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HOW FISCAL DECENTRALIZATION FLATTENS PROGRESSIVE TAXES

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Abstract

We study the tension between fiscal decentralization and progressive taxation. We present a multi-community model in which households differ in incomes and housing preferences and in which the local income tax rate is a function of an exogenous progressive tax schedule and an endogenous local tax shifter. The progressivity of the tax schedule induces a self-sorting process that results in substantial though imperfect income sorting. The actual tax structure is thus less progressive than the exogenous tax schedule. Empirical evidence from the largest Swiss metropolitan area supports the predictions of our model.

JEL Code: H73, R23.

Keywords: progressive taxation, fiscal decentralization, income segregation.

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1 Introduction

In this paper, we study the tension between fiscal decentralization and progressive taxation. We investigate to what extent fiscal decentralization reduces the progressivity of a common tax schedule in a federation in which communities can set the level of taxation. We find that progressive taxation and fiscal decentralization lead to income sorting, which reduces the progressivity of the tax schedule.

We base our analysis on a multi-community model, in which the income tax rate is a function of an exogenous progressive tax schedule and an endogenous local tax shifter. Local tax revenue is used to finance a local good. In the basic version of the model, the mobile individual households differ only in their incomes.

In equilibrium, no household wants to move, local housing markets clear and the communities’ budgets are balanced. It follows that the local tax shifters must be higher in communities in which housing prices are lower. The progressivity of the tax schedule then induces a self-sorting process that results in perfect income sorting. Poor households locate in high tax communities while rich households locate in low tax communities. Different from most of the previous literature, sorting is a direct result of the progressive tax schedule and does not require strong assumptions on the preferences for either public goods or housing. The perfect spatial segregation of the population by incomes implies that the actual tax structure must be less progressive than the exogenous tax schedule if progressive at all.

While some degree of income sorting is observed in reality, this sorting is never perfect (see e.g. Epple and Sieg, 1999, Hardman and Ioannides, 2004, 1 See e.g. Ellickson (1971), Westhoff (1977), Epple and Romer (1991) and the literature surveyed in Ross and Yinger (1999).
and Ioannides, 2004). A potential reason for imperfect income sorting is that households differ in their preferences. We therefore add heterogeneity in the households’ preferences to our model. In particular, we assume heterogeneity in the preferences for housing. As each household’s location choice depends now on its income and its preferences, the income sorting is imperfect in equilibrium: households with the same income are found in different communities, though rich households are still more likely to locate in low tax communities than poor households.

To investigate the quantitative implications of this model, we calibrate a fully-specified version to the Zurich area, the largest Swiss metropolitan area. Swiss metropolitan areas offer an excellent laboratory for the analysis of fiscal decentralization. In Switzerland, each community can individually set the level of income taxes by a local tax shifter while the cantons (states) fix the (progressive) schedule of income taxes. The equilibrium values of this simulation show the same pattern across communities as we observe in the Zurich area: Rich households locate mainly, but not exclusively, in communities with low tax shifters and poor households mainly in communities with high tax shifters.

We then use data on the spatial distribution of incomes in the Zurich area to estimate the actual tax structure, i.e. average tax rates as a function of income as faced by the households in this area. We find that the actual tax structure is substantially less progressive than the tax schedule implemented by the canton because rich households are more likely to live in low tax communities than poor households. This finding is in line with the predictions of our theoretical model.

This paper is most closely related to Feldstein and Wrobel (1998), Epple and Platt (1998) and Schmidheiny (2004). Feldstein and Wrobel show that
a shift in a single US state's tax progressivity has no redistributive effects since migration leads to an adjustment of the net wages and the employment structure. Complementary, we show that location choices undermine the redistributive effect of progressive taxation in presence of fiscal decentralization even if wages do not adjust. Our theoretical model shares the formal structure with Epple and Platt. Schmidheiny shares the location choice part of our model and shows empirically that rich households are more likely to move to low tax communities than poor households.

More generally, our paper relates to the literature on fiscal federalism.\textsuperscript{2} It is a well known normative principle of this literature that income redistribution should be centralized. As progressive income taxes are a particular mean to redistribute income, it directly follows that "progressive income taxation [...] - if substantial in scope - must be uniform within the entire area over which there is a high degree of capital and labor mobility" (Musgrave 1971, p. 7). In this paper, we provide some support for this view by showing that fiscal decentralization does indeed undermine the progressivity of the tax schedule. However, we also find theoretical and empirical evidence that the income sorting of the population does not completely offset progressivity; hence leaving room for substantial redistribution through progressive income taxation at the local level.

The paper is organized as follows: Section 2 briefly informs about fiscal decentralization and progressive taxation in Switzerland and some other countries with a comparable tax system. Section 3 presents the theoretical model and some results concerning the agents' location choice. It further proves that an (asymmetric) equilibrium exists. Section 4 presents the simulation of a fully-specified version of our model, which is calibrated to the

\textsuperscript{2}For a recent survey of this literature see Oates (1999).
Zurich metropolitan area. Section 5 estimates the actual tax structure faced by the households in this area. Section 6 concludes.

2 Fiscal Decentralization and Progressive Taxation in Switzerland (and elsewhere)

Switzerland is an exemplary federal fiscal system. The Swiss federation comprises 26 states, the so-called cantons. The cantons are divided into roughly 3000 municipalities of varying size and population. All three state levels finance their expenditures essentially by their own taxes and fees. 46% of the total tax revenue are imposed by the federation, 32% by the cantons and 22% by the municipalities. While the federal government is mainly financed by indirect taxes (61% of federal tax revenue) such as the VAT, the cantons and municipalities largely rely on direct taxes. Income taxes account for 60% of cantonal and 84% of municipal tax revenue.

