CHAPTER 17

Taxes in Cities

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Abstract

Most cities enjoy some autonomy over how they tax their residents, and that autonomy is typically exercised by multiple municipal governments within a given city. In this chapter, we document patterns of city-level taxation across countries, and we review the literature on a number of salient features affecting local tax setting in an urban context. In OECD countries, urban local governments on average raise some 10% of total tax revenue, and in non-OECD countries, they raise around half that share. We show that most cities are highly fragmented: urban areas with more than 500,000 inhabitants are divided into 74 local jurisdictions on average. The vast majority of these cities are characterized by a central municipality that strongly dominates the remaining jurisdictions in terms of population. These empirical regularities imply that analyses of urban taxation need to take account of three particular features: interdependence among tax-setting authorities (horizontally and vertically), jurisdictional size asymmetries, and the potential for agglomeration economies. We survey the relevant theoretical and empirical literatures, focusing in particular on models of asymmetric tax competition, of taxation and income sorting, and of taxation in the presence of agglomeration rents.

Keywords

Cities, Taxes, Tax competition, Fiscal federalism, Agglomeration, Sorting

JEL Classification Codes

H71, H73, R28, R51

17.1. INTRODUCTION

Cities the world over are big collectors of taxes. In the Organization for Economic Cooperation and Development (OECD), local governments raise about 13% of total tax revenue, and close to 80% of the population lives in cities. Hence, as a rough approximation, 1 in 10 tax dollars, on average, is raised by urban local governments. That share is lower in non-OECD countries, but with fiscal decentralization and urbanization both progressing in most developing countries, convergence toward OECD levels would seem to be only a matter of time.

While taxation by city governments is important on average, it is also very heterogeneous, even among developed countries. In the OECD, the local share of total tax revenue ranges from 1% to 33%. The set of tax instruments available to local governments differs as well, as does the degree of autonomy allowed to individual municipalities in setting their own tax rates.

The city-level tax authority typically represents the bottom of a federal pyramid of tax-raising government layers. Most countries in addition feature taxation by intermediate-level (state, provincial, cantonal, etc.) authorities as well as by the national government. Hence, city-level taxation will be characterized by interactions in at least three dimensions: among local governments within a city, among cities, and between local governments and the upper government layers.

In this chapter, we focus on characteristics that are of particular importance to city-level taxes and that can differ substantially from those of international fiscal relations.[1] We note three special features of city-level taxation, each of which we seek to address:

1. Interdependence: Given the comparatively small spatial scale of cities and the resulting mobility of the tax base, tax decisions by local governments are "horizontally" interdependent. Moreover, because all city-level governments coexist with one or several layers of governments above them, "vertical" interdependencies among government tiers must be considered as well. These interdependencies are furthermore affected almost everywhere by fiscal equalization schemes that redistribute tax revenue horizontally and vertically.
2. Asymmetry: Cities typically consist of a large central jurisdiction and several smaller surrounding jurisdictions. Central and noncentral jurisdictions differ in a number of ways, but a large disparity in economic and population size is of first-order relevance everywhere.
3. Agglomeration: One taxpayer's location decision within and between cities is often linked to the location decisions of other agents. Firms seek proximity to each other in local clusters, and people often prefer to live near other people like them. Such agglomeration and sorting phenomena influence and are influenced by local tax policy.

A note on terminology: in this chapter, we use the term "city" in a geographic rather than in a political sense; that is, we use this term to denote a functional urban area, synonymous to terms such as "metropolitan area," "urban local labor market," or "travel-to-work area." Cities contain multiple contiguous political jurisdictions. We refer to these jurisdictions as "municipalities," and to the taxes they collect as "municipal" or "local" taxes. Among the municipalities within a city, we distinguish the "central municipality," or simply "the center," from its fringe of "noncentral" or "suburban" municipalities.[2]

What intellectual case is there for cities to raise their own tax revenues? The most frequently invoked analytical framework is the "decentralization theorem" formalized by Oates (1972) and Besley and Coate (2003). This approach highlights the trade-off between, on the one hand, spatially differentiating tax policy so as to satisfy heterogeneous voter preferences, and, on the other hand, internalizing fiscal spillover effects across jurisdictions. Considering in addition that taxpayers are mobile within and between cities, decentralized taxation can be efficient as taxpayers "vote with their feet" (Tiebout, 1956).

[1] Wilson (1999), Gordon and Hines (2002), Brueckner (2003), Epple and Nechyba (2004), Fuest et al. (2005), Keen and Konrad (2013), and several of the chapters in Ahmad and Brosio (2006) are among the relatively recent surveys on intergovernmental fiscal relations without a specifically urban focus.

[2] We mostly treat local governments as if they were of a single type, thereby abstracting from functional jurisdictions such as school or other special-purpose districts, whose boundaries might not overlap. In a seminal theoretical treatment, Hochman et al. (1995) show that differences in optimal spatial scopes across types of local public goods strengthen the case for city-level jurisdictional consolidation. For a discussion of the merits of multiple functional local jurisdictions, see, for example, Frey and Eichenberger (1996).

The interdependencies traditionally modeled in this literature are expenditure spillovers, but Brueckner (2004) shows that they could just as well be conceived of as interdependencies due to competition over a mobile tax base. Both these issues feature particularly prominently in the within-city context. As the case for local taxation is the stronger the larger are the spatial differences in voter preferences and the weaker are spillovers, much will depend on the within-city heterogeneity of voter preferences. This chapter will therefore pay particular attention to decentralized taxation acting as a trigger for spatial population sorting.

Decentralization of the tax authority from the central or regional level to local governments will furthermore have different implications depending on the size distribution of local jurisdictions. The decentralization theorem applies in this dimension too: more jurisdictionally fragmented cities will be able to cater better to local differences in preferences, at the cost of incomplete internalization of spillovers. In addition, greater jurisdictional fragmentation can imply efficiency losses in the provision of public goods that are subject to scale economies (Alesina et al., 2004), but it can also generate efficiency gains through Tiebout sorting and yardstick competition (Hoxby, 2001). In this chapter, we consider not only fragmentation itself but also the degree of asymmetry in jurisdictional size distributions and how that interacts with agglomeration economies.

We restrict this chapter to features we consider to be particularly germane to city-level taxation and which have been the subject of recent scholarly research. We therefore have no claim to a general treatment of urban public finance, but we can point readers to some excellent complementary surveys. The big trade-offs inherent in fiscal decentralization are summarized by Epple and Nechyba (2004), and work on political and institutional determinants of city-level policies is reviewed by Helsley (2004). For a survey focusing specifically on urban housing markets and tax capitalization, see Ross and Yinger (1999). Research on fiscal equalization policies, which constrain local fiscal autonomy in many countries, is reviewed in Boadway (2004). Glaeser (2013) offers a survey focusing on three central features of urban taxation in the United States: property taxation, intergovernmental transfers, and balanced-budget rules. Finally, the chapters by Gyourko and Molloy and Olsen and Zabel in this volume review research on the determinants and effects of city-level regulatory policies with respect to land and housing.

The chapter is organized as follows. We begin by providing a cross-country description of intracity allocations of the authority. In the remainder of the chapter, we survey the theoretical literature and empirical literature on the three topics we consider most relevant for city-level tax policy: jurisdictional asymmetry, population sorting, and agglomeration economies. The final section offers a concluding summary.

17.2. INSTITUTIONAL BACKGROUND

This section documents city-level fiscal decentralization patterns and thereby shows how tax competition among different jurisdictions *within* the same city potentially takes place in many countries around the world.

We see two prerequisites for tax competition to occur within a city: First, the city needs to be divided into several local jurisdictions—that is, municipalities. Second, the local jurisdictions need to have significant autonomy to raise local taxes. We study the first prerequisite in Section 17.2.1 for 28 OECD countries, and we document the second prerequisite for 40 OECD and non-OECD countries in Section 17.2.2. Section 17.2.3 combines the results of the two previous sections and identifies countries with good conditions for intraurban tax competition. Section 17.2.4 explores asymmetries in the size of local jurisdictions.

While our analysis is limited by the availability of informative data, we establish that decentralized taxation in cities is a ubiquitous phenomenon. The stylized facts from our analysis are summarized in Section 17.2.5.

17.2.1 Urban jurisdictional fragmentation across the world

This subsection documents to what degree cities around the world are fragmented into local jurisdictions that potentially compete in tax levels. We think of cities as large *functional urban areas* that typically stretch across different administrative government units. A key challenge is therefore to work out an operational definition of cities that is consistent across countries. Given the available data, we shall consider only *large* cities, defined as functional urban areas with more than 500,000 inhabitants.

We use recently collected data from a collaborative venture by the OECD and the European Commission (EC).[3] The OECD/EC definition of functional urban areas comprises three steps. Step 1 partitions sample country surfaces into 1 km^2 grid cells and identifies as high-density cells those with a population density greater than 1500 inhabitants per square kilometer on the basis of categorized satellite images. Step 2 generates clusters of contiguous (sharing at least one border) high-density cells. Low-density cells surrounded by high-density cells are added. Clusters with a total population of at least 50,000 inhabitants are identified as urban cores. Step 3 uses administrative data to calculate commuting flows from local administrative units (municipalities) into urban cores.[4] Local administrative units with at least 15% of employed individuals in an urban core are assigned to the urban core. A contiguous set of assigned local administrative units forms a larger urban zone or functional urban area—that is, a "city" in our terminology. Noncontiguous urban cores with bilateral commuting flows of more than 15% of employed individuals are combined into a single polycentric larger urban zone.[5] An example is provided in Figure 17.1, where the single panels illustrate the three steps for the case of the Berlin area in Germany. The public OECD data contain information on all functional urban areas with total population above 500,000 inhabitants.

[3] See Brezzi et al. (2012) and Dijkstra and Poelman (2012) for a detailed description of the data collection method.

[4] In the United States, counties are used.

[5] A threshold of 50% instead of 15% is applied as an exception for the United States. See (OECD, 2013b).

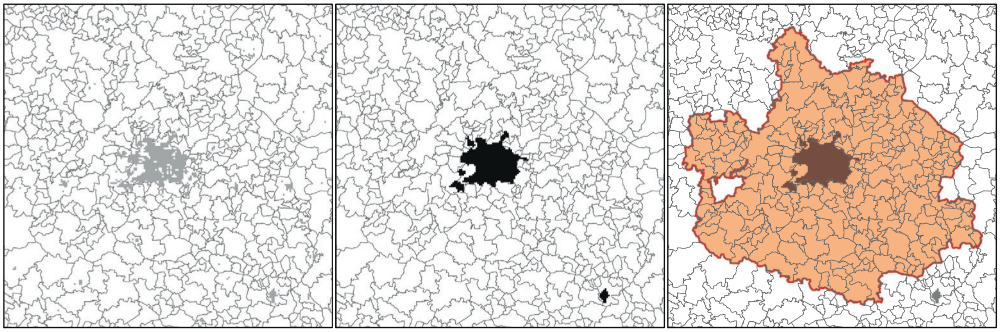

Figure 17.1 Construction of the Berlin functional urban area. The left panel shows the high-density cells with more than 1500 inhabitants per square kilometer and administrative municipal boundaries. The middle panel illustrates the construction of urban centers with a total population of more than 50,000 inhabitants. The right panel shows the construction of the larger urban zone based on bilateral commuting flows. *Source: European Commission, Directorate-General Regional and Urban Policy.*

This OECD/EC definition of urban areas has important advantages over the use of population data for administratively defined cities. Most importantly for our purpose, the definition is largely identical across countries. The procedure also identifies cities that straddle national borders, such as Geneva or Basel. Finally, the OECD/EC data are complementary to other approaches which draw on fine-grained satellite images of population clusters (Rozenfeld et al., 2008, 2011) or night-lights (Henderson et al., 2012) to define "cities," but which do not include economic linkages across space such as commuting flows. The OECD/EC definition therefore represents a uniquely suitable operationalization of functional urban areas for our purpose.[6]

The OECD defines a "local government" as the lowest level of general-purpose government with relevant responsibilities.[7] It explicitly does not consider special purpose jurisdictions such as school districts. See Table A.1 for a description of the local

[6] For a critical discussion of city definitions and an alternative algorithm based solely on commuting patterns, see Duranton (2013).

[7] The exact OECD criterion for "local governments" is as follows: "Have only one level of local government per country, notably the lowest tier (even if more than one level of government may have relevant responsibilities over the same territory). Identify only general-purpose local governments, excluding the specific function governments (for example, school district, health agencies, etc.). United Kingdom: For those areas where the County Councils were abolished the local authority (either a Metropolitan District Council or a Unitary District Council) is used. For London, the Borough Councils are used. United States: In the geographic areas where municipalities or townships do not represent a general purpose government, the county governments were considered" (OECD, 2013a, p. 174).

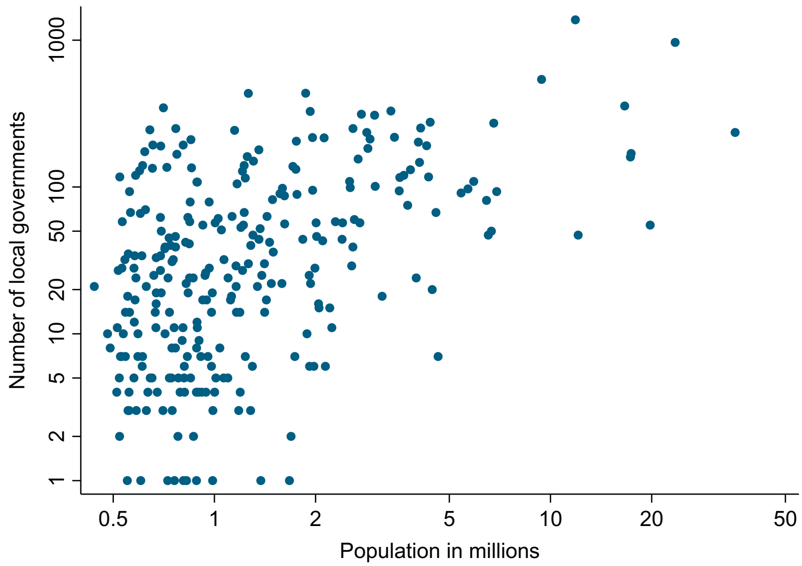

Figure 17.2 Number of municipalities and population across 275 cities in 28 OECD countries, 2012. *Source: OECD (Regional Statistics).*

government level in each country. We shall use the term "municipality" to refer to all of these country-specific types of local jurisdiction.

Figure 17.2 plots the number of municipalities against the population of all sampled functional urban areas in 28 OECD countries. The first observation is that only 10 cities (all of them in Mexico) are entirely contained in one municipality. The other 265 urban areas are fragmented into up to 1375 municipalities (Paris, France). Table 17.1 shows the cities with the highest number of municipalities. The top 10 cities are found in France (Paris and other cities), Korea (Seoul), the United States (Chicago and other cities), Austria (Vienna), and the Czech Republic (Prague). The most fragmented cities in the other sampled OECD countries are also listed in Table 17.1. The average OECD city is divided into 74 municipalities.

Not surprisingly, larger cities tend to contain more municipalities. A regression of the logarithm of the number of municipalities on the logarithm of population yields a highly significant slope coefficient of 0.90 (standard error 0.10, $p < 0.001$). The OECD therefore also reports an index of urban fragmentation which takes account of the different sizes of cities: the number of municipalities per 100,000 inhabitants in the city. Table 17.1 also shows the top urban areas with respect to this index. We again find a number of French cities among the top 10 (e.g., Rouen with 49 local governments per 100,000 inhabitants), but also cities from the Czech Republic (Brno), Austria (Graz), Spain (Saragossa), and Switzerland (Geneva).

Table 17.1 Most fragmented OECD cities

Number of local jurisdictions				Local governments per 100,000			
Rank	**Urban area**	**ISO country code**	**Number**	**Rank**	**Urban area**	**ISO country code**	**Index**
1	Paris	FRA	1375	1	Rouen	FRA	49.06
2	Seoul Incheon	KOR	965	2	Brno	CZE	38.13
3	Chicago	USA	540	3	Toulouse	FRA	34.39
4	Prague	CZE	435	4	Strasbourg	FRA	32.57
5	Toulouse	FRA	434	5	Grenoble	FRA	29.42
6	New York	USA	356	6	Graz	AUT	28.04
7	Rouen	FRA	346	7	Rennes	FRA	27.45
8	Minneapolis	USA	329	8	Saragossa	ESP	24.67
9	Lyon	FRA	327	9	Geneva	CHE	23.9
10	Vienna	AUT	313	10	Prague	CZE	23.28
...				...			
11	Hamburg	DEU	308	14	Wichita	USA	21.54
13	Madrid	ESP	272	18	Bratislava	SVK	18.83
14	Milan	ITA	252	29	Porto	PRT	11.48
19	Lisbon	PRT	235	34	Augsburg	DEU	10.96
19	Tokyo	JPN	235	52	Quebec	CAN	6.87
28	Geneva	CHE	193	53	Budapest	HUN	6.39
30	Montreal	CAN	191	54	Busan	KOR	6.35
32	Budapest	HUN	183	58	Liege	BEL	6.14
45	Bratislava	SVK	136	59	Milan	ITA	6.13
63	Warsaw	POL	101	60	Oaxaca de Juárez	MEX	6.01
64	Brussels	BEL	99	77	Tallinn	EST	5.28
68	Athens	GRC	94	83	Lublin	POL	4.92
95	Amsterdam	NLD	57	86	Ljubljana	SVN	4.86
95	Copenhagen	DNK	57	118	Thessaloníki	GRC	2.9
100	Mexico City	MEX	55	121	Copenhagen	DNK	2.84
108	Santiago	CHL	47	125	Eindhoven	NLD	2.74
108	London	GBR	47	132	Tokushima	JPN	2.5

Top 10 or top of country in respective ranking.
Source: OECD (Regional Statistics), various years.

We next turn to a comparison of urban jurisdictional fragmentation across countries. Figure 17.3 shows the average number of municipalities per city for each country. The first and most important observation is that urban areas are substantially fragmented in all OECD countries. Even in the lowest-ranked country (Ireland), the only sampled city (Dublin) is fragmented into seven local governments. France tops the OECD countries, with on average 280 municipalities per city, followed by the Czech Republic, Austria, and Portugal. The right panel in Figure 17.3 shows that there is substantial variation

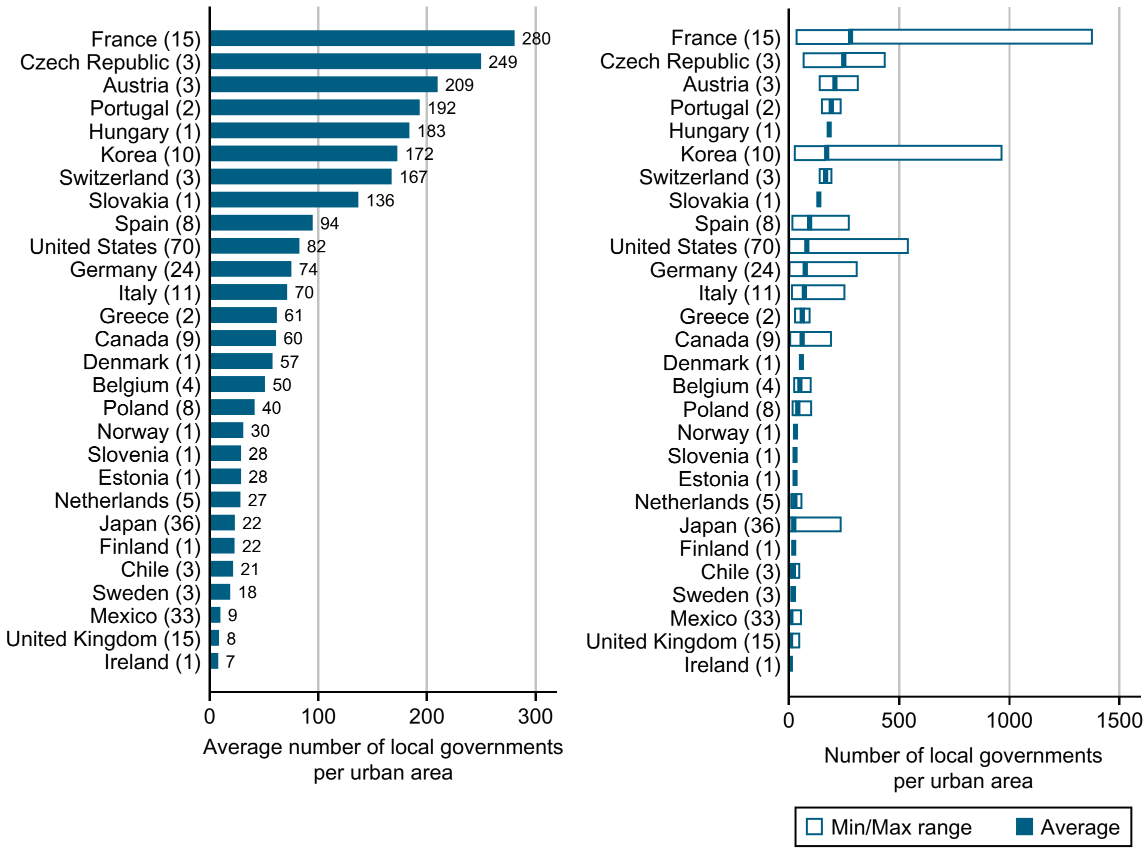

Figure 17.3 Number of municipalities within OECD cities. Number of sample cities in parentheses. *Source: Own calculations based on OECD (Regional Statistics).*

within many countries. In France the range is from 35 to 1375, in Korea it is from 27 to 965, and in the United States it is from 2 to 540. The variation within counties is larger than that across counties (within-country standard deviation 109, between-country standard deviation 80).

