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ABSTRACT

We examine majority choice of tax instruments in single- and multi-jurisdictional economies with heterogeneous households. In our framework majority voting equilibrium exists despite the multidimensional policy choice set. We identify five competing incentives that influence choice of tax instruments. Equilibria generally entail a mixture of tax types. With multiple jurisdictions, strong reliance on head taxation in rich communities arises to deter poorer households from immigrating. Mobility fundamentally affects the equilibrium tax system with redistribution incentives dominating choice of instruments when mobility is limited. Limiting or eliminating head taxation fundamentally alters stratification, public good provision levels, and tax systems.

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1. Introduction. Tax systems vary widely across local economies. While some economies rely mainly on property taxes to finance public goods, others employ income taxes as the primary means of finance. Taxation is also necessary to redistribute wealth, whether directly, or indirectly through uneven finance of public goods. Taxation generally uses multiple tax instruments. Almost all of the 38,917 general-purpose local government jurisdictions in the United States employ property taxes. These jurisdictions include 3,031 counties and 35,886 municipalities, towns, or townships. These local property tax rates vary between about 0.2% and 4% of home value. In most states, local governments are required to have authorization from the state legislature to impose an income or payroll tax. In the 16 states that authorize some form of local income tax and in which at least one general-purpose local government employs an income tax, 3,984 out of a total of 17,560 local government jurisdictions use an income tax, usually in conjunction with a property tax. Of these 17,560 general-purpose local governments, 1,009 are counties, and 220 of these counties impose an income tax and property tax. In addition, three states (Iowa, Ohio, and Pennsylvania) authorize school districts to use income taxes. These three states have a combined 1,548 independent school districts and 947 use an income tax as well as a property tax. Local income tax rates in the U.S. vary between 0.01% and 3.6% with an average of approximately 1.5%.[1] Over the past four or five decades income taxation as a source of revenue for local governments has grown significantly compared to property taxation. The ratio of local income tax revenue to local property tax revenue in the United States was 1.6% in1960 compared to 8.4% in 2008.[2]

Internationally local taxation of property is widespread. Additionally, in many countries local governments have traditionally relied heavily on income tax. These include the Scandinavian countries, Belgium, and Switzerland. The Scandinavian countries in general apply flat local taxes. Belgium and

[1] Siniavskaia, 2011, Advisory Commission on Intergovernmental Relations, 1988, U.S. Census Bureau, *Local Governments by Type and State,* 2012, and Tax Foundation, *Local Income Tax Rates by Jurisdiction,* 2011.
[2] U.S. Census Bureau; Federal, State and Local Governments, "State Government Finances 2008," June 2011, and Department of Commerce, Bureau of Census, *Historical Statistics on Governmental Finances and Employment,* an annual report, *Government Finances, 1968.*

Switzerland use progressive tax schemes at the municipal level (Schmidheiny, 2006). Canada had a similar system as the Belgium and Switzerland systems at the provincial level between 1977 and 1996 (Boadway and Kitchen,1980) when personal income taxes in Canadian provinces were a percentage of the progressive federal tax.

Understanding the mixture and variation of taxes poses a difficult problem for economists. Taking the position that tax systems are the outcome of a political process, we find and study the determinants of majority choice equilibrium in an economy where voters have multiple tax instruments at their disposal.

We examine a closed economy. Households differ by income with utility over housing, a (congested) public good, and a composite consumption good. They vote over a triplet of tax types, namely an income tax, a property tax, and a head tax.[3] Tax proceeds can be used to finance the public good and direct redistribution. We examine equilibrium if the economy is just one jurisdiction or if it is divided into multiple jurisdictions each with taxing and expenditure authority. In the multi-jurisdictional analysis, households first decide where to live and, in the main analysis, can relocate after local policies have been majority selected. We then find the economy's Nash equilibrium among voters who take as given the tax system in the jurisdictions where they do not vote. Because voters choose levels of multiple tax instruments, we confront the standard existence problem of majority choice over a multi-dimensional policy (see Plott, 1967). Majority choice equilibrium is shown to exist in our model because we adopt a particular, but appealing, form of the household utility function (see (1) below).

In addition to the need to raise revenue to finance local public goods, we identify five forces that can be relevant to the structure of the equilibrium tax system. We note these here, while providing a more thorough discussion as the analysis unfolds. Voters are influenced by an efficiency motive in raising tax revenues, i.e., preferring non- or less-distorting taxation. This incentive pulls for a head tax. Second, some voters desire redistribution, a force for an income and/or property tax and a negative head tax. Third, voters that rent housing might pass along property taxes to housing suppliers; an "appropriation

[3] A consumption tax is redundant if there is no income tax distortion under conditions discussed in Section 5.

incentive" arises. The latter incentive is not present for housing owners; we consider both renter and owner cases. The last two incentives are driven by mobility effects that arise in the multi-jurisdictional analysis. If there are positive income and/or property taxes, then voters prefer to attract into their jurisdiction richer households who confer a positive fiscal externality. Thus, a "household selection incentive" exists. But the latter is opposed by a "congestion effect" in housing markets for renters, who face higher rents as households relocate into their jurisdiction, richer immigrants having a stronger effect. The congestion effect is the opposite for home owners who generally value increased demand for housing. The force and relevance of these incentives varies with the jurisdictional (and economy) income distribution, the elasticity of housing supply, income tax distortions, parameters of the utility function, whether households are renters or owners, and the relevance of mobility. We clarify these incentives in a series of theoretical results, for example, by examining incentives absent mobility. Where outcomes depend on resolution of trade-offs, we examine equilibria in a computational version of the model. As well, the computational analysis is used to verify existence of the Nash equilibrium among voters in multiple jurisdictions and to illustrate theoretical findings.

We view our contribution as providing a rich equilibrium analysis of tax systems in an interesting setting. The utility specification that permits establishment of voting equilibrium is presented in an earlier paper, Calabrese, Cassidy, and Epple (2002). We generalize that analysis is several ways. First, we provide a characterization of equilibrium using *composite public goods* that result from the policy vector. This approach facilitates using a single-crossing property of preferences that is illuminating and may help to generalize this line of research. Second, we find Nash equilibrium in majority choice of tax instruments among multiple jurisdictions.[4] Third, we provide a framing of the competing incentives that determine the structure of the equilibrium tax system. As part of this, we develop new theoretical results regarding the equilibrium tax structure in cases with no household mobility. For example, despite the availability of income and property taxes, housing owners would then rely exclusively on a head tax if the

[4] Calabrese, Cassidy, and Epple (2002) employ a "utility-taking" specification, where voters in a jurisdiction take as given the equilibrium utility levels in other jurisdictions when voting. In contrast, voters in a jurisdiction take as given the equilibrium tax vector in other jurisdictions in the present analysis.

median income exceeds the mean in a community. Fourth, we provide a new computational analysis of equilibrium.

We find in our computational analysis that household mobility radically affects the equilibrium tax structure. In equilibrium with a single jurisdiction (or with multiple jurisdictions but without mobility), equilibrium has a mixture of property and income taxes with direct redistribution. If we divide the economy into multiple jurisdictions and allow households to move freely, they sort by income among the jurisdictions. Income taxes disappear for most of the parameterizations and, rather than direct (i.e., cash transfer) redistribution, head taxes arise. In the case of housing renters, the dominant force in the richer communities is to attract (repel) the relatively rich (poor) implying heavy reliance on a head tax to finance the local public good. This is explained by the fiscal externality resulting from renters' partial reliance on property taxation, where relatively poorer household would move into richer suburbs to consume their high quality local public good and free ride by consuming little housing. A head tax limits this behavior. This is in spite of an incentive to redistribute income present in the suburbs, which have right skewed income distributions. Head taxes also dominate in the suburbs with housing owners', but here it is to attract households with the highest housing demands to increase property values. Again, this is in spite of an incentive to redistribute. Shutting down mobility, equilibrium with multiple jurisdictions reverts to an equivalent allocation to that in the single jurisdiction case. Limiting the use of head taxes more directly changes the tax system, while also preventing very elite communities from developing.

This paper is related to the large theoretical "Tiebout (1956) literature" on multi-jurisdictional economies with endogenous policy determination.[5] Much of the literature on Tiebout economies is focused on efficiency issues.[6] Our focus is positive. In the positive Tiebout literature, there is a dearth of research on multiple tax instruments, surely because of the Plott existence problem. Along the lines of

[5] Some important references not discussed elsewhere in this paper are Ellickson (1971), Inman (1989), deBartolome (1990), Nechyba (1999,2000), Fernandez and Rogerson (1996,1998), and Epple and Platt (1998).

[6] Contributions are Oates, (1972), Hamilton (1975), Wooders (1980), Wildasin (1980), Boadway (1982), Brueckner (1983), Gordon (1983), Zodrow (1984), Wilson (1997), Benabou (1993,1996), Epple and Romano (2003), Brueckner (2004), and Calabrese, Epple, and Romano (2012). A strand of the literature concerns taxation of mobile capital which is not an element of our model.

the Plott conditions, Bucovetsky (1991) provides sufficient restrictions on voters' utility function that imply existence of majority choice equilibrium in a single jurisdiction setting with multiple policy instruments. Bucovetsky then shows what his restrictions mean for some examples of tax and public good provision problems. Our analysis here is more applied, focusing on the implications for taxation of the multi-jurisdictional model we adopt.[7] Krelove (1993) examines the preferred tax form in a multi-jurisdictional model with community maximization of land rent. In addition to the alternative process that determines the tax system, Krelove assumes identical households. This assumption eliminates incentives to redistribute among households. Henderson (1994) also studies choice of tax instruments in a multi-jurisdictional setting, comparing voting equilibrium to developer equilibrium. Henderson also assumes identical households, this resolving the existence problem among voters. Nechyba (1997) shows in a multi-jurisdictional model with mobile heterogeneous households that, with availability of both income and property taxes, only property taxation arises unless communities collude (or there is another centralized tier of government). In Nechyba's model, voting is over just the property tax with community planners (or a central authority) setting income taxes. The dominance of property taxes absent collusion is due to household mobility. Our models differ in several ways, but we also find household mobility has profound effects on the equilibrium tax system.[8] Calabrese, Cassidy, and Epple (2002) is the most closely related paper, as we have already discussed.