The cantons organize their tax systems autonomously. For example, they decide upon the level of income and corporate taxes and the degree of tax progression. The individual municipalities in turn can set a tax shifter for income and corporate taxes. The municipal tax is then the cantonal tax rate multiplied by the municipal tax shifter. Federal and cantonal systems of fiscal equalization limit the tax differences across cantons and across municipalities within the same canton to some extent, but still leave room for considerable variation.

The above outlined federal system leads to ample differences of income taxes across Swiss municipalities. For example, for a two-child family with a gross income of 80,000 Swiss francs (CHF) combined cantonal and municipal

income taxes ranged from 3.6% to 11.3% in the year 1997 (and its federal income tax was 0.7%). With an income of 500,000 CHF a two-child family faced much higher tax rates due to the progressivity of the tax schedules. Combined cantonal and municipal income taxes ranged from 10.9% to 28.7%\(^4\) for this household (and its federal income tax was 9.4%). Within metropolitan areas the (municipality) tax differences are smaller but still differ by a factor of 1.5 in e.g. the Zurich area.

While local taxation of *property* is widespread, especially in the United States, local taxation of *income* is rarer. Local income taxation at municipal level is e.g. observed in four U.S. states (Indiana, Maryland, Ohio, and Pennsylvania) and in Denmark. Different from the progressive local tax scheme in Switzerland, these states and countries apply a *flat* local tax. Belgium is to our knowledge the only country with a similar system of fiscal decentralization at municipal level as Switzerland. In Belgium, each of the three regions, i.e. Flanders, Wallonia and the Brussels Region, collects progressive income taxes. Furthermore, each municipality can generate its own income tax revenue by adding a fixed percentage surcharge on the (progressive) regional income tax. Canada had a similar system at provincial level between 1977 and 1996 (see Boadway and Kitchen, 1980): Personal income taxes in Canadian provinces (except Quebec) were a percentage of the (progressive) federal tax.

3 The Model

In this section, we introduce and solve the model. After presenting the general setting, we characterize the preferences and derive the resulting alloca-

\(^4\)Note, however, that this high tax rate is rather hypothetical as it is very unlikely to find a household with such high income in one of the very high tax municipalities.
tion of households across distinct communities. We then prove the existence of an asymmetric equilibrium. Finally, we introduce heterogeneity in the households’ preferences and discuss how this affects our results.

3.1 The Setting

Given is a metropolitan area with \( J \) communities. This area is populated by a continuum of households, which differ in their income \( y \in [y_l, y_u] \). Income follows a distribution function \( f(y) > 0 \).

There are three goods in the economy: private consumption \( b \), housing \( h \), and a publicly provided local good \( g \). The housing \( h \) is provided by absentee landlords, and the housing market is competitive. Hence, the price for housing \( p_i \) equates the housing supply \( HS_i \) with the aggregate housing demand \( HD_i \). We assume that the housing supply \( HS_i = HS(L_i, p_i) \) is a non-decreasing function of the land area \( L_i \) and the price \( p_i \).

Each community \( i \) spends the amount \( n_i g \) to provide the local good \( g \), where \( n_i \) is the measure of households living in community \( i \). The communities levy income taxes to finance the local good. In each community \( i \), the tax rate consists of two parts, a local tax shifter \( t_i \) and a progressive tax rate structure \( r(y) \). We assume \( r(y) \) continuous and increasing in \( y \), \( r(y) > 0 \), the average tax rate \( t \cdot r(y) \in [0, 1) \) and the marginal tax rate \( t[r + yr'](y) \in [0, 1) \). The tax rate structure \( r(y) \) is exogenous (to the communities) and identical across communities.

We assume that the local good \( g \) is fixed and identical across communities. In each community \( i \), the tax shifter \( t_i \) is therefore determined by budget balance. There are two reasons for assuming exogeneity of the local good. First, the local good \( g \) can be thought as a locally provided, locally financed but centrally decided good. We think that many locally financed goods,
particularly in Switzerland, satisfy this description. Schooling, for example, accounts for the largest item in municipal budgets in Switzerland; local neighborhood schools are locally provided and locally financed, however, cantonal regulation leave little discretionary power for financially relevant decisions. Our model focuses therefore on the revenue side of fiscal decentralization. Second, we think that the progressivity of income taxes is a very important factor for income sorting in Switzerland. However, our model would become intractable allowing for both progressive taxation and endogenous provision of local goods. Schmidheiny (2005) studies endogenous local goods determined in municipal majority votes, but financed by flat local income taxes. His model exhibits very similar equilibrium properties.

Further, we assume that each household can move costlessly and chooses the community maximizing its utility as place of residence.

3.2 Preferences and Location Choice

The preferences of the households are described by the utility function

$$ U(h,b) , $$

where $h$ is the consumption of housing and $b$ the consumption of the private good. We assume the utility function to be strictly increasing, strictly quasi-concave, twice continuously differentiable in $h$ and $b$ and homothetic.

Households face the budget constraint (omitting community indices)

$$ ph + b \leq y_d = y[1 - t \cdot r(y)] , $$

5In particular, teachers’ salaries and class size are regulated by cantonal law. Furthermore, cantonal courts ruled, based on equity considerations, that schools (in rich neighborhoods) are not allowed to provide additional tutoring or extra classes for extraordinary strong or weak pupils.

