

Majority Choice of Taxation and Redistribution in a Federation

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Abstract. To study redistribution and taxation in a federations, we provide a model with a central government and multiple local governments, the former with power to levy an income tax for redistribution, and the latter choosing a local income tax, property tax, lump-sum tax or subsidy, and a local public good. Policy is set by majority choice at each tier of government by households that differ by income and ability to move among local jurisdictions. We provide sufficient conditions for existence of equilibrium and examine its properties. Central findings are federal income distribution, little local redistribution, and local preference for property taxation over income taxation to fund local public goods.

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1. Introduction

The division of responsibility for redistribution between federal and local governments has been an issue of longstanding interest within economics. In his submission to the Joint Economic Committee on Federal Expenditure Policy for Economic Growth and Stability, Stigler (1957) argued that “redistribution is intrinsically a national policy.” In making his case, he commented that “If 99 communities tax the rich to aid the poor, the rich may congregate in the hundredth community, so this uncooperative community sets the tune.” Echoing this theme Musgrave (1971) states “Policies to adjust the distribution of income among individuals must be conducted on a nationwide basis. Unless such adjustments are very minor, regional differentiation leads to severe locational inefficiencies. Moreover, regional measures are self-defeating, as the rich will leave and the poor will move to the more egalitarian-minded jurisdictions.”

Formalizing these ideas in a positive collective choice model has proven elusive. Meltzer and Richard (1981) develop a positive model with majority choice of redistribution by a national government. Epple and Romer (1991) develop a positive model with majority choice of redistribution by local governments in a multi-community setting with mobile households. The challenge of combining these elements in a single model is compounded by the requirement that a realistic positive model also take account of the important role of local jurisdictions in providing local public goods. In addition, a positive model needs to reflect the ability of local governments to choose how much to rely on property versus income taxation. Combining these elements requires confronting the well-known result (Plott, 1967) that existence of majority voting equilibrium with multiple policy instruments is problematic, even in a single jurisdiction. Our goal in this paper is to develop and draw out the implications of a model with majority choice that embodies all of the elements just enumerated: 1) The model endows national governments with the authority to tax income and redistribute. 2) The model endows local governments with the authority to levy property, income, and lump-sum taxes, provide local public goods, and redistribute. 3) Decisions at both governmental levels are made by majority rule.

More specifically, our model has two tiers of government, a federal government and multiple local jurisdictions. Policy is determined by majority choice of tax instruments by each government in the federation. At the federal level, the electorate is the entire population. The federal government can impose an income tax and use the funds for redistribution. At the local level, eligibility to vote in a jurisdiction is limited to residents. Each local jurisdiction has purview over a defined geographic area, with housing supply constrained by the given developable land. The government of each jurisdiction has access to four policy instruments: property tax, income tax, lump-sum tax or local income subsidy, and provision of a local (congested) public good. Households are mobile and heterogeneous in incomes.

Of course, despite this array of features, the model does not embody all elements of U.S. governmental structure. For example, the model has two governmental tiers whereas the U.S. has three. Our goal is to provide a framework that permits tractable and insightful analysis while avoiding excessive complexity. We hope that readers will see this balance as being struck judiciously.

We provide conditions sufficient for existence of equilibrium in our theoretical analysis, and we find those conditions to be satisfied in a quantitative counterpart to our theoretical model. As we noted above, (Plott, 1967) shows that existence of majority voting equilibrium with multiple policy instruments is problematic, even in a single jurisdiction. Hence, it may be surprising that existence of majority voting equilibrium can be established with two separate but interdependent tiers of government, and with multiple local jurisdictions each of which uses majority rule to choose the values of multiple policy instruments. We adopt a preference structure that preserves empirically relevant features of the policy environment while permitting existence and characterization of equilibrium with multiple communities voting over multiple policy instruments. We view our approach to demonstration of existence to be a contribution that is of interest in its own right. To our knowledge, we are the first to show majority choice equilibrium at two tiers in a federal system.