Figure 17.4 shows country averages of the number of municipalities per 100,000 inhabitants.[8] The Czech Republic appears as the country with the highest average degree of jurisdictional fragmentation, with 24 local governments per 100,000 inhabitants. It is followed by France (21), Austria (21), and Switzerland (19). There is again substantial variation *within* countries, although now smaller than *between* countries (within-country standard deviation 4.2, between-country standard deviation 7.2). For example, there are between six (Toulon) and 49 (Rennes) municipalities per 100,000 inhabitants in French urban areas, between two (Barcelona) and 25 (Saragossa) municipalities per 100,000 inhabitants in Spain and between 0.2 (Tampa, Florida) and 22 (Wichita, Kansas) municipalities per 100,000 inhabitants in the United States.

In sum, almost all cities in OECD countries with a population above 500,000 inhabitants are fragmented into several local governments (municipalities). On average, there are 74 municipalities per city and 4.9 municipalities per 100,000 inhabitants. We explore in the next section to what extent these local governments can autonomously set local taxes.

17.2.2 Local fiscal decentralization across the world

This subsection documents the degree of local fiscal decentralization in 40 countries across the world. Our principal data source are the Government Finance Statistics (GFS) collected by the International Monetary Fund (IMF).[9] The GFS report revenue and expenditure data of different government units for countries around the world. For many countries, the data are reported separately for different levels of government: the central government, state governments and local governments. In addition, aggregates for *general government* are reported, eliminating double counting from transfers between government layers. This data source has been widely used to document the degree of government decentralization (e.g., Arzaghi and Henderson, 2005; Stegarescu, 2006) at the subcentral (state plus local) level. We will focus on the *local* (municipal) level, which corresponds most closely to the definition we use to document urban jurisdictional fragmentation in Section 17.2.1. The GFS do not report spatially

[8] We use unweighted averages. OECD (2013a, p. 47) reports averages weighted by the population of the urban area. The unweighted average is more informative to document how many cities are fragmented to what degree.

[9] See International Monetary Fund (2001) for a detailed description of the data-collecting process. The OECD Fiscal Decentralization Database is an alternative data source with very similar information about OECD countries. We use the IMF GFS because they cover more countries and are more transparently documented.

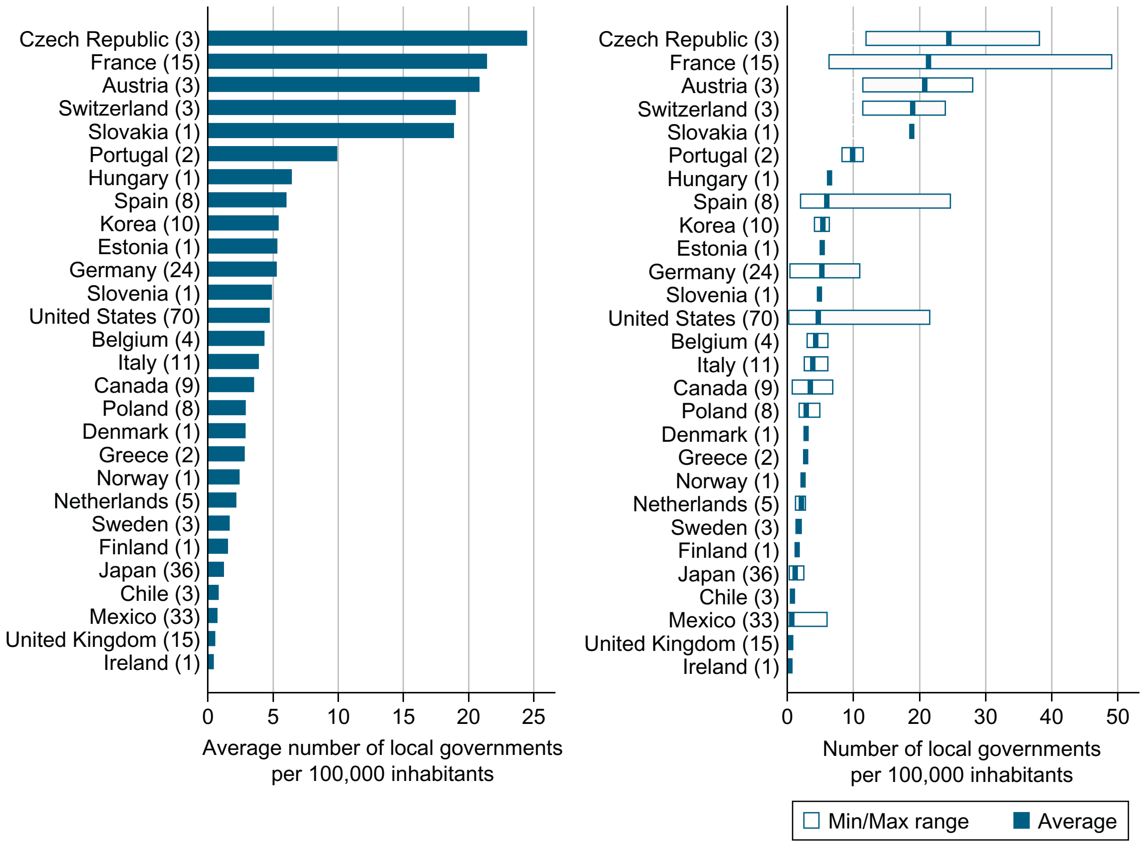

Figure 17.4 Jurisdictional fragmentation of OECD cities. Number of sample cities in parentheses. *Source: Own calculations based on data from OECD (Regional Statistics).*

disaggregated data for the United States for recent years. We therefore use the historical database on individual government finances (IndFin) from the US Census Bureau and replicate the GFS definitions of revenue and expenditure categories as closely as possible.[10]

We can identify municipal tax revenue for 40 countries. Using the World Bank country classification, we observe data from 17 high-income OECD countries, 4 other high-income countries, 12 upper-middle-income countries, and 7 lower-middle-income countries.[11] Unfortunately, there are, in addition, a number of countries for which the GFS do not distinguish the regional (state) and local (municipal) levels.[12] For example, "local" data for France include 26 regions and 100 departments in addition to 36,000 communes, and "local" data for Sweden include 20 county councils in addition to 116 municipal associations and 290 municipalities. Table A.3 lists the local government units which are used in our cross-country sample. For each country, we use the most recent year for which revenue information is available at the local level. The observed years range from 2012 (United Kingdom) to 2003 (Swaziland). Table A.3 reports the observed years for all sample countries.

Stegarescu (2006) proposes several indices of fiscal decentralization at the subcentral (state and municipal) level. We apply these indices to the local (municipal) level. The first index is local government tax revenue as a share of general government tax revenue:

$$\mathrm{LTS} = \frac{\text{local government tax revenue}}{\text{general government tax revenue}}, \tag{17.1}$$

where LTS stands for local tax share.

The index LTS is calculated from the GFS/IndFin data. A detailed description of the variables used is provided in the Appendix. Figure 17.5 shows the LTS for the 40 countries in our sample; exact numbers and averages are reported in Table A.5. Finland ranks top, with 33% of tax revenue collected at the local level. Iceland, Estonia, Switzerland, Latvia,

[10] For the years 1987 and 1992, we have local data for the United States from both GFS and IndFin. The decentralization indices based on IndFin data are systematically smaller than those based on GFS data. However, the differences do not substantially alter the ranking of tax decentralization across countries. See the Appendix for a detailed comparison.

[11] We use the World Bank list of economies (February 2014) available online at http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS. The World Bank divides economies according to 2012 gross national income *per capita* into four income groups: low income, USD 1035 or less; lower-middle income, USD 1036 to USD 4085; upper-middle income, USD 4086 to USD 12,615; and high income, USD 12,616 or more.

[12] The excluded countries are Afghanistan, Azerbaijan, Belarus, China, Republic of the Congo, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, France, Georgia, Hungary, Ireland, Israel, Italy, Japan, Kazakhstan, Korea, Lesotho, Mauritius, Mexico, Moldova, Mongolia, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Sweden, Tajikistan, Thailand, Tunisia, Turkey, Ukraine, and the West Bank and Gaza. See Table A.4 for a description of the problematic regional units.

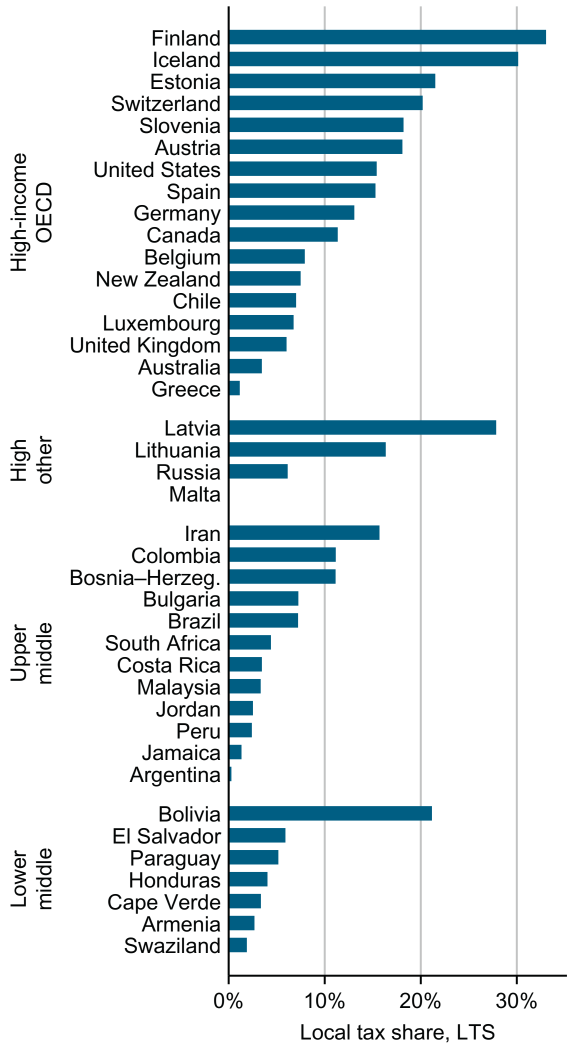

Figure 17.5 Decentralization of tax revenue at local (municipal) level. Local tax revenue as share of general government tax revenue. *Source: Own calculations based on data from the IMF (GFS) and US Census (IndFin).*

and Bolivia also have local tax revenue shares of over 20%. At the bottom of this list, we find Swaziland, Jamaica, Greece, Argentina, and Malta, with local tax revenue shares below 2%. On average, 10% of tax revenue is collected at the local level in our sample (13% in OECD countries). Figure 17.5 clearly shows that many countries other than the United States feature substantial tax collection at the local level.

Tax competition can take place at the local level only if those jurisdictions have real autonomy over the revenue they collect. The OECD (1999) therefore classifies local taxes into nine groups with decreasing local autonomy over determining the tax rate and tax base. Table 17.2 shows the nine categories relabeled for local governments instead of all subcentral government levels. According to the classification in Table 17.2, only tax groups (a)–(c) are relevant local tax revenue. Stegarescu (2006) proposes calculating local governments' tax revenue in groups (a)–(c) as a fraction of general government tax revenue:

$$\text{ALTS} = \frac{\text{local government tax revenue (a) to (c)}}{\text{general government tax revenue}}, \tag{17.2}$$

where ALTS stands for autonomous LTS.

The GFS/IndFin data do not report the degree of autonomy in tax setting. We therefore draw on additional data sources. On the basis of surveys of national financial laws and constitutions, Blöchliger and Rabesona (2009) report the share of local tax revenue in each of tax groups (a)–(e) in Table 17.2. For the United States, we use similar data from Stegarescu (2006) because Blöchliger and Rabesona (2009) do not distinguish local tax groups for the United States. These data are available for 14 high-income countries out of the 40 countries in our initial sample. We can therefore calculate ALTS as

$$\text{ALTS} = \frac{\text{local government tax revenue} \times \text{share in classes (a)–(c)}}{\text{general government tax revenue}}. \tag{17.3}$$

Table A.6 presents the reported shares of the individual tax categories.

Figure 17.6 shows ALTS for 15 high-income countries; the exact numbers are reported in Table A.5. For most countries, ALTS is very similar to LTS. In these countries, most of the local tax revenue belongs to tax classes (a)–(c). For two countries, however, the effective local tax autonomy is dramatically lower than that reported in LTS: autonomous local tax revenue in Austria is only 1.5% of general government tax revenue rather than the 18% when counting all local tax revenue, and in New Zealand ALTS is 0% instead of 7.4%. Autonomous local tax revenue is also somewhat smaller in Spain and Germany. Finland leads the ranking in autonomous tax decentralization. There are still

Table 17.2 Classification of local (municipal) taxes

(a)	LG determines tax rate and tax base
(b)	LG determines tax rate only
(c)	LG determines tax base only
(d)	Tax sharing
(d.1)	LG determines revenue split
(d.2)	Revenue split changed only with consent of LG
(d.3)	Revenue split changed unilaterally by CRG (legislation)
(d.4)	Revenue split changed unilaterally by CRG (annual budget)
(e)	CRG determine tax rate and tax base

LG, local (municipal) government; CRG, central and/or regional governments.
Source: Adapted from (OECD, 1999, p. 11).

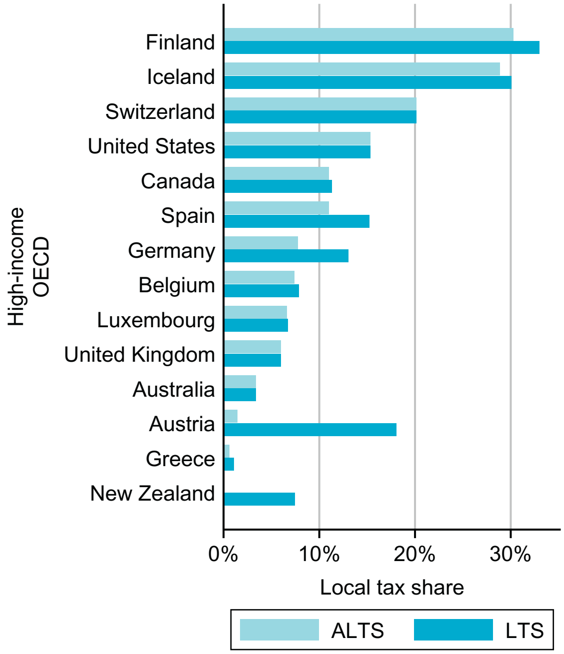

Figure 17.6 Decentralization of tax revenue at the local (municipal) level. Local tax revenue with real tax-raising autonomy as a share of general government tax revenue (ALTS). *Source: Own calculations based on data from the IMF (GFS), US Census (IndFin), and OECD.*

three countries (Finland, Iceland, and Switzerland) with local tax revenue shares above 20% of global tax revenue and six (additionally the United States, Canada, and Spain) with shares above 10%.

The GFS/IndFin data furthermore allow us to decompose local tax revenue into different tax sources: tax on household income, corporate income, property, and consumption of goods and services (including sales and value-added tax) and other tax bases. Figure 17.7 illustrates the composition of the total LTS for 38 countries; the exact numbers are reported in Table A.5. In our sample of countries, *property taxes* are the most important source of local revenue, with an average share of 43%, followed by personal income taxes (21%), consumption taxes (21%), other taxes (8%), and corporate income taxes (5%). Among the 16 countries with the highest degree of fiscal decentralization (LTS > 10%), however, personal income taxes dominate, with an average share of 42%, followed by property taxes (25%), consumption taxes (21%), other taxes (7%), and corporate income taxes (5%).

History appears to play a significant role in explaining which tax instruments are used by local governments. Property taxation is most important in the former British Empire. In our five "Anglo-Saxon" sample countries (Australia, Canada, the United Kingdom, the United States, and New Zealand), the local revenue share of property taxation ranges

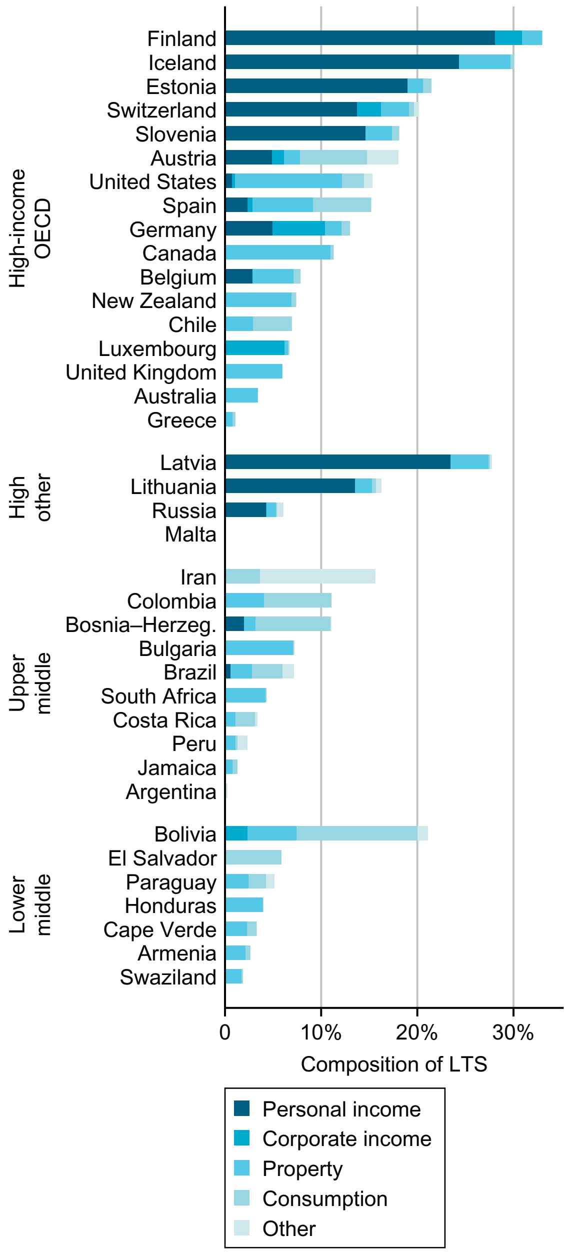

Figure 17.7 Decomposition of local (municipal) tax revenue into tax on personal income, corporate income, property, consumption, and other tax bases. Consumption taxes are taxes on goods and services, including sales, motor vehicle, and alcohol taxes. Local tax revenue is reported as a share of total general government tax revenue. *Source: Own calculations based on data from the IMF (GFS) and US Census (IndFin).*

from 72% to 100%. This share exceeds 50% in only two of the remaining 12 sample OECD countries (Belgium, 55%, and Greece, 75%).

17.2.3 Urban jurisdictional fragmentation and fiscal decentralization across the OECD

Section 17.2.1 documented how cities in OECD countries are fragmented into a multitude of local governments. In Section 17.2.2, we showed that local governments have substantial taxing powers in many countries around the world. Here, we combine the information of these two sections.