6Since the local good $g$ is constant across communities and not of primary interest for our considerations, we assume for simplicity that it does not enter the utility function. Equivalently, we could assume that it enters separably.
where \( p \) is the price of housing; the price of the private good is set to unity. Disposable income \( y_d \) depends on the local tax shifter \( t \) and the tax rate structure \( r(y) \).

Maximization of the utility function (1) with respect to \( h \) and \( b \) subject to constraint (2) yields housing demand \( h^* = h(p, y_d) = h(t, p, y) \), demand for the private good \( b^* = y(1 - t) - ph(t, p, y) \), and indirect utility

\[
V(t, p, y) = U(h^*, b^*) .
\]  

(3)

For later use note that \( V \) is continuous in \( t, p \) and \( y \).

We assume that the elasticity of housing with respect to the disposable income is smaller or equal to unity, i.e.,

\[
\varepsilon_{h,y_d} := \frac{\partial h^*}{\partial y_d} \leq 1 \quad \text{for all } y_d \text{ and } p.
\]  

(4)

The assumption of income elasticity for housing demand below one is well supported by the large empirical literature on housing demand. Mayo’s (1981) seminal survey of empirical studies using microdata reports consistent income elasticity below one. This result is robust controlling for housing prices, demographic household variables (e.g. Mayo 1981, Hansen, Formby and Smith, 1998), tenure choice (e.g. Henderson and Ioannides 1986, Hansen, Formby and Smith, 1998) and functional form (Hansen, Formby and Smith, 1996). The assumption is also support by the Swiss data used in the calibration of our model.

Next, we present two properties of the households’ indifference curves that will lead to segregation of the population by incomes:

**Property 1**

\[
M(t, p, y) := \frac{dt}{dp}\bigg|_{dV=0} = -\frac{\partial V/\partial p}{\partial V/\partial t} = -\frac{h^*}{y \cdot r(y)} < 0
\]
Property 1 follows from the strictly increasing utility function after applying the implicit function theorem and the envelope theorem. It implies that a household can be made indifferent towards an increase in the tax shifter $t$ when it is compensated by decreased housing prices $p$, and vice versa.

Property 2

$$\frac{\partial M}{\partial y} = \left[ 1 - \frac{\partial h^*}{\partial y} \frac{y_d}{h^*} \right] \frac{h^*}{y^2 r(y)} + \frac{\partial r(y)}{\partial y} \frac{h^*}{y^2 r^2(y)} > 0 \text{ for all } y, t \text{ and } p.$$

Proof: By assumption, $(\partial h^*/\partial y_d)(y_d/h^*) \leq 1$. Our assumptions about the bounds of the average and the marginal tax rate guarantee $(\partial y_d/\partial y)(y/y_d) = [1 - tr - tyr'(y)]/[1 - tr(y)] \in [0, 1)$. The assumption that $r(y)$ increases in $y$, implying $\partial r(y)/\partial y > 0$, concludes the proof. □

Property 2 implies that the decrease in housing prices $p$ which compensates a household for a higher tax shifter $t$ has to be larger for poor households than for rich ones.

Given a set of community characteristics, $(p_i, t_i)$ for $i = 1..J$, a household prefers community $i$ if and only if

$$V(p_i, t_i, y) \geq V(p_j, t_j, y) \text{ for all } j \neq i .$$

(5)

From this, the following proposition directly follows:

Proposition 1 (Order of community characteristics)

If any two populated communities differ in their characteristics $(p_i, t_i)$, then the community with the higher housing prices $p_i$ must impose a lower tax shifter $t_i$.

Proof: Suppose the opposite, i.e., that the housing prices $p_i$ and the tax shifter $t_i$ are both higher in one community. In this case, no household would
choose to live in this community (for the same reason that leads to property 1). This is a contradiction. □

In the remaining part of this section, we show how households allocate themselves across distinct communities. Distinct communities differ in both tax shifters and prices. Note that our model allows for groups of communities with identical community characteristics \((t_i, p_i)\). Such groups appear as one community in our notation.

**Lemma 1 (Boundary indifference)**

There is a ‘border’ household between any two communities \(i\) and \(j\) that is indifferent between these two communities. That is, if a household with income \(y'\) prefers to live in \(i\) and another household with income \(y'' > y'\) prefers to live in \(j\), then there exists a household with income \(\hat{y}_{ij} = \hat{y}(p_i, t_i, p_j, t_j)\), \(y' \leq \hat{y}_{ij} \leq y''\), such that \(V(p_i, t_i, \hat{y}_{ij}) = V(p_j, t_j, \hat{y}_{ij})\).