The model can be adapted to analyze variation in tax restrictions, household mobility, and renting versus ownership of housing. We also can eliminate the federal government or eliminate multiple local jurisdictions. We examine a number of these variations quantitatively to make comparisons across policy regimes and economic settings in general equilibrium. For example, not surprisingly housing owners tax property less than renters to avoid capital losses.

Four key positive implications from our theoretical and quantitative analysis accord well with features observed in the U.S. in the main federated settings we study.¹ 1) At the federal level, an income tax is adopted to fund income redistribution. 2) At the local level, there is income stratification across jurisdictions. 3) When use of lump-sum taxes is constitutionally limited, as observed in practice, localities other than the central city rely on property taxation to fund provision of local public goods. They eschew use of income taxes, and they do not redistribute. 4) Within the central city, revenue is raised with property taxes supplemented for some parameters with very modest income taxation. This revenue is used to provide local public goods and to provide some limited income redistribution.

As we noted above, the traditional argument, going back to Stigler (1957) and Musgrave (1971), is that households' ability to relocate among local jurisdictions curtails the incentive to attempt local redistribution; an attempt by the pivotal voter in a community to redistribute would cause richer households to emigrate and poorer households to immigrate, with dire consequences for the tax base. Our

¹ See Baicker, Clemens, and Singhal (2012) for U.S. evidence regarding federal vs. local public expenditure and taxation policies. Specific evidence is provided in Section 5.

findings support the prediction that localities will not redistribute, but, interestingly, the mechanism giving rise to this outcome is somewhat different from that suggested by Stigler and Musgrave. In our model, households choose communities optimally prior to local policy determination (anticipating continuation equilibrium), but we allow them to relocate following all policy choices. While this is more difficult to analyze than having locational choice just once, it is to allow “unlimited” mobility.² Households sort across communities because of differing preferences for local public goods. This gives rise to income stratification across communities. Median income is typically less than the mean in communities, seemingly setting the stage for pivotal voters in all communities to tax for redistribution. However, because of stratification, the difference between median and mean income within communities is relatively small. In addition, any local taxes for redistribution come atop taxes that fund the local public good and atop the federal income tax. Such additional local taxes would create an additional deadweight loss larger than the gain that the pivotal voter would obtain from the local redistribution. We find that local redistributive taxes would not arise even if we shut down voters’ ability to relocate to avoid such a tax. Household sorting to live among those having similar preferences for public goods is sufficient to curtail local income redistribution: A threat by the rich (poor) to leave (move to) a community that attempts redistribution as in the traditional argument is unnecessary.³

We also undertake quantitative comparison of normative properties of equilibrium in federal systems to cases of one-tiered government. The main results here are: 1) Permitting federal taxation for redistribution increases equity but reduces efficiency as a result of their redistributive policy; and 2) Household sorting across localities in a federal system is highly inefficient unless local lump-sum taxation is unrestricted, this a generalization of the main finding in Calabrese, Epple, and Romano (2012).

As noted, a key theoretical challenge is the “Plott (1967) problem” that arises with majority choice equilibrium over multiple policy variables. The preference function we adopt permits us to map preferences over a 6-element policy and price vector into a simple linear indirect utility function over two “composite public goods.” This greatly simplifies the analysis and provides intuition about relative policy preference of households with differing incomes. It facilitates proving existence of majority choice in the local jurisdictions and also facilitates the analysis of household sorting.⁴ In addition, this

² To be clear, we vary the proportion of households that are mobile following initial community choices, but do consider the case of unlimited mobility. Kessler and Lufesmann (2005) likewise model household locational choice and examine redistribution in a Tiebout model with one tier of government.

³ The initial mobility that implies income sorting is needed for the logic of the result of no or very limited local redistribution. Still the logic is different than the traditional argument that the threat of relocations unfavorable to the local tax base precludes local redistribution. The income sorting in the equilibria we obtain is also relevant to when the model is applicable, as we discuss later. We discuss later how our model and findings relate to research on federal and local governments by Boadway, Marchand, and Vigneault (1998) and Gordon and Cullen (2011).