We have data on both local jurisdictional fragmentation and fiscal decentralization for 13 OECD countries. For 10 of them we observe the more informative decentralization index ALTS, and for 3 only the index LTS. Figure 17.2 shows the position of all 13 countries in the space of fragmentation and decentralization. Tax competition *within* cities can take place only if cities are fragmented into municipalities with some autonomy over local tax rates and/or the tax base. In Figure 17.8, this is the northeast corner, where Switzerland is positioned. Austria has a higher degree of jurisdictional fragmentation than Switzerland, but Austrian *Gemeinden* have no real local taxing power. Finland has a higher degree of tax decentralization but Finnish cities are fragmented into relatively few *Kommuner*. We also identify a group of countries

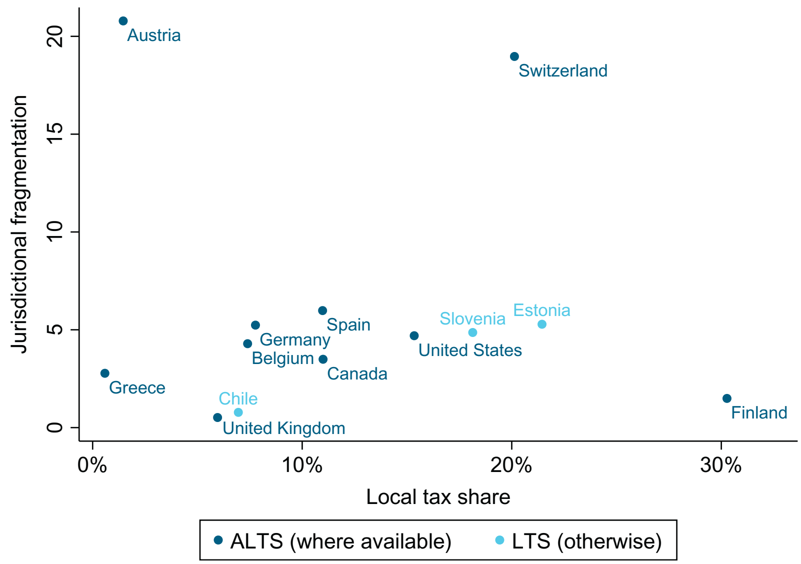

Figure 17.8 Jurisdictional fragmentation (average number of municipalities per 100,000 inhabitants, 2012) and local tax decentralization (local tax revenue as a share of general government tax revenue, various years). ALTS considers local tax revenue with real tax autonomy; LTS considers all local tax revenue. *Source: Own calculations based on data from the OECD (Regional Statistics), IMF (GFS), and US Census (IndFin).*

(the United States, Spain, Canada, Germany, and Belgium) with substantial values in both fragmentation and decentralization. Slovenia and Estonia also belong to this group, although we do not know the assignment of real taxing autonomy in these countries. Chile, the United Kingdom, and Greece have a low degree of both fragmentation and decentralization. However, even in this group of countries there may very well be scope for local-level tax competition.

Note that the sample of countries in Figure 17.8 is determined by the availability of comparative cross-country data. There are likely many more countries with good conditions for urban tax competition. In particular, we cannot include many OECD countries with a high degree of subcentral tax decentralization but where the municipal share is unknown, such as Sweden, Denmark, Norway, Japan, France, and Italy. We also do not include all non-OECD countries with a substantial degree of fiscal decentralization, such as Latvia, Lithuania, Iran, Colombia, Bosnia–Herzegovina, and Bolivia (see Section 17.2.2).

17.2.4 Asymmetries in jurisdictional fragmentation

In this section, we study the size distribution of local jurisdictions *within* cities. Anecdotal evidence suggests that the core municipality in large urban areas typically "dominates" the urban area in terms of population. This section seeks to quantify this casual observation.

The OECD data do not report population figures for individual municipalities within cities. We therefore use alternative data provided by the EC for the year 2006 and the US Census for 2012 (see the Appendix for details). The EC data are based on the joint OECD/EC definition of cities, but unfortunately differ substantially in some details.[13] The US data for 2012 complement the EC data with information on US cities.

We first calculate the population of the largest local jurisdiction as a share of the total population of the city. Table 17.3 shows the European and US cities with the highest population share of the dominant municipality. The list is topped by the city of Saragossa in Spain, the main municipality of which hosts 93% of the city's population. It is followed by Genoa in Italy (85%) and El Paso, Texas, in the United States (81%). On average, in our sample of 158 cities across 17 countries the population share of the largest municipality is 38.9%.

[13] The EC data combine the German cities of Essen, Dortmund, Duisburg, and Bochum into the combined city "Ruhrgebiet," which makes it the largest city in Germany. The number of municipalities (local governments) is identical or very similar in the EC and the OECD data, except for Saragossa (Spain), for which the OECD reports 210 municipalities and the EC reports 21, while both report a similar total population. All cities in the Czech Republic contain a significantly greater number of municipalities in the EC data than in the OECD data—for example, 435 and 729, respectively, for Prague. Because of this resulting lack of comparability with Section 17.2.1, we do not include the Czech Republic in Section 17.2.4.

Table 17.3 Population shares of largest municipalities

Rank	Urban area	ISO country code	Population	Local governments	Share of largest (%)
1	Saragossa	ESP	702,349	21	93.2
2	Genoa	ITA	736,058	38	84.5
3	El Paso	USA	830,827	7	81.1
4	Lodz	POL	967,581	17	78.5
5	Malaga	ESP	729,280	9	76.8
6	Wrocław	POL	829,453	19	76.6
7	Tallinn	EST	536,059	24	73.3
8	Jacksonville	USA	1,190,394	14	70.3
9	Palermo	ITA	968,197	26	68.6
10	Berlin	DEU	4,980,394	246	67.5
...					
16	Vienna	AUT	2,599,439	313	63.6
18	Budapest	HUN	2,781,514	186	60.9
22	The Hague	NLD	796,581	7	59.0
30	Gothenburg	SWE	894,311	14	54.7
34	Ljubljana	SVN	485,374	26	52.1
41	Marseille	FRA	1,692,351	132	50.2
52	Oslo	NOR	1,113,227	34	47.3
56	Antwerp	BEL	1,014,444	32	45.6
60	Helsinki	FIN	1,248,302	14	43.2
102	Thessaloníki	GRC	996,428	29	31.2
103	Zurich	CHE	1,097,224	130	31.2
	Average		1,940,193	97.8	38.9

Top 10 or top of country in respective ranking.
Source: European data for 2006 from the EC (Urban Audit); US data for 2012 from the OECD (Regional Statistics) and US Census (Population Estimates Program).

The population share of the largest municipality needs to be compared with the share of the city's other municipalities. We calculate three measures to make such a comparison: the first measure is the ratio of the population of the largest municipality to the average population of all the city's municipalities. This measure would be 1 if all municipalities were of identical size. The second measure is the ratio of the population of the largest municipality to the population of the second largest municipality. This measure would also be 1 with identical municipality sizes, and it would be 2 if municipality sizes followed Zipf's rank-size rule.[14] The third measure is the ratio of the population of the largest municipality to its theoretical population size if all the city's municipalities

[14] Zipf (1949) postulated in his nonstochastic version that city sizes follow the rank-size rule:

$$\text{pop}_r = \text{pop}_1 / r,$$

where pop_r is the population of a city with rank r and pop_1 is the population of the largest city.

followed Zipf's rank-size rule.[15] The third measure would be 1 if all municipality sizes followed the rank-size rule.

Table 17.4 shows the top-ranked cities according to each of the three measures. We see for all three measures that the top-ranked cities deviate starkly from both the uniform distribution rule and the rank-size rule. For example, the central municipality of Paris is 268 times bigger than the average municipality in the Paris urban area, the central municipality of Saragossa is 102 times bigger than the town of Zuera, which is the second largest municipality in the Saragossa urban area, and the central municipality of Berlin is 4.1 times bigger than what the rank-size rule would predict for the Berlin urban area.

Substantial deviations from both the uniform distribution rule and the rank-size rule can be found in all of the 17 sample countries. Figure 17.9 shows the average of the three measures for each country. The exact numbers along with minima and maxima are reported in Table A.7. At the top of the left panel is Hungary, where the largest municipality in the only urban area (Budapest) is 113 times larger than the average municipality; at the bottom is Finland, where the largest municipality in the only urban area (Helsinki) is 6 times larger than the average municipality. At the top of the right panel is Estonia, where the largest municipality in the only urban area (Tallinn) is 29 times bigger than the second largest municipality; at the bottom is Finland, where the largest municipality in Helsinki is only 2.4 times bigger than the second largest municipality.

17.2.5 Summary of institutional facts

Our analysis of data from the IMF (GFS), the OECD (Regional Statistics), Eurostat (Urban Audit), and the US Census (IndFin, Population Estimates Program) can be summarized in the following four stylized facts:

Result 17.2.1. *With the exception of some Mexican cities, all OECD cities with more than 500,000 inhabitants are fragmented into multiple local governments. On average, there are 74 local governments per functional urban area. The degree of urban jurisdictional fragmentation differs substantially both within and across countries.*

Result 17.2.2. *All of our 40 sample countries collect some tax revenue at the local (municipal) level. On average, 10.0% of the countries' total tax revenue is collected locally; 6 countries collect more than 20% locally, and 16 countries collect more than 10% locally. Considering*

[15] The theoretical size of the largest municipality in an urban area with a given total population pop and given number of municipalities N is calculated as follows:

$$\text{pop}_1 = \text{pop}/[\psi(N+1) - \psi(1)],$$

where $\psi(.)$ is the digamma function. $\psi(N+1) - \psi(1)$ equals the finite harmonic series $1 + 1/2 + \cdots + 1/N$.

Table 17.4 Top asymmetry measures of urban areas

Largest vs. average-sized municipality				Largest vs. second largest jurisdiction				Largest vs. Zipf prediction			
Rank	**Urban area**	**ISO country code**	**Ratio**	**Rank**	**Urban area**	**ISO country code**	**Ratio**	**Rank**	**Urban area**	**ISO country code**	**Ratio**
1	Paris	FRA	268.1	1	Saragossa	ESP	102.1	1	Berlin	DEU	4.1
2	Hamburg	DEU	229.1	2	Genoa	ITA	57.2	2	Vienna	AUT	4.0
3	Vienna	AUT	199.0	3	Vienna	AUT	43.3	3	Rome	ITA	3.7
4	New York	USA	178.7	4	Baltimore	USA	41.4	4	Hamburg	DEU	3.6
5	Berlin	DEU	166.2	5	Jacksonville	USA	38.5	5	Genoa	ITA	3.6
6	Toulouse	FRA	163.7	6	Rome	ITA	33.1	6	Budapest	HUN	3.5
7	Chicago	USA	155.7	7	New York	USA	30.1	7	Wichita	USA	3.5
8	Budapest	HUN	113.2	8	Munich	DEU	29.3	8	Saragossa	ESP	3.4
9	Louisville	USA	96.5	9	Tallinn	EST	29.0	9	Louisville	USA	3.4
10	Rome	ITA	96.2	10	Wrocław	POL	29.0	10	New York	USA	3.2
...				...				...			
13	Madrid	ESP	93.1	11	Budapest	HUN	28.1	12	Warsaw	POL	2.9
27	Warsaw	POL	52.1	19	Paris	FRA	19.1	15	Tallinn	EST	2.8
34	Geneva	CHE	43.8	39	Zurich	CHE	11.3	16	Marseille	FRA	2.7
72	Athens	GRC	20.8	43	Antwerp	BEL	10.4	52	Ljubljana	SVN	2.0
79	Tallinn	EST	17.6	52	Stockholm	SWE	8.4	58	Oslo	NOR	1.9
82	Oslo	NOR	16.1	56	Ljubljana	SVN	8.2	67	Antwerp	BEL	1.8
85	Antwerp	BEL	14.6	59	Rotterdam	NLD	8.1	70	Gothenburg	SWE	1.8
88	Amsterdam	NLD	14.1	92	Oslo	NOR	5.0	74	Rotterdam	NLD	1.7
91	Ljubljana	SVN	13.5	103	Athens	GRC	4.3	78	Zurich	CHE	1.7
104	Stockholm	SWE	10.5	135	Helsinki	FIN	2.4	97	Helsinki	FIN	1.4
136	Helsinki	FIN	6.1					115	Thessaloníki	GRC	1.2
	Average		33.7		Average		9.7		Average		1.7

Top 10 and top of country in respective ranking.
Source: European data for 2006 are from the EC (Urban Audit); US data for 2012 are from the OECD (Regional Statistics) and US Census (Population Estimates Program).

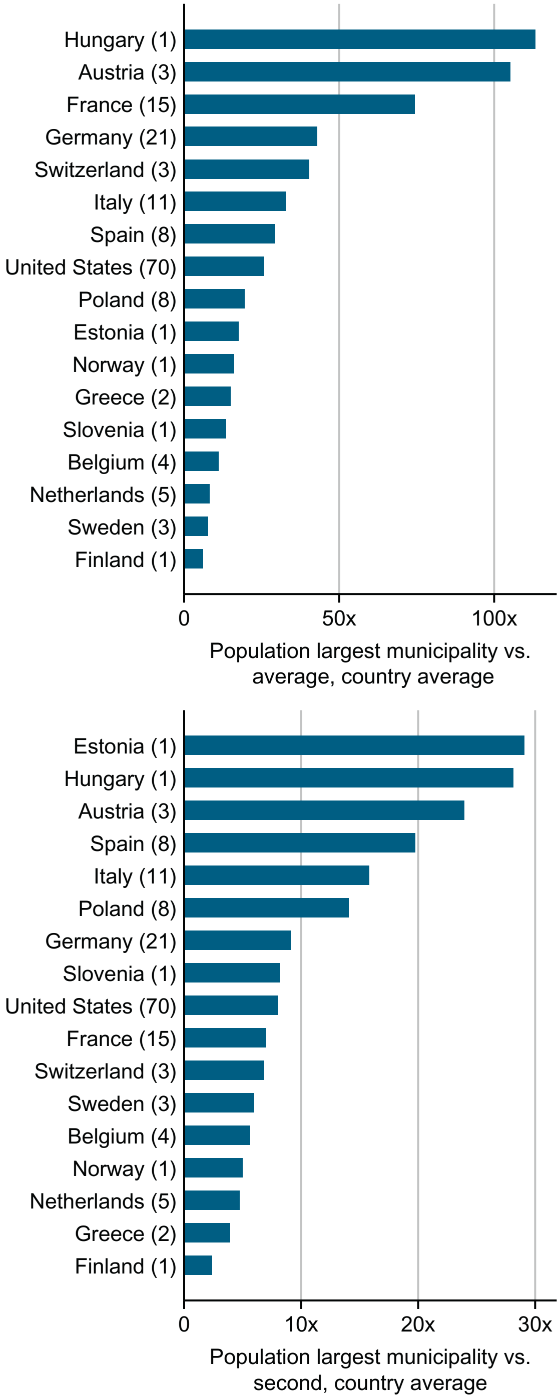

Figure 17.9 Asymmetries across local governments within cities. Number of sample cities in parentheses. *Source: Own calculations based on European data for 2006 from the EC (Urban Audit) and US data for 2012 from the OECD (Regional Statistics) and US Census (Population Estimates Program).*

local tax autonomy substantially reduces the effective degree of tax decentralization for some countries. The degree of local fiscal decentralization differs substantially both within and across countries.

Result 17.2.3. *We identify eight countries with conditions for intraurban tax competition at least as strong as those in the United States.*

Result 17.2.4. *Most OECD cities are characterized by a central municipality that strongly dominates the city in terms of population, beyond what would be predicted by Zipf's law.*

17.3. TAX SETTING ACROSS ASYMMETRIC JURISDICTIONS

Among the most striking stylized facts emphasized in Section 17.2 are differences in the population share of the central municipality of a city, and in the number of municipalities in a city. Just as the structure of an industry affects the prices charged by firms, the structure of a city should influence the tax rates set by its municipalities.

17.3.1 Horizontal tax competition

17.3.1.1 Theory

If there were only one level of government, how should the size distribution of jurisdictions affect tax rates? Much of the theoretical (and empirical) analysis of this issue has used what will be referred to here as the "basic tax competition model," developed in Wilson (1986), Zodrow (1986), and Wildasin (1988). In that model, capital is perfectly mobile within a city, and all other factors of production are immobile. This immobility assumption makes the basic tax competition model better suited to competition among larger units than to competition among municipalities within a single city. In the basic model, local public output benefits only the immobile residents, not owners of mobile capital. Allowing (some categories of) public expenditure to increase the return to capital will reduce or reverse governments' incentives to attract capital by cutting tax rates. An even more important extension for urban public finance is to incorporate mobility of residents. Some attempts to do so are discussed in this subsection. However, to date there are no coherent and plausible models of taxation which incorporate these features. New approaches are needed to analyze more "urban" fiscal competition, approaches in which different levels of government, population sorting, and locational features play a greater role.

The basic tax competition model makes a strong prediction about how tax rates vary across the municipalities within a city: smaller municipalities have lower tax rates. Bucovetsky (1991) and Wilson (1991) provide a derivation of this result in the case of two jurisdictions, and Wilson (1999) offers a survey of the first 15 years of this literature.

This prediction persists in many extensions and modifications of the model. The positive correlation of tax rates and the population is one of the clearest predictions of models of tax competition, perhaps more general than any prediction on the shape of jurisdictions' fiscal reaction functions.

The basic tax competition model also provides some predictions about tax rates across cities, when the population distribution within these cities differs. Two simple comparative-static exercises can be considered. First, consider a city with n identical municipalities. In a symmetric equilibrium, all these municipalities will levy the same tax rate. The basic tax competition model predicts that this tax rate should decrease with the number n of municipalities.[16] Fiscal equalization schemes redistributing tax revenue as a function of municipalities' *per capita* tax base will attenuate the rate-lowering effect of horizontal tax competition (see Köthenbürger, 2002; Bucovetsky and Smart, 2006). This attenuating effect of fiscal equalization has been confirmed in empirical research, for example, by Buettner (2006) and Egger et al. (2010). Second, consider the extent of asymmetry within a city. If there are only two municipalities within the city, the basic tax competition model predicts that the average tax rate within the city should increase with the degree of asymmetry—the population share of the larger municipality. This prediction again contrasts with the predictions from alternative models. New economic geography models suggest that tax differences are due to the ability of large jurisdictions to extract the rents from agglomeration economies. Such models imply that greater asymmetry will be associated with higher taxes in the larger municipality. Models with (some) population mobility lead to similar conclusions. In the Kanbur and Keen (1993) model of cross-border shopping, more asymmetry leads to lower tax rates in each municipality, and to a lower average tax rate for the whole city.[17]

The mechanism behind these conclusions from the basic tax competition model is quite straightforward. Suppose that a municipality's output is a quadratic function of its employment of mobile capital. If capital were perfectly mobile among municipalities, the quantity of capital attracted to a municipality would be proportional to the difference between the average unit tax rate on capital in the city, and the tax rate in the municipality. If municipalities differ only in size, then this relation between taxes and capital employment is exactly the same in each municipality, and can be written as

$$k_i = \overline{k} + \beta(\overline{t} - t_i), \tag{17.4}$$

where k_i is the capital employed per resident in municipality i, $\overline{k}$ is the capital available per person in the city, t_i is the tax rate in the municipality, $\overline{t}$ is the average tax rate in the city,

[16] This literature assumes n to be exogenously given. For models of endogenous local jurisdiction formation, see, for example, Henderson (1985), Alesina et al. (2004), or Gordon and Knight (2009).

[17] This model has been extended to analyze income tax competition when people are less than perfectly mobile by Gabszewicz et al. (2013).

and $1/\beta$ is the coefficient on the quadratic term in the production function. However, the average tax rate $\bar{t}$ in the city itself will depend on municipality i's own tax rate. The larger the population share in the municipality, the stronger the influence of the municipality's own t_i on $\bar{t}$. So, tax reductions have a smaller impact on the capital employment per person in larger municipalities, since they have a larger absolute effect on the city's average tax rate. This differential impact underlies the positive correlation within a city between the municipal population and the equilibrium municipal tax rate.

The implications of the basic tax competition model for tax rate differences across cities are derived in Bucovetsky (2009). In addition to assuming a quadratic production function, he assumes that the marginal rate of substitution between the tax-financed local consumption good and the numéraire is constant. So, residents of a municipality seek to maximize $x_i + (1+\varepsilon)t_i k_i$ subject to Equation (17.4), where x_i is private consumption $f(k_i)-(r+t_i)k_i+r\bar{k}$ (with r the city's net return to capital and $f(\cdot)$ the quadratic production function), and $\varepsilon > 0$ measures the premium placed on public consumption. The Nash equilibrium tax rate in a municipality can be expressed as a function of the average tax rate in the city and the share of the population in the municipality. Not only is the equilibrium tax rate an increasing function of the municipality's population, it is also a convex function of the population.

Because of this convexity, the overall average level of municipal tax rates within a city depends on the concentration of the population among municipalities. A "concentration index" for the population, similar (but not identical) to measures of concentration used in industrial organization, determines the city's average tax rate. Any movement of the population from a smaller municipality to a larger municipality within the same city must raise the equilibrium tax rate in the city.

In this framework, the share of the population of the largest municipality in a city plays an important role. Conditional on the largest municipality's share of the city's population, the average tax rate in the city still depends on the distribution of the population among the remaining municipalities. This rate will be highest when the population of these other municipalities is most concentrated and lowest when the population is least concentrated.[18] However, as Figure 17.10 illustrates, for a given share of the population in the largest municipality, the average tax rate is not too sensitive to the population distribution in the remaining municipalities. For comparison, Figure 17.10 also shows the negative relationship between the population share of the largest jurisdictions and the average tax rates predicted by the Kanbur and Keen (1993) model described above.

[18] Here "most concentrated" means that there are k other municipalities each with the same share s_1 of the population as the largest municipality and one other municipality with a share $1-ks_1$, where k is the largest integer less than or equal to $1/s_1$. "Least concentrated" means that there are n other municipalities, each with a share $\frac{1-s_1}{n}$ of the population, and $n \to \infty$.