**Proof:** Let \(V_i(y) := V(p_i, t_i, y)\) be a household’s utility in \(i\) and \(V_j(y) := V(p_j, t_j, y)\) in \(j\). The household with income \(y'\) prefers \(i\) to \(j\), hence \(V_i(y') - V_j(y') \geq 0\). The opposite is true for a household with income \(y'':\ V_i(y'') - V_j(y'') \leq 0\). From the continuity of \(V\) in \(y\) follows the continuity of \(V_i(y) - V_j(y)\) in \(y\). The intermediate value theorem proves that there is at least one \(\hat{y}\) between \(y'\) and \(y''\) such that \(V_i(\hat{y}) - V_j(\hat{y}) = 0\). □

**Lemma 2 (Two-community income segregation)**

Given two populated communities \(i\) and \(j\) with distinct characteristics \((t_i, p_i) \neq (t_j, p_j)\), where \(t_i < t_j\), then any household in \(i\) is richer than any household in \(j\). That is, if a household with income \(\hat{y}\) is indifferent between \(i\) and \(j\), then any household \(y' < \hat{y}\) strictly prefers \(j\) and any household \(y'' > \hat{y}\) strictly prefers \(i\).
Figure 1: Indifference curves in the \((t, p)\) space

Proof: The proof uses figure 1, which shows the indifference curves in the \((t, p)\)-space for three different income levels \(y' < \hat{y} < y''\). The indifference curves represent all \((t, p)\) combinations that households consider as good as community \(j\)'s \((p_j, t_j)\)-pair. Each household prefers pairs south-west of its indifference curve. It follows from property 1 that the indifference curves decrease in the \((t, p)\)-space and from property 2 that they become flatter as income rises. Imagine now a community \(i\), characterized by \(t_i < t_j\) and \(p_i > p_j\), where household \(\hat{y}\) is indifferent to \(j\). All poorer households, e.g., \(y'\), prefer \(j\) to \(i\) and all richer households, e.g., \(y''\), prefer \(i\) to \(j\). □

Proposition 2 (Multi-community income segregation)

Given \(J\) populated communities with distinct characteristics \((t_i, p_i)\), then it holds for any two communities \(i\) and \(j\) with \(t_i < t_j\) that any household in \(i\) is richer than any household in \(j\).

Proof: The proposition implies that \([y, \bar{y}]\) must be partitioned into \(J\) non-empty and non-overlapping intervals. Suppose the opposite, i.e., \(y'\) as
well as \( y'' \) prefer community \( i \), but \( y''' \), \( y' < y''' < y'' \), strictly prefers another community \( j \). Then it follows from lemma 1 that there is a \( \hat{y}_{ij}, y' \leq \hat{y}_{ij} < y''' \). Lemma 2 implies that \( y'' > \hat{y}_{ij} \) strictly prefers \( j \) to \( i \), which is a contradiction. \( \square \)

### 3.3 Equilibrium

In this section, we prove that an asymmetric equilibrium exists. That is, we show that an allocation in which communities exhibit different characteristics \((p_i, t_i)\) can be an equilibrium.

An equilibrium requires that each household is located in the community that maximizes its utility, that each household maximizes its utility within the given community, that the housing market clears in each community, that each community has a balanced public budget and that each community has a positive population.

There always exists a symmetric equilibrium in which all communities have identical characteristics \((p_i, t_i)\) and in which the households allocate themselves such that all communities show the same income distribution.\(^7\) However, we are interested in the case in which at least some communities differ in their characteristics \((p_i, t_i)\). We therefore show that an asymmetric equilibrium, i.e., an equilibrium in which \((p_i, t_i) \neq (p_j, t_j)\) for some \( i \) and \( j \), exists too. For simplicity, we focus thereby on the case of two distinct communities, 1 and 2.

We assume with no loss of generality that \( t_1 > t_2 \). Hence, any household in 2 must be richer than any household in 1, as lemma 2 implies. We define

\[
\Delta V(\hat{y}) = V_1(p_1(\hat{y}), t_1(\hat{y}); \hat{y}) - V_2(p_2(\hat{y}), t_2(\hat{y}); \hat{y}),
\]

\(^7\)Other equilibria in which all communities have identical characteristics \((p_i, t_i)\) might exist as well.
where \( p_i(\hat{y}) \) and \( t_i(\hat{y}) \) are the equilibrium housing price and the equilibrium tax shifter, respectively, in \( i \) given that households with \( y < \hat{y} \) live in 1 and households with \( y > \hat{y} \) in 2. Hence, \( V_i(p_i(\hat{y}), t_i(\hat{y}), \hat{y}) \) is the indirect utility of a household with \( \hat{y} \) in \( i \) given this allocation of households.

In addition, we assume:

(i) The housing supply \( HS(L_i, p_i) \) satisfies \( HS(L_i, 0) = L_i > 0 \) for \( i = 1, 2 \).

(ii) The minimum income \( y > g \).

(iii) If \( h_i \to \infty, b_i > 0, h_j < \infty \) and \( b_j < \infty \), then \( U(h_i, b_i) > U(h_j, b_j) \).

**Proposition 3 (Existence of an asymmetric equilibrium)**

*There exists an equilibrium in which the communities 1 and 2 exhibit different characteristics, i.e. \( t_1 > t_2 \) and \( p_1 < p_2 \).*

Proof: We prove proposition 3 by showing (1) that \( \Delta V(\hat{y}) \) is continuous and (2) that \( \Delta V(\hat{y}) > 0 \) as \( \hat{y} \to y \) and that \( \Delta V(\hat{y}) < 0 \) as \( \hat{y} \to \overline{y} \). It follows then from the intermediate value theorem that there is at least one \( \hat{y} \), \( y < \hat{y} < \overline{y} \), such that \( \Delta V(\hat{y}) = 0 \). This implies - from the definition of \( \Delta V \) - that the border household \( \hat{y} \) is indifferent between the two communities, the prices \( p_1 \) and \( p_2 \) clear the local housing markets and the tax shifters \( t_1 \) and \( t_2 \) balance the community budgets.

(1) The equilibrium housing price \( p_i \) is determined by \( HS(L_i, p_i) = HD_i \).