Section 2 develops the basic model and examines the case with one jurisdiction. Section 3 extends the analysis to multiple jurisdictions. Section 4 examines the effect of having housing owners rather than renters. Section 5 provides concluding remarks and discussion. Our investigation is limited in various ways, while studying numerous alternatives is of interest. We discuss the potential for extending the analysis in Section 5. We do not believe our analysis is definitive, but hope it provides some insights.

[7] As we have already noted, we develop a somewhat different perspective on the voting problem that uses composite public goods and a single-crossing condition. But, our problem can be framed along the lines of Plott or Bucovetsky, and, for example, the Plott sufficient conditions for equilibrium are satisfied.

[8] Nechyba's consideration of state income taxation with local property taxation relates to the fiscal federalism literature, which considers taxation with tiers of government. Seminal references are Musgrave (1971), Oates (1972,1977), and Inman and Rubinfeld (1996). Cullen and Gordon (2012) provide a recent analysis. Our model has one tier of government, an issue we return to in the concluding section.

2. The Case of One Jurisdiction.

a. The Model. The economy consists of a continuum of households that differ in their endowed income y, with population normalized to one. The economy pdf is denoted f(y), positive on its support $S \subset R^+$. Households obtain utility from consumption of the congested public good, g, the quality/quantity of units of housing, h, and numeraire consumption, b. Households have the same utility function of form:

(1) $U(g, h, b) = v(g)u(h, b);$

with all functions increasing and twice differentiable, and u(h,b) quasi-concave and homogeneous of degree 1.[9] While obviously restrictive, (1) permits substantial variation in preferences, and income affects demands in a realistic way. The specification is consistent with the empirical evidence on housing demand (Harmon, 1988), which suggests an income elasticity of housing demand close to 1. Higher income households obtain a higher marginal benefit from increases in the local public good. Implications of (1) for equilibrium will become apparent.

We assume for now that all households rent housing, and examine the effects of ownership in Section 4. Units of housing are supplied competitively by absentee housing owners, according to non-decreasing housing supply function $H_s(p_h)$, where p_h is the supplier price of housing services.

The policy vector is a triplet, $P = (t, m, r)$, where t is a property tax on housing services, m is a proportional income tax, and r is a lump-sum income transfer or, if negative, a head tax. The level of the local public good, g, is determined by government budget balance. While r can be positive or negative, we require a non-negative income tax on [0,1] and a non-negative property tax. Since the existence of head taxes is debatable, we consider cases without allowing them or with tight restrictions on their level. A tax on consumption of the composite private good is discussed in the concluding section, which we do not consider in the main analysis.

Households first vote on the policy vector in Stage 1, equilibrium requiring a policy that is weakly majority preferred to any other policy. Second, in Stage 2, housing markets clear, the government

[9] Our results apply to an extended version of the utility function with $U = v \cdot (u+\varphi)$, where φ is a constant. Other extensions are discussed in Section 5.

budget balances determining g, and consumption results. Households correctly anticipate all continuation equilibrium values.

Property taxes are distorting in the usual way unless housing supply has 0 elasticity. The consumer price of housing is denoted p, where:

(2) $p = (1+t)p_h$.

Since endowed income is exogenous and there is no labor market in our model, the potential deadweight loss from labor market distortions of income taxation is not directly captured. Following Feldstein (1999), we introduce an income tax distortion by assuming the household budget constraint is given by:

(3) $y \cdot [1-(1+\gamma(m))m] + r = ph + b;$

with $\gamma(m) \geq 0$ is a non-decreasing and continuous function. Taxed income is then given by:

(4) $x(y) = \dfrac{y \cdot [1-(1+\gamma(m))m]}{1-m}$.

Feldstein (1999) shows that the deadweight loss of tax avoidance through changes in forms of compensation (e.g., provision of health insurance by employers) and through changes in the patterns of consumption that avoid taxation (e.g., leisure consumption) can be evaluated as the deadweight loss of an excise tax on non-deductible consumption. Total non-deductible consumption is given by housing expenditures (ph) plus consumption of the composite good b, but subtracting the lump-sum transfer r that we assume is not taxed. Thus, (3) is the budget constraint. In turn, taxed income x satisfies (4).

Government budget balance is:

(5) $r + g = \int_S m x(y) f(y) dy + tpH_s(p_h)$.

Let $h_d((1-m)x(y)+r, p)$ denote the ordinary (Marshallian) demand for housing of household with income $(1-m)x(y)+r$ that can be spent on housing and composite good consumption.[10] We

[10] Housing demand does not depend on g due to the form of (1).

usually use the more compact notation $h_d(y,p)$ to denote this demand function, suppressing the tax rates. The housing market is in competitive equilibrium:

(6) $$\int_S h_d(y,p)f(y)dy = H_S(p_h).$$

We now provide a more formal description of equilibrium.

<u>Definition of Equilibrium</u>: *In Stage 1, a policy vector P= (t,m,r) is established that is weakly majority preferred by all households to all other allowed policies* P' *(i.e., with* $t \geq 0$ *and* $m \in [0,1]$ *), households correctly anticipating continuation equilibrium values for all policies. In Stage 2, households maximize utility over housing and composite commodity consumption, housing markets clear, and the government budget balances simultaneously. Specifically, each household solves* $Max_{b,h}\, v(g)u(b,h)$ *subject to (3), taking as given (t,m,r,p,g). This determines housing demands and composite commodity consumption. Housing market clearance satisfies (2) and (6) for given P and individual housing demands, determining* (p, p_h). *Government budget balance satisfies (4) and (5) for given* $(P, f(y), x(y), p, p_h)$, *determining g.*

c. <u>Theoretical Results</u>. The assumed form of the utility function in (1) implies an indirect utility function at Stage 1 over "composite local public goods" that tremendously facilitates the analysis.

<u>Proposition 1</u>. Indirect utility of a household is given by:

(7)
$$\begin{aligned} &V(\Gamma,\Omega,y) = y\cdot\Gamma + \Omega;\\ &\Gamma \equiv v(g)\cdot[1-(1+\gamma(m))m]\cdot w(p);\\ &\Omega \equiv v(g)\cdot r\cdot w(p);\\ &\text{where } w'(p) < 0. \end{aligned}$$

Proof is provided in the appendix, while here we focus on interpretation and implications. Expression (7) shows that preferences can be reduced to those over two composite public goods, Γ and Ω, which are functions of the policy variables and gross housing price.[11] Both composite public goods are increasing in the amount of the public good (g) and decreasing in the housing price (p), and by

[11] The property tax rate does not appear explicitly but it affects g and p.

the same factor (v(g)w(p)). Ω is increasing (decreasing) in the lump-sum income transfer (head tax). Γ is decreasing in the income-tax rate (m). The fact that Γ is multiplied by y in indirect utility implies that higher income households have a relative preference for using head taxes as compared to property taxes to finance the public good. Put differently, higher-income households have weaker preference for direct redistribution financed by an income tax. The linear form in income of indirect utility over the composite public goods implies "single-crossing preferences" and existence of majority-choice equilibrium, to which we now turn.

The three-tuple policy vector P typically precludes existence of majority choice equilibrium (Plott, 1967). However, the form of the utility function implies this existence. Given policy P, it is easy to see that the second-stage equations [(2),(4),(5),(6)] imply unique values for g and p. Using that households anticipate the second-stage equilibrium when voting, one can see by inspection of (7) that the composite public goods can be written as functions of the policy vector. Write $(\Gamma_e(P), \Omega_e(P))$ to denote these continuation equilibrium values. A voter has preferred policy that solves:

$$\text{(8)} \qquad \begin{aligned} &\mathrm{Max}_P \; y\Gamma + \Omega \\ &\quad \text{s.t. } \Gamma = \Gamma_e(P) \text{ and } \Omega = \Omega_e(P) \end{aligned}$$

over allowed policies P. We then have:

Proposition 2: Majority choice equilibrium exists and is a preferred policy of the median income household.

Proof of Proposition 2:[12] Figure 1 graphs indifference curves $y\Gamma + \Omega = \text{const.}$ in composite-public-good space for households with two different incomes.[13] These have slope equal to -1/y, and thus flatten as income increases. Thus, indifference curves cross at most once, the single-crossing property. Denote median income y_m. Refer to Figure 2, which depicts the choice set $(\Gamma_e(P), \Omega_e(P))$ and preferred choice

[12] The structure of the proof uses the single-crossing property of preferences and is "standard" (see, e.g., Epple and Romer (1991) and the references therein). The indirect utility function that is derived from (1), linear in the composite public goods, is a special case of "intermediate preferences." Such preferences are defined in Grandmont (1978) and shown to imply majority choice equilibrium. The contribution here with respect to majority choice equilibrium regards the application, not establishment of existence per se.
[13] The labeling of the two points will become clear in the multi-jurisdictional analysis.

of the median-income household assumed to be unique for now. Let P_e denote the median's preferred policy. We first argue that no feasible policy would be preferred by a strict majority to the median household's preferred policy, implying it is a majority choice equilibrium. Points to the "northeast" of the median household's indifference curve are infeasible. Consider all remaining points with $\Gamma \leq \Gamma_e(P_e)$. All households with income lower than the median have steeper indifference curves through $(\Gamma_e(P_e), \Omega_e(P_e))$, and thus prefer the latter policy. Thus, no such alternative points are strictly majority preferred. The remaining points would be opposed by households with incomes higher than the median who have flatter indifference curve through $(\Gamma_e(P_e), \Omega_e(P_e))$, thus implying it is a majority choice equilibrium. If the median income household has multiple preferred policies, then the same argument applied to each of these policies and implies each is a majority choice equilibrium. It is easy to confirm that any feasible policy that is not a preferred policy of the median income household would lose by strict majority choice to any preferred point of the median income household, since the latter policy(ies) would be strictly preferred by at least either all those with income higher than the median and all with income in the vicinity of the median; or by all those with income lower than the median and all with income in the vicinity of the median. Thus, only a preferred policy of the median income household is a majority choice equilibrium. ■

While the Proposition is focused on existence of majority choice equilibrium, it is implied that equilibrium exists in the model. Moreover, it is clear that equilibrium is generically unique.