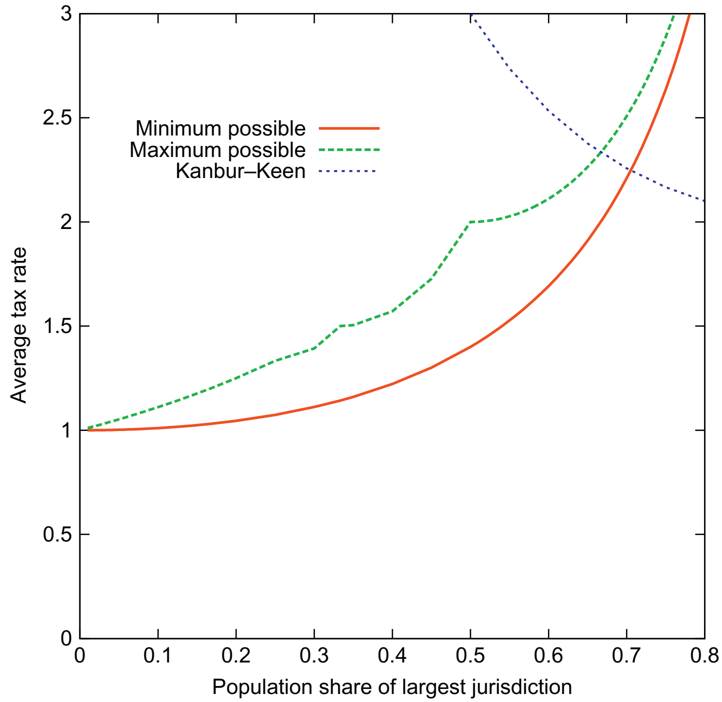

Figure 17.10 Average tax rate as a function of the largest jurisdiction's population share in the basic tax competition model. The average tax rate in a city is particularly sensitive to the population share of the largest municipality but is not too sensitive to the population distribution in the remaining municipalities.

In the basic tax competition model, tax revenue is used exclusively to finance a public consumption good. Peralta and van Ypersele (2005) assume instead that the revenue is used to make cash payments to residents.[19] They also allow for municipalities to differ in two attributes: population, and capital endowment per person. They show that a ranking of municipalities by population similar to that in the earlier literature can be made.[20] Given quadratic technology, and assuming that taxes are strategic complements, the absolute value of a municipality's capital tax rate increases with its population, with the capital endowment per person being held constant.[21] The mechanism here is similar to that in the basic model: taxes are levied solely to influence the city's terms of trade, and larger municipalities have a greater influence on them. It also remains true that smaller municipalities do better than large municipalities. The additional dimension of heterogeneity

[19] Alternatively, the public consumption good is assumed to be a perfect substitute for the private good.
[20] Peralta and van Ypersele (2005), Proposition 4, p. 268.
[21] Recent empirical research suggests that strategic complementarity of local tax rates may not be an innocuous assumption (Parchet, 2014).

also influences tax rates. If the population is held constant, municipalities with higher *per capita* endowments have lower tax rates. Here "lower" does not mean "lower in absolute value." Municipalities with the highest endowment *per capita* will subsidize capital in equilibrium.

In Pieretti and Zanaj (2011), there is also no public consumption good. But in their model, municipal governments are leviathans, seeking to maximize net tax collections. There are several other features of the Pieretti–Zanaj model that differentiate it from the basic model. One attractive feature is that municipal governments provide a public intermediate good, which benefits investors; this feature makes the model more relevant to urban location models, in which residents' location decisions may be influenced by the local public sector. So, municipal governments here seek to maximize revenue collected from source-based taxes on investment, net of the cost of public intermediate investments which attract that investment.

There are two other novel features. Capital owners within each municipality prefer to invest at home, rather than in other municipalities. They are also heterogeneous in terms of the strength of this preference. A type x investor incurs a cost of αx from investment outside his/her home municipality, the parameter α measuring the strength of the home-biased preference. The idiosyncratic attachment-to-home parameter x is assumed to be uniformly distributed over [0,1] in each municipality. Moreover, the assumed production technology is different. The return on investment in any municipality is constant, rather than a decreasing function of the level of investment in that municipality.[22] This constancy of the return on investment eliminates the channel through which population influences tax rates in the basic model. In the basic model, municipal tax rates influence the gross return on investment in the city, and the greater influence of larger municipalities' taxes on that return explains why they set higher tax rates in equilibrium. In Pieretti and Zanaj (2011), this citywide gross return is fixed.

These modifications to the basic model weaken the positive relationship between population and tax rates. Whether the smaller municipality levies the lower tax rate depends on the degree of capital mobility. When capital is less mobile (α is high), the smaller municipality will levy the lower tax rate. But if capital is sufficiently mobile, the smaller municipality will levy a higher tax rate, and will still be a capital importer because of the higher quality of its productive infrastructure.

The main theoretical findings on horizontal tax competition are summarized in the following results:

Result 17.3.1. *In the basic model of horizontal tax competition, if a city contains* n *identical municipalities, then the municipalities' equilibrium tax rates are a decreasing function of n.*

[22] This is as in Marceau et al. (2010), or Köthenbürger and Lockwood (2010), for example.

Result 17.3.2. *In the basic model of horizontal tax competition, tax rates within a city will be positively correlated with municipal populations.*

Result 17.3.3. *In the basic model of horizontal tax competition, increased concentration of the population among the municipalities of a city increases the average tax rate in the city.*

Result 17.3.4. *If local public expenditure increases the return on investment, tax rates within a city may be negatively correlated with municipal populations, provided that the return on investment is not sensitive to the level of investment in the municipality.*

17.3.1.2 Empirical studies

Although many empirical studies of tax competition have provided evidence of the relationship between a municipality's population and its tax rate, in many instances, this relationship was not the focus of the study.[23] Estimating the slope of municipalities' reaction functions (one municipality's tax rate as a function of another's) is an active research area. The sign of these slopes is not directly relevant for the theoretical results emphasized here.[24] But a municipality's population is often used as a regressor in this empirical work, providing some evidence for how tax rates vary with the population within a given city.

Hauptmeier et al. (2012) offer fairly strong empirical support for the more conventional tax competition outcome, although in a framework that is closer to that of Pieretti and Zanaj (2011). They estimate the determinants of local tax rates and of local public input provision (roads) for a sample of municipalities in Baden-Württemberg in four different time periods. The coefficient on the population in the tax regression is positive and significant in nearly all the estimated equations. It is the effect of the population on reaction functions that is being estimated here, while the theoretical result of Pieretti and Zanaj (2011) pertains to the effect of the population on equilibrium tax rates. Nonetheless, under relatively weak conditions, a jurisdiction which wants to set a higher tax rate than another, when all jurisdictions levy the same tax rates, will be the one choosing the higher tax rate in equilibrium.

[23] For example, population is one of the regressors in the regressions run in Buettner (2006) in his study of the effects of fiscal equalization programs on tax setting, but the coefficient on the population is not reported.

[24] The sign of these slopes is indeterminate in the basic tax competition model. The results in Wilson (1991) for two-municipality cities hold regardless of the sign of these slopes. The stronger assumptions in Bucovetsky's (2009) extension to more than two municipalities imply that reaction curves must slope up, but there is no suggestion that this positive slope is necessary for the results. For an application to within-city tax reaction functions, see Brueckner and Saavedra (2001). For a promising new way to identify tax competition, based not on reaction functions but on estimable differences between desired and equilibrium tax rates, see Eugster and Parchet (2014).

The studies summarized in Table 17.5 all provide estimates of the effect of a jurisdiction's population on the level of some fiscal variable in that jurisdiction. With one exception, the fiscal variable is a tax rate: business property tax rates, income tax rates, or excise tax rates on tobacco or gasoline. The one exception in the table is the article by Solé-Ollé (2006), in which a jurisdiction's total public expenditure is the dependent variable. The theory would predict a positive coefficient here (only) if a jurisdiction's tax base were an inelastic function of the tax rate.

With one exception, the articles cited in the table estimate reaction functions. Typically the lagged value of some weighted average of neighboring jurisdictions' tax rates is the independent variable of interest. The exception is the article by Egger et al. (2010), where the main focus is on the effect of equalization grant rules on a jurisdiction's tax rate. This is the one study that estimates the reduced form presented in the previous section: the equilibrium tax rates in municipalities as functions of exogenous variables. Because of fixed effects, the dependent variable is the change in a jurisdiction's tax rate, and the change in that jurisdiction's population is one of the explanatory variables. The coefficient on this variable is close to zero, varies in sign across regressions, and is not significantly different from zero in any of the reported results.

There is less empirical work so far on the relation between population concentration within a city and the average tax rate in a city. One article that does examine this relation deals as well with vertical tax competition and so is discussed in Section 17.3.2.

The main empirical findings on horizontal tax competition among asymmetric jurisdictions in Table 17.5 do not mirror the prediction of most theoretical models:

Result 17.3.5. *Empirical estimates provide conflicting evidence for the effect of population size on jurisdictions' tax rates.*

Table 17.5 Empirical evidence for the effect of population size on local tax rates

Article	Dependent variable(s)	Country/state	Year(s)	No. of jurisdictions	Sign of population
Allers and Elhorst (2005)	Property tax	Netherlands	2002	496	+
Bordignon et al. (2003)	Business property tax	Milan Province	1996	143	−
Devereux et al. (2007a)	Tobacco, gasoline	USA	1977–1997	48	Mixed
Edmark and Ågren (2008)	Income tax	Sweden	1993–2006	283	−
Egger et al. (2010)	Change in business tax	Lower Saxony	1998–2004	440	0
Hauptmeier et al. (2012)	Business tax	Baden-Württemberg	1998–2004	1100	+
Solé-Ollé (2006)	Expenditure	Spain	1999	2610	Convex

17.3.2 Vertical tax competition

While the basic model of tax competition among same-level governments implies that tax rates are set inefficiently low, that conclusion may be reversed when different levels of government share a common tax base and set their tax rates noncooperatively. Suppose that there is a higher-level city government that can levy its own taxes, on top of those set by lower-level municipal governments. This vertical interaction yields an additional externality. If the city contains N identical municipalities, the extent of this vertical tax externality, like the horizontal externality, increases with N. A single municipality, in choosing to raise its tax rate, lowers the tax base of the higher-level city government. Residents of the municipality bear a share $1/N$ of the costs of that tax base reduction, and so are less inclined to internalize the costs of this effect, the larger is N.[25] Because of these offsetting effects, it is not immediately clear whether increased decentralization leads to higher or lower taxes. Keen and Kotsogiannis (2004) analyze this sort of model. While the effects of increased decentralization on tax rates cannot be signed, the effect on overall welfare can. Since the vertical and horizontal externalities both increase with the number of municipal governments, equilibrium welfare of residents must fall. The Keen–Kotsogiannis model also extends the basic tax competition model by allowing for a variable total supply of capital (to the city), as an increasing function of the net return to capital. Without this extension, there would be no vertical externality, since the city's tax base would not be affected by municipal tax rates.

A natural extension of the Keen–Kotsogiannis model is to model explicitly competition among cities. The article by Wrede (1997) was one of the first works to attempt this extension, although vertical tax competition was assumed away in this article. More recent work includes the work of Hoyt (2001) and Breuillé and Zanaj (2013). Breuillé and Zanaj maintain the assumption of fixed aggregate capital supplies prevalent in the horizontal tax competition literature. But with several cities, vertical externalities will occur even with this fixity: a tax increase in one of the municipalities reduces capital supply to the whole city. With quadratic production functions, and preferences separable in the public consumption goods provided by each level of government, Breuillé and Zanaj show that a merger of any municipalities must (1) raise tax rates set by each city (including those not party to the merger), (2) lower all municipal tax rates, and (3) increase all combined (city plus municipal) tax rates.

Result 17.3.6. *With vertical externalities, tax rates may increase with the number of municipalities in a city if the city's overall capital supply function is upward sloping.*

Brülhart and Jametti (2006) modify the Keen–Kotsogiannis model to a form in which the relative importance of vertical and horizontal effects can be tested empirically. In their

[25] Keen and Kotsogiannis (2002), p. 366.

theoretical model, it is assumed that each city contains N identical municipalities. The marginal payoff from a tax increase in municipality i can be decomposed between two terms, one due to horizontal externalities and the other to vertical externalities. In that model, a positive correlation between the number of municipalities and the tax rates in the municipalities indicates that vertical externalities are more important.

Brülhart and Jametti (2006) estimate the relation between a municipality's population share and its tax rates using a panel of Swiss municipalities. The sample is divided between the set of municipalities in which decisions must be approved directly at a public meeting open to all citizens, and those in which, instead of open meetings, local government decisions must be approved by a referendum. The first sample corresponds to municipalities in which decision making is most likely made by some representative citizen; referenda give considerable power to local government officials through their control of the agenda. Brülhart and Jametti find a significant negative relationship between a municipality's population share and its tax rates for the first (public meeting) subsample, indicating that vertical externalities dominate horizontal ones. The relationship is also negative for the second (referendum) subsample, although the coefficient here tends not to be significant.

Result 17.3.7. *Evidence from Swiss municipalities indicates that at the local level vertical tax externalities may be as relevant as horizontal tax externalities.*

17.3.3 Voting

One of the major weaknesses of the basic model in its applicability to urban taxation is the assumption that people are immobile. We now turn to literature that models the relation between the municipal population and tax rates when people are mobile, differ in income, and vote on tax policy. In this subsection, we focus on the interaction of the voting equilibrium within municipalities and the sorting equilibrium across municipalities. See also the chapter by Ross and Yinger (1999) on the early contributions. Section 17.4 focuses in more detail on population sorting across municipalities. Within a municipality, the shape of the distribution of income across the population will determine the progressivity of the tax system. A widely used, tractable model of voting on income tax schedules is that of Romer (1975), Roberts (1977), and Meltzer and Richard (1981), in which self-interested voters choose a flat income tax, the proceeds of which are distributed equally (thus implying a progressive effect of the system), and in which the efficiency loss due to this distortionary tax is a quadratic function of the tax rate. In such a model, the Condorcet winner among tax rates chosen by majority rule is proportional to the ratio of the median income to the mean income.

These models can be used to explain the variation of tax rates across municipalities, if municipalities differ in population, and in the distribution of income over that population.

Suppose, for example, that the distribution of income in some municipality was a truncated Pareto distribution over some interval (L, H). A property of that distribution is that the ratio of median income to mean income in the municipality is a decreasing function of the ratio of the lowest to the highest income L/H, independent of the "scale" parameter L. This means that if a municipality contained only people whose incomes fell in some segment (L, H) of the overall metropolitan income distribution, then the median–mean ratio would have to be very close to 1, if the segment were small enough.[26] In other words, the actual size of a municipality may affect the tax rate chosen: small municipalities will not vote to levy high income taxes.

Suppose that people vote on tax schedules taking the population composition as given.[27] That is, either voters are myopic, and ignore the effect of their own choices on mobility, or voting takes place after people have made their location choices. When will a sorting equilibrium arise in which each municipality contains a disjoint segment of the income distribution? If municipalities are numbered in increasing order of their income, so that municipality j contains a slice (L_j, H_j) of the income distribution, with $H_j = L_{j+1}$, then a necessary condition for the population allocation to be an equilibrium is that the person with income $H_j = L_{j+1}$ is indifferent between municipalities j and $j+1$. If people care only about their net income, and if municipalities are allowed to charge a flat admission fee p_j to each resident, the payoff from choosing to reside in municipality j for a resident with (exogenous) income y is $y(1-t_j) + t_j\overline{y_j} - p_j$ if the income tax rate in the municipality is t_j and if income tax proceeds are distributed equally to all residents. If the equilibrium is stratified, and if y is the highest income level in municipality j, then

$$y(1-t_j) + t_j\overline{y_j} - p_j - y(1-t_{j+1}) - t_{j+1}\overline{y}_{j+1} + p_{j+1} = 0. \tag{17.5}$$

In order for a stratified equilibrium to exist, not only must Equation (17.5) hold as an equality for people with income $y = H_j = L_{j+1}$, but the left side of the equation must be decreasing in y near $y = H_j = L_{j+1}$: people with income below H_j must prefer strictly to live in municipality j, and people with income higher than L_{j+1} must prefer strictly municipality $j+1$.

Therefore, a necessary condition for the existence of a sorting equilibrium in this sort of model is that the tax rate be lower the higher is the income in the municipality.

Underlying Equation (17.5) is the assumption that all entrants to a municipality pay the same entry fee p_j regardless of income. But the result can be generalized: if entry to municipalities is rationed by differences in (unit) housing prices, this necessary condition still holds, provided that the income elasticity of the demand for housing is less than 1.

[26] And if L were bounded away from 0.

[27] This is, for example, assumed in Calabrese et al. (2006) and Epple et al. (2012) as discussed in Section 17.4.1.1.

Hansen and Kessler (2001) reconcile these two necessary conditions for the existence of sorting equilibrium with voting on tax schedules that (1) the tax rate in a municipality depends only on the shape of the income distribution within the municipality, and (2) the income tax rate chosen in each municipality must be lower the higher is the segment of the income distribution of people choosing to live in the municipality.

The characterization above shows that for a sorting equilibrium to exist, the ratio of median income to mean income needs to increase as we move to higher segments of the income distribution. That could not happen, for example, if the overall income distribution for the city were uniform. But if the distribution were a Pareto distribution, the discussion above shows that this ratio will increase if (and only if) the ratio of the lowest to highest income increases as we move to higher segments of the income distribution. Now suppose that the upper bound for income for the whole city were some finite Y. Then if one municipality were sufficiently small, the ratio of the lowest to highest income L/H would have to be close to 1 if the municipality contained a segment of the income distribution. So if the city contained only two municipalities, one much larger than the other, and if the income distribution for the whole city were a truncated Pareto distribution over some interval $[y_0, Y]$, then the tax rate would have to be lower in the smaller municipality in any sorting equilibrium.

Hansen and Kessler (2001) generalize this result.[28] The restriction to the Pareto distribution is not necessary. As long as the overall income distribution has finite support, the ratio of the median income to the mean income in any one municipality must approach 1 if the municipality contains a small enough segment of the income distribution. They can therefore show that if a city is divided into two municipalities, then a sorting equilibrium will exist if population asymmetries between municipalities are large enough. And, in this case of large disparities, the stratification must involve the smaller municipality having the lower taxes, and the higher segment of the income distribution.

Now, stratification is not the only possible equilibrium. A completely symmetric distribution, in which equal shares of all income groups move into each municipality, will always be an equilibrium. Hansen and Kessler (2001, p. 1109) show that there are cases in which no sorting equilibrium exists. Hence, asymmetries in municipal size may lead to symmetries in taxes: only if there are large enough size differences can a heterogeneous equilibrium exist.[29]

The main finding on voting is summarized in the following result:

[28] They need to assume that the mean income for the whole city exceeds the median income, and that the income distribution for the whole city is unimodal. This latter requirement ensures that the mean income exceeds the median income in the richest municipality, so that all municipalities have positive tax rates in equilibrium.

[29] For this model, Equation (17.5) shows that if there are any differences at all in tax rates across municipalities, then there must be complete stratification.

Result 17.3.8. *Voting within municipalities implies that municipal income should be negatively correlated with the municipal population if municipalities are stratified by income.*

17.3.4 Central municipalities and suburbs

The distinction between the center and the suburbs seems important, and has not been considered much in the theoretical literature on tax competition. There are a few recent articles that have emphasized this distinction. The models in these articles are quite specific, and the conclusions appear quite sensitive to the modeling assumptions. These articles certainly represent an important step in the right direction. But further work seems needed in order to establish plausible, tractable theories of the effect of urban structure on municipal tax policy.

One such model is that of Janeba and Osterloh (2013). They show how tax competition among cities may affect the central municipality of each city more than the suburbs. In their model, as the total number of cities becomes large, the tax rates set by each municipality within each city shrink. But the suburban tax rates approach a positive asymptote, whereas central tax rates approach zero as the number of cities grows.

There are no differences among cities in this model, but there are differences within each city. Each city contains a single central municipality with a share $1 - s$ of the total city population, and m suburbs, each with a share s/m of the population.

The other differences in the model between central and suburban municipalities help drive the results here. Capital is assumed to be mobile among cities and within cities, but it is assumed to be more mobile within cities. Decision making is sequential. Central governments set their tax rates (simultaneously) first. Next, owners of capital decide how to allocate their capital among different cities. Then suburban municipalities choose their tax rates, at which time the quantity of capital within the city has already been fixed. Finally, capital owners decide on the allocation of capital within cities.

These differences in timing are crucial. The authors use evidence from a survey of local decision makers as the basis for their assumption.[30] The survey asked mayors which jurisdictions they perceived as providing the most competition (with their own jurisdiction) for business. The responses show that mayors of less populous jurisdictions tended to regard other jurisdictions within the same state as their strongest competitors, while mayors of more populous jurisdictions perceived additional competition as arising from jurisdictions outside the state or country.