It follows from lemma 2 that

\[
HD_i = \int_{y_i}^{\overline{y}_i} h(p_i, t_i; y) f(y) dx,
\]

where \( y_i \) and \( y_i \) are the highest and lowest incomes in community \( i \). The hereby implicitly defined \( p_i \) is continuous in \( \overline{y}_i \) and \( y_i \) given continuity of

---

As it will become evident in section 4, these assumptions are sufficient, but not necessary for the existence of an asymmetric equilibrium.
HS(·), h(·) and f(·). The balanced budget requirement and lemma 2 imply that the equilibrium tax shifter in community \( i \) is

\[
t_i = \frac{n_i g}{\int_{y_i}^{\bar{y}_i} r(y)f(y)dx},
\]

(8)

where

\[
n_i = \int_{y_i}^{\bar{y}_i} f(y)dx.
\]

(9)

Given continuity of \( r(·) \) and \( f(·) \), \( t_i \) is continuous in \( y_i \) and \( \bar{y}_i \). Since the indirect utility \( V_i \) is continuous in \( p_i \), \( t_i \) and \( y \) and since \( p_i \) and \( t_i \) are continuous in \( y \), \( \Delta V(\hat{y}) \) is continuous in \( \hat{y} \).

(2) It follows from equations (7) and (9) that \( HD_1 \to 0 \) and \( n_1 \to 0 \) as \( \hat{y} \to y \). Since assumption (i) guarantees that \( HS(L_1, 0) = L_1 > 0 \) (and since \( \partial HS(L_1, p_i)/\partial p_i \geq 0 \), it holds that \( h^*(p_1, t_1; y) \to \infty \) and \( p_1 \to 0 \) as \( \hat{y} \to y \). Hence, \( b^* \to \bar{y} - g > 0 \), where the strict inequality follows from assumption (ii). Assumption (iii) then guarantees that \( \Delta V(\hat{y}) > 0 \) as \( \hat{y} \to \bar{y} \). Analogously, it can be shown that \( \Delta V(\hat{y}) < 0 \) as \( \hat{y} \to \underline{y} \).\(^9\)

3.4 Adding Heterogeneous Preferences

So far, we have assumed that households differ in their incomes \( y \) only. This set of assumptions has led to perfect income sorting, which is not observed in reality. In this section, we extend the model by assuming that the households’ preferences are heterogeneous as well. As we will show, income sorting is imperfect in this extended model.

The household preferences are now represented by the utility function \( U(h, b; \alpha) \), where the parameter \( \alpha \) describes the taste for housing. The higher \( \alpha \), the more a household is, ceteris paribus, willing to spend on housing.

\(^9\)The only difference is that \( b^* \to \bar{y} - g \), which exceeds \( \underline{y} - g \).
Hence, the housing demand increase in $\alpha$, i.e.

$$\frac{\partial h^*}{\partial \alpha} = \frac{\partial h(t, p; y, \alpha)}{\partial \alpha} > 0 \text{ for all } t, p, y \text{ and } \alpha. \quad (10)$$

Income and preferences are jointly distributed according to the density function $f(y, \alpha)$.

It follows that perfect income segregation still holds, but only within the subpopulation of households with identical preferences. Preference segregation occurs as well: That is, among the subpopulation of households with the same income $y$, households with a high $\alpha$, i.e. a strong taste for housing, tend to allocate themselves to communities with higher tax shifters $t_i$ than households with a low $\alpha$.

Simultaneous heterogeneity by incomes and tastes leads to a more realistic pattern of household segregation. Although income groups tend to gather, the segregation is no longer perfect. Figure 2 shows the resulting allocation of household types to communities. The households on the borders are indifferent between neighboring communities $j$. Community 1 with the lowest housing prices is populated by the poorest households with strong taste for
housing, while the richest households with low housing taste are situated in community $J$ with the lowest tax shifter and the highest housing prices. However, rich households with strong taste for housing prefer lower-priced communities, and poor households with weak taste for housing group with relatively rich households in lower-tax communities.

4 A Specified Version of the Model

To investigate the qualitative and quantitative properties of the model we construct a fully specified example in this section. The specification is kept as simple as possible but still captures all mechanisms of the model. The example is calibrated to the Zurich area, the largest Swiss metropolitan area.

The tax schedule is taken from Young (1990)

$$r(y) = r_0 \left\{ 1 - \left[ 1 + r_2 (y - d)^r_1 \right]^{-1/r_1} \right\}$$

with parameters $r_0 > 0$, $r_1 > 0$ and $r_2 > 0$. Different from Young, we also include a deductible $d > 0$. The average local tax rate $t r(y)$ and the local marginal tax rate $t[y_i \partial r(y)/\partial y + r(y)]$ are increasing in income $y$. The marginal tax rate is above the average tax rate for all incomes exceeding the deductible $d$, and both asymptotically approach a maximum $t r_0$.

Household preferences are described by a Cobb-Douglas utility function:

$$U = h^{\alpha} b^{1-\alpha},$$

where $0 < \alpha < 1$ stands for the taste parameter of the general model. Utility function and tax schedule satisfy properties 1 and 2.

We adopt the housing supply function

$$H S_i = L_i(p_i)^6$$

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from Epple and Romer (1991).\footnote{Epple and Romer derive this housing supply function from an explicit production function, where $0 \leq \theta \leq 1$ is the ratio of non-land to land input.}

We calibrate the above outlined model to the Zurich metropolitan area, the largest metropolitan area in Switzerland. The city of Zurich has about 330 thousand inhabitants and is the capital of the canton (state) of Zurich. The canton of Zurich counts 1.2 million inhabitants in 171 individual communities. As described in section 2, each of these communities can choose its own tax shifter.