The proof depends on the properties of indifference curves and, in particular, places no restrictions on the choice set. We can then further restrict the policy alternatives (e.g., disallow head taxes) or expand them (allow negative income and/or property taxes), and Propositions 1 and 2 remain valid. Such restrictions affect the composite-goods set over which households vote, but this is irrelevant to the existence argument. We will consider some of these variations.

Relative to the equilibrium values of the composite public goods, those with higher income than the median prefer higher Γ and lower Ω on the boundary of the choice set. The reverse holds for those with lower income. This means that higher income types have a relative preference for lowering the income tax, while decreasing (increasing) the lump-sum income transfer (the head tax), which is very intuitive. If property taxes are to be used solely to finance the public good (m = r = 0), the preference for this tradeoff does not vary with income. This follows since indirect utility is then v(g)w(p)y. However, this will change when we consider housing owners. In addition, higher-income households have weaker preference to employ property taxes to finance an income transfer.

The effects of the relative preferences of different income households on the equilibrium policy are particularly stark if there is no income tax distortion, i.e., $\gamma(m) \equiv 0$. Let $\overline{y}$ denote mean income and ε_H the elasticity of housing supply assumed to be constant. We have:

Proposition 3: Assuming no income-tax distortion, if $\varepsilon_H = \infty$, then:

a. m = 1, t = 0, and r > 0 whenever $y_m < \overline{y}$;

b. m = t = 0 and r = - g < 0 whenever $y_m > \overline{y}$.

The Proof of Proposition 3 is in the on-line appendix. We provide an intuitive explanation here. With no income-tax distortion, taxes can be raised *efficiently* with either an income tax or a head tax. With housing supply infinitely elastic, renters bear the full burden of a property tax. Thus, *appropriation* of housing supplier rents using property taxation is infeasible. If the median income household and thus pivotal voter has lower income than the mean, then there is a *redistribution* incentive. By taxing income at a rate of 100 percent, income is fully redistributed through positive r and with remaining tax revenues used to provide the preferred level of g.[14] Thus, in Case a of Proposition 3, there is complete redistribution with efficient taxation. Of course, the extreme assumptions lead to an unrealistic outcome, but the incentives that dominate here carry over to less extreme circumstances as we will see.

If, alternatively, the median income is above the mean, the pivotal voter's incentive to redistribute disappears. Then all taxes are raised through a non-distorting head tax, r < 0, with r = - g. Since m = 0 is optimal, the results in Proposition 4b do not require that income taxation is non-distorting.

[14] Anticipating the complete income redistribution, all households prefer the level of g engendered by the pivotal voter.

Corollary 1: Proposition 3b applies as well without $\gamma(m) \equiv 0$.

The next proposition is intended to bring out the incentive to appropriate rents from housing suppliers.

Proposition 4: Assuming no income-tax distortion:

a. If $y_m < \bar{y}$, m = 1, r > 0; and, if ε_H is sufficiently small, then t > 0.

b. If $y_m > \bar{y}$, m = 0. If ε_H is sufficiently small, t > 0. If, instead, ε_H is such that t = 0, then m = 0 and r = -g. The results apply as well here with an income-tax distortion.

The Proof of Proposition 4 is also in the on-line appendix. The incentives to redistribute (or not) and tax efficiently remain. However, though renters bear part of the burden of taxing property unless $\varepsilon_H = 0$, the effective transfer from housing suppliers toward finance of the local public good (and toward redistribution when $y_m < \bar{y}$) outweighs the cost born by the pivotal voter for ε_H sufficiently small. Here an *appropriation* incentive plays a role.

d. Computational Model and Analysis. Development of more specific implications about the features of equilibrium requires more specific information about preferences, the distribution of income, and the housing supply. We therefore turn to numerical computations based on the theoretical model above to illuminate properties of equilibrium. The parameterization utilizes functional forms and parameter values that are broadly consistent with empirical evidence on housing supply, demand functions, government expenditures, and the distribution of income in the U.S.

We describe the baseline calibration, though we will consider some comparative statics. We assume a Cobb-Douglas utility function, with parameters that satisfy the homogeneity assumption required of (1):

(9) $$U(g,h,b) = g^{\beta} h^{\alpha} b^{1-\alpha}.$$

We chose values for α and β such that, if g, h, and b were all privately purchased goods, the gross-of-tax expenditure on housing would be 20%[15] and the fraction spent on local public goods would be 9%, which is approximately the share of GDP spent on local public goods.[16] This yields $\alpha = 0.21978$ and $\beta = 0.098901$.

To calibrate the housing supply function, we assume price taking housing producers combine the given developable land and perfectly elastically supplied non-land factors to produce housing according to a constant returns to scale Cobb-Douglas production function. Under these assumptions, housing supply is given by a constant elasticity supply function:[17]

$$H_s(p_h) = L \cdot (p_h)^{\frac{1-\mu}{\mu}}, \quad \varepsilon_H = \frac{1-\mu}{\mu}; \tag{10}$$

where μ is the ratio of non-land to land expenditure in the production of housing and L is the inelastically supplied land. Based on available evidence regarding the share of land and non-land inputs in housing (Epple, Gordon, and Sieg, 2010), ε_H is set equal to three. We set $L = 1$ with no loss in generality.

We assume the economy's income distribution is lognormal. The distribution is calibrated using the 2010 U.S. Census findings of mean and median household income of \$67,392 and \$49,276, respectively.[18] These values imply $\ln y \sim N(10.805, 0.791)$.

To calibrate the income tax distortion, we assume for simplicity that $\gamma(m) \equiv \gamma$ is constant. Using the 2010 U.S. Census, we calculate aggregate household income of \$7,865,744,350,464. Total U.S. Federal Income tax receipts in 2010 were \$898,549 million.[19] Hence, we estimate the average 2010 household income tax rate as 11.4%. Given the other calibrated parameters, we find the γ such that the baseline equilibrium has $m = 11.4\%$. This implies $\gamma = 0.2471$.

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[15] The share of aggregate income spent on housing of 20% is in the range of values estimated in the literature.
[16] Data for this approximation are from the 2008 *Statistical Abstract* Tables 442 and 645 for 2004. We calibrate to public expenditure on local public goods since we go on to analyze a multi-jurisdictional economy.
[17] See Epple and Zelenitz (1981). This derivation is provided in the on-line appendix.
[18] U.S. Census Bureau, 2011,Table H-6 from Historical Income Tables.
[19] Budget of the U.S. Government, Fiscal Year 2015, Historical tables, Table 2.1 Receipts by Source: 1934-2019.

Table 1 reports our computational findings, with the first column values in the baseline calibration.[20] We report equilibrium per capita expenditure on the public good (g), the lump-sum income transfer (r, or head-tax if negative), the income tax rate (m), property tax rate (t), the proportions of total taxes collected by the head tax, income tax, and property tax, the gross price of housing services (p), and the mean and median household incomes. The other columns report equilibrium values for parameter variations, where in each column we vary just one parameter from the baseline values.

In the baseline case, the income tax is rate is .11 to which we have calibrated. We find g equals $4,799, about 7% of mean income. A substantial direct income transfer of $9,415 arises, about 14% of mean income. The median income is below the mean income implying an incentive to redistribute. Redistribution, while substantial, is far from complete, this because of the distortion from taxing income. The property tax rate of .85 may appear very high, but this is a tax rate on services (rent), not value. In his analysis of housing user cost, Poterba (1992) derives a conversion for which annualized rent (i.e., p_h) on housing services is 11% of housing value.[21] Hence, a .85 tax on rent translates to a .09 tax on value (= (.11)(.09)). More meaningful are the proportions of taxes collected by the tax forms, which we then focus our discussion on throughout the rest of the paper. We see that the tax proportions collected from income and property taxes are close, with, obviously, 0 head-tax proportion. Property taxation has attraction to the median voter both because it implies redistribution and because the non-infinite housing supply elasticity implies part of the incidence is born by the absentee housing suppliers; the *appropriation incentive*. On the other hand, the median voter does bear a cost of this taxation as rents rise, and the tax provides a limited means to redistribute. We report the gross housing price for comparison across cases, keeping in mind the calibration is such that 20% of income is spent on housing in the baseline.

Turning to the comparative statics, keep in mind we maintain the income distribution so that an incentive to redistribute persists. The first comparative static has a markedly lower income tax distortion

[20] The on-line appendix describes the structure of the programs we use.

[21] Letting z denote the "user cost factor" and V the value of housing, the equilibrium rental rate of housing equals its user cost, according to: $p_h = z \cdot V$. The user cost factor is the sum of four values, $z = z_1+z_2+z_3+z_4$, where z_1 is the real interest rate, z_2 the risk premium from housing investment, z_3 is proportional maintenance cost, and z_4 is depreciation. Poterba's calculation yields $z \approx .11$, the value for the conversion reported in the text.

parameter $\gamma = .05$, this leading to much higher income transfer, income tax rate and proportion, modestly higher expenditure on the public good, and substantially lower property tax. The next case considers a more modest increase in this distortion, with opposite and less extreme effects. In the fourth column we cut in half the housing supply elasticity. With more power to appropriate economic rents from housing suppliers, the property tax and its share in tax revenues rises, with the proceeds used to fund more public good expenditure and especially a larger income transfer. Increasing by half the parameter that weights the public good in utility (β) leads to virtually no change in taxes, but a shift in public expenditure from the income transfer to the public good.[22] Last, increasing the relative weight on housing (α) among private goods in the utility function leads to a modest increase in the property tax rate, a modest decrease in the income tax rate, but substantially higher property tax share and income transfer. These effects are driven by higher expenditure on housing, which makes property taxation a more appealing means to transfer income. Overall, the parameter changes affect the relative mix of income and property taxation, but redistribution always arises; and, given the availability of the head tax, taxation is always inefficient.

Since head taxes do not arise, restricting them has no effects. We could consider other limits on taxation, but leave this for future research. Our analysis in this section is novel in its investigation of voting over the full set of tax instruments in a single-jurisdiction setting. Given that head taxation does not arise in the single-jurisdiction setting, this analysis then also unifies the treatment of income and property taxes and public good provision in a single-jurisdiction setting without head taxes.[23]

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[22] The small decline in total public expenditure is because the income tax actually declines from .114 to .113.