⁴ This simplification permits us to use single-crossing properties to establish existence results, placing the Plott existence conditions in the background.

characterization permits development of sufficient conditions for existence of majority choice of the federal income tax for direct redistribution. This approach may in turn prove valuable in other applications with multiple policy instruments, discussed in Section 5.

This paper bridges two literatures. The equilibrium among the local jurisdictions in our model conforms to a Tiebout equilibrium, so this paper relates to the large theoretical Tiebout (1956) literature on multi-jurisdictional economies with endogenous policy determination.⁵ Much of this literature is focused on efficiency issues, while our key theoretical contribution about existence is positive. Limited positive research on multiple tax instruments exists, surely because of the Plott existence problem, with the following exceptions. Along the lines of 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. Krellove (1993) examines the preferred tax form in a multi-jurisdictional model assuming identical households. Henderson (1994) also studies choice of tax instruments in a multi-jurisdictional setting with identical households, comparing voting equilibrium to developer equilibrium. The assumption of identical households resolves the existence problem among voters in the latter two papers. Nechyba (1997) shows in a multi-jurisdictional model with mobile heterogeneous households that, with availability of both income and property taxes to finance public goods, only property taxation arises unless jurisdictions collude (or there is another centralized tier of government). 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, including our examination of majority choice in both tiers of government and of direct redistribution.⁶ The utility specification used here to establish existence of majority choice equilibrium is presented in Calabrese, Cassidy, and Epple (2002). We generalized the latter analysis in Calabrese, Epple, and Romano (2015; CER henceforth). In this paper, we build on the CER (2015) model by adding a central tier of government to study central vs. local tax-redistribution policies in political equilibrium. The present paper's focus is on taxation and redistribution in a federation, while CER (2015) has only one tier of government. Adding a central government is essential for providing a positive analysis of tax and expenditure instruments chosen at different government levels, for explaining

⁵ Gravel and Oddou (2014) provide general conditions for income sorting in Tiebout equilibria with exogenous public good levels and taxes. We discuss this paper further below. Important references not discussed elsewhere in this paper are Ellickson (1971), Hamilton (1975), Westhoff (1977), Wooders (1980), Wildasin (1980), Boadway (1982), Brueckner (1983,2004), Zodrow (1984), Epple, Filimon, and Romer (1984), Inman (1989), deBartolome (1990), Benabou (1993,1996), Wilson (1997), Nechyba (1999,2000), Fernandez and Rogerson (1996,1998), and Epple and Platt (1998), and Epple and Romano (2003). A strand of the literature concerns taxation of mobile capital which is not an element of our model.

⁶ Nechyba's model includes a national public good, which we do not have. Nechyba's consideration of state income taxation with local property taxation relates to the fiscal federalism literature discussed below.

the extent of redistribution that arises in reality, and for analyzing how local majority choice is affected by the central government. Having a multi-layered governmental structure poses new theoretical challenges that we address in this paper.⁷ Epple and Romer (1991) show local redistribution can characterize equilibrium in a single-tiered Tiebout model that assumes local property taxation, in contrast to our findings. As summarized above and discussed further below, the key difference explaining the alternative findings about local redistribution is the existence of local public goods in our model: Local public good provision increases the distortion from property taxation, deterring local property taxation to redistribute.⁸