We restrict the analysis to the city of Zurich and a ring of the most integrated communities around the center. This ring is formed by all communities in the canton of Zurich with more than 1/3 of the working population commuting to the center.\footnote{The number of commuters to the city of Zurich and the size of the working population in the communities is based on the 1990 Census. This definition of the urban area is chosen to justify the model’s assumption that households income is exogenous, i.e. that they choose their place of residence independent of where they work. It results in a set of communities closest to the central business district.} The top-left map in figure 4 shows the city of Zurich and the thus defined ring of 40 communities. This agglomeration is modelled as two distinct jurisdictions with equal land size. In the asymmetric equilibrium, we refer to these two communities as the low-tax and the high-tax community, respectively. The details of the calibration are described in the appendix. Table 1 summarizes the parameters and reports various descriptive statistics for the Zurich metropolitan area in the last six columns.

### 4.1 Simulated Equilibrium

The equilibrium values $p_i$ and $t_i$ in both communities satisfy equations (7) and (8) and guarantee that no households wants to move. As there is no closed form solution to this nonlinear system of four equations and four un-
Table 1: Equilibrium values of the specified model.

<table>
<thead>
<tr>
<th></th>
<th>model simulation</th>
<th>data, metropolitan area of Zurich</th>
<th>data, metropolitan area of Zurich</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>homogeneous</td>
<td>heterogeneous</td>
<td>including</td>
</tr>
<tr>
<td></td>
<td>preferences</td>
<td>preferences</td>
<td>city of Zurich</td>
</tr>
<tr>
<td></td>
<td>unified</td>
<td>high-tax</td>
<td>low-tax</td>
</tr>
<tr>
<td>L: area</td>
<td>1</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>p: rent</td>
<td>11.3</td>
<td>9.3</td>
<td>12.7</td>
</tr>
<tr>
<td>t: tax shifter</td>
<td>0.86</td>
<td>2.95</td>
<td>0.57</td>
</tr>
<tr>
<td>n: inhabitants</td>
<td>1</td>
<td>0.41</td>
<td>0.59</td>
</tr>
<tr>
<td>Ey: mean income</td>
<td>68,656</td>
<td>38,628</td>
<td>89,954</td>
</tr>
</tbody>
</table>

The calibrated model parameters: \( g = 2500, E(\ln y) = 11.0, SD(\ln y) = 0.517, \ y_{\text{min}} = 15,300, \ y_{\text{max}} = 500,000, \ E(\alpha) = 0.25. \)

\( S.A.(\alpha) = 0 \) (homogeneous preferences), \( S.A.(\alpha) = 0.11 \) (heterogeneous preferences), \( \theta = 3, r_0 = 0.2, r_1 = 0.5 \) and \( r_2 = 0.00065. \)

\( ^a \) 32 communities with lowest taxes vs. 9 communities with highest taxes

\( ^b \) 23 communities with lowest taxes vs. 18 communities with highest taxes

\( ^c \) population weighted mean, \( ^d \) based on the same estimation as the calibration and described in section 5.1
Column 1 in table 1 gives the equilibrium values for the hypothetical case that the two communities merged or harmonized their taxes. Columns 2 and 3 show the equilibrium values for the case of homogeneous tastes. In this case, households are perfectly segregated: All households in the low-tax community are richer than all households in the high-tax community. This causes large differences in mean incomes, taxes and housing prices between the two communities: Compared to the low-tax community, the mean income in the high-tax community is less than half, taxes are about five times higher and housing prices about 25% lower.

The prediction of perfect segregation and the implied differences in community characteristics are extreme. The consideration of heterogeneous hous-

\footnote{The aggregation of individual behavior requires double integrals over the community population. These integrals cannot be calculated analytically. We use Gauss-Legendre Quadrature with 40 nodes in each dimension to approximate the various double integrals. We numerically solve for the equilibrium values by minimizing the sum of squared deviations from the equilibrium conditions with the Gauss-Newton method.}
ing tastes leads to a more realistic situation. Table 1 shows in columns 4 and 5 the equilibrium values allowing for heterogeneous tastes. The differences between the two communities are still substantial but smaller than with homogeneous tastes: The high-tax community exhibits now about three times higher taxes and about 15% lower housing prices than the low-tax community. The left graph in figure 3 shows the segregation pattern in the income-taste space. The population is now imperfectly sorted by incomes: While it is still true that more rich households are found in the low-tax community, rich households with a strong taste for housing prefer the high-tax low-price community and poor households with a low taste for housing prefer the low-tax high-price community. The right graph in figure 3 shows the resulting income distributions in the two communities. The mean income in the high-tax community is now slightly more than half the one in the low-tax community.

Figure 4 shows the actual local housing prices (upper right map), the local tax shifters (lower left map) and the spatial income distribution (lower right map) in the 41 communities within the calibrated area. Comparing the two lower maps demonstrates the striking relationship between income taxation and spatial income distribution: the local share of rich households is almost an inverted picture of the local tax shifters. In addition, comparing the two maps on the right shows the positive correlation between local housing prices and the local share of rich households.