[23] Modeling of taxation by majority rule was initiated by Bowen (1943) in investigation of voting over a public good and a proportional income tax (g and m in our notation) in a model with a public and a private good, and no tax distortions. Romer (1975) investigates voting over properties of a linear income tax (m and r in our notation), introducing deadweight loss of taxation via distortion of the labor-leisure choice. Romer's analysis utilizes single-peakedness, which is achieved by limiting the range of admissible taxes. Roberts (1977) generalizes Romer's analysis, establishing existence of majority voting equilibrium without invoking single-peakedness. Meltzer and Richard (1981) build on the work of Romer and Roberts to provide a positive theory of the size of government. Westhoff (1977) initiated study of multi-community equilibrium with income taxation and communities each providing a pure public good utilizing. Epple, Filimon, and Romer (1984) extend Westhoff by introducing housing markets and studying voting over property tax and a congested local public good (t and g in our notation) in a multi-community model. Goodspeed (1989) studies voting over income taxation and public good provision (m and g) in a multi-community model. Westhoff (1977), Epple, Filimon and Romer (1984), and Goodspeed (1989) all study voting using single-peakedness. Epple and Romer (1991) study voting over property taxation and redistribution (t and r in our notation) when voters anticipate the effects of tax policy on relocation. They show that single-

3. Multi-Jurisdictional Economies

a. The Extended Model. We now consider equilibrium in a Tiebout-like setting where the economy is divided into an integer number of J jurisdictions, each with taxing authority and supplying locally the (congested) public good. The focus is on cases with $J \geq 2$, but the single-jurisdictional case above can be regarded as a special case. The economy income distribution is unchanged, and household preferences are the same. It is sometimes more natural to refer to a jurisdiction as a community, so we use the terms interchangeably.

A community is characterized by a housing supply $H_s^j(p_h^j)$, $j = 1, 2, ..., J$, where j will generally indicate a particular community. Housing suppliers are again absentee. The sense in which the economy is "divided" into communities is that we assume $\sum_{j=1}^{J} H_s^j(p_h) = H_s(p_h)$, the latter recall the economy housing supply. One motivation for this, which underlies our computational analysis, assumes again a community's given developable land and perfectly elastically supplied non-land factors are used to produce housing according to a constant returns to scale Cobb-Douglas production function. As discussed above, then a community's housing supply is given by a constant elasticity supply function:

$$(11) \qquad H_s^j(p^j) = L^j \cdot (p^j)^{\frac{1-\mu}{\mu}}, \; \varepsilon_H = \frac{1-\mu}{\mu};$$

where L^j is the land area of community j as a proportion of total (developable) land area in the economy (normalized to 1), and μ is the ratio of non-land to land expenditure in the production of housing. Note that aggregating these community housing supplies returns the housing supply function used in the J = 1 computations above.

We consider two cases of the model, one with "mobility" and the other without it. The timing of choices in the mobility case is described in Figure 3. In Stage 1, households select a

peakedness need not prevail, and instead provide a proof of existence of voting equilibrium by exploiting single-crossing, akin to the strategy developed by Roberts (1977). Calabrese, Cassidy, and Epple (2002) study multiple tax instruments, as in this paper, with differences in approach discussed previously.

jurisdiction. In Stage 2, they vote over the local policy, $P^j = (t^j, m^j, r^j)$, taking as given equilibrium policies in the other communities denoted P^{-j}. In Stage 3, they can costly locate to any other jurisdiction. In Stage 4, housing markets clear, local government budgets balance, and households consume. It is natural to refer to Stage 4 as the consumption stage. Households correctly anticipate all continuation equilibrium values.

Figure 3			
Stage 1	Stage 2	Stage 3	Stage 4
Households Select Jurisdiction	Households Vote Over Local Policy	Households Costlessly Relocate	Households Consume, Government Budget Balances, Markets Clear

The no-mobility case simply eliminates Stage 3. Households are stuck in their initially chosen community. Note that the model assumes income to be independent of community, so it is best applied to local economies like metropolitan areas.

Consider the results in the single-community case that carry over. Let $f^j(y)$ denote the measure of households that live in community j in equilibrium (following any relocation in the mobility case) and $n^j = \int_s f^j(y)dy$ the proportion of the population that lives there. *Equilibrium in the consumption stage in community j is exactly as in the single-community case using the relevant type distribution,* $f^j(y)/n^j$.

We discuss majority choice equilibrium below, as its detail varies between the mobility and no-mobility cases.

A key issue is how households sort across the communities. Anticipating equilibrium including the community j where they will live, household utility is given by: $V^j = y\Gamma^j + \Omega^j$, with the community j's composite public good values evaluated at equilibrium in community j. We refer to an equilibrium as "stratified" if $\Gamma^j \neq \Gamma^i$ for all communities $j \neq i$, in which case we number the communities so that $\Gamma^1 < \Gamma^2 < ... < \Gamma^J$. We have:

Proposition 5: A stratified equilibrium with all communities occupied is characterized by:

a. *Income Stratification*: Each community contains all households with incomes in a single interval, incomes ascending across communities in the same order as Γ^j.

b. *Diverging Bundles*: The Ω^j's descend strictly with j.

c. *Boundary Indifference*: Between each pair of communities in the income ordering is a single household type y that is indifferent between the two communities.

Proof of Proposition 5: In choosing their equilibrium community, households anticipate the equilibrium (Γ^j, Ω^j) in all communities and choose a community that maximizes indirect utility (whether in Stage 3 in the mobility case or Stage 1 in the no-mobility case). Since $\Gamma^1 < \Gamma^2 < ... < \Gamma^J$, it must then be that the Ω^j's strictly descend with j or at least one community would fail to attract residents. Thus *diverging bundles* holds. Refer to Figure 1. Using that the indifference curves flatten as income increases it is simple to confirm *income stratification*. *Boundary indifference* is implied by continuity of the indirect utility function in y and that the density of y is positive on its support. ■

Income stratification reflects the preference of higher income households for lower income taxes relative to an income transfer. To say more about equilibrium, including when stratified equilibria arise, we must consider mobility.

b. The No-Mobility Case. Keeping in mind that there is no Stage 3 in the no-mobility case, observe that, once communities are selected in Stage 1, the continuation equilibrium in each community is precisely as in the single-community equilibrium using the income distributions determined in Stage 1. Majority choice equilibrium in each community holds as in Proposition 2. There is no need here to write out a formal definition of equilibrium.

This case requires little discussion because we do not find stratified equilibria in our computational analysis. Rather, the only equilibrium that arises is analogous to the single-community equilibrium. More completely, each community has the same income distribution as the population distribution with $n^j = L^j$, and with policies and prices the same as in the single-community equilibrium. Given the same income distributions and with populations proportional to the housing supply, the continuation equilibrium beginning in Stage 2 is just as in the single-community case. Anticipating the same outcome in each community, all households are indifferent to their community choice in the Stage 1, implying sorting so that income distributions are the same is in fact an equilibrium. Thus, for the same parameters as in Table 1, each community has equilibrium values as reported there.

Why do stratified equilibria fail to arise? First, we should note that we do not have a general proof that a stratified equilibrium could never arise and do not claim generality. Rather, our findings are based on our computational analysis, which we have attempted to make realistic (and we have also considered substantial parameter variations). The intuition is that if households do sort across communities it will be by income. Then, in the richest community (and perhaps others), the income distribution will be right skewed implying an incentive to redistribute. The income tax and transfer would be relatively high in the rich community, limited only by the income-tax distortion. But this implies poorer households will have a strong incentive to move to the richer community disrupting a stratified equilibrium. We take the message of these findings to be that mobility is important to obtaining stratification when the tax system permits substantial income redistribution.[24] This interpretation is based in part on the next analysis.

c. <u>Multi-Jurisdictional Equilibrium with Mobility</u>.

[24] Epple and Romer (1991) obtain stratified equilibria with income redistribution in a simplified variant of the no-mobility model of this paper with only property taxation and no provision of a local public good. Redistribution is due mainly to appropriation using property taxes from absentee housing suppliers. We show here that if income taxation where also an option, the stratified equilibria are disrupted.

Since households can costlessly relocate in Stage 3 of equilibrium (see Figure 3) and do not individually affect voting equilibrium due to their atomism, they are actually indifferent to their initial community choice. We then examine the "no-move equilibrium," where households initially locate in the community where they will prefer to stay in Stage 3. This focus is appealing for two reasons. First, moving costs would induce such an initial community choice, though explicit consideration of moving costs would introduce other effects on equilibrium and much complication.[25] Second, if households were allowed to vote to adjust policy after relocations, then the same equilibrium we examine would prevail. It bears emphasis that since we assume households rationally anticipate continuation equilibrium values on and *off the equilibrium path* our examination of the no-move equilibrium does not imply the option to relocate in Stage 3 fails to effect on equilibrium. In fact, it has fundamental effects. We now provide a more formal description of the mobility equilibrium.

<u>Definition of Equilibrium</u>: *Timing of choices is as in Figure 3, with rational expectations of all continuation equilibrium values. In Stage 1, households locate in a community that maximizes utility, taking as given other households' community choices, correctly anticipating equilibrium values, and with no incentive to relocate in Stage 3* ***in equilibrium***. *In Stage 1, $f^j(y)$ and n^j are determined. In Stage 2, the policy P^j is established that is weakly majority preferred to all other allowed policies $P^{j'}$ by residents of community j, taking as given majority choice policies P^{-j}; correctly anticipating continuation equilibrium values for all $(P^{j'}, P^{-j})$. In Stage 3, households initially located in community j relocate to a utility maximizing community $k \neq j$, taking as given all policies P^i $(i \in \{1,2,\ldots,J\})$ and all implied continuation equilibrium values, if there exists a community k that would increase utility. In this stage, the final community income distributions are determined. In Stage 4, utility maximization over housing and composite commodity consumption takes place, housing markets clear, and the community government budgets balance. Specifically, each household solves $Max_{b,h}\, v(g^j)u(b,h)$ subject to (3), taking as given $(t^j, m^j, r^j, p^j, g^j)$. This determines housing demands and composite commodity consumption.*

[25] See Epple, Romano, and Sieg (2012) for a Tiebout model that includes explicit moving costs.

Housing market clearance satisfies (2) and (6) for given $(P^j, f^j(y))$ *and individual housing demands, determining* (p^j, p_h^j). *Government budget balance satisfies (4) and (5) for given* $(P^j, f^j(y), n^j, x^j(y), p^j, p_h^j)$, *determining* g^j.