Labor is supplied inelastically, and people are immobile. Each municipality finances a local public consumption good, with a head tax and a source-based capital tax. The availability of the head tax means that public good supply is efficient. Capital taxes are used to

[30] One thousand one hundred eight mayors in Baden-Württemberg were contacted, of whom 714 responded.

influence the net return to capital: central governments seek to influence the "national" net rate of return, and suburban governments see to influence the return within the city.

Capital taxes are positive in equilibrium, despite the symmetry within and across cities. This incentive to use positive capital taxes to lower the return to capital comes from an assumption of asymmetries *within* municipalities. While the pattern of capital and labor ownership is identical across cities (and across municipalities within a city), it differs within each municipality. As seems realistic, the distribution of the ratio between capital endowment and labor endowment is assumed to be asymmetric, with the median less than the mean. Therefore, the median voter gains from a fall in the net return to capital, even though there is no net inflow or outflow of capital to the "world" as a whole.

Assuming that output per person is a quadratic function of the capital–labor ratio enables the study authors to derive closed-form expressions for the central and suburban capital tax rates in a symmetric equilibrium. These tax rates are both positive. They depend on the number n of cities, the number m of suburbs within each city, and the fraction s of the population in the suburbs of each city. As the number n of cities increases, capital tax rates everywhere decrease, but they decrease more rapidly in the central municipalities.[31] Since capital taxation is not necessary for the public sector here, owing to the availability of the nondistortionary tax, the conventional result in single-tiered tax competition is that tax rates should approach zero as the number of identical municipalities becomes large. Here that result continues to hold for centers, but it will not hold for suburbs. Suburban tax policy is directed at affecting the return to capital within the city, *after* the allocation to capital across cities has been determined. As $n \to \infty$, the suburban tax rate approaches the positive asymptote, which is proportional to $\frac{\hat{e}}{1+\hat{e}}\frac{s}{m-s^2}$, where $\hat{e}$ is the (common) median value of the ratio of labor endowment to capital endowment, relative to the mean, a tax rate that decreases with the number m of suburbs in the city, and with the share $1-s$ of the population in the center. Because the central voters make their decisions before suburban voters, (only) the central voters worry about the effect of their tax increases on the overall supply of capital to the city. Even if the geography were symmetric within each city—one center and a single suburb with the same population in this model—the tax rate would be higher in the suburb if there is more than one city.

Kächelein (2014) develops a model similar to that of Janeba and Osterloh (2013), in that there are asymmetries within cities, and complete symmetry among different cities.[32] However, fiscal policy takes place in a single stage, and there is no distinction between capital movement within and across cities. In Kächelein's model, identifying different

[31] This is Proposition 2 of Janeba and Osterloh (2013).

[32] Braid (1996, 2005) has also developed a model of tax competition with commuting: residential location is fixed, but people may commute within a city, the supply of capital to the city is perfectly elastic, and some of the land in a municipality may be owned by nonresidents. He assumes that all municipalities in a city are identical, and so does not address the asymmetries which are the focus of this subsection. Nonetheless, these articles represent an important step in addressing tax competition which is truly urban in nature.

municipalities as "central" and "suburban" is less obvious. In this model, workers may commute within a city. In equilibrium, workers commute from the larger municipality to the smaller municipality, so the larger municipality is best identified as an aggregate of suburbs, rather than as the center.

In the base case, municipalities have a single tax instrument, a source-based tax on capital employed within the municipality. The revenue from this tax is used to finance a publicly provided consumption good.[33] It is assumed that the number of cities is large, so the world return to capital is unaffected by changes in any single municipality's tax rate. Thus, absent the commuting, each municipality would levy the same tax rate.

However, here there are only two municipalities within each metropolitan area, and workers can commute only within the city. Therefore, each municipality's capital tax rate will affect the wage rate in that municipality, and in the other municipality in the city. Municipalities are also assumed to differ in their population—but not in their endowment of a third, immobile, factor, land. In the absence of any tax differences, some residents of the more populous municipality would choose to work in the other municipality. That means that the smaller municipality can export some of the burden of its source-based capital tax onto workers who commute from the larger municipality. In the article, it is shown that this tax-exporting effect yields somewhat similar implications for the implications of population asymmetries as those in the basic tax competition model. In particular (Proposition 2), residents of the smaller municipality will be better off in equilibrium, and the smaller municipality will levy lower tax rates (Proposition 1). In an extension of the model, Kächelein shows that the availability of a source-based wage tax does not change the basic results of the model: municipalities still use capital taxation, and larger municipalities tend to rely more on wage taxation and less on capital taxation. This latter result is a prediction about the effect of the relative population on the tax mix, which is not present in most other models of taxation and asymmetry.

In Gaigné et al. (2013), production is not restricted to the central business district (CBD). However, the geographic center of the city—which need not coincide exactly with the central municipality—is assumed to be more productive. Workers' productivity is fixed, and is at least as high in the city's CBD as it is anywhere else in the city.[34] The city is (exogenously) divided into $m+1$ jurisdictions, a central municipality, and m identical suburbs. The city is "one-dimensional" in that it consists of m rays through the CBD. People living along any of the rays at a distance less than b from the CBD are residents of the central municipality. Those living further than b from the CBD reside in a suburb: each ray contains a different suburb. (Both m and b are taken as exogenous.)

From the point of view of efficiency, there are two offsetting costs determining the pattern of location and employment. As mentioned, workers are at least as productive in

[33] That is an imperfect substitute for the private good.

[34] Production is assumed not to use any land, so all production in each location takes place at a single point.

the CBD, at the geographic center of the city. But commuting to work is costly. Gaigné et al. (2013) also assume that the costs of the local public sector depend on population size. In particular, the *per capita* cost of each municipality's public sector is a U-shaped function of the population served. These population effects on the cost of the local public sector mean that the location of municipal borders matters, separately from the location of municipalities' employment. Since productivity throughout the city does not vary—except in the CBD—commuting costs within a suburb are minimized by locating employment at the midpoint of the municipality's employment region. This region may differ from the political boundaries, as some suburban residents may choose to work in the center.

Therefore, each suburb contains an employment point at a distance $(y + B)/2$ from the CBD, where B is the radius of the city and y is the location of the central workers who reside at the greatest distance from their workplace.

From a social planner's viewpoint, residential location can be decoupled from employment location. The cost function for the public sector implies that a given population should be divided evenly among all the occupied municipalities.[35] If there were no cost advantage to central employment, minimization of commuting costs would require $y = B/3$. Equating the population of all the municipalities requires that the city's radius b be a fraction $1/(m+1)$ of the distance to the edge of the city. Thus, from the planner's perspective, $y \geq b$ if and only if $m \geq 2$. With three or more suburbs, it is optimal for some workers to commute from the suburbs to the center. Having a positive productivity advantage in the CBD strengthens this effect.

Under decentralization, municipal governments choose fiscal policies to maximize residents' incomes. As in much of the literature, Gaigné et al. (2013) simplify the choice of the maximand by having residents commit to location choices before the local public sector is determined, anticipating the equilibrium choices that will be made. Further, they assume that the land rents in each municipality are divided equally among all residents of the municipality. The size of each local public sector is assumed to be fixed. The fiscal choice made in each municipality is how to divide the cost of the local public sector. Taxes may be levied on those who live in the municipality, and on firms located there. Firms operate under constant returns to scale; free entry and the fact that labor is the only input to production imply that the incidence of the tax on firms falls entirely on people who work in the municipality.[36] When $b \neq y$, a municipality's workers are not the same as its residents.

[35] Since the total cost of the public sector of a municipality of population P is assumed to be $F + \alpha P^2$, these costs decrease with the number $m+1$ of municipalities if and only if $m + 1 \leq \sqrt{\frac{\alpha}{F}}L$, where L is the total population of the city.

[36] Recall that production does not use land in this model.

Any difference in the tax rate levied on firms in the center and on those in the suburbs will be distortionary. In the absence of tax differences, workers (and firms) locate so as to maximize net output in the city, minus commuting costs. A higher tax on central firms than on suburban firms must imply an inefficient pattern of production, with not enough production in the center.

Gaigné et al. (2013) show that a municipality will levy a positive tax rate on firms if there are people from elsewhere who choose to work in the municipality. It can export some of the tax burden.

But they also derive two more specific and surprising results. The only possible commuting is from the suburbs to the center. Depending on commuting costs β, the size B of the city, the radius b of the center, and the cost advantage $E \geq 0$ of the CBD, three cases arise: all production takes place in the center if $b \geq 5B/3 - 2E/\beta$, no commuting takes place in equilibrium ($y = b$) if $5B/3 - 2E/\beta > b \geq B/3 + 2E/3\beta$, and otherwise there is some commuting from the suburbs to the center. The center will therefore choose a positive tax on firms, except in the second case ($b = y < B$), in which case it levies a tax of zero.

The second specific result is that the suburbs choose not to tax firms, nor to subsidize them, in equilibrium. The tax rate T levied by any suburb and the central tax rate T_0 determine the boundary y between the employment zone of that suburb and that of the center. The star-shaped nature of the city ensures that there is no interaction here between different suburbs. Suburban governments choose their tax rate T so as to maximize total output produced by residents of the suburb, minus commuting costs of residents, minus taxes paid to the central government by suburban residents who commute to the CBD. A tax rate of zero turns out to maximize this net output.

These two specific results imply that there will be too little commuting to the center. The model yields a closed-form solution for the tax rate on firms in the center:

$$T_0 = \frac{E}{2} + \frac{\beta(B - 3b)}{4}. \tag{17.6}$$

Equation (17.6) implies a relationship between the population of the center and its tax rate. Since b is the radius of the center, and B is the radius of the city, Equation (17.6) implies that the source-based tax rate T_0 in the center will decline with the center's share of the city's population. Other things being equal, an increase in the center's population means that there are fewer suburban commuters to whom to shift the tax burden, so the center's optimal T_0 declines. Since suburbs set a source-based tax rate T of zero, regardless of their size, the model of Gaigné et al. implies that more concentration of the population in the central jurisdiction leads to *lower* source-based tax rates in the city.

The maximum commuting distance y to the CBD is determined by the equality, for the marginal worker, of net-of-tax earnings in the CBD, and in the suburban employment center, located halfway between the employment boundary y and the outer boundary of the city. Therefore, y must satisfy

$$\beta y + T_0 = \beta\left(\frac{B+y}{2} - y\right) + E + T. \tag{17.7}$$

Given Equation (17.6) and this definition of y, the fact that $T = 0$ in equilibrium implies that

$$y = \frac{1}{6}\left(B + 3b + 2\frac{E}{\beta}\right). \tag{17.8}$$

When there are no productivity differences among locations ($E = 0$), Equation (17.8) implies that $y = \frac{B}{6} + \frac{b}{2}$, which must be less than the efficient radius of employment $y^\star = B/3$ mentioned above. The center's shifting of the tax burden onto commuters leads to too little CBD employment. This result continues to hold when the productivity advantage of the CBD is strictly positive.

The results in Janeba and Osterloh (2013) imply the following:

Result 17.3.9. *If capital is mobile among cities and central tax rates are important in firms' location choices among cities, tax rates will be lower in the center.*

The results in Gaigné et al. (2013) imply the following:

Result 17.3.10. *In a single-city model in which residents can commute, tax rates on capital will be higher in the center if the direction of commuting goes from the suburbs to center. These tax rate differences imply that too few of a city's workers will work in the center.*

17.4. TAXATION AND URBAN POPULATION SORTING

17.4.1 Tax-induced urban population sorting: theory

17.4.1.1 Aspatial general equilibrium models

Starting with Ellickson (1971) and Westhoff (1977), there is a long tradition of formally modeling fiscal decentralization *within* cities populated by heterogeneous agents in the spirit of Tiebout (1956). This literature on multijurisdiction models has almost entirely focused on local *property* taxation and has been comprehensively surveyed in earlier volumes of the handbook (Ross and Yinger, 1999; Epple and Nechyba, 2004). We therefore limit ourselves to recalling the basic setup of these models and the associated main results in this section.

In all of these models, households that differ in income choose among a fixed number of local jurisdictions (municipalities). The residents of the local jurisdictions vote on the provision of a local public good that is financed by local property taxes (see also Section 17.3.3). Note that the local "public good" in these models is strictly speaking a "publicly provided private good" as it is both excludable and rivalrous in consumption. Local public budgets are balanced and local housing prices adjust to the local demand for housing. The models are aspatial in the sense that distances between and within local jurisdictions are irrelevant. The literature focuses on asymmetric equilibria with different levels of property tax rates, public good provision, and housing prices across municipalities. Sorting depends on the nature of the public goods and housing. In multijurisdiction models with property taxes, households base their location decision on the after-tax price of housing. The property tax rate itself is therefore not a separate location characteristic. Each household faces in equilibrium a trade-off between public good provision and after-tax housing prices. For models with linear property taxes, sorting depends on the nature of the public goods and housing:

Result 17.4.1. *If the income elasticity of housing demand equals 1 and public goods are easily substituted by private goods (e.g., a pure monetary transfer), then rich households sort into municipalities with low public good provision and low after-tax housing prices. If public goods cannot be easily substituted by private goods, then rich households prefer municipalities with high public good provision and high after-tax housing prices.*

Note that there is no theoretical prediction about the relation between municipal income levels and the property tax rate itself.

The basis for calibrating and estimating multijurisdiction models is the version in Epple and Platt (1998), where households are heterogeneous in both income and tastes, leading to realistic incomplete sorting by incomes. In the original Epple–Platt model, rich households sort into municipalities with low public good provision and low after-tax housing prices. This contradicts the pattern typically observed in US cities. Empirical applications of the model (e.g., Epple and Sieg, 1999) therefore use a version of the model of Epple and Platt (1998) in which public goods are not easily substituted by private goods and rich households sort into municipalities with high public good provision and high after-tax housing prices. More recently, the basic models have been extended in several dimensions. In Calabrese et al. (2007), the local population can also vote for zoning in the form of minimum housing size requirements. Zoning aggravates income sorting and increases aggregate welfare, but with significant welfare losses for the poorer households relative to the equilibrium without zoning. Epple and Ferreyra (2008) use the model with peer effects to study the effect of school finance equalization and show that the generalized model is able to correctly predict the observed effects of the school finance reform. Epple et al. (2012) incorporate an overlapping generations model where older households without children are less interested in school quality than younger households with children. The resulting equilibrium sorting by both income and age can reduce inequality in educational outcomes compared with models with income sorting only.

Calabrese et al. (2012) study the welfare effects in a calibrated version of the Epple–Platt model with local property taxation. They find both a *per capita* welfare loss and a welfare loss by most of the population in the decentralized equilibrium with population sorting compared with a centralized equilibrium with no sorting. The welfare loss is small (less than 0.1% of mean income) and is mainly (more than 99.5% of the welfare loss) shouldered by landowners through falling rents. This welfare loss is remarkable as the decentralized equilibrium with high public good provision in small elite jurisdictions is a Tiebout-type equilibrium. They attribute the inefficiency of the decentralized property-tax equilibrium to "a jurisdictional choice externality, where relatively poorer households free ride on richer households in suburbs by buying small houses to avoid taxes" (Calabrese et al., 2012, p. 1082). The efficient equilibrium features decentralized local head taxes and produces substantial welfare gains compared with both the decentralized and the centralized property tax equilibrium. Interestingly, the head-tax equilibrium produces larger differences in public good provision and more sorting than the decentralized property tax equilibrium, realizing the efficiencies typically associated with Tiebout-type equilibria.

Result 17.4.2. *If public goods cannot be easily substituted by private goods and when households differ in both incomes and tastes, rich households and households with a strong taste for public goods sort into municipalities with high public good provision and high after-tax housing prices. Such equilibria with decentralized property taxation are not more efficient than equilibria with uniform public good provision, centralized property taxation, and no population sorting. Equilibria with decentralized head taxation are substantially more efficient than equilibria with property taxation but imply more pronounced sorting of the population.*

This welfare analysis, however, does not consider the informational advantages of decentralized decision making (see, e.g., Kessler, 2014), and it abstracts from equity concerns.

We showed in Section 17.2 that property taxation is the principal local government revenue source in the United States and in Commonwealth countries. In most other higher-income countries, income taxation is the more important local revenue source. Multijurisdiction models with local income taxation have been studied by Goodspeed (1989), Schmidheiny (2006a,b), and Hodler and Schmidheiny (2006). These models are identical to property tax models in all basic assumptions except for the tax base. Studying *income* taxes introduces a severe technical difficulty into the formal models: in income tax models, tax rates and housing prices are two separate dimensions of location characteristics. Analyzing the sorting of heterogeneous agents across municipalities that differ in more than two dimensions (tax rate, housing price, public goods) is challenging and only produces nonambiguous sorting under restrictive additional assumptions about household preferences (see Gravel and Oddou, 2014). Apart from the technical difficulties, the established results for income tax models are very similar to the results with property taxes. As in property tax models, the literature focuses on asymmetric equilibria with different levels of income tax rates, public good provision, and housing prices across municipalities. Sorting depends on the nature of the public goods and housing. In multijurisdiction models with *income* taxes, each household in equilibrium faces three bilateral trade-offs between public good provision, housing prices, and income tax rates. This leads to a rich possible set of equilibrium configurations depending on the nature of the public goods and housing. Goodspeed (1989) establishes the following empirically relevant cases:

Result 17.4.3. *If the income elasticity of housing demand equals 1 and public goods are easily substituted by private goods (e.g., a pure monetary transfer), then rich households sort into municipalities with low income tax rates, high housing prices, and low public good provision. If public goods cannot easily be substituted by private goods, then rich households sort into municipalities with low income tax rates, high housing prices, and high public good provision.*

Schmidheiny (2006b) derives sufficient sorting conditions behind this result and extends it to incomplete sorting of households that differ in both incomes and preferences as in Epple and Platt (1998). Schmidheiny (2006a) introduces *progressive* income taxation as an alternative motive that predicts sorting of high-income households into low-tax municipalities.

Note that the housing market is essential in sustaining the empirically most relevant case in which high-income households locate in low-tax, high-public-good-provision municipalities. It is the high housing prices which prevent the low-income households from following the high-income households into the low-tax, high-public-good-provision locations.

Sorting of the population by income is a general phenomenon which is also observed in cities with uniform tax rates. The prime explanation is *social interactions* in various forms. See Ioannides (2013) for an extensive discussion of the theoretical and empirical literature. Calabrese et al. (2006) combine both social interactions and tax decentralization into a unified formal framework. The public good is modeled as expenditure on education and social interactions are modeled as peer group effects in education. This model leads to a rich set of possible equilibrium configurations. After calibrating the model (see also Section 17.4.2.2), they find that rich households sort into municipalities with high public good provision and high after-tax housing prices, as in the model without peer effects. However, different from calibrations of the basic model and in line with empirical observations, property taxes are *lower* in high-income municipalities than in low-income municipalities:

Result 17.4.4. *If there are peer effects in the production of educational quality, and the public provision of education cannot be easily substituted by private provision, rich households sort into municipalities with high housing prices, high public good provision, and low property tax rates.*

17.4.1.2 Asymmetry and centrality

There is no locational specificity in the models presented in the previous subsection: equilibria are unique only up to a permutation of the names of the municipalities.

The one feature in most of this work which distinguishes the central municipality from other (sub)urban municipalities is the size of the central municipality, which has a larger area or more housing units. So, if the central municipality has 40% of the housing stock, there will be one equilibrium in which the poorest 40% of the population live in the central municipality, but also another in which the poorest 60% live in the suburban municipalities.

Three articles by de Bartolome and Ross (2003, 2004, 2007) show that introducing locational heterogeneity into this sort of model can break the multiplicity of equilibria.[37] de Bartolome and Ross assume that workers commute to the CBD. The cost of commuting is assumed to be higher for high-income people than for low-income people. For tractability, demand for space is assumed not to vary with income. If the city comprises a single municipality, there would be a unique equilibrium location pattern in this model. People would sort by income, with the richest people living closest to the center of the city.

de Bartolome and Ross divide the area into two municipalities: a round central city with the CBD at its core and a ring-shaped suburban municipality that surrounds the central city. Each municipality provides a public output that is financed by a head tax. The income elasticity of demand for this public good is assumed to be positive. Hence, each jurisdiction provides the public output level preferred by the median-income resident of the jurisdiction. This heterogeneity of demand for the local public output generates multiple equilibria. There will still be an equilibrium in this model in which income throughout the metropolitan area *declines* monotonically with the distance from the center. There are two reasons why the rich will bid the most for land in the central municipality: they are willing to pay the most for accessibility to the CBD, and they prefer the public output provided in the CBD.