The last six columns in table 1 summarize the information in figure 4. It reports the actual housing rents, tax shifters and mean income for three sets of communities: Column 6 shows averages for the whole metro area, column

\footnote{Data from the following sources: Housing prices: Wüest & Partner, Zürich. Tax rates: Statistisches Amt des Kantons Zürich, Steuerfüsse 1997. Income distribution: Swiss Federal Tax Administration. Considered are all communities where more than 1/3 of the working population is commuting to the center community.}
Figure 4: Housing prices, taxes and incomes in the Zurich metropolitan area.

7 shows the values for the 9 communities with highest taxes and column 8 for the 32 communities with lowest taxes. Note that these two groups have equal land area dedicated to development. A comparison of our simulation results with the actual data shows that our simple two-community model captures the relation of taxes and incomes across communities. The predicted relation of housing prices and incomes is only supported by the data when the city of Zurich is excluded (see columns 10 and 11).14

14The city of Zurich is the central business district (CBD) where both housing prices
4.2 The Resulting Tax Schedule

The average tax rate $t_r(y)$ depends not only on the individual household’s income but also on its place of residence. As the model shows the place of residence is not random and rich households are more likely to reside in low-tax communities. In this section, we ask what tax schedule is realized after considering the sorting of the population. In other words, we ask what tax rate a household with income $y$ pays on average.

In the case of homogeneous taste this question is trivial. All households with income below the median income household face the average tax rate in the high-tax community; rich households the one in the low-tax community. The left graph in figure 5 shows the resulting tax schedule. While progressive within the communities, it is insofar regressive as most relatively rich households face lower average tax rates than many relatively poor households.

and taxes are relatively high. This is most likely due to the center’s intrinsic attractiveness (e.g. its cultural life, low commuting costs) which is not captured in our model. Multi-community models usually abstract from geography, i.e. physical distance, and exclude the CBD in the empirical test (see e.g. Epple and Sieg, 1999).
In general, the expected or mean average tax for a household with income \( y \) is

\[
E[t r(y)|y] = \sum_i [P(i|y) \cdot t_i \cdot r(y)] ,
\]

(11)

where \( t_i r(y) \) is the average tax rate for a household with income \( y \) in community \( i \). The probability that a household with income \( y \) lives in community \( i \),

\[
P(i|y) = \frac{f(y|i)P(i)}{f(y)} ,
\]

(12)

is calculated from the income density \( f(y|i) \) in community \( i \), the probability \( P(i) \) that an arbitrary household resides in community \( i \) and the income distribution \( f(y) \) of the whole area.

In the case of heterogenous tastes, the marginal income distribution \( f(y|i) \) in a community \( i \) (shown in the right figure 3) is calculated by integrating over tastes in community \( i \):

\[
f(y|i) = \int_{\alpha_i}^{\bar{\alpha}_i} f(y, \alpha) d\alpha ,
\]

where \( \alpha_i \) and \( \bar{\alpha}_i \) are the lowest and highest tastes in community \( i \).

The right graph in figure 5 shows the mean average tax rate in case of heterogenous tastes. The realized tax schedule becomes much smoother: While very poor and very rich households still face the tax rates of the high-tax and the low-tax community, respectively, (as they actually live in these communities,) middle income households face on average tax rates in between. In this part, the realized tax schedule is evidently much flatter than the tax schedule implemented by the canton.

5 Evidence

In this section, we estimate the mean average tax rates that households with a given income face in the Zurich metropolitan area. We then compare our
estimates to the results obtained in the previous section.

5.1 Method

In principle, the mean average tax rate can be estimated from a random sample of households in the studied area. Knowing each households’ income and community tax rate allows to directly estimate the mean average tax rate with e.g. a kernel regression. The random sampling automatically accounts for the sorting of the population by incomes. Unfortunately, we do not have such microdata with tax information. Furthermore, available survey data suffers from small sample sizes and stratified sampling over communities.

We therefore follow an alternative estimation strategy. The mean average tax rate of a household with income \( y \) can be estimated from equation (11):

\[
\hat{E}[t r(y)|y] = \sum_i [\hat{P}(i|y) \cdot t_i r(y)]
\]

As the canton sets the tax structure \( r(y) \) and the individual communities their tax shifters \( t_i \), the average tax rate \( t_i r(y) \) for any income \( y \) in any community \( i \) is known.

The estimated probability that a household with income \( y \) lives in community \( i \) is given by equation (12):

\[
\hat{P}(i|y) = \frac{\hat{f}(y|i)\hat{P}(i)}{\hat{f}(y)} = \frac{\hat{f}(y|i)n_i}{\sum_j[\hat{f}(y|j)n_j]},
\]

where \( n_i \) is the known number of households living in community \( i \).

It remains, therefore, estimating the income density \( \hat{f}(y|i) \) of each community \( i \) in the area. We estimate \( \hat{f}(y|i) \) from publicly available local income distribution data. The federal tax administration publishes the number of households with taxable income in seven different income classes.\(^{15}\) We as-

sume that incomes are log-normally distributed and estimate mean and variance of this distribution using maximum likelihood.\textsuperscript{16} We estimate a truncated log-normal distribution as the first reported income interval is empty for technical reasons. The log likelihood function for any community $i$ is

$$
\log L_i = \sum_{k=1}^{6} s_k \cdot \log \left[ \frac{\Phi\left( \frac{c_{k+1} - \mu_i}{\sigma_i} \right) - \Phi\left( \frac{c_k - \mu_i}{\sigma_i} \right)}{1 - \Phi\left( \frac{c_1 - \mu_i}{\sigma_i} \right)} \right],
$$

where $\mu_i$ and $\sigma_i^2$ are mean and variance of log income in community $i$. $s_k$ is the number of households in income class $k$ with lower interval limit $c_k \in \{\log(15000), \log(20000), \log(30000), \log(40000), \log(50000), \log(75000), \infty\}$. $\Phi(\cdot)$ is the cdf of the standard normal distribution. The income density in community $i$ is then estimated as

$$
\hat{f}(y|i) = \frac{1}{\hat{\sigma}_i y \sqrt{2\pi}} \exp\left[ -\frac{1}{2} \left( \frac{\log(y) - \hat{\mu}_i}{\hat{\sigma}_i} \right)^2 \right].
$$