Another large literature on fiscal federalism concerns the vertical relationship between tiers of government. Much of the fiscal federalism literature is intended to explain decentralized (local) versus centralized (federal) provision of public goods, with Oates' (1972a, 1972b) Decentralization Theorem the centerpiece.⁹ Within the fiscal federalism literature, papers most closely related to ours are those that examine equilibrium choice with two tiers of government. In particular, Boadway, Marchand, and Vigneault (1998; BMV henceforth) and Gordon and Cullen (2011; GC henceforth) analyze redistributive income taxation in two tiered government employing an alternative to majority decision making.¹⁰ BMV and GC both assume the objective of the central government's decision maker weighs all households, with an incentive to redistribute wealth, and local government decision makers have the same form of objective but place weight only on residents in their locality.¹¹ Given imperfect mobility of households between local jurisdictions and some taxation and redistribution by the central government, the local government decision makers have one incentive to engage in excessive local redistribution since part of the efficiency costs spill over to other localities through the effects on central redistribution – a vertical

⁷ For tractability in the more complex setting here, we use a “utility taking” assumption concerning voters' beliefs, while a Nash assumption is made in CER (2015). This is explained below.

⁸ Hansen and Kessler (2001) examine mobility, redistribution, and income sorting assuming income taxation with one tier of government and two jurisdictions. If one jurisdiction is sufficiently small, then income stratification results in equilibrium with the rich clustered in the small jurisdiction and very limited redistribution there. The latter finding is akin to the lack of local redistribution we find resulting from sorting. In a very similar model, Rohrs and Stadelmann (2014) show that a sufficiently large immobile population (equated to home owners in their model) supports equilibrium income sorting and local redistribution can arise. Like in Epple and Romer (1991), these models have no local public good.

⁹ The thrust of the Theorem is that public good provision should be locally determined whenever no externalities outside the locality arise, this to facilitate local preference matching. See Oates (1999) for discussion and references and Nechyba and Epple (2004) for a wider survey and additional references. A second wave of research on centralization v. decentralization begins with the observation that centralized provision can vary across localities, thus expanding the inquiry about the relative advantage of decentralized provision. This strand of the literature shows alternative political regimes can explain whether centralization or decentralization is relatively efficient. See Lockwood (2006) for a survey and references.

¹⁰ See also Gordon (1983), Johnson (1988), Wildasin (1991), Inman and Rubinfeld (1996), and Feldstein and Wrobel (1998).

¹¹ For expositional efficiency, our discussion of these two papers suggests the papers are essentially the same, when in fact GC significantly advance the earlier BMV analysis. BMV assumes linear income taxation, while GC examine fully nonlinear taxation. GC use a more general objective function of the government decision makers. GC evaluate their more complete predictions empirically.

externality - but they (sometimes in BMV) have a counter-incentive to redistribute too little to attract (repel) wealthier (poorer) households – a horizontal externality. The central government engenders the efficient allocation by taxing and redistributing so that the vertical externality localities face offsets the horizontal externality. Then equilibrium has both federal and local income taxation and redistribution, in contrast to our findings. After we have developed our results, we discuss what underlies the differences in the findings.

To summarize our contributions: (i) First we show existence of equilibrium for a federation with two tiers of government and majority choice of tax instruments and redistribution at both tiers. (ii) Second, we provide a model that is consistent with empirical regularities, redistribution being the purview of the central government, household sorting locally by income, and heavy reliance on property as opposed to local income taxation to fund local public goods. The model clarifies the incentives that underlie these findings. (iii) We compare in general equilibrium policy regimes that vary with respect to tax limitations, as well as examine differences if housing is rented or owned, these generally having expected quantitative effects, while preserving our main qualitative findings. (iv) We also generalize a result (Calabrese, Epple, and Romano, 2012) concerning the inefficiency of household sorting in Tiebout equilibria that proscribes lump-sum taxation and relies on property taxation.

This paper proceeds as follows. In the next section, we present the model. General theoretical results are presented in Section 3. The quantitative analysis makes up Section 4, including analysis of variations in the main model. Section 5 discusses the application of our model and related empirical evidence, and discusses our modelling assumptions. A summary makes up Section 6. Some technical analysis is collected in an on-line appendix.

2. The Model

Here we develop the main federal system model.