But there can be a "reverse equilibrium" as well. Suppose that the central city has a lower median income than the suburb. If that is the case, rich residents face a trade-off. The central city still offers better accessibility to the CBD, but it now offers a public output package which the rich like less than that provided by the higher-income suburb. If the income elasticity of public output demand is high relative to the income elasticity of commuting costs, then the second effect will outweigh the first. The theoretical argument above is presented in de Bartolome and Ross (2003). In subsequent work, de Bartolome and Ross constructed numerical examples which confirm that there may be equilibria in which the richest residents of a city locate in the suburban municipality in equilibrium. In their examples, a city consists of a circular central municipality surrounded by a single annular suburb. Each municipality chooses its public output level (financed by a head tax) by majority rule, and voters are myopic. In de Bartolome and

[37] Epple et al. (2010) also show that within-jurisdiction amenities such as the distance to the center can in principle be integrated into the multijurisdiction models presented in the previous subsection. However, they do not study the properties of the equilibrium.

Ross (2004) there are two income classes in the city, and in de Bartolome and Ross (2007) the distribution of (exogenous) income is continuous. In each model, there must exist an equilibrium in which the highest stratum of the income distribution chooses to locate in the central municipality. But in each model, for some parameter values there also exists a second, stable, equilibrium, in which the richest people choose to locate in the suburb in equilibrium, because of the higher level of public output chosen there. So, it remains true that, within a given jurisdiction, income declines with the distance from the CBD. In this second type of equilibrium, the very poorest people locate in the furthest-out portion of the central municipality, and the very richest locate just beyond them, in the part of the suburb closet to the CBD.

The second type of equilibrium appears somewhat inefficient, in that the people who are willing to pay the most for accessibility end up located fairly far from the center, because of the self-fulfilling belief that central cities are poorest. de Bartolome and Ross (2007) show that aggregate welfare, added up over all residents, is higher in the first type of equilibrium, in which the poor locate in the suburb. However, this first type of equilibrium does not necessarily Pareto dominate the second. de Bartolome and Ross compute an example in which the poorest people are actually better off in the second type of equilibrium, in which they live in the central city.

The findings of de Bartolome and Ross (2003, 2004, 2007) can be summarized as follows:

Result 17.4.5. *Assuming that high-income households have a higher relative willingness to pay for centrality than low-income households, high-income households sort into the more central parts of a city, which is formed of a single jurisdiction. This equilibrium sorting can be sustained when the city is partitioned into a large center municipality and many small suburban municipalities. There also exist "reverse" equilibria in which high-income households sort into the (sub)urban municipalities far from the center.*

17.4.2 Tax-induced urban population sorting: Empirical studies

The effect of local taxes on the location decisions of individuals and firms can in principle be studied by relating individual or aggregate location choices to the local tax burden.[38] This typically observed negative relationship, however, cannot be interpreted as a causal effect because of an intrinsic reverse causality problem. A large local tax base of high-income households can lead to high tax returns even when the tax rates are relatively low. Municipalities with a large tax base are therefore able to balance their budgets with

[38] Kirchgässner and Pommerehne (1996) and Feld and Kirchgässner (2001), for example, study Swiss municipal data and show that high-income households are systematically located in cantons and municipalities with low income tax rates. Liebig et al. (2007) show that Swiss municipalities with high tax rates have higher emigration than municipalities with low tax rates. They also show a positive correlation between tax rate changes and emigration.

lower tax rates. Individual location decisions therefore affect local taxes—at least in the long term—through the local budget constraint and the political process behind it. This produces reverse causality, which is hard to overcome in nonexperimental studies. This section outlines four different approaches to overcome the endogeneity problem.[39]

17.4.2.1 Estimation of individual location choice

The first empirical approach directly targets the location choice of individual households in a multinomial response framework. Friedman (1981) uses a conditional logit model to study the location choice of 682 households among nine residential areas in the San Francisco area. Nechyba and Strauss (1998) apply the same model to study the choice of over 22,000 households among six school districts in the suburbs of Philadelphia. Both studies show that high public expenditures (such as per pupil school spending) and low per-unit housing prices attract residents. However, these studies cannot estimate the effect of the property tax rate *per se*, because it affects people's decisions only through the after-tax housing price.

This approach seemingly circumvents the endogeneity problem because, from the perspective of a single household, the community characteristics can be taken as given. However, the local tax rates are still a function of all individual location decisions. Schmidheiny (2006a) therefore focuses on the location choice of households which are moving in a given year. *Movers* are a relatively small share of the whole population, while the equilibrium tax rates are mainly driven by the large share of *stayers*. Schmidheiny (2006a) estimates the location choice of the universe of households that moved in 1997 from the central municipality to any other municipality in the Basel urban area in Switzerland. He starts from the following indirect utility function:

$$V_{ni} = \alpha_n \log(p_i) + \gamma_n \log(1 - t_{ni}) + \varepsilon_{ni}, \tag{17.9}$$

where p_i is the per-square-meter rental price of housing in municipality i, t_{ni} is the location- and income-specific progressive tax rate for household n in municipality i, and ε_{ni} is a household- and location-specific error term. Assuming that ε_{ni} follows an extreme value type I distribution leads to McFadden's (1974) conditional logit model. The parameters α_n and γ_n are modeled as linear functions of a vector x_n of observable household characteristics such as income and the number of children:

$$\alpha_n = \alpha_0 + \alpha_1 x_n \quad \text{and} \quad \gamma_n = \gamma_0 + \gamma_1 x_n. \tag{17.10}$$

This leads to interactions between location-specific and household-specific variables in the indirect utility function (17.9). Interaction effects and all other location-and household-specific variables are identified after introducing location-specific fixed effects

[39] See also Kuminoff et al. (2013) for a survey of the estimation of equilibrium sorting models.

θ_i absorbing all observed and unobserved location attributes that are equally important to all households:

$$V_{ni} = \theta_i + \alpha_1 \log(p_i) \cdot x_n + \gamma_0 \log(1 - t_{ni}) + \gamma_1 \log(1 - t_{ni}) \cdot x_n + \varepsilon_{ni}. \tag{17.11}$$

Note that the base effect γ_0 of housing prices and all other location-specific variables are not identified in Equation (17.11).

Schmidheiny (2006a) finds that local income tax rates are a highly significant and substantial determinant of household location choices. High-income households are more likely to move to low-tax municipalities. This is partly explained by the progressivity of the local tax rates. The results holds when controlling for observed social interactions including local average income and ethnic composition as explanatory variables.

17.4.2.2 Estimation of individual location choice in equilibrium

The empirical approach summarized in this section seeks to identify all parameters in the indirect utility function underlying the individual location choice including the base effects of location-specific variables such as housing prices. It also explicitly models how individual location choices affect location-specific characteristics in equilibrium, making it possible to perform counterfactual exercises.

The empirical strategy is borrowed from the empirical industrial organizations literature. Berry et al. (1995) introduced an econometric model to estimate the demand for cars based on their characteristics. Bayer et al. (2004) apply the Berry–Levinsohn–Pakes framework to the choice of neighborhoods j or individual housing units by households n.[40] The first step in Bayer et al. (2004) is the estimation of a multinomial choice model with the following indirect utility function:

$$V_{ni} = \alpha_n p_i + \beta_n x_i + \gamma_n z_i + \varepsilon_{ni}, \tag{17.12}$$

where p_i is the price of housing in neighborhood i, x_i are exogenous characteristics of the neighborhood j, and ε_{ni} is an individual- and location-specific error term. To allow for social interactions, they also include additional variables z_i with endogenous location characteristics such as average incomes and ethnic composition. In an empirical setting with local income taxes, the tax rates t_i would be another variable in z_i. The effects α_n, β_n, and γ_n are specific to the individual and are assumed to depend linearly on attributes x_n of individual n:

$$\alpha_n = \alpha_0 + \alpha_1 x_n\ , \quad \beta_n = \beta_0 + \beta_1 x_n, \quad \text{and} \quad \gamma_n = \gamma_0 + \gamma_1 x_n \tag{17.13}$$

[40] See also Sections 2.3 and 2.4 in the chapter by Holmes and Sieg in this handbook and Kuminoff et al. (2013) for more technical details and results.

The resulting indirect utility function is therefore

$$V_{ni} = \theta_j + \alpha_1 x_n \cdot p_i + \beta_1 x_n \cdot x_i + \gamma_1 x_n \cdot z_i + \varepsilon_{ni}, \tag{17.14}$$

where $\theta_i = \alpha_0 p_i + \beta_0 x_i + \gamma_0 z_i$. If ε_{ni} follows an extreme value type I distribution, this leads to estimating McFadden's (1974) conditional logit model with location fixed effects in the first step. The estimation in the first step typically implies the estimation of a large number of fixed effects θ_i, which can be numerically demanding in the maximum-likelihood estimation of Equation (17.14). Bayer et al. (2004) therefore propose a fixed-point algorithm that efficiently calculates the unique set of θ_i's given the parameters α_1, β_1, and γ_1 for which the predicted shares of choosing neighborhood i in the sample $n = 1,\ldots,N$ equal the observed shares. This is a property of the maximum-likelihood estimator of the conditional logit model, and the resulting θ_i's are therefore maximum-likelihood estimates. The parameters α_1, β_1, and γ_1 are then estimated by maximizing a concentrated-likelihood function.[41]

In the second step of the estimation, the neighborhood fixed effects are regressed on the neighborhood characteristics:

$$\theta_i = \alpha p_i + \beta_0 x_i + \gamma_0 z_i + \eta_i. \tag{17.15}$$

Bayer et al. (2004) deal with the obvious endogeneity in the second step in the spirit of Berry et al. (1995) and use functions of exogenous characteristics in all other neighborhoods as instruments for local housing prices p_i. With the use of individual housing units as choice alternatives (see footnote 41), the endogeneity of social contextual variables z_i is addressed by restricting the analysis to a sample of houses near school attendance zone boundaries and including boundary fixed effects as in Black (1999). However, Bayer et al. (2004) do not deal with endogeneity in the first step.[42]

The method of Bayer et al. (2004) makes it possible to perform counterfactual exercises. Changes in exogenous variables x_j will have a direct effect on the equilibrium location choices via β as well as an indirect effect through changing the endogenous location characteristics z_j. For example, the ethnic composition of a neighborhood is the aggregate of all individual location decisions in equilibrium. For counterfactual exercises, the effect of individual location choices on endogenous variables z_j has to be explicitly modeled and the new equilibrium has to be solved.

[41] Bayer et al. (2004) estimate the first stage with individual housing units as choice alternatives. N individual households choose among N alternatives. With potentially hundreds of thousands of individuals and the same number of choice alternatives, the maximum-likelihood estimation is very expensive if not impossible. They therefore draw on a result obtained by McFadden (1978): the conditional logit model can be estimated on the basis of a random subset of choice alternatives for each individual. This choice set contains the actual choice plus a (small) random selection from the remaining alternatives. This estimation strategy depends on the independence of irrelevant alternatives (IIA) assumption.

[42] Note that Berry et al. (1995) and the subsequent industrial organizations literature do not cause the endogenous variable p_j to interact with individual characteristics and do not include social interaction variables z_j.

Bayer et al. (2007) estimate the marginal willingness to pay for school quality. They find significant willingness to pay for increased school performance in the form of high housing prices but substantially smaller effects than previous estimates. Bayer et al. (2011) address the endogeneity of the location-specific variables z_i in Equation (17.14) by focusing on the relocation decision. They find that estimates based on a cross section of residents understate the willingness to pay for amenities such as air quality, but overstate the willingness to pay for living with one's own ethnic group.

To our knowledge, the Bayer et al. (2004) sorting strategy has not yet been used to study the impact of within-city tax differentials on population sorting.

17.4.2.3 Structural estimation

The theoretical models presented in Section 17.4.1.1 can be used for structural estimation.[43] Epple and Sieg (1999) take the theoretical model of Epple and Platt (1998), which introduced heterogeneity of households in terms of both income and tastes for public goods. This two-dimensional heterogeneity produces more realistic *partial* sorting in equilibrium: the residents of high-income municipalities are *on average* richer than those in low-income municipalities but the income distributions overlap. Different from Epple and Platt (1998), where the public good is a pure monetary transfer, public goods enter the utility function, leading to more realistic equilibria in which rich households sort into municipalities with high public good provision and high after-tax housing prices. Epple and Sieg (1999) fully parameterize the household's indirect utility function and the joint distribution of household heterogeneity (bivariate log-normal). In a first step, a subset of the structural parameters and a series of municipality fixed effects are estimated by matching the predicted income quartiles with the observed income quartiles across all municipalities in the city. In a second step, the municipality fixed effects are related to observed dimensions of public good provision (school quality, crime, parks, pollution, etc.) and per-unit housing prices using nonlinear least squares. The error term in this parameterization is unobserved public good provision, which is likely correlated with observed dimensions of public good provision and with housing prices. Instruments therefore need to be used for these variables in the second step. Note that different from the estimation in the Section 17.4.2.2, there is no idiosyncratic shock which lets households prefer different municipalities. Epple and Sieg (1999) estimate the model using data for the 92 cities and towns in the Boston metropolitan area in 1980. The estimated model fits the observed pattern of income sorting, housing prices, and public good provision remarkably well. The estimated model can be used to simulate the effect of property tax rates on the equilibrium location pattern.

[43] See also Sections 2.3 and 2.4 in the chapter by Holmes and Sieg in this handbook and Kuminoff et al. (2013) for a more technical discussion.

Epple et al. (2001) also use the theoretical conditions of the majority voting equilibrium in the structural estimation. They find parameter estimates that are difficult to reconcile with the ones from the locational equilibrium in Epple and Sieg (1999). Calabrese et al. (2006) structurally estimate the model by adding peer group effects and show that this eliminates the inconsistency between parameters based on the locational and the voting equilibrium. Epple and Sieg (1999) assume that while households differ in their taste for the *level* of local public good provision, all households share the same valuation for the different *dimensions* of public good provision. Epple et al. (2010) address this by allowing different types of households to have different valuation over the public good dimensions. We summarized the main results of this literature in Section 17.4.1.1.

The key finding of the three different empirical approaches is as follows:

Result 17.4.6. *There is empirical evidence that high-income households are attracted to low-income-tax states within countries and to low-income-tax municipalities within cities.*

All evidence to date on tax-induced population sorting at the local level is based on either microeconometric studies using observational data or structural estimation. Recent quasi-experimental evidence shows that very mobile and highly skilled workers are attracted to countries with low income tax rates.[44]

17.5. TAXATION AND AGGLOMERATION ECONOMIES

So far in this chapter, while considering interactions among households, we have assumed that firms' location choices are mutually independent. This approach implies a presumption toward the spatial dispersion of economic activity, as density is deterred by the competition for inelastic housing. More broadly, to assume individual location choices to be independent is to ignore the central mechanism of urban economics: agglomeration forces. If agents generate positive externalities for other agents in the neighborhood, then activities will cluster in space and their sensitivity to taxes will not be the same as in the absence of such externalities. In this section, therefore, we aim to provide a summary of the theoretical literature and empirical literature on decentralized fiscal policy in the presence of agglomeration economies.

[44] Kleven et al. (2013) study the location choice of soccer players in Europe after the Bosman ruling by the European Court of Justice which lifted pre-existing restrictions on soccer player mobility. Kleven et al. (2014) analyze the effect of special tax breaks for high-income foreign workers in Denmark. Young and Varner (2011) study the effect of a substantial increase in the income tax rates on top earners in New Jersey. Closer to the focus of this survey, Agrawal and Hoyt (2013) use within-city state borders to identify tax effects on commuting times, and they find that city dwellers are indeed prepared to accept longer commutes in return for lower income tax rates.

17.5.1 Theory

The key implication of agglomeration economies for tax competition models is that economic activities, even if mobile in terms of the institutional setting, may be *de facto* immobile because in order to remain competitive firms need to locate at the industry cluster. Hence, policy makers can tax agglomerations without necessarily jeopardizing their tax base. This mechanism has been analyzed extensively in " new economic geography" models, featuring agglomeration equilibria in which a core region hosts the entire mobile sector that is subject to agglomeration forces while the periphery hosts some of the immobile industry only (Ludema and Wooton, 2000; Kind et al., 2000; Baldwin and Krugman, 2004; Krogstrup, 2008).[45] The key insight of this literature is that agglomeration forces make the world "lumpy": when capital (or any other relevant production factor) is mobile and trade costs are sufficiently low, agglomeration forces lead to spatial concentrations of economic activity that cannot be dislodged by tax differentials, at least within certain bounds. In fact, agglomeration externalities create rents that can, in principle, be taxed by the jurisdiction that hosts the agglomeration. Moreover, decentralized fiscal policy can itself reinforce agglomeration tendencies when scale economies in the production of publicly provided goods make the locus of agglomeration even more attractive (Andersson and Forslid, 2003).[46] The core-periphery outcome, however, is quite extreme, particularly when considered at the scale of a city. It is therefore important to note that agglomeration economies need not be as stark as in the core-periphery case to reduce the intensity of tax competition. Borck and Pflüger (2006) show that local tax differentials can also be generated in models that produce stable equilibria with partial agglomeration, and where the mobile factor therefore does not derive an agglomeration rent.

Result 17.5.1. *Agglomeration economies can generate taxable rents and weaken the intensity of tax competition.*

While the mobility-reducing effect of agglomeration economies and the attendant attenuation of horizontal tax competition have been the most talked about policy insights generated by the new economic geography, the very same models in fact can generate the opposite result: knife-edge situations in which a very small tax differential can trigger large changes in the spatial distribution of the tax base. In those configurations, agglomeration economies in fact *add* to the sensitivity of firm location to tax differentials because one firm's location choice can trigger further inflows and thus the formation of a new cluster. In such configurations, agglomeration economies exacerbate the intensity of tax competition (Baldwin et al., 2003, Result 15.8; Konrad and Kovenock, 2009). A similar result is found by Burbidge and Cuff (2005) and Fernandez (2005), who have studied tax competition in models featuring increasing returns to scale that are external to

[45] See Baldwin et al. (2003, chapters 15, 16) for an overview.

[46] The reverse mechanism, whereby decentralized fiscal policy favors economic dispersion, can be modeled as well, by considering the widely documented fact that public expenditure tends to be biased toward local suppliers (Brülhart and Trionfetti, 2004).

firms, with firms operating under perfect competition. In these models, individual firm mobility is not constrained by agglomeration economies, and governments may compete even more vigorously to attract firms than in the standard tax competition model.

Result 17.5.2. *Potential agglomeration economies in spatially dispersed activities can imply large tax-base elasticities and thereby intensify tax competition.*

These results are essentially based on two-region models. In models featuring multiple regions, subtler differences emerge. Hühnerbein and Seidel (2010), using a standard new economic geography model, find that the core region might not be able to sustain higher tax rates in equilibrium if it is itself subdivided into competing jurisdictions. Similarly to the model of Janeba and Osterloh (2013), therefore, their model implies that tax competition puts particular pressure on central cities, which compete over mobile tax bases with other central cities as well as with their own hinterlands.

Such geography models hold particular promise for the analysis of tax policies within cities, given that production factors are highly mobile at that spatial scale and that agglomeration economies have been found to decay steeply over space (Rosenthal and Strange, 2004). If we focus on the scenario whereby locally stable clusters have already formed, such agglomeration forces could reduce race-to-the-bottom-type competitive pressures on local tax setting and thus make decentralized taxation efficient. It has furthermore been shown that decentralized tax setting can act as a mechanism of undoing inefficient spatial equilibria, where industry clusters are initially locked in a suboptimal location (Borck et al., 2012). Moreover, agglomeration economies may make decentralization more politically feasible, as they likely favor larger, central jurisdictions, thus giving central municipalities an advantage where in asymmetric models without agglomeration forces they generally are found as losing out from decentralization.

Result 17.5.3. *Agglomeration economies likely work to the advantage of central urban municipalities.*

The potential importance of agglomeration economies for urban public finance, therefore, is hard to overstate. However, firm-level agglomeration economies are not the only force that shapes intracity geographies. As we discussed in Section 17.4.1.2, endogenous population sorting can lead to the geographically central municipality not being the economic center.[47]

17.5.2 Empirical studies

An empirical assessment of the prediction for decentralized tax setting from recent theoretical work in economic geography boils down to three hierarchically nested questions

[47] Another interesting implication of agglomeration externalities is that they strengthen the theoretical case for some degree of intracity fiscal equalization (Haughwout et al., 2002; Riou, 2006; Gaigné and Riou, 2007; Haughwout and Inman, 2009; Wrede, 2014).

(in the sense that the second and third of these questions are only relevant if the answer to the preceding question is positive):

1. Do firms internalize agglomeration economies in their location choices such that differences in tax burdens across locations become relatively less important (or more important, depending on the initial equilibrium)?
2. Do local governments realize that the mobility of their tax base is affected by agglomeration economies, and do they choose their tax rates accordingly?
3. Is the effect of agglomeration economies on local tax setting sufficiently strong to affect the equilibrium tax competition outcome significantly?

A number of empirical researchers have been looking for answers to these questions in recent years.