Consider majority choice equilibrium among communities at Stage 2, in light of household relocation in the next stage. *Assuming a voter in community j votes myopically as though he would never relocate,* his preferred policy would satisfy:

$$(12) \qquad \begin{aligned} &\mathrm{Max}_{P^j} \ y\Gamma^j + \Omega^j \\ &\text{s.t. } \Gamma^j = \Gamma_e^j(P^j, P_e^{-j}) \text{ and } \Omega^j = \Omega_e^j(P^j, P_e^{-j}); \end{aligned}$$

where P_e^{-j} is the vector of majority chosen policies in other communities than j and $\Gamma_e^j(\cdot)$ and $\Omega_e^j(\cdot)$ are the equilibrium continuation values *that take account of everyone's final community choices.*[26] Because the majority choice result in Proposition 2 does *not* depend on the character of the choice set, here $(\Gamma_e^j(\cdot), \Omega_e^j(\cdot))$ for all P^j, it can be applied. Denote the majority choice for this artificial problem as P_{ea}^j. If we then assumed voters took proper account of others' incentives to relocate but ignored their own incentive to do so when voting, the equilibrium values of P^j would be P_{ea}^j for all communities. Refer to this allocation as the "artificial equilibrium."

Now we provide a condition such that the actual equilibrium corresponds to the artificial equilibrium. Let $VF(P^j)$ denote the proportion of households that "vote for" P_{ea}^j matched against any $P^j \neq P_{ea}^j$ in the artificial equilibrium in community j. Let $M(P^j) \equiv VF(P^j) - .5 \geq 0$ denote the majority excess by which P_{ea}^j defeats P^j in the artificial equilibrium. Let $SW(P^j)$ denote the proportion of households in j that would actually prefer to relocate to another community under P^j, weakly prefer P_{ea}^j to P^j in the artificial equilibrium, but would strictly prefer P^j to P_{ea}^j given that they optimally relocate. The condition is:

[26] The constraint set $(\Gamma_e^j(\cdot), \Omega_e^j(\cdot))$ is not itself influenced by the voter's myopic behavior regarding his own potential to move because any one household's residence decision has no effect on equilibrium due to a household's atomism.

(C1) $SW(P^j) \leq M(P^j)$ in all communities j and for all policies $P^j \neq P^j_{ea}$ in the artificial equilibrium.

Proposition 6. If (C1) holds, the artificial equilibrium beginning at Stage 2 is an actual equilibrium.[27]

Proof of Proposition 6. The proportion $VF(P^j)$ that would vote for P^j_{ea} matched against any $P^j \neq P^j_{ea}$ in actual equilibrium equals $VF(P^j) – SW(P^j)$, which continues to be at least .5 under (C1). Thus, P^j_{ea} continues to be majority preferred in community j, and in all communities by the same argument. ▪

While some households would relocate for non-equilibrium policies P^j and some would switch to preferring P^j over the artificial equilibrium policy, the condition is just that these relocaters and switchers are not enough to disrupt majority preference for the artificial equilibrium policy. As such, it is the actual equilibrium policy. We verify computationally the condition is satisfied in our quantitative results that follow.

We now turn to computational analysis of equilibrium with mobility. The baseline calibration of the utility function, economy income distribution, and economy housing supply function is the same as in the single-community case. We assume J = 3, the idea to have a central city and two suburbs.[28] We must calibrate the land areas. If the land areas and thus housing supplies differ, then multiple stratified equilibria can result that differ with respect to which income strata live in the variably "sized" communities. With three different land areas, the poorest segment could live in any of the communities, the next poorest segment in any of the remaining two communities, with then the richest segment living in the remaining community. Thus, six alternative stratified equilibria could arise. To resolve this multiplicity, we designate one community to be the city and assume it is the poorest community.[29] We further assume the remaining two communities have the same land areas. We calibrate the land shares in the city and in the suburbs so that the population proportions in the city and both suburbs approximate empirical values. Based on the results of the 2010 U.S. Census, the total U.S. population living in

[27] Absent satisfaction of (C1), majority choice equilibrium fails to exist under our equilibrium requirement that no one wants to relocate on the equilibrium path. This is proved in the on-line appendix.
[28] In an earlier version of this paper we had 5 communities, with the same character of results.
[29] DeBartolome and Ross (2002) provide a dynamic analysis that predicts the relative wealth of the city as compared to the suburbs.

Metropolitan Statistical Areas (MSA's) was 258,317,763, of which 39%, or 100,742,583, live in principle MSA cities. Hence, to calibrate land shares in the baseline computational equilibrium, we constrain the city's population to 40% of the total population, while assuming the land shares in the two suburbs to be equal. This computation results in the city having 32.51% of the total metropolitan land area and each of the suburbs having 33.74% of the land area.

Table 2 reports equilibrium values, with the first column for the baseline calibration, which we discuss first. We report in Table 2 most of the same values provided in Table 1 for the single-community case but now for each community, while suppressing the tax rates. In addition, we report the economy average g, the community populations and mean incomes, and in which communities the median income is less than the mean implying an incentive to tax to redistribute. We obtain a stratified equilibrium.[30] Thus, we find a non-trivial example of an equilibrium where Propositions 5 and 6 apply.[31] The public good expenditure rises steeply with the income strata and the community populations weakly shrink. The richer suburb contains 20% of households, while having approximately the same land area and thus housing supply as the other communities. What keeps the poorer households from moving to richer communities to consume more of the public good? Note, first, that it is not increasing gross prices of housing services that explains this, as the increase is very modest. Rather it is the character of the tax system.

Income taxes are zero and a substantial head tax is imposed in spite of the incentive to redistribute in the suburbs. The over-riding incentive is to *select* relatively richer households and deter relatively poorer households to increase the tax base and limit free riding. The threat of relocation keeps the pivotal voter from trying to redistribute in the suburbs. The incentive to keep relatively richer households from moving out and deter relatively poor households from immigrating is also in spite of the *congestion* effect on the price of housing services. In the suburbs, a property tax is imposed as a result of

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[30] Given space constraints, we do not consider the less interesting "clone community equilibrium" that might also arise. Also, as indicated, the stratified equilibrium we examine has the poorest income segment in the "city."

[31] We verify computationally that equilibrium satisfies (C1) as we indicated above. This applies to all the equilibria we present.

the *appropriation* incentive, but the proportion of taxes so collected is not large. Keep in mind, too, that a head tax is an *efficient* tax. In the city, property taxes are the primary source of revenues, though there is a small head tax. Here there is no incentive to redistribute since the mean income ($24,950) is slightly below the median income ($25,316).

It is of interest to compare the equilibrium values in the mobility model to those values where relocation is not permitted, keeping in mind the latter values in each community are the same as in the single-community equilibrium (see the first column of Table 1).[32] Absent relocation, income taxes are the primary source of revenues and substantial redistribution results. *Thus mobility induces stratification and eliminates income taxation and redistribution.* In addition to mobility eliminating direct redistribution, the stratified equilibrium has rising public goods expenditure with the income strata. The economy average expenditure on g is higher ($6,798 compared to $4,799), but the city residents who are the poorest 40% of the population obtain less of the public good. Given our positive focus, we do not make any welfare calculations, but it is obvious poorer households fair much worse under mobility.

The next four columns in Table 2 vary one parameter from the baseline values as in Table 1. The same fundamentals hold as in the baseline calibration, but with some substitution of taxes and some direct redistribution in the city in some of the variants. Only when the income tax distortion is substantially reduced ($\gamma = .05$, Column 2 of Table 2) does income taxation arise and only in the city.[33] Most of these changes are easy to interpret. Lowering the housing supply elasticity (Column 3, Table 2) induces increased reliance on property taxes and much higher gross housing prices. Increasing the exponent on the public good (Column 4, Table 2) leads to substantially higher expenditures on the public good and more reliance on head taxes, the latter due to stronger incentives to free ride.

The last column severely restricts the use of head taxes. Specifically, it is assumed that the maximum permitted head tax is fixed in each community, and we set that maximum at 5 percent of the

[32] Each community has population equal to the land share in the multi-community no-mobility case.
[33] Since there is no incentive to redistribute in the city, it must be that an income tax with some redistribution is the majority choice to deter richer households to keep down the price of housing services. Here the congestion effect plays a key role. This arises in the present case that has the poorest city in the comparative statics.

equilibrium expenditure on the public good. While we obtain a stratified equilibrium, it entails much more free riding as evidenced by the large populations in the suburbs, especially the richest one. Income taxation continues to not be used anywhere. The city is small and very poor, and does not use the head tax, rather has a small direct redistribution. The suburbs are on the bound of the head tax constraint. Housing prices rise more steeply as crowding of the suburbs bids them up. If we shut down head taxation completely, then we do not obtain a stratified equilibrium.

Are head taxes empirically relevant? In fact, local jurisdictions in the U.S. generally do not seem to have the authority to impose head taxes.[34] However, Hamilton (1975) argued some time ago that zoning restrictions on housing consumption combined with a property tax provides a potential substitute for head taxation. Building on the ideas in Hamilton, we (2007) showed the near equivalence of political equilibrium with head taxes to that with property taxes and minimum housing quality restrictions in a model with multiple jurisdictions.[35] This provides an argument for the legitimacy of considering head taxes in the presence of legal barriers, but the near equivalence breaks down in the case of renters who might enact property taxes to appropriate housing supplier surplus. More research is needed here.[36]

4. Home Ownership

a. The Model with Home Ownership. Home owners have substantially different policy preferences so it is important to consider them. We assume in this variation of the model that all households are owners. We describe the extension in the context of the multi-community model with mobility. Refer, again, to

[34] Local taxing authority in the U.S. varies by state, with some federal constitutional restrictions. The preclusion of local head taxes we note in the text is implicit in the character of what taxation is permitted in state constitutions. There are "occupational privilege taxes" used in localities of some states, which are also sometimes of a fixed amount. But these are collected by employers, on employees that earn a minimum amount, and generally linked to location of the employer rather than the employee's residence. It is an interesting legal question as to whether use of local head taxes would satisfy federal law. Federal law requires that taxes are nondiscriminatory, but whether local head taxes would be legally discriminatory is unclear.