2.1 Households. The economy consists of a continuum of households that differ in their endowed income y and whether they are mobile. The economy pdf of income is denoted $f(y)$, positive on its support $S = [y_{\min}, y_{\max}] \subset \mathbb{R}^+$. Normalize the economy's population to equal 1. An exogenous proportion $\rho(y) \in [0, 1]$ of income y households are mobile, the precise meaning clarified below. Households obtain utility from consumption of a local public good, g , the quality/quantity of housing consumed, h , and numeraire consumption, b . Households have the same utility function of form:

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

with all functions increasing and twice differentiable, and with $u(h,b)$ quasi-concave and homogeneous of degree 1.¹² While obviously restrictive, (1) permits substantial variation in preferences, and income affects demands in a realistic way. Though estimates of the income elasticity of housing demand vary, the unitary elasticity implied by this specification falls well within the range of empirical estimates (e.g., Harmon 1988). Higher income households obtain a higher marginal benefit from increases in the local public good.

2.2 Jurisdictions and Housing Supplies. The economy is divided into an integer number of local jurisdictions, J , each characterized by a non-decreasing housing supply function: $H_s^j(p_h^j)$, $j=1,2,\dots,J$; where p_h^j denotes the supplier price of housing services. Throughout we use a j superscript to indicate a value for jurisdiction j , though dropping it when obvious by context. The notation ‘ $-j$ ’ indicates the set of jurisdictions other than j . Households rent housing in their local competitive housing market. We assume housing suppliers are absentee for simplicity. We later show the main results carry over to a case with housing owners. We frequently refer to a local jurisdiction alternatively as a “community.”

2.3 Policy and Timing of Choices. We first give a brief overview of the timing of choices, and then provide the detail. Equilibrium unfolds in five stages (see Figure 1). In Stage 1, households choose by majority vote an economy-wide or federal income tax $m^f \geq 0$, the proceeds of which finance a uniform lump-sum income transfer, r^f . Second, in Stage 2, households select a jurisdiction where they plan to live and will vote on local policy. Third, in Stage 3, households vote on local policy consisting of a property tax, $t^j \geq 0$; local income tax, $m^j \geq 0$; and local lump-sum transfer (or tax if negative), r^j ; with net tax revenues used to provide a local public good, g^j . Fourth, in Stage 4, mobile households can costlessly relocate to another jurisdiction.¹³ Fifth, in Stage 5, housing is chosen and local housing markets clear, federal and local budgets balance determining respectively r^f and g^j , and households consume.

We can now provide a more detailed description, working backward from Stage 5. Entering Stage 5, the policy vector $P^j \equiv (m^j, t^j, r^j, m^f)$ in each jurisdiction j is given, where we include the federal income tax rate in the vector. Each jurisdiction’s measure of income types, denoted $f^j(y)$, is also determined prior to Stage 5. Let $n^j \equiv \int_S f^j(y) dy$ denote the “number” of households residing in j . In Stage 5, the values of individual housing consumption, $h_d^j(y)$, numeraire consumption, $b_d^j(y)$, taxable

¹² As shown in the on-line appendix, u can be homogeneous of any degree. Also, our results apply to an extended version of the utility function with $U = v \cdot (u + \phi)$, with ϕ a constant.

¹³ We use the expression “mobility” here to refer to the ability to move between jurisdictions following initial community choice, in contrast to Epple and Romer (1991) who use mobility to refer to the ability to select a jurisdiction in which to live prior to local policy choices. The present model also assumes the latter “mobility.”

income, $x^j(y)$, the gross and net housing prices, (p^j, p_h^j) , local public good levels, and the federal transfer are determined, satisfying the following set of equations.