17.5.2.1 Do agglomeration economies make firms more or less sensitive to local taxation?

The first question boils down to testing the partial effect on a firm f's location choice L_{fij} in location i and industry j of the local tax burden t_{fij}, of agglomeration effects a_{ij}, of a vector of other exogenous determinants x_{ij}, and of a random term ε_{fij}:

$$L_{fij} = g\left(t_{fij}, a_{ij}, t_{fij} \cdot a_{ij}, x_{ij}, \varepsilon_{fij}\right), \qquad (17.16)$$

where L_{fij} equals 1 for the firm-location-industry cell corresponding to an actual location choice, and 0 for all other combinations of firm, location, and industry.[48] These models are typically estimated via conditional logit or Poisson count models, implying that g represents an exponential mean function (Schmidheiny and Brülhart, 2011; Brülhart and Schmidheiny, 2015). The key element of Equation (17.16) is the interaction term $t_{fij} \cdot a_{ij}$, which implies that the effects of taxation are not separable from the effects of agglomeration.[49]

Devereux et al. (2007b) were the first to analyze the effect of both fiscal policy and agglomeration on location choices. They explore a variant of Equation (17.16) in which the measure of agglomeration is purely location specific, meaning that it can be written as a_i. Using data on British regional grants (their measure for t_{fij}), they find that, other things being equal, firms are more responsive to financial incentives in areas with pre-existing activity in the relevant industry. It may thus be cheaper to attract a new plant to an existing cluster than to a peripheral location. This is an important and evidently policy-relevant result, but not what the theory necessarily predicts. For an interior spatial

[48] Although most of the studies presented below include a time dimension on some or all of the variables, we abstract from it here in order to simplify the notation.

[49] A large body of empirical literature exists on variants of Equation (17.16) that do not feature the interaction term. See, for example, Hines (1999) for a survey, and de Mooij and Ederveen (2003) for a meta-analysis. Studies of the responsiveness of tax bases to tax rates at the local level include those of Buettner (2003) for Germany, Haughwout et al. (2004) for the United States, and Duranton et al. (2011) for the United Kingdom.

equilibrium with no relocation costs, expected profits at the locus of the agglomeration and at the periphery are equalized. Whether a given change in fiscal inducements is then more effective at attracting firms to a central location or to a peripheral location is indeterminate, as it depends on the functional form of the relationship between real returns and industry shares across locations. In the simulations reported by Borck and Pflüger (2006), for example, a given fiscal inducement will in fact attract a larger number of firms if offered at the peripheral location than if offered at the central location. Moreover, Rohlin et al. (2014) find that the deterrence effect of income taxes on firm location across US state borders is in fact stronger in denser areas.

Brülhart et al. (2012) explore this question by asking instead whether *industry*-level agglomeration economies reduce firms' sensitivity to local tax differentials. They estimate empirical location choice models for firm start-ups across Swiss municipalities. The distinctive feature of their model is an interaction term between local corporate tax rates and the Ellison and Glaeser (1997) index, a measure of industry-level agglomeration (a_j). Positive estimated coefficients on this interaction term imply that location choices of firms in more agglomerated sectors are less sensitive to tax differences across potential locations. By exploiting a setting in which municipal corporate taxes apply identically to firms across all sectors (such that taxes are not tailored to individual firms or sectors, allowing them to be written as t_i), and by instrumenting both tax rates and agglomeration measures, they seek to minimize potential endogeneity bias. They find that firm births, on average, react negatively to corporate tax burdens, but that the deterrent effect of taxes is weaker in sectors that are more spatially concentrated. Firms in sectors with an agglomeration intensity in the top quintile are less than half as responsive to differences in corporate tax burdens as firms in sectors with an agglomeration intensity in the bottom quintile. This finding supports the relevance of the theoretical prediction whereby agglomeration economies reduce the importance of tax differentials for firms' location choices.

Jofre-Monseny and Solé-Ollé (2012) expand on the approach of Brülhart et al. (2012) by estimating their regression model separately for Catalonian cities (local labor markets) featuring strong primacy of the central jurisdiction (defined as 40% or more of employment being concentrated in the largest municipality) and for more dispersed cities. Thereby, they seek evidence on the theoretical prediction whereby agglomeration forces can exacerbate the tax sensitivity of firm location if one is starting from a dispersed economic geography. Unlike Brülhart et al. (2012), they find the coefficient on the interaction term $t_i \cdot a_j$ to be significantly negative, and this particularly so in cities featuring strong primacy of the central municipality. Significant positive coefficient estimates on the interaction term are obtained only when the sample is limited to the central municipalities of the cities featuring strong jurisdictional primacy. These results appear to be in line with the theoretical prediction whereby, depending on the initial spatial configuration, agglomeration economies can strengthen or weaken firms' sensitivity to tax differentials.

Result 17.5.4. *The available evidence supports the prediction that agglomeration economies can make firms less sensitive to tax differentials across jurisdictions.*

This line of research leaves considerable scope for cross-validation and further elaboration. In particular, the dividing line between sensitivity-enhancing and sensitivity-reducing agglomeration economies could be fruitfully explored further, in particular by considering asymmetries not just in terms of aggregate jurisdiction size but also in terms of the initial-period spatial distribution of activity in the individual industries.

17.5.2.2 Do local-level tax policies take account of agglomeration economies?

The diagnosis that agglomeration economies exist and that they matter for firms' responses to tax differentials constitutes but the first step in a full evaluation of the prediction that agglomeration forces affect tax competition. The second question is whether policy makers recognize agglomeration forces and effectively seek to tax the associated rents or to compete all the more vigorously.

Most of the empirical literature in fact addresses this second question, taking the offsetting effect of agglomeration economies on firms' sensitivity to tax differentials as a given. These studies estimate models of the following type:

$$t_{ij} = h\left(a_{ij}, x_{ij}, \varepsilon_{fij}\right), \tag{17.17}$$

where x_{ij} now stands for exogenous determinants of local tax rates other than agglomeration economies a_{ij}, and h typically represents a linearly additive function.

The results of this literature are easily summarized: all of the existing studies conclude that observed tax rates are higher in places that are identified by researchers as hosting an agglomeration. This is particularly pronounced for the early studies: Buettner (2001) finds that more populous German municipalities set higher local business tax rates, and Charlot and Paty (2007) observe that French municipalities with greater market potential set higher business tax rates. This means that they find large and statistically significant coefficients on location-specific agglomeration measures, a_i. The estimates of Charlot and Paty (2007), for instance, imply that a 10% increase in market access increases the business tax rate by 1.3% on average.

Such analyses have to contend with formidable empirical challenges. One issue is the potential for reverse causation, whereby t affects A rather than the other way around—a theoretically well established link (e.g., Andersson and Forslid, 2003). More recent studies have sought to allay this problem by using as an instrument for location-specific agglomeration measures a_i agglomeration measured at a date prior to the introduction of the left-hand-side variable t_i (Jofre-Monseny, 2013; Koh et al., 2013; Luthi and Schmidheiny, 2014). While these approaches go a long way toward allaying the reverse-causation concern, one cannot rule out that some related tax instrument existed in the past and played a part in determining agglomeration patterns.

A probably even greater empirical challenge arises from local revenue needs as a confounder of agglomeration. Larger, denser, and more central locations invariably correspond to more urban places, and central cities are typically associated not only with agglomeration economies but also with stronger demand for publicly provided goods. Researchers typically try to control for as many observables as possible, by including vectors of sociodemographic characteristics among the location-level controls x_i. Yet, a lot is asked of these controls if they are to filter out differences in demands for publicly provided goods completely.

Jofre-Monseny (2013) and Koh et al. (2013) have addressed this issue by considering not just aggregate density (a_i) but also location-industry-level agglomeration measures (a_{ij}), thus adding an industry dimension that is in principle orthogonal to the problematic location dimension. Both studies find measures of a_{ij} to be associated with significantly higher average local-level tax rates as well.

Luthi and Schmidheiny (2014) in addition distinguish differentials *across* cities from differentials *within* cities (defined as Swiss metropolitan areas). They observe that between cities, both jurisdictional size and centrality—two alternative measures of a_i—are associated with higher tax rates. This is consistent with asymmetric tax competition models as well as with core-periphery models. Within cities, however, only jurisdictional size appears to matter, whereas proximity to the center (conditionally on size) is not significantly correlated with observed tax rates. Importantly, given the focus of this chapter, the study authors interpret their finding as evidence that the standard asymmetric tax competition mechanism is at play both within and among cities, but that the agglomeration mechanism seems to matter only for tax differentials across cities. To our knowledge, this is the only study so far to have distinguished intraurban from interurban determinants of local tax setting while considering agglomeration economies. This seems to be a promising area for further research.

Another approach to addressing potential omitted-variable bias due to heterogeneous revenue needs is adopted by Brülhart and Simpson (2015). They take advantage of the fact that British regional development subsidies, interpreted as inverse taxes, can be varied across firms, thus yielding a dependent variable that can be denoted as t_{fij}. With such a regressand, identification can come from the industry dimension instead of the location dimension. Brülhart and Simpson (2015) test whether subsidies requested by applicant firms offered by the government take account of firms' differential spatial mobility according to the extent of industry localization measured through the Ellison and Glaeser (1997) index. They find evidence of firms internalizing agglomeration economies in their applications and of government agencies reflecting this in the generosity of their subsidy offers.

However, they also observe that local government agencies structure their offers so as to try to preserve existing employment in more agglomerated industries at the locus of agglomeration. Such behavior corresponds better to theories of policy capture by dominant incumbent industries than to geography models in which disinterested local governments shape their tax policy in order to account for agglomeration effects. Put simply, while agglomerations in principle are taxable, they might leverage their weight in local economies to obtain favorable tax treatment. This is consistent with political-economy theories according to which policy capture by vested interest is stronger at the local level than at the national level (Bardhan and Mookherjee, 2000; Redoano, 2010).

Result 17.5.5. *Larger and more central municipalities are generally found to apply higher tax rates. The extent to which this reflects taxable agglomeration rents remains moot.*

17.5.2.3 Do agglomeration economies affect the equilibrium tax competition outcome significantly?

It would seem fair to summarize the relevant literature as yielding a cautious "yes" to the first two questions: firms in agglomerated sectors trade off higher taxes for greater proximity to other firms, and local governments seem to recognize this to some extent and set their taxes accordingly. Does this mean that agglomeration forces significantly counterbalance race-to-the bottom forces of horizontal tax competition within and between urban areas? And how relevant are agglomeration forces for personal rather than corporate tax bases (i.e., local sorting effects; see Section 17.4)? These questions have so far remained unaddressed. A rigorous treatment would likely require structural modeling allowing counterfactual simulations for different agglomeration intensities.

17.6. CONCLUDING REMARKS

As shown in Section 17.2, the typical OECD city is divided into 74 municipalities of on average 20,000 inhabitants when we define a "city" as a functional urban area of at least 500,000 residents. This population average masks huge size variations: the typical central municipality accounts for fully 40% of the city's population and is thus some 50 times bigger than its average surrounding urban municipality. One key task of these urban jurisdictions is to raise tax revenue amounting to 10% of consolidated (local, regional, and national) taxation. The representative urban municipality raises 43% of its revenue from property taxes, 21% from taxes on personal income, and 21% on taxes on the consumption of goods and services. The dominance of local property taxes is a feature mainly of English-speaking countries—in countries with the highest levels of local tax autonomy, personal income taxes tend to dominate even at the municipal level.

These stylized facts make it abundantly clear that models of tax competition, although originally framed in an international setting, hold considerable relevance also for tax setting within urban areas, where multiple horizontally and vertically nested jurisdictions of very different sizes compete at close quarters for a range of mobile tax bases. We have shown that different plausible models have sharply differing implications for the relationship between municipal population and tax rates, and that quintessentially urban features need to be better incorporated into these models.

Intraurban tax competition is different from intercity and international tax competition in that all tax bases are highly mobile within cities, including private households. This means that taxation within cities shapes and is shaped by residential sorting. The decentralized provision and financing of public goods within cities allows rich households to sort into rich municipalities with high public good provision, low tax rates, and high housing prices that prevent low-income households from following. Such Tiebout-type sorting is potentially efficient, as different (income) groups consume public goods tailored to their preferences. However, calibrated theory models show that such welfare gains turn out to be elusive in the case of municipal property taxation.

While firms and households are mobile within cities and to some extent also between cities within a country, this mobility can be constrained by agglomeration forces. This phenomenon has been subject to particular scientific scrutiny in recent years, owing to the prediction of "new economic geography" models that agglomeration forces can make firms *de facto* immobile and thereby generate taxable location rents. We reviewed this literature in Section 17.5 and found that, while agglomeration forces could in theory both intensify and attenuate tax competition, the evidence points toward an attenuating effect, as agglomeration forces are found to reduce firms' sensitivity to local tax differentials. Whether this mechanism is of first-order importance in determining local tax rates, however, remains uncertain.

The literature on intraurban tax setting is still patchy, and many articles we discussed in this survey, while relevant to the issue, are not intentionally aimed at shedding light on this particular problem. Moreover, most of the literature we have covered focuses on positive theoretical predictions and their support in the data. Robust welfare-relevant results, however, are scarce, as is empirical work looking specifically at policy making by intraurban jurisdictions. Given the global trend toward urbanization and, in many countries, fiscal decentralization, this surely offers a fruitful area for further research.

APPENDIX

The data on jurisdictional fragmentation of consistently defined urban areas are from the OECD data Web site at http://stats.oecd.org under the theme "Regions and Cities" and the subtheme "Metropolitan areas" (DOI 10.1787/region-data-en). We use the variables "total population metro area (persons)," "local governments (count)," and "territorial fragmentation." We exported data for 2012 which reports population figures for 2012 and the number of local governments from various years. See OECD (2013a, p. 174) and Table A.1 for reported years by country.

The data on local fiscal decentralization for all countries except for the United States are from the IMF at http://elibrary-data.imf.org. Note that GFS data are accessible only with a subscription. We downloaded the data using the IMF query builder through the following steps: "Sign in" with user name and password. "Query within a dataset: Government Finance Statistics (GFS)." Choose "Time" 1960–2012 (we downloaded 10-year intervals to limit the size of the individual datasets). Choose "Unit," tick "National currency" and "Euros," choose "Concept," expand "2001 GFS," expand "Cash," mark "Local Government," click "Select Branch." Repeat with "Noncash" and with "General Government" for both "Cash" and "Noncash" data. This choice results in the selection of 1666 of 7548 items. Choose "Country," click "Select All." Export data.

The index LTS in Equation (17.1) is calculated from the GFS variable `GLRT_G01_AC` for the numerator "local government tax revenue," and `GGRT_G01_AC` for the denominator "general government tax revenue." For countries which do not report noncash budgetary information, we used `GLRT_G01_CA` and `GGRT_G01_CA`, respectively. We used the most current observation for which local data are reported. We used only countries for which the local data do not include subcentral government units such as states and regions, which are clearly larger than urban areas. See Table A.3 for the list of included countries and years and Table A.4 for the list of excluded countries. The composition of local taxes is taken from the variables `GLRTII_G01_AC` for personal income tax, `GLRTIC_G01_AC` for corporate income tax, `GLRTP_G01` for property tax, and `GLRTGS_G01` for tax on consumption, and the residual `GLRT_G01_AC` – `GLRTII_G01_AC` – `GLRTIC_G01_AC` – `GLRTP_G01_AC` – `GLRTGS_G01_AC` for other tax sources. For countries that do not report noncash budgetary information, we use the `_CA` versions of the variables. The index ALTS in Equation (17.3) uses the share of local tax revenue in tax groups (a) plus (b1) plus (b2) plus (c) from Blöchliger and Rabesona (2009, p. 5, Table A.2).

The GFS data offer no information on local fiscal decentralization in the United States after 2001. We therefore used data from the Historical Finance Data Base (IndFin) provided by the US Census Bureau. This dataset reports time series of financial variables from 1967 to 2011 on an annual basis. IndFin is not publicly accessible, but access can be requested by e-mail: govs.census.management@census.gov. We used data for 2007, the most recent year with data on the universe of local units. We used the variable `total-taxes` for total tax revenue, `individualincometax` for personal income tax revenue, `corpnetincometax` for corporate income tax revenue, `propertytax` for property tax revenue, and `totsalesgrrectax` for consumption tax revenue. Revenue from other tax sources was calculated as the residual between total taxes and the four components. Tax revenue of all local governments was calculated as the aggregate of all revenue from government units for which the variable `typecode` takes values 2 (municipality), 3 (township), 4 (special district), or 5 (school district, independent only). Note that IndFin data report annual cash flows only and therefore correspond to the

Table A.1 Local government units in OECD/EC data

Country	ISO country code	Year	Source	Local governments reported by OECD
Austria	AUT	2001	Eurostat	Gemeinden (LAU2)
Belgium	BEL	2001	Eurostat	Gemeenten/communes (LAU2)
Canada	CAN	2006	Statcan	Census subdivisions (towns, villages, etc.) (CSD)
Chile	CHL	2002	INE	Chile, comunas
Czech Republic	CZE	2001	Eurostat	Obce (LAU2)
Denmark	DNK	2001	Eurostat	Sogne (LAU2)
Estonia	EST	2000	Eurostat	Vald, linn (LAU2)
Finland	FIN	2000	Eurostat	Kunnat/kommuner (LAU2)
France	FRA	1999	Eurostat	Communes (LAU2)
Germany	DEU	2001	Eurostat	Gemeinden (LAU2)
Greece	GRC	2001	Eurostat	Demotiko diamerisma/koinotiko diamerisma (LAU2)
Hungary	HUN	2001	Eurostat	Települesek (LAU2)
Ireland	IRL	2001	Eurostat	Local governments (LAU1)
Italy	ITA	2001	Eurostat	Comuni (LAU2)
Japan	JPN	2006	NLFTP	Shi (city), machi or cho (town), and mura or son (village)
Korea	KOR	2009	KOSIS	Eup, myeon, dong
Luxembourg	LUX	2001	Eurostat	Communes (LAU2)
Mexico	MEX	2010	INEGI	Municipios
Netherlands	NLD	2001	Eurostat	Gemeenten (LAU2)
Norway	NOR	2001	Eurostat	Municipalities (LAU2)
Poland	POL	2002	Eurostat	Gminy (LAU2)
Portugal	PRT	2001	Eurostat	Freguesias (LAU2)
Slovak Republic	SVK	2001	Eurostat	Obce (LAU2)
Slovenia	SVN	2002	Eurostat	Obeine (LAU2)
Spain	ESP	2001	Eurostat	Municipios (LAU2)
Sweden	SWE	2000	Eurostat	Kommuner (LAU2)
Switzerland	CHE	2000	Eurostat	Municipalities (LAU2)
United Kingdom	GBR	2001	ONS	County councils
United States	USA	2000	US Census	Municipalities or townships

Year in which the local government units are counted. The local governments used in this report were identified on the basis of the following criteria: Have only one level of local government per country, notably the lowest tier (even if more than one level of government may have relevant responsibilities over the same territory). Identify only general-purpose local governments, excluding the specific function governments (for example, school district, health agencies, etc.). For the United Kingdom, for those areas where the county councils were abolished, the local authority (either a metropolitan district council or a unitary district council) is used. For London, the borough councils are used. For the United States, in the geographic areas where municipalities or townships do not represent a general purpose government, the county governments were considered.
Source: (OECD, 2013a, p. 174).

Table A.2 Jurisdictional fragmentation across OECD countries

		Functional urban areas Population			Number of local governments per area			Local governments per 100,000 inhabitants		
Country	**ISO country code**	**No.**	**Average**	**Max.**	**Average**	**Min.**	**Max.**	**Average**	**Min.**	**Max.**
Austria	AUT	3	1,323,321	2,737,753	209	140	313	20.8	11.4	28.0
Belgium	BEL	4	1,230,263	2,536,106	50	24	99	4.3	3.0	6.1
Canada	CAN	9	2,181,109	6,671,162	60	6	191	3.5	0.8	6.9
Chile	CHL	3	2,803,954	6,531,598	21	6	47	0.8	0.6	1.0
Czech Republic	CZE	3	1,024,677	1,868,631	249	67	435	24.4	11.9	38.1
Denmark	DNK	1	2,007,352	2,007,352	57	57	57	2.8	2.8	2.8
Estonia	EST	1	530,640	530,640	28	28	28	5.3	5.3	5.3
Finland	FIN	1	1,476,662	1,476,662	22	22	22	1.5	1.5	1.5
France	FRA	15	1,706,750	11,862,466	280	35	1375	21.4	6.3	49.1
Germany	DEU	24	1,321,825	4,386,551	74	3	308	5.2	0.4	11.0
Greece	GRC	2	2,256,708	3,547,773	61	28	94	2.8	2.7	2.9
Hungary	HUN	1	2,862,326	2,862,326	183	183	183	6.4	6.4	6.4
Ireland	IRL	1	1,735,182	1,735,182	7	7	7	0.4	0.4	0.4
Italy	ITA	11	1,672,074	4,109,109	70	14	252	3.9	2.6	6.1
Japan	JPN	36	2,426,972	35,441,287	22	3	235	1.2	0.3	2.5
Korea	KOR	10	3,660,358	23,496,373	172	27	965	5.4	4.1	6.4
Mexico	MEX	33	1,807,044	19,802,161	9	1	55	0.7	0.1	6.0
Netherlands	NLD	5	1,244,345	2,406,043	27	11	57	2.1	1.2	2.7
Norway	NOR	1	1,261,977	1,261,977	30	30	30	2.4	2.4	2.4
Poland	POL	8	1,433,687	3,008,921	41	17	101	2.9	1.8	4.9
Portugal	PRT	2	2,073,419	2,840,065	193	150	235	9.9	8.3	11.5
Slovakia	SVK	1	722,106	722,106	136	136	136	18.8	18.8	18.8
Slovenia	SVN	1	576,370	576,370	28	28	28	4.9	4.9	4.9
Spain	ESP	8	2,126,111	6,779,528	94	16	272	6.0	2.0	24.7
Sweden	SWE	3	1,181,950	1,991,310	18	12	28	1.6	1.4	2.1
Switzerland	CHE	3	935,770	1,226,332	167	140	193	19.0	11.4	23.9
United Kingdom	GBR	15	1,721,399	12,090,254	8	3	47	0.5	0.3	0.8
United States	USA	70	2,400,635	17,378,937	82	2	540	4.7	0.2	21.5

Source: Own calculations based on OECD (Regional Statistics). Population data from 2012, number of local governments from various years (see Table A.1).