[35] The majority choice existence problem with public choice of property tax and minimum housing quality is resolved using a version of Besley and Coate's (1997) representative democracy model.

[36] We have seen that with multiple tax instruments, renters combine head taxes and property taxes, the latter due to incidence on housing suppliers (i.e., the appropriation incentive), while not using income taxes. If head taxes were unavailable but minimum housing consumption could be required, renters would face a tradeoff between appropriation via property taxation versus use of minimum housing consumption requirements to approximate head taxation. In our 2007 paper, we did not consider multiple tax instruments so this trade off did not arise. In contrast to renters, housing owners, examined next, do not have an incentive to use property taxes for appropriation, thus making minimum housing requirements an attractive substitute for head taxes.

Figure 3. Stage 1 is modified to have households sign a contract with a competitive housing supplier in the community they initially select to build them a house in Stage 4 of quality/quantity h, at agreed upon price per unit of h.[37] The contract may be renegotiated in Stage 4 when housing is actually built and consumed. The price in the contract must equal the ultimate equilibrium housing price since all agents have rational expectations, but it is convenient to have different notation for the equilibrium contract price, p_{h1}^{j}. Stages 2 and 3 are the same as with renters. However, relocation and consumption adjustments for out-of-equilibrium policies could change the supplier price of housing. Specifically, housing value would change by $(p_h^j - p_{h1}^j)h$, out of equilibrium. In Stage 4, households optimally "buy out" of their housing contract and adjust consumption to the level of h equal to demand at price $(1+t^j)p_h^j$ and with income including capital gain/loss equal to $(p_h^j - p_{h1}^j)h$. Housing suppliers are just as well off under the buy-out, and owners are better off.[38] If $p_h^j > p_{h1}^j$, owners experience a capital gain. The housing supplier is just as well off paying the buyer $(p_h^j - p_{h1}^j)h$ to not build since the supplier can instead supply h at equilibrium price p_h^j. If $p_h^j < p_{h1}^j$, then the buyer must compensate the supplier $(p_{h1}^j - p_h^j)h$ to not build as agreed upon. Buyers are better off since they can adjust their housing consumption reflecting the change in housing price. Note that the buyer may have moved to another jurisdiction in Stage 3, experiencing the same capital gain/loss, but then consuming housing at price p^k in their new community.

The single community case just drops Stage 1 (as everyone is stuck in one community) and Stage 3 (as there is nowhere to relocate). Nevertheless, the single-community equilibrium is different than with renters because out-of-equilibrium policies engender capital gains/losses and housing renegotiation.

The only difference in the primitive equations (i.e., (1)-(6)) is that $y[1-(1+\gamma(m^j))m^j]$ is replaced everywhere by $y[1-(1-\gamma(m^j)m^j)]+(p_h^j - p_{h1}^j)h_d(y,p^j)$, where we are assuming households contract for

[37]The modeling here of housing owners is similar to that in Epple and Romer (1991).

[38] One might alternatively assume suppliers and buyers share in capital gains/losses, by specifying the capital gain/loss to buyers equal to $\theta \cdot (p_h^j - p_{h1}^j)h$, with $\theta \in (0,1)$; and with the remainder accruing to the supplier.

their equilibrium preferred level of housing initially.[39] While no capital gain/loss arises in equilibrium, the potential for a gain or loss will have a marked effect on equilibrium policies.

As shown in the appendix, indirect utility is modified to be:

$$
\begin{aligned}
&V(\Gamma_o^j, \Omega_o^j, y) = y \cdot \Gamma_o^j + \Omega_o^j; \\
&\Gamma_o^j \equiv v(g^j) \cdot [1 - (1 + \gamma(m^j))m^j] \cdot [1 + (p_{h1}^j - p_h^j) G(p^j)] \cdot w(p^j); \\
&\Omega_o^j \equiv v(g^j) \cdot r^j \cdot [1 + (p_{h1}^j - p_h^j) G(p^j)] \cdot w(p^j); \\
&\text{where } G'(p^j) < 0.
\end{aligned} \tag{13}
$$

Thus, Proposition 1 above is modified to have composite public goods that weigh capital gains/losses that might arise. The main other Propositions, specifically 2,5, and 6, carry over as well (*and their proofs*) with the redefined composite public goods.[40]

b. Single Community Case. We use the same calibration for comparison. Table 3 shows the same equilibrium values as in Table 1 for the baseline calibration, but now with the second column for the owners' case.[41] Owners are relatively reluctant to tax housing as doing so lowers the net price of housing resulting in a capital loss (out of equilibrium). They have no appropriation incentive. In equilibrium, housing is taxed by less than in the renters' case, with lower tax level and share. Since an incentive to redistribute is present, both an income and property tax is used to finance direct redistribution along with the public good. Total public expenditure is lower with owners because property taxation is more costly. Note, too, that restricting the head tax has no consequences since no head tax arises.

c. Multi-Community Case. Table 4 presents the results for the multi-community case with owners, where we again compare to the renters' case. To simplify the computations, we approximate by having households ignore the out-of-equilibrium effects of capital gains/losses *on others* when they vote. Own capital gains are taken account and play a key role in equilibrium![42] The first two columns compare the stratified equilibria that arise in the baseline cases of renters and owners. Income taxes again fail to

[39] This is an optimal choice since no capital gains or losses actually materialize in equilibrium. As above, we continue to write $h_d(y,p)$ for housing demand, but the relevant y is after taxes and any capital gains.
[40] Proposition 4 actually applies more generally, but not Proposition 5. The former is shown in the on-line appendix.
[41] We have done the same comparative statics as in Table 1, with qualitatively similar effects. These results are available on request from the authors.
[42] The simplification is akin to ignoring an out-of-equilibrium income effect. In experimentation with simpler cases with just two communities, we find this approximation to be very good.

materialize, with more reliance on head taxation relative to property taxation and markedly so in the city and poorer suburb. Note, too, that equilibrium is "more stratified," with a larger and poorer city and more elite suburbs.

In addition to a reluctance to tax housing to avoid capital losses, there is no congestion effect and the "selection effect" is stronger. *Owners generally have an incentive to attract residents to bid up housing prices.* The elimination of the congestion effect seems to be strongest in the city where households are relatively poor, leading to a large change in reliance on the head tax relative to the property tax, attracting households from the suburbs. The change in incentives is weakest in the elite suburb that becomes more elite. It bears emphasis that no direct redistribution takes place anywhere, though the median income is below the mean in all three communities.

The last two columns compare the renters' and owners' cases with the severe restriction on head taxes.[43] With owners, all three communities are at the bound of the head tax. As in the renters' case, the stratification is very different with large suburbs and much free riding. Given the reluctance to tax housing and the severe limit on head taxation, income taxation makes up a significant share of tax revenues in the richer suburb. The income tax rate there is, however, only 3.07% (not in table), compared to 11% in the single-community owners' case. The level of expenditure in the richer suburb is below the level in the single-community case with owners though the suburb is, of course, richer. Head taxes are severely limited, and there is a reluctance to tax both income and property due to mobility.

5. Discussion and Summary

We begin here by discussing two key issues of generality that we have examined theoretically. The model can be generalized to allow a tax on consumption of the composite private good in addition (or alternatively) to the other taxes. Assume that this consumption expenditure must be within one's community, then including the single-jurisdiction case. Let s denote this tax rate. Dropping j superscripts

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[43] Again we have done other comparative statics as in Tables 1 and 2 that are available on request.

if the application is to the multi-community case and taking the example of renters, it is straightforward to show indirect utility is given by:[44]

$$
\begin{aligned}
&V(\Gamma,\Omega,y) = y\cdot\Gamma_s + \Omega_s;\\
(14)\qquad &\Gamma_s \equiv v(g)\cdot\frac{[1-(1+\gamma(m))m]}{1+s}\cdot w(\frac{p}{1+s});\\
&\Omega_s \equiv v(g)\cdot\frac{r}{1+s}\cdot w(\frac{p}{1+s}).
\end{aligned}
$$

The analysis then proceeds as above. In addition, if there is no income-tax distortion, then it is straightforward to show that taxing composite private-good consumption and income is redundant; one can eliminate one of these taxes. Moreover, continuing to assume no income-tax distortion, it is then implied a consumption tax would not characterize equilibrium in the multi-community case if households can travel to consume. Given final community choice, a tax on composite private good consumption would induce such travel, while income taxation cannot be escaped. These results induced us to consider income taxation, without taxation of numeraire consumption. However, the equivalence does break down with an income tax distortion. In addition, if one considers retired voters with low incomes but relatively high levels of consumption, such a tax may become attractive. Thus, it is of interest to consider further the extension.

What are the prospects for extending the analysis to taste differences? Suppose that utility continues to be as in (1), but parameterized by tastes (T): $U^T = v(g;T)u(h,b;T)$; where $u(\cdot)$ is still linearly homogenous of degree 1 in (h,b). Then, assuming renters and one community to convey the ideas, indirect utility can be written:[45]

[44] The results that follow concerning a numeraire consumption tax are shown in the on-line appendix.
[45] We again abstract from the just-discussed tax on numeraire consumption. More complete confirmation of the results discussed here are in the on-line appendix.

$$
(15)\quad \begin{aligned} &V(\Gamma^T, \Omega^T, y; T) = y \cdot \Gamma^T + \Omega^T; \\ &\Gamma^T \equiv v(g;T) \cdot [1 - (1 + \gamma(m))m] \cdot w(p;T); \\ &\Omega^T \equiv v(g;T) \cdot r \cdot w(p;T). \end{aligned}
$$

Restrict taste variation, feasible policies[46], and perhaps housing supply and the utility function so that:

(a1) any type T's composite public good choice set is convex; and:

(a2) the signs of $d\Gamma^T = \Gamma_g^T dg + \Gamma_p^T dp + \Gamma_m^T dm$ and $d\Omega^T = \Omega_g^T dg + \Omega_p^T dp + \Omega_r^T dr$ are invariant to type T.