$$(2) \quad (h_d^j, b_d^j) = \text{ARGMAX}_{h^j, b^j} v(g^j)u(h^j, b^j) \\ \text{s.t. } b^j + p^j h^j = r^j + r^f + y\{1 - [1 + \omega(m^f + m^j)](m^f + m^j)\}$$

$$(3) \quad x^j(y) = \frac{y \cdot \{1 - [1 + \omega(m^f + m^j)](m^f + m^j)\}}{1 - m^f - m^j}.$$

$$(4) \quad \int_S h_d^j(y) f^j(y) dy = H_s^j(p_h^j)$$

$$(5) \quad p^j = (1 + t^j) p_h^j$$

$$(6) \quad n^j(r^j + g^j) = \int_S m^j x^j(y) f^j(y) dy + t^j p_h^j H_s^j(p_h^j)$$

$$(7) \quad r^f = \sum_{j=1}^J \int_S m^f x^j(y) [f^j(y) / n^j] dy$$

Equations (2) and (3) describe individual consumption, where $\omega(\cdot) \geq 0$ is a non-decreasing and continuous income tax distortion function. This specification follows Feldstein (1999). 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 $(p^j h^j)$ plus consumption of the composite good b^j , but subtracting the lump-sum transfers $r^j + r^f$ that we assume are not taxed. Thus, the household's budget constraint is as stated in (2). In turn, taxed income, x^j , satisfies (3). The subscripts d on the consumption values are to denote Marshallian demand.

Equation (4) is the housing-market clearance condition, with (5) the identity between gross and net housing price. Equation (6) is the local government budget balance condition. Equation (7) is the federal government budget balance condition.

With our assumption on the utility function and the housing supply functions, all values determined in Stage 5 are unique given the input vector $(P^j, f^j(y))$.

In Stage 4, mobile households can costlessly relocate to another community. The $1 - \rho(y)$ immobile households with income y are locked into the community they choose in Stage 2. We investigate computationally how varying $\rho(y)$ affects equilibrium. Following the literature on club goods, we assume mobile households are “utility takers” in making their own relocation choice and in

anticipating relocation choices of others. To clarify this simplifying assumption, note first that no one relocates in equilibrium as explained below, but relocation can occur off the equilibrium path. Utility taking means that households in community j take the equilibrium policies and prices in communities $k \neq j$ as given, and then compute utilities of any mobile households under this assumption in predicting moving. This is an approximation since this utility would not generally equal the continuation utility if there is a finite population change in community k .¹⁴ Note that households correctly anticipate all continuation equilibrium values in their initially chosen community given the latter relocations.

Entering Stage 3, initial locations and the federal tax rate are fixed. In each community j , majority choice of the local policy vector (m^j, t^j, r^j) occurs, with all households anticipating the continuation values in Stages 4 and 5.

In Stage 2, given m^f , households choose their “initial” communities, anticipating how equilibrium will unfold. Since households are atomistic and thus individually have no effect on policy, mobile households are actually indifferent to their initial community choice. We then restrict attention to “no-relocation equilibria,” which assumes mobile households select the community where they will ultimately reside. As noted above, no household relocates *on the equilibrium path*. *A no-relocation equilibrium is also the only type of equilibrium if households discover whether they are mobile after having chosen their initial community.*¹⁵

In Stage 1, majority choice by all households of the federal income tax occurs, with households anticipating the resulting equilibrium from Stage 2 forward. In Section 5 we analyze some variations in the model and discuss further some of our modelling assumptions.

2.4 Existence of Equilibrium, Community Differentiation, and Equilibrium Selection. We do not have a general existence proof, but develop sufficient conditions for existence that can be checked computationally. We confirm that these conditions hold in our quantitative analysis in cases of interest.

We show equilibrium has income stratification.¹⁶ A multiplicity issue arises if jurisdictional housing supplies differ. Suppose, for example, that $J = 2$ and one jurisdiction has rightward shifted

¹⁴ Since P^j is committed before Stage 4, it is the values of g^j and r^f that can change following finite relocations and then change utility from the models’ equilibrium utility. Utility taking then means that households do not have fully rational expectations off the equilibrium path. This assumption greatly simplifies computation of equilibrium and some proofs, and we have found it in closely related analysis (e.g., CER, 2015) to have very minor quantitative effects relative to assuming full rationality and subgame perfection.