\textbf{5.2 Results}

Figure 6 shows that the average tax rates that households with income $y$ face in the Zurich metropolitan area. The top line is the average tax rate $t_i r(y)$ of households living in the community with the highest tax shifter $t_i$. The bottom line is the average tax rate of households in the community with the lowest tax shifter $t_i$. The middle line is the estimated mean average tax rate that households in this area face, $\hat{E}[t r(y)|y]$. This is the expected unconditional, i.e. not conditioned on the place of residence, average tax rate. As one can see, the average poor household faces almost the average tax rate in the highest-tax community (or in the city of Zurich).\textsuperscript{17} This is,

\textsuperscript{16}Note that this maximum likelihood estimator corresponds to an ordered probit with known thresholds.

\textsuperscript{17}The tax shifter is 131 in the highest-tax community and 130 in the city of Zurich.
of course, because most poor households live in high tax communities. As households become richer, they live more often in the low-tax communities and thus face an average tax rate that is on average substantially smaller than in high-tax communities. The mean average tax rate of households with very high incomes $y$ is even relatively close to the average tax rate of very rich households living in the lowest-tax community.

The results from the estimation (figure 6) are very similar to the predictions of the calibrated model with taste heterogeneity (right figure 5). There are though two noteworthy differences: First, the difference between the highest and the lowest tax shifters is in reality smaller than our model predicts. Second, the mean average tax rate of very rich households remains in reality above the average tax rate of very rich households in the lowest-tax community, unlike in our simulation. While polito-economical considerations may account for the first difference,\(^\text{18}\) the second might indicate that the location choice depends also on preference characteristics other than the taste.

\(^{18}\)The threat of a so-called tax harmonization often prevents low-tax communities from further lowering their tax shifters.
for housing.

6 Conclusions

We have focused on the tension between fiscal decentralization and progressive taxation. We have presented a multi-community model in which the local income tax rate depends on an exogenous progressive tax schedule and a tax shifter that can differ across communities. The progressivity of the tax schedule induces a self-sorting process that results in income sorting. This income sorting is however imperfect if households differ in their preferences for housing. But rich households are, of course, still more likely to locate themselves in communities with low tax shifters than poor households. As a consequence, the actual tax structure becomes less progressive than the exogenous tax schedule. Empirical evidence from the largest Swiss metropolitan area, the Zurich area, supports our predictions: Rich households are more likely to live in communities with low tax shifters than poor households, and the actual tax structure is thus substantially less progressive than the tax scheme of the state (canton) of Zurich.

These findings suggest, in line with the literature on fiscal federalism, that progressive taxes should indeed be implemented at the state or national level if one wants them to unfold their full redistributive effect. But they also show that substantial redistribution through progressive income taxation is even possible at the community level.
Appendix: Calibration

Tax schedule: The parameters $r_0 = 0.2$, $r_1 = 0.5$ and $r_2 = 0.00065$ almost perfectly approximate the tax scheme of the canton of Zurich for a married couple. The deductible $d = 15,300$ is based on a family with one child.\textsuperscript{19}

Income Distribution: The income distribution is calibrated with data from the Swiss Federal Tax Administration. We use a log-normal distribution to approximate this right-skewed distribution. The estimation of the mean $E(\ln y) = 11.0$ and standard deviation $SD(\ln y) = 0.517$ from the observed income bins is described in the empirical section 5.1. For numerical tractability, the model distribution is truncated at a minimum income equal to the deductible $y_{\text{min}} = 15,300$ and a maximum income $y_{\text{max}} = 500,000$.

Taste Distribution: The distribution of the taste for housing is calibrated with data from the Swiss labor force survey.\textsuperscript{20} The Swiss labor force survey contains the monthly housing expenditure of renters.\textsuperscript{21} Note that the taste parameter $\alpha$ in the Cobb-Douglas utility function is the share of housing in a utility maximizing household. We therefore estimate each household taste parameter as $\alpha = (ph)/y_d$, where $ph$ is observed households housing expenditure and $y_d$ is observed household income minus federal, state and communal taxes. A beta distribution with mean $E(\alpha) = 0.25$ and standard deviation $SD(\alpha) = 0.11$ describes the distribution of the so calculated taste parameter well. Taste and income are assumed to be uncorrelated.

Housing and Public Good Production: The price elasticity of housing supply is $\theta = 3$ as in Epple and Romer (1991) and Goodspeed (1989). The tar-

\textsuperscript{19}Tax scheme according to Steuergesetz vom 8. Juni 1997, Tarif a.
\textsuperscript{21}Of course, there is a selection bias by only considering renters. This seems nevertheless justified because the proportion of renters is very high in Switzerland (65% in the data set used).
geted public goods provision \( g = 2,500 \) is such that the (population) weighted average tax shifter in the calibrated model with heterogeneous tastes equals the observed one.
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