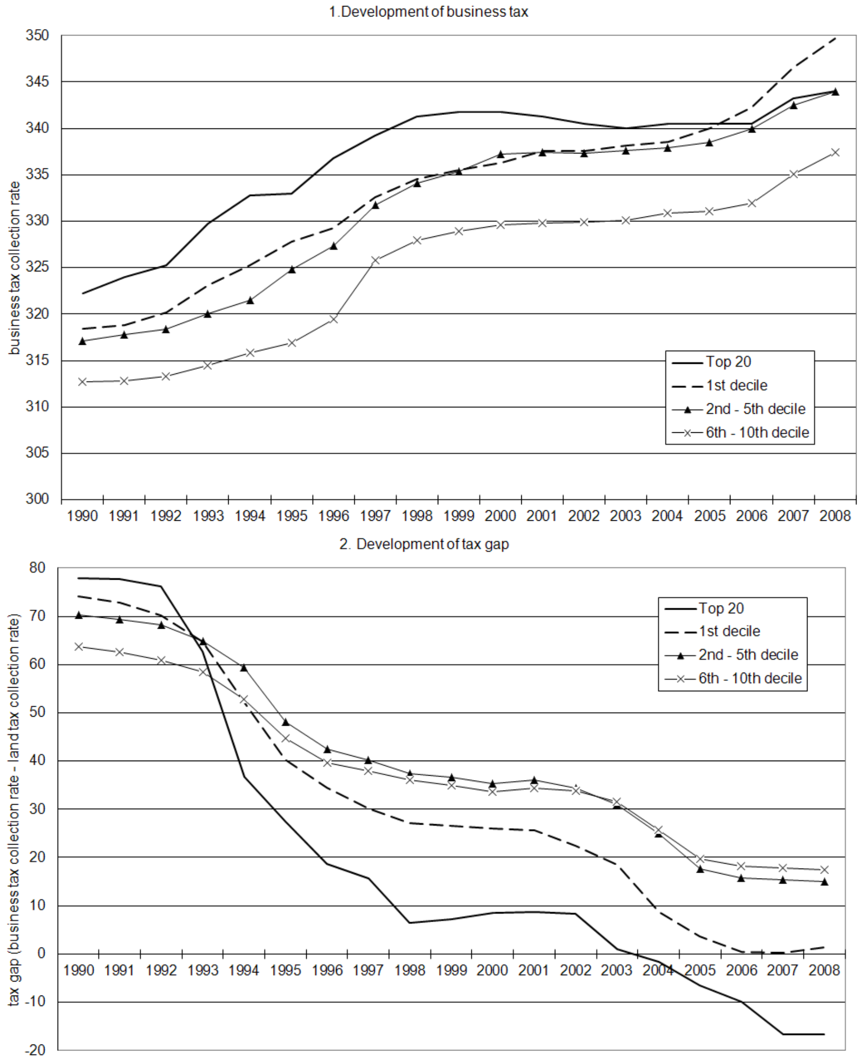
In our theoretical analysis, we have demonstrated that two different effects interact in our model of local tax competition. First, we have observed a pure size effect, which is well-known from the literature of asymmetric tax competition. This suggests that the smaller jurisdictions rely less on capital 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 competitors, as indicated by an increasing n, implies a stronger shift to the use of immobile tax bases in the cities than in the hinterlands. Consequently, given a sufficient large number of competitors, the cities might actually make less use of capital taxation than their hinterlands.

We now check the plausibility of our theoretical predictions by describing actual taxes set in the state of Baden-Württemberg, the state on which our survey in section 2 was based. This requires a slight reinterpretation of our theoretical model as the most important autonomous tax instruments (and revenue sources) for jurisdictions in Baden-Württemberg are the local business tax rate ("Gewerbesteuer") and a land tax ("Grundsteuer B"). The former matches well the capital tax rate in our theoretical model. The latter, however, obviously differs from the labour tax that we assumed in section 3 (local jurisdictions in Baden-Württemberg do not control their own income or labour tax). Nevertheless, the land tax is qualitatively similar to the labour tax in that it is likely to be less distortionary than the local business tax.[16] To sustain the applicability of the model,

[16]Note that in the real world the German land tax is also levied on business land so that it theoretically also affects the capital allocation. Quantitatively, however, the land tax mainly affects private land owners, so that it is much less relevant for location decisions of firms than the local business tax.

and in particular the nature of the political equilibrium, we would also need to assume a monotonic relationship between the size of land and its population. While this may be considered unrealistic in a narrow sense, we feel that our theoretical model captures the qualitative setting in Baden-Württemberg well: There are two tax instruments available, one on a mobile factor and another one on a fixed factor, which is the less distortionary tax.