With these restrictions, one can show majority choice equilibrium continues to exist. Using (a1), one can map any type's preferences over policies into one of the composite public goods for that type (e.g., into Γ^T) and these preferences are single peaked. The derivatives of the composite public goods in (a2) are with respect to policy changes, taking account of the implied effects on g and p. If (a2) is satisfied, types assess policy changes similarly enough so that the Median Voter Theorem can be applied. The restrictions are non-trivial. In the case of Cobb-Douglas utility, type differences correspond to differences in (β, α). The restriction in (a2) is satisfied, for example, allowing variation in α (along with income) if housing supply is perfectly elastic and only income and head taxes are allowed. The approach we have taken does permit *some* generalization with respect to tastes. Taking a different angle, using composite public goods in understanding and solving complicated public choice problems has also recently been applied in Epple, Romano, and Sieg (2012).

In our multi-jurisdictional analysis, we have assumed either no mobility following initial community choice or costless mobility. In the latter case, an innovation of our analysis is that, when voting, each voter takes account of the possibility that he or she may subsequently relocate. In prior analyses of voting, this has not been considered (e.g., Epple and Romer, 1991). Extending the analysis to have mobility costs that vary across households is of interest. Intuition suggests this would increase the scope for local redistribution. Another extension would consider a mixture of housing owners and renters. We have preliminary results for a version of the model with a mixture of housing owners and

[46] Weaker conditions permit existence of equilibrium when the choice set is restricted to only a policy pair as, for example, in Epple and Platt (1998).

renters, where we use Besley and Coate's (2003) representative democracy model to obtain public choice equilibrium.

Our paper contributes to the positive theoretical and quantitative analysis of tax systems. The model has households that differ by income and has majority choice of multiple tax instruments. Income, property, and head taxation are allowed, which can be used to finance a congested public good and direct redistribution. The utility specification permits policy preferences to be specified over two composite public good, this enabling demonstration of majority choice equilibrium with multiple tax instruments. The analysis clarifies competing incentives to adopt tax forms.

The initial analysis assumes voters rent housing that is supplied by absentee landlords, implying an incentive to use property taxes to appropriate surplus. In the single-jurisdictional case we examine, where the income distribution implies an incentive to redistribute, a mixture of income and property taxes arises, with the proceeds used to provide the public good and to redistribute directly via cash transfers. Both taxes are distortionary, which induces voters to limit their levels and redistribution. For the same specification but with housing owners, property taxation is reduced, mainly leading to less direct redistribution. Housing owners bear the full cost of imposing property taxes, and they accordingly vote to limit property taxation.

We also study equilibrium determination of tax systems in a multi-jurisdictional Tiebout-like version of the model, with the economy geographically divided into communities that have taxing authority. Households initially select where to reside and vote, thus permitting sorting by income across communities. In one version of the model they can relocate after local policies are set. If that relocation is not permitted, then the only equilibrium we find is no different from the single community case. Tiebout-type sorting fails to arise. If households were to sort by income, then redistribution in a rich community would attract poorer households that anticipate this redistribution, disrupting the potential for such an equilibrium. If, however, households can relocate following policy choices, then equilibrium with sorting by income arises and with taxation that is fundamentally different than in the single-community case. Income taxation and direct redistribution fail to arise, rather property and head taxes are used to finance provision of the public good. The driving incentive of voters is to retain (deter) richer (poorer) households to maintain the tax base, in spite of incentives to redistribute with sorting (except in the poorest community). Thus, household mobility associated with the option to relocate radically changes equilibrium both with respect to the extent of direct and indirect redistribution (the latter through local provision of the public good), and the nature of public finance. Again, housing owners have weaker incentives to tax property, while also having stronger incentives to retain and attract residents who bid up property values whether rich or poor.

In the multi-jurisdictional analysis head taxes arise and in fact are important to supporting stratified equilibrium. The heavy reliance on the head taxes, especially in the owners' case, provides a theoretical vindication of Tiebout's (1956) original analysis, which implicitly *assumed* head taxation.[47] While we have discussed approximations to head taxes, their empirical relevance is an open and highly debated issue. We continue to obtain stratified equilibrium with severe restrictions on the levels of permitted head taxes, but the richer communities are over-populated relative to reality. One interesting question is why income sorting arises in other multi-community models of majority choice without head taxation (see, e.g., the references in footnote 23**),** while not so here. Our model is unique in having both income and property taxes and with direct and indirect redistribution. Thus, the scope for redistribution is extensive; this precludes stratification if head taxes are not allowed. On the other hand, if head taxes are allowed, then sorting arises but direct income redistribution is severely limited if not eliminated. While we believe these findings yield important insights, the question of generality is open.

The latter issue points to an important simplification of our model and direction for more research. The model assumes one tier of government, while many economies have both central and local governments (if not more tiers) that have taxing authority. A central finding of the literature on fiscal federalism is that redistribution is largely, though not exclusively, the domain of the central government (see Boadway, Marchand, and Vigneaulty (1998) and Gordon and Cullen (2012) and the references therein). This literature has not analyzed the types of taxes that arise endogenously at different tiers of

[47] Head taxation is implicit in Tiebout's discussion of a benefits tax (p. 417).

government. Extending the present model has the potential to investigate further this issue and perhaps show the type of taxes that are adopted endogenously at the central and local levels. Calabrese (2014) has taken a step toward studying this by examining a version of this problem that assumes federal income taxation and local property taxation. A related and interesting feature of the U.S. system that could also be investigated is that state governments can restrict the instruments available to local governments. We think the analysis we have developed here can be helpful for framing future research of such issues.

Appendix.

Proof of Proposition 1: In Stage 2, a household chooses (b, h) to solve the following problem:

$$\text{(A.1)} \quad \begin{aligned} &\operatorname{Max}\ v(g)u(b,h) \\ &\quad \text{s.t. } y[1-(1+\gamma(m))m]+r = ph + b; \end{aligned}$$

where u is homogenous of degree 1 and quasi-concave. Below we suppress that γ is a function of m. The conditions for the solution for h are:

(A.2) $-pu_b + u_h = 0$ and the constraint in (A.1).

The homogeneity assumption conforms to:

(A.3) $u(\lambda b, \lambda h) = \lambda u(b,h)$ for all λ.

Differentiating with respect to λ and then setting $\lambda = 1$ we obtain Euler's Theorem:

(A.4) $u(b,h) = bu_b(b,h) + hu_h(b,h)$.

The latter will be useful later. Differentiating (A.3) with respect to b yields:

(A.5) $u_b(\lambda b, \lambda h) = u_b(b,h)$.

Then setting $\lambda = 1/b$ implies:

(A.6) $u_b(1, h/b) = u_b(b,h)$.

Likewise, one obtains:

(A.7) $u_h(1, h/b) = u_h(b,h)$.

Now substitute (A.6) and (A.7) into the first-order condition (A.2) and rewrite it as:

(A.8) $$\frac{u_h(1,h/b)}{u_b(1,h/b)} = p.$$

Call the left-hand side of (A.8) Z(h/b). From the quasi-concavity assumption: $u_b u_{hh} - u_h u_{bh} < 0$; it is simple to confirm that Z is a decreasing function. From (A.8), $h = Z^{-1}(p)b$, where Z^{-1} is also a decreasing function. Now substitute the constraint on (A.1) for b in the latter equation, and rearrange to obtain:

(A.9)
$$\begin{aligned} h &= (y[1-(1+\gamma)m) + r]\cdot\left[\frac{Z^{-1}(p)}{1+pZ^{-1}(p)}\right] \\ &= [y(1-(1+\gamma)m) + r]G(p) \text{ where } G(p) \equiv \left[\frac{Z^{-1}(p)}{1+pZ^{-1}(p)}\right]. \end{aligned}$$

which is the demand for h. To confirm that G is a decreasing function, differentiate the term in brackets and rearrange to get:

(A.10) $$G'(p) = \frac{(Z^{-1})' - (Z^{-1})^2}{(1+pZ^{-1})^2} < 0,$$

recalling that Z^{-1} is a decreasing function.

Now substitute h = (y(1-m)+r)G(p) into the constraint on (A.1), solve it for b, and substitute b so written and h so written into the utility function to obtain the indirect utility function:

(A.11)
$$\begin{aligned} V &= v(g)u\left([y(1-(1+\gamma)m] + r)(1-pG(p)), [y(1-(1+\gamma)m) + r]G(p)\right) \\ &= v(g)[y(1-(1+\gamma)m) + r]u(1-pG(p), G(p)) \\ &= v(g)[y(1-(1+\gamma)m) + r]w(p) \quad \text{where } w(p) \equiv u(1-pG(p), G(p)). \end{aligned}$$

Note that the second line of (A.11) follows by the homogeneity assumption on u, i.e., by (A.3). Note that w(p) is a decreasing function, as obviously utility declines with p. Thus we have found the indirect utility function (7) in Proposition 1, completing the proof. ▪

b. Owners' Case. In the owners' case, the Stage 4 utility maximization problem is:

(A.12)
$$\begin{aligned} &\text{Max } v(g)u(b,h) \\ &\text{s.t. } y[1-(1+\gamma(m))m] + r + (p_{h1} - p_h)h_d(y,p) = ph + b \\ &\quad h_d(y,p) = [y(1-(1+\gamma)m) + r]G(p); \end{aligned}$$

where $h_d(y,p)$ is the housing level contracted in Stage 1, given by (A.9). (We write housing demand as a function of (y,p) for simplicity, though disposable income is impacted by the policies.) Again applying (A.9), the re-contracted housing consumption in Stage 4 is given by:

(A.13) $$h = [y(1-(1+\gamma)m) + r]\cdot[1 + (p_{h1} - p_h)G(p)]\cdot G(p).$$

Numeraire consumption is given by:

(A.14) $$b = [y(1-(1+\gamma)m) + r]\cdot[1 + (p_{h1} - p_h)G(p)] - ph,$$

for h satisfying (A.13). Substituting these into the direct utility function and following the same logic of (A.11) yields the modified indirect utility function in (13), completing the proof. ▪