Table A.3 Local government units in GFS/IndFin data, included countries

Country	ISO country code	Year	Local government units reported by IMF
Argentina	ARG	2004	1617 municipalities
Armenia	ARM	2012	900 marzes or communities
Australia	AUS	2012	900 cities, district councils, municipalities, shires, and towns
Austria	AUT	2011	2358 municipalities (excluding Vienna), municipal associations (education services), Vienna
Belgium	BEL	2011	589 communes
Bolivia	BOL	2007	9 municipalities of departmental capitals and numerous other municipalities
Bosnia–Herzegovina	BIH	2012	4 cities and 140 municipalities
Brazil	BRA	2011	5564 local governments
Bulgaria	BGR	2011	264 municipalities
Canada	CAN	2012	Municipal governments
Cape Verde	CPV	2009	22 municipalities, 3 municipal associations, and 15 water supply and sanitation agencies
Chile	CHL	2012	Municipalities and municipal mutual fund.
Colombia	COL	2011	1108 municipalities, including the municipality of Bogotá
Costa Rica	CRI	2007	81 municipalities
El Salvador	SLV	2011	262 municipalities
Estonia	EST	2011	39 city councils and 202 municipalities
Finland	FIN	2011	432 municipalities
Germany	DEU	2011	15,000 municipalities and municipal associations
Greece	GRC	2011	1033 communities and municipalities
Honduras	HND	2012	298 municipalities
Iceland	ISL	2011	17 municipalities, including public nursery and primary schools, and old persons' residential institutions
Iran	IRN	2009	1000 municipalities
Jamaica	JAM	2005	Kingston and St. Andrew Corp., Municipal Services Commission, Parish Council Services Commission, and 13 parish councils
Jordan	JOR	2011	Greater Amman municipality, 172 municipalities, and 350 village councils
Latvia	LVA	2012	109 amalgamated municipalities and 7 major towns
Lithuania	LTU	2012	60 local governments and nonprofit institutions (nursing homes, pre-primary, primary, and secondary schools, etc.), which are controlled and mainly financed by local governments. Municipal enterprise Vilniaus Miesto Bustas
Luxembourg	LUX	2011	116 communal administrations and municipalities

Continued

Table A.3 Local government units in GFS/IndFin data, included countries—cont'd

Country	ISO country code	Year	Local government units reported by IMF
Malaysia	MYS	2001	2 agencies with the functions of a local government, 12 city councils, 38 municipal councils, and 96 district councils. States reported separately
Malta	MLT	2011	68 local councils
New Zealand	NZL	2011	86 local government units
Paraguay	PRY	2012	Capital and 239 municipalities
Peru	PER	2012	7 decentralized agencies, 194 provincial councils, and 1836 district councils. Regions reported separately
Russia	RUS	2012	24,255 local governments
Slovenia	SVN	2011	210 municipalities
South Africa	ZAF	2011	6 metropolitan municipalities, 46 district municipalities, and 231 local municipalities
Spain	ESP	2012	9000 municipalities and other local authorities
Swaziland	SWZ	2003	2 city councils, 3 town boards, and 3 town councils
Switzerland	CHE	2010	2600 communes
United Kingdom	GBR	2012	540 local councils and local government units
United States	USA	2007	19,484 cities, 16,475 townships, 35,574 special districts, and 13,742 school districts

Year means latest observation with revenue data at the local level.
Source: IMF (Government Finance Statistics Yearbook, various years).

variables with suffix _CA in the GFS data. The tax revenue of the general government in 2007 was taken from p. 42 of the Financial Statements of the United States Government (downloaded from https://www.fms.treas.gov/fr/07frusg/07stmt.pdf). We calculated the index ALTS in Equation (17.3) for the United States using the share of local tax revenue in tax groups (a) plus (b) plus (c) from Stegarescu (2006, p. 32, Table 2.2).

To assess whether the IndFin and GFS accounting frameworks are comparable, we calculated the decentralization indices for the United States in 1987 and 1992 from both data sources. Both datasets report data based on cash flows. In 1987, the index LTS equals 12.8% in the IndFin data and 16.8% in the GFS data. In 1992, LTS is 14.2% in the IndFin data and 18.9% in the GFS data. While this systematic underestimation of decentralization in the IndFin data is substantial, it is not different by orders of magnitude and does not substantially change the comparison of tax decentralization across countries.

The OECD data on jurisdictional fragmentation at http://stats.oecd.org do not contain population figures for individual municipalities within cities (urban areas). We therefore additionally used a dataset provided by the EC (Urban Audit) which lists names and 2006 population figures for all individual municipalities within European

Table A.4 Local government units in GFS/IndFin data, excluded countries

Country	ISO country code	Year	Local government units reported by IMF
Afghanistan	AFG	2011	Partial information was provided. Municipalities. No state level reported
Azerbaijan	AZE	2012	51 districts (rayons) consisting of 5 cities and 1494 municipalities; the city of Baku, which consists of 52 municipalities; 171 Nakhichevan Autonomous Republic municipalities grouped into 7 districts and the city of Nakhichevan
Belarus	BLR	2012	1 city of Minsk, 12 oblast cities, 6 oblast/provincial, 118 rayon/districts, rayon 14 cities, 1289 rural, and 64 settlement/townships budgets
China	CHN	2011	656 cities, 2487 counties, 31 provinces (excluding Taiwan, Hong Kong, and Macao and including Beijing, Shanghai, Chongqing, and Tianjin), 333 subprovincial administrative regions, 44,067 townships, and 678,589 villages
Republic of the Congo	COG	2005	Brazzaville and 5 other municipalities, 11 departments
Croatia	HRV	2011	1 city (Zagreb), 20 counties, 126 towns, and 429 municipalities
Cyprus	CYP	2011	6 districts, 33 municipalities, and 298 village authorities
Czech Republic	CZE	2011	8 regional committees of cohesion, 14 regions, and 6300 municipalities
Denmark	DNK	2011	5 regions, 98 municipalities, regional and municipal agencies
France	FRA	2012	100 departments, 26 regions, and 36,000 communes
Georgia	GEO	2012	Adjaria Autonomous Republic, Abkhazia Autonomous Republic, and 62 administrative districts, towns, and cities
Hungary	HUN	2012	19 county governments, 3200 municipalities and local minority governments
Ireland	IRL	2011	5 borough councils, 5 city councils, 29 county councils, and 75 town councils, as well as 2 regional assemblies and 8 regional authorities
Israel	ISR	2012	260 local government units (local councils, municipalities, regional councils)
Italy	ITA	2011	2 autonomous provinces, 20 regions, 104 provinces, 311 municipalities' unions, and 8101 municipalities
Japan	JPN	2011	1800 local public entities
Kazakhstan	KAZ	2011	2 cities (Almaty and Astana) and 14 oblasts (province) bodies.

Continued

Table A.4 Local government units in GFS/IndFin data, excluded countries—cont'd

Country	ISO country code	Year	Local government units reported by IMF
Korea	KOR	2011	6 metropolitan cities, 8 provinces, 69 autonomous districts, 73 cities, 86 counties, 228 basic local government units, special self-governing province Jeju, and special metropolitan city Seoul
Lesotho	LSO	2008	Maseru Municipal Council and district councils
Mauritius	MUS	2012	4 district councils and 5 municipal councils
Mexico	MEX	1998	Federal district, 31 state governments, and 2418 municipal governments
Moldova	MDA	2012	8393 local government budgetary organizations, 2 municipalities, and 32 rayons
Mongolia	MNG	2012	9 districts (ulaanbaatar), 21 provinces (aimags), and 331 districts (soums)
Morocco	MAR	2011	41 arrondissements, 61 prefectures and provinces, 16 regions, 1298 rural communes, 132 trade unions, and 200 urban communes
Netherlands	NLD	2012	316 communal arrangements, 418 municipalities, 12 provinces, and 26 public water boards
Norway	NOR	2012	18 counties and 430 municipalities
Poland	POL	2011	16 districts, 372 counties, and 2478 communes
Portugal	PRT	2012	Regional governments of the Azores and Madeira, 18 districts, and 308 municipalities
Romania	ROU	2011	1 city (Bucharest), 41 counties, 103 municipalities, 211 towns, and 2850 communes
Serbia	SRB	2011	Autonomous Province Vojvodina, cities, and municipalities
Slovakia	SVK	2011	8 regions and 2900 municipalities and other units
Sweden	SWE	2012	20 county councils, 186 municipal associations, and 290 municipalities
Tajikistan	TJK	2004	3 provinces, 15 cities, and 54 districts
Thailand	THA	2002	75 changwat administrative organizations, 1129 municipalities, 6745 district administrative organizations, Bangkok metropolitan administration, and Pattaya City.
Tunisia	TUN	2011	24 government councils and 264 municipalities
Ukraine	UKR	2011	1 republic (Crimea), 2 cities (Kiev and Sevastopol), 24 oblasts, 176 municipalities, and 488 districts
West Bank and Gaza	PSE	2010	428 localities/municipalities and 16 main governorates

Year means latest observation with revenue data at the local level.
Source: IMF (Government Finance Statistics Yearbook, various years).

Table A.5 Decentralization of local (municipal) revenue

Country	ISO country code	Year	LTS Total	LTS Personal income	LTS Corporate income	LTS Property	LTS Consumption	LTS Other	ALTS
OECD countries									
Australia	AUS	2012	3.4	0.0	0.0	3.4	0.0	0.0	3.4
Austria	AUT	2011	18.0	4.9	1.2	1.7	6.9	3.3	1.5
Belgium	BEL	2011	7.9	2.8	0.0	4.3	0.7	0.0	7.4
Canada	CAN	2012	11.3	0.0	0.0	11.0	0.3	0.0	11.0
Chile	CHL	2012	7.0	0.0	0.0	2.9	4.1	0.0	
Estonia	EST	2011	21.4	19.0	0.0	1.6	0.8	0.0	
Finland	FIN	2011	33.0	28.1	2.8	2.1	0.0	0.0	30.3
Germany	DEU	2011	13.0	5.0	5.4	1.7	0.9	0.0	7.8
Greece	GRC	2011	1.1	0.0	0.0	0.8	0.3	0.0	0.6
Iceland	ISL	2011	30.1	24.3	0.0	5.3	0.4	0.0	28.8
Luxembourg	LUX	2011	6.7	0.0	6.2	0.4	0.1	0.0	6.6
New Zealand	NZL	2011	7.4	0.0	0.0	6.9	0.5	0.0	0.0
Slovenia	SVN	2011	18.1	14.6	0.0	2.7	0.8	0.0	
Spain	ESP	2012	15.2	2.3	0.5	6.3	6.0	0.0	11.0
Switzerland	CHE	2010	20.1	13.7	2.5	2.9	0.5	0.5	20.1
United Kingdom	GBR	2012	6.0	0.0	0.0	6.0	0.0	0.0	6.0
United States	USA	2007	15.3	0.8	0.3	11.1	2.3	0.9	15.3
Non-OECD countries									
Argentina	ARG	2004	0.2	0.0	0.0	0.0	0.0	0.2	
Armenia	ARM	2012	2.6	0.0	0.0	2.1	0.5	0.0	
Bolivia	BOL	2007	21.1	0.0	2.3	5.1	12.6	1.0	
Bosnia–Herzegovina	BIH	2012	11.1	2.0	0.0	1.2	7.8	0.1	
Brazil	BRA	2011	7.2	0.6	0.0	2.2	3.1	1.2	
Bulgaria	BGR	2011	7.2	0.1	0.0	7.0	0.1	0.0	
Cape Verde	CPV	2009	3.3	0.0	0.0	2.3	0.9	0.0	
Colombia	COL	2011	11.1	0.0	0.0	4.1	7.0	0.0	
Costa Rica	CRI	2007	3.4	0.0	0.0	1.1	2.1	0.2	
El Salvador	SLV	2011	5.8	0.0	0.0	0.0	5.8	0.0	

Continued

Table A.5 Decentralization of local (municipal) revenue—cont'd

Country	ISO country code	Year	LTS Total	LTS Personal income	LTS Corporate income	LTS Property	LTS Consumption	LTS Other	ALTS
Honduras	HND	2012	4.0	0.0	0.0	4.0	0.0	0.0	
Iran	IRN	2009	15.6	0.0	0.0	0.0	3.6	12.0	
Jamaica	JAM	2005	1.3	0.0	0.0	0.8	0.5	0.0	
Jordan	JOR	2011	2.5						
Latvia	LVA	2012	27.8	23.5	0.0	4.0	0.2	0.2	
Lithuania	LTU	2012	16.3	13.5	0.0	1.8	0.4	0.6	
Malaysia	MYS	2001	3.3						
Malta	MLT	2011	0.0	0.0	0.0	0.0	0.0	0.0	
Paraguay	PRY	2012	5.1	0.0	0.0	2.5	1.8	0.8	
Peru	PER	2012	2.3	0.0	0.0	1.1	0.2	1.0	
Russia	RUS	2012	6.1	4.3	0.1	1.0	0.1	0.7	
South Africa	ZAF	2011	4.3	0.0	0.0	4.2	0.1	0.0	
Swaziland	SWZ	2003	1.8	0.0	0.0	1.7	0.1	0.0	
Average			10.0	4.2	0.6	3.1	1.9	0.6	10.7
OECD			13.1	6.4	1.1	4.0	1.4	0.3	10.7
Non-OECD			7.4	2.2	0.1	2.3	2.3	0.9	
Minimum			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum			33.0	28.1	6.2	11.1	12.6	12.0	30.3

Indices in percentage points. Year means latest observation with data at the local (municipal) level.
Source: Own calculations based on data by the IMF (GFS) and US Census (IndFin).

Table A.6 Taxing autonomy of local (municipal) governments

Country	ISO country code	Share of local tax revenue in class							
		(a)	(b)	(c)	(d.1)	(d.2)	(d.3)	(d.4)	(e)
Australia	AUS	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Austria	AUT	2.6	5.5	0.0	0.0	0.0	65.3	0.0	20.7
Belgium	BEL	8.4	85.7	0.0	0.0	0.0	0.0	0.0	5.8
Canada	CAN	1.8	95.6	0.0	0.0	0.0	0.0	0.0	1.6
Finland	FIN	0.0	91.8	0.0	0.0	0.0	0.0	8.1	0.2
Germany	DEU	0.0	59.7	0.0	0.0	39.4	0.0	0.0	0.0
Greece	GRC	0.0	53.9	0.0	0.0	0.0	0.0	0.0	46.1
Iceland	ISL	0.0	95.9	0.0	0.0	0.0	0.0	0.0	0.0
Luxembourg	LUX	98.5	0.2	0.0	0.0	0.0	0.0	0.0	1.1
New Zealand	NZL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	ESP	22.6	49.5	0.0	0.0	17.4	0.0	0.0	5.3
Switzerland	CHE	3.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0
United Kingdom	GBR	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
United States	USA	71.4	28.6	0.0	0.0	0.0	0.0	0.0	0.0

Source: Blöchliger and Rabesona (2009) and Stegarescu (2006). Shares in percentage points.

cities. This dataset is not publicly available and was kindly provided to us by Lewis Dijkstra, Deputy Head of the Analysis Unit in the EC Directorate-General for Regional Policy. These data are based on the joint EC/OECD definition of cities. However, there are unfortunately substantial differences in the public OECD data used in Section 17.2.1 and the EC data used in Section 17.2.4. See footnote 13, for example. We only used data on OECD countries as in Section 17.2.1. We dropped the United Kingdom, Ireland, Denmark, Slovakia, and Portugal because the EC reports smaller units than the municipalities counted in the OECD data as local governments. We also dropped the Czech Republic, because the number of local governments differs considerably from the numbers in the OECD data. We used the same sample of cities as in the OECD data in Section 17.2.1—that is, we included some cities with a population below 500,000 inhabitants in 2006 but above that level in 2009; we also excluded some cities with a population above 500,000 inhabitants in the EC data but not included in the OECD data. We used the 2006 population figure for the largest and the second largest municipality for each city as well as the 2006 total population. The population share of the largest municipality was calculated as the population of the largest municipality divided by the total population of the city (urban area). The average municipality size in an urban area was calculated as the 2006 population in the EC data divided by the number of local jurisdictions in the EC data. The Zipf prediction in footnote 15 is based on the 2006 population of the largest municipality in the EC data and the 2012 total population of the urban area in the OECD data.

Table A.7 Asymmetries across local governments within urban areas

Country	ISO country code	Population share of the largest			Largest vs. average			Largest vs. second largest			Largest vs. Zipf prediction		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Austria	AUT	46	31	64	105.2	43.5	199.0	23.9	6.6	43.3	2.7	1.7	4.0
Belgium	BEL	30	7	46	11.0	7.3	14.6	5.6	1.7	10.4	1.2	0.4	1.8
Estonia	EST	73	73	73	17.6	17.6	17.6	29.0	29.0	29.0	2.8	2.8	2.8
Finland	FIN	43	43	43	6.1	6.1	6.1	2.4	2.4	2.4	1.4	1.4	1.4
France	FRA	31	15	50	74.3	10.5	268.1	7.0	2.2	19.1	1.8	1.0	2.7
Germany	DEU	39	11	68	42.9	4.6	229.1	9.1	1.0	29.3	1.9	0.5	4.1
Greece	GRC	25	19	31	14.9	9.0	20.8	3.9	3.6	4.3	1.1	1.0	1.2
Hungary	HUN	61	61	61	113.2	113.2	113.2	28.1	28.1	28.1	3.5	3.5	3.5
Italy	ITA	53	28	85	32.6	6.9	96.2	15.8	5.3	57.2	2.3	1.5	3.7
Netherlands	NLD	41	31	59	8.2	4.1	14.1	4.7	2.5	8.1	1.4	1.1	1.7
Norway	NOR	47	47	47	16.1	16.1	16.1	5.0	5.0	5.0	1.9	1.9	1.9
Poland	POL	55	12	79	19.4	7.0	52.1	14.1	1.4	29.0	2.2	0.5	2.9
Slovenia	SVN	52	52	52	13.5	13.5	13.5	8.2	8.2	8.2	2.0	2.0	2.0
Spain	ESP	58	37	93	29.3	6.9	93.1	19.7	3.5	102.1	2.4	1.7	3.4
Sweden	SWE	48	40	55	7.7	4.8	10.5	6.0	2.7	8.4	1.6	1.4	1.8
Switzerland	CHE	25	22	31	40.4	36.8	43.8	6.8	3.6	11.3	1.4	1.2	1.7
United States	USA	34	7	81	25.7	1.7	178.7	8.0	1.2	41.4	1.4	0.4	3.5

Source: European data for 2006 from the EC (Urban Audit); US data for 2012 from the OECD (Regional Statistics) and US Census (Population Estimates Program).

For the United States, we used data from the Census Bureau's Population Estimates Program available at http://www.census.gov/popest/data/cities/totals/2013/. We used 2012 population data for local units that are incorporated—for example, cities and towns. In three special cases, we used the "consolidated city-county," where the city and county administration are merged (Indianapolis-Marion county, Indiana; Louisville-Jefferson county, Kentucky; and Nashville-Davidson county, Tennessee). We used the Geographic Correspondence Engine from the Missouri Census Data Center at http://mcdc.missouri.edu/websas/geocorr12.html to link towns and cities to the urban areas in the OECD data using a list of counties for each urban area provided by the OECD at http://www.oecd.org/gov/regional-policy/List-municipalities.xls.

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