Figure 4: Development of taxes in Baden-Württemberg



The upper graph in figure 4 presents the development of the collection rates ("Hebesätze") of the local business tax for jurisdictions of different size (groups). We view the period from 1990 to 2008 as one where external competition increased due to globalisation in general and the Eastern enlargement of the EU and German unification in particular. Figure 4 shows that local business tax rates in small communities grew over the last twelve years, while they were fairly stable in the 20 largest cities. The finding of rising business taxes is neither consistent with our Proposition 2, which shows that capital tax rates are monotonically decreasing in n, nor with the empirical literature cited above, which suggests a race to the bottom of capital tax rates due to increasing competition and spatial interactions. Yet, we believe that other reasons are causing an increase in need of financial resources (and, hence, an increase of all types of taxes), such as mandated shifts of responsibilities from higher level governments to local communities for social welfare policies, the inclusion of the (poorer) Eastern German states in the federal fiscal equalisation systems or an offset for lower corporate tax rates at the national level. Consequently, we believe that the tax rate gap – expressed as the collection rate of the business tax minus the collection rate of the land tax – is the more meaningful measure for comparison.

In the lower graph of figure 4, the trends for the tax rate gaps are depicted. Over the observation period, the tax gap decreased in all size classes, that is the business tax rates were lowered in relation to the land taxes.[17] This drop is in line with reductions in corporate tax rates at national levels, which arise from increasing external competition (see e.g., Slemrod, 2004). In the light of our model, globalisation-related changes – such as the reduction in transport costs and institutional openings of markets to other countries, e.g. the Eastern enlargement of the EU – allowed for the entry of more-distant jurisdictions in the competition for capital. Consequently, competitive pressures on cities in Germany increased and forced local decision-makers to resort more to non-distortionary land taxes.[18] Most notably, the development of the tax gaps in the beginning and mid-1990s is remarkable. At that time, German cities were confronted with the emergence of a huge number of new competitors after the fall of the iron curtain and German reunification (the negative impact of the former on international corporate tax levels is documented by Overesch and Rincke, 2009). Consequently, the sharp drop in local tax gaps coincides with the view that the competition with external competitors – expressed as the number of regions in our model – increased especially in the 1990s.

Yet, different types of jurisdictions were unequally affected by this development. Ini-

[17]The interpretation of the levels of the measure needs to be done with care as the two tax bases are not directly comparable. Rather, we see this gap as a qualitative measure for shifts from one tax base to the other.

[18]Part of the common drop can also be explained by institutional characteristics of the two taxes since the tax base of the land tax is levied on predetermined land prices, which are adjusted very little over time. Since the revenues of the business tax tend to increase in nominal terms over time, the rate of the land tax has to be raised regularly in order to keep the revenue ratio constant.

tially, the tax gaps were rather similar in urban centres and rural areas; but in the course of time, this pattern changed markedly. In particular the biggest cities – as well as urban centres from the first size decile – tended to decrease their business tax rates relative to the land tax rates much stronger than the smaller jurisdictions. This finding is well in line with the theoretical predictions made above (see Figure 3): The increasing pressure from external competition pushes down the ratio of capital to land taxes in all jurisdictions, but this effect is much stronger for urban centres.

These findings give support to our theoretical predictions – big cities might actually rely less on corporate taxation – which are 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 (Baldwin and Krugman, 2004; Haufler et al., 2009; Haufler and Wooton, 2010). This discrepancy to earlier literature can be explained with some special characteristics of local tax competition. 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 the agglomeration benefits and infrastructure of an urban centre even in smaller jurisdictions, as long as they are located within a reasonable distance to the urban centre.

We conclude by emphasising the importance of considering asymmetries, in particular concerning the structure of competition in local tax competition. Not all jurisdictions are identical and, consequently, the perceived pressures from competition differ between jurisdictions, as we have demonstrated. This has important implications for the theoretical modelling of tax competition. We believe that accounting for differences in a jurisdiction's involvement in levels of competition is an important innovation compared to the existing theoretical literature on local tax competition. Clearly, much work needs to be done to better understand the structure of local tax competition.