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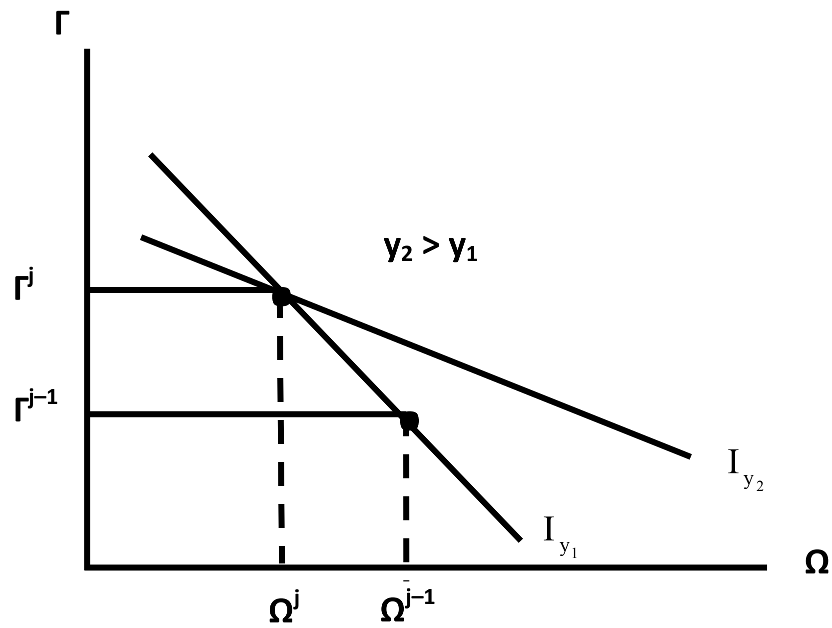

Figure 1: Indifference Curves over Composite Public Goods

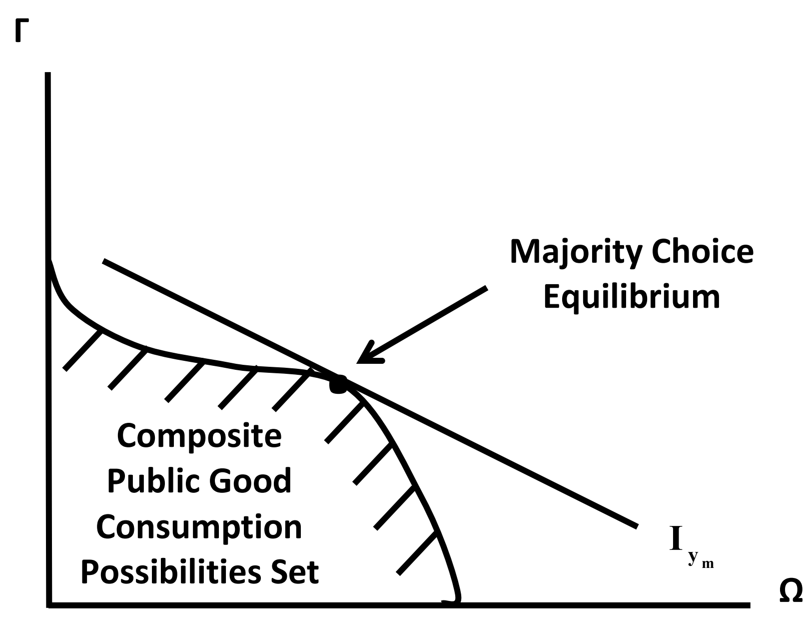

Figure 2: Majority Choice Equilibrium

Table 1: Single Community with Renters*

	Baseline	$\gamma = 0.05$	$\gamma = 0.30$	$\varepsilon_H = 1.50$	$\beta = 0.15$	$\alpha = 0.33$
g =	$ 4,799	$ 5,294	$ 4,784	$ 4,954	$ 6,944	$ 4,987
r =	$ 9,415	$ 35,608	$ 5,149	$ 11,041	$ 7,084	$ 12,543
m =	0.11	0.57	0.04	0.11	0.11	0.10
t =	0.85	0.56	0.90	1.29	0.87	0.90
r prop ** **=**	0.00	0.00	0.00	0.00	0.00	0.00
m prop =	0.52	0.88	0.28	0.47	0.53	0.36
t prop =	0.48	0.12	0.72	0.53	0.47	0.64
p =	$ 17.5	$ 15.1	$ 17.9	$ 77.2	$ 17.5	$ 20.1
Mean y =	$ 67,392	$ 67,392	$ 67,392	$ 67,392	$ 67,392	$ 67,392
Median y =	$ 49,276	$ 49,276	$ 49,276	$ 49,276	$ 49,276	$ 49,276

*Baseline values for parameters are $\gamma = .247$, $\beta = .099$, $\alpha = .220$, and $\varepsilon_H = 3.00$.
**'Prop' is shorthand for proportion of tax revenues with analogous notation used throughout.

Table 2: Multi-Community Case with Renters

	Baseline*	$\gamma = 0.05$	$\varepsilon_H = 1.50$	$\beta = 0.15$	$\alpha = 0.33$	Restricted Head Tax**
g^1 =	$ 2,154	$ 2,134	$ 2,167	$ 3,149	$ 2,263	$ 1,081
g^2 =	$ 6,333	$ 6,047	$ 7,100	$ 8,758	$ 6,958	$ 2,483
g^3=	$ 17,015	$ 16,582	$ 19,939	$ 22,811	$ 18,962	$ 7,964
g avg. =	$ 6,798	$ 6,812	$ 7,517	$ 9,522	$ 7,027	$ 5,658
r^1 =	$ (333)	$ 166	$ 703	$ (1,525)	$ 894	$ 264
r^2 =	$ (3,913)	$ (3,685)	$ (3,002)	$ (6,269)	$ (3,693)	$ (124)
r^3 =	$ (12,282)	$ (11,846)	$ (12,666)	$ (16,769)	$ (14,556)	$ (398)
r prop1* =**	0.15	0.00	0.00	0.48	0.00	0.00
r prop2 =	0.62	0.61	0.42	0.72	0.53	0.05
r prop3 =	0.72	0.71	0.64	0.74	0.77	0.05
m prop1 =	0.00	0.34	0.00	0.00	0.00	0.00
m prop2 =	0.00	0.00	0.00	0.00	0.00	0.00
m prop3 =	0.00	0.00	0.00	0.00	0.00	0.00
t prop1 =	0.85	0.66	1.00	0.52	1.00	1.00
t prop2 =	0.38	0.39	0.57	0.28	0.47	0.95
t prop3 =	0.28	0.29	0.36	0.26	0.23	0.95
Pop prop1** =**	0.40	0.37	0.41	0.39	0.42	0.12
Pop prop2 =	0.40	0.42	0.40	0.40	0.41	0.27
Pop prop3 =	0.20	0.21	0.19	0.21	0.17	0.61
p^1 =	$12.29	$11.36	$53.21	$11.81	$14.39	$8.95
p^2 =	$13.03	$13.09	$59.76	$12.98	$14.31	$11.91
p^3 =	$13.23	$13.38	$59.01	$13.88	$13.66	$19.50
Mean y^1 =	$24,950	$23,737	$25,497	$24,661	$25,737	$14,049
Mean y^2 =	$62,950	$60,291	$64,724	$61,384	$66,255	$29,689
Mean y^3 =	$162,849	$159,141	$166,727	$158,314	$171,573	$95,211
Communities where Median y < Mean y	2,3	2,3	2,3	2,3	2,3	2,3

*Baseline values for parameters are $\gamma = .247$, $\beta = .099$, $\alpha = .220$, $\varepsilon_H = 3$, J=3, $L_1 = .325$, and $L_2 = L_3 = .337$.
**Head tax restricted to not exceed 5% of equilibrium expenditure on g.
***'Prop1' is shorthand for proportion of tax revenues in community 1, with analogous notation used throughout.
****These are the population proportions.

Table 3: Single Community: Comparing Renters to Owners

	Renters*	Owners*
g =	$ 4,799	$ 4,642
r =	$ 9,415	$ 7,755
m =	0.11	0.11
t =	0.85	0.53
r prop ** **=**	0.00	0.00
m prop =	0.52	0.60
t prop =	0.48	0.40
p =	$ 17.5	$ 15.1
Mean y =	$ 67,392	$ 67,392
Median y =	$ 49,276	$ 49,276

*Values for parameters are the baseline values, $\gamma = .247$, $\beta = .099$, $\alpha = .220$, and $\varepsilon_H = 3.00$.
**'Prop' is shorthand for proportion of tax revenues, with analogous notation used throughout.

Table 4: Multi-Community: Comparing Renters to Owners

	Renters Baseline*	Owners Baseline*	Renters Restricted Head Tax**	Owners Restricted Head Tax**
g^1 =	$ 2,154	$ 2,740	$ 1,081	$1,194
g^2 =	$ 6,333	$ 6,584	$ 2,483	$2,446
g^3=	$ 17,015	$ 14,116	$ 7,964	$7,013
g avg. =	$ 6,798	$ 5,787	$ 5,658	$ 4,699
r^1 =	$ (333)	$ (2,670)	$ 264	$ (60)
r^2 =	$ (3,913)	$ (6,186)	$ (124)	$ (122)
r^3 =	$ (12,282)	$ (10,238)	$ (398)	$ (351)
r prop1* =**	0.15	0.97	0.00	0.05
r prop2 =	0.62	0.94	0.05	0.05
r prop3 =	0.72	0.73	0.05	0.05
m prop1 =	0.00	0.00	0.00	0.00
m prop2 =	0.00	0.00	0.00	0.08
m prop3 =	0.00	0.00	0.00	0.44
t prop1 =	0.85	0.03	1.00	0.95
t prop2 =	0.38	0.06	0.95	0.87
t prop3 =	0.28	0.27	0.95	0.51
Pop prop1** =**	0.40	0.54	0.12	0.17
Pop prop2 =	0.40	0.29	0.27	0.29
Pop prop3 =	0.20	0.17	0.61	0.54
p^1 =	$12.29	$10.14	$8.95	$8.37
p^2 =	$13.03	$10.85	$11.91	$11.53
p^3 =	$13.23	$12.63	$19.50	$15.63
Mean y^1 =	$24,950	$30,572	$14,049	$15,884
Mean y^2 =	$62,950	$74,317	$29,689	$33,589
Mean y^3 =	$162,849	$172,268	$95,211	$101,134
Communities where Median y < Mean y	2,3	1,2,3	2,3	2,3

*Baseline values for parameters are $\gamma = .247$, $\beta = .099$, $\alpha = .220$, $\varepsilon_H = 3$, J=3, equal land areas.
**Head tax restricted to not exceed 5% of equilibrium expenditure on g.
***'Prop1' is shorthand for proportion of tax revenues in community 1, with analogous notation used throughout.
****These are the population proportions.