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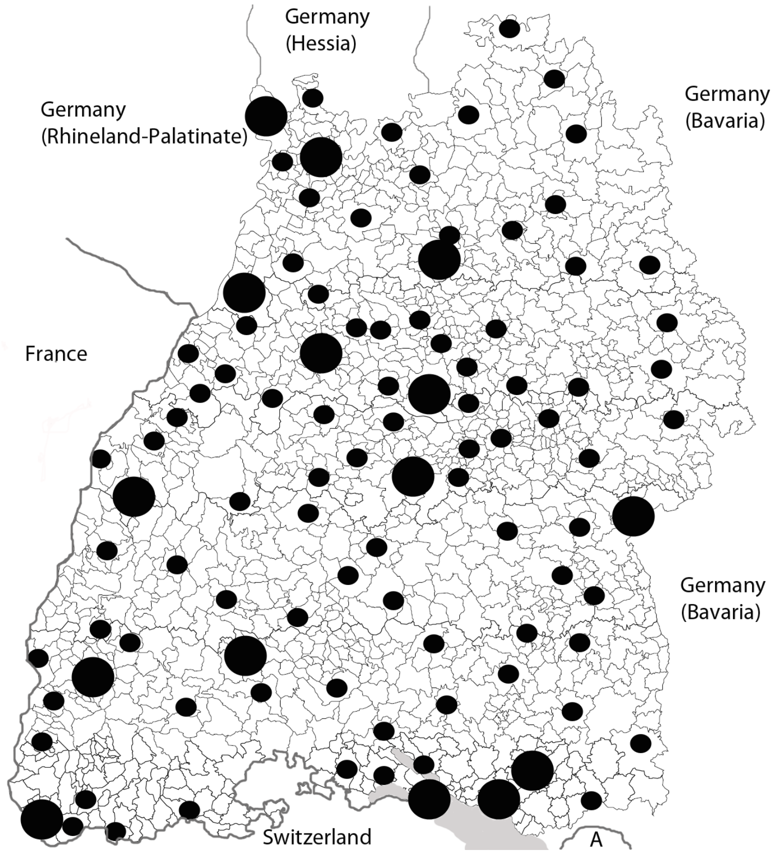
A Appendix

A.1 Data

Figure 5: Map of Baden-Württemberg



Small (big) points indicate the location of secondary (regional) centres.

Table 3: Descriptive statistics

Variable	Description	Mean	Std. Dev.	Min	Max	Source
Perception: competition within state	Survey response	1.98	1.88	-4	4	own survey
Perception: competition with other states	Survey response	-1.20	2.27	-4	4	own survey
Perception: competition with other countries	Survey response	-1.91	2.42	-4	4	own survey
Regional centre	Dummy = 1 if classified as regional centre	0.02	0.14	0	1	LEP 2002
Secondary centre	Dummy = 1 if classified as regional centre	0.10	0.30	0	1	LEP 2002
State border	Dummy = 1 if municipality shares border with another German state	0.07	0.26	0	1	own calculations
Country border	Dummy = 1 if municipality shares border with another country	0.05	0.21	0	1	own calculations
Mayor	Dummy = 1 if survey was responded by the mayor	0.48	0.50	0	1	own survey
Inhabitants (log)	Log of number of inhabitants	8.71	0.98	5.81	13.30	Statistical Office BW (Stala)
Share left	Share of left-wing parties at municipal election 2004	0.19	0.15	0	0.71	Stala
Share free voters	Share of free voters at municipal election 2004	0.46	0.30	0	1	Stala
High contribution rate	Dummy = 1 if fiscal capacity below 60% of average	0.39	0.49	0	1	Stala
Medium contribution rate	Dummy = 1 if fiscal capacity between 60% and 100% of average	0.52	0.50	0	1	Stala
Population working age	Share of inhabitants between 15 and 65 years	0.66	0.02	0.57	0.74	Stala
Unemployed	Share of unemployed	0.02	0.01	0.01	0.04	Stala

Fiscal equalisation system: It has to be assumed that municipalities with a higher contribution rate – i.e. the extent to which a decrease in the tax base increases the received transfers – perceive a lower pressure from competition. These municipalities are compensated more strongly by the equalisation system for any capital outflows they experience. In particular, we are able to identify three groups of jurisdictions which differ highly in their level of marginal contribution rates; they are captured by dummy variables in our regressions. This identification is possible due to discontinuities in the regulations that determine the marginal contribution rate as discussed by Buettner (2006).

Ideological bias: We add the share of seats taken by left-wing parties as well as the free voters in the local council in order to capture the political preferences of the jurisdiction. Moreover, in several cases the mayors delegated the completion of the questionnaire to the responsible staff of the administration, so that not the perception of the directly-elected mayor, and thus a politician, was recorded, but that of his bureaucracy. Hence, we insert a dummy for responses given by the mayors in order to control for possible differences between these two groups of individuals.

A.2 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 the respective 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, (A4) and (A5) simplify 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 rate for the city and hinterland 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.

We now characterise properties of the equilibrium tax policy in the simultaneous game, which are similar in nature to the results presented for the sequential model in section 3. 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 $A_3 \equiv s(1-s)/(nm-s^2) \geq 0$. From here it follows 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.3 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 total change of a city's capital stock to *all* cities 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.