¹⁵ Specifically, then let $\rho(y)$ denote the known probability that a household with income y will be mobile, an individual’s mobility discovered following initial location but before Stage 3 commences.

¹⁶ In many multi-jurisdictional models where equilibria with differentiated communities exists, equilibria also exist in which two or more jurisdictions have the same income distributions and the same policies. We do not find such “clone community” equilibria in our model due to household mobility. In such equilibria, households anticipate the same populations and policies, and then are indifferent to where they locate initially, thus are content to sort to have clone communities. Moreover, with the same community populations, equilibrium policy choices will be the same.

housing supply relative to the other. Any stratified equilibrium has a rich and poor jurisdiction. Two such equilibria can then arise, one with the “larger” community being the rich one, and the other with the larger community the poor one. The threshold income separating the two income strata in the two equilibria will generally differ. More generally, $J!$ alternative stratified equilibria can exist. We resolve this issue by assuming the largest jurisdiction (i.e., with most rightward shifted housing supply) is the poorest (the central city), the second largest is the second poorest (poorest suburb), and so on. Thus, when voting in Stage 1 on the federal income tax rate and when making their initial community choices in Stage 2, households anticipate among any multiplicity of stratified equilibria the latter type equilibrium. Note, too, that if each jurisdiction has the same housing supply, this multiplicity issue does not arise.

3. Theoretical Results

3.1 Indirect Utility over Composite Public Goods. The form of the utility function in (1) underlies existence of equilibrium, including with regard to existence of majority choice equilibrium over local policies. Lemma 1 describes an indirect utility function that facilitates showing our main results.

Lemma 1. Indirect utility of household y living in community j is given by:

$$(8) \quad \begin{aligned} V(\Gamma^j, \Omega^j, y) &= y \cdot \Gamma^j + \Omega^j; \\ \Gamma^j &\equiv v(g^j) \cdot [1 - (1 + \omega(m^f + m^j))(m^f + m^j)] \cdot w(p^j); \\ \Omega^j &\equiv v(g^j) \cdot (r^f + r^j) \cdot w(p^j); \\ &\text{where } w'(p^j) < 0. \end{aligned}$$

Lemma 1 is shown by solving the maximization in (2) using the assumed form of utility in (1).¹⁷ Lemma 1 is closely related to Proposition 1a in CER (2015).¹⁸ A proof is provided in the on-line appendix, which closely tracks the proof in the latter paper.

An example helps to clarify interpretations. Let utility be Cobb-Douglas, $U = g^\beta h^\alpha b^{1-\alpha}$, which we adopt in our computational analysis. The indirect utility function in community j is given by:

However, provided some households are mobile (i.e., $\rho(y)$ is bounded above 0) and the same local policies and populations characterize communities, then a marginal policy change in one jurisdiction will induce finite population relocation. We find computationally that the pivotal voter would generally prefer a small policy change to induce “massive” desirable household relocations (e.g., increasing the local lump-sum tax to draw in richer households, while driving out poorer households). With jurisdictions stratified by income, marginal local policy changes induce marginal relocations so that equilibrium with stratification can then exist.

¹⁷ The indirect utility function is an example of what Grandmont (1978) termed “intermediate preferences.”

¹⁸ In CER (2015), there is no federal government, hence no federal income tax and transfer. Lemma 1 generalizes Proposition 1a in CER (2015) to the presence of a federal policy.

$$\begin{aligned}
V &= (g^j)^\beta \alpha^\alpha (1-\alpha)^\alpha (p^j)^{-\alpha} \{y[1-(1+\omega)(m^f + m^j)] + [r^f + r^j]\} \\
(9) \quad v(g^j) &= (g^j)^\beta; \quad w(p^j) = \alpha^\alpha (1-\alpha)^\alpha (p^j)^{-\alpha} \\
\Gamma^j &= (g^j)^\beta \alpha^\alpha (1-\alpha)^\alpha (p^j)^{-\alpha} [1-(1+\omega)(m^f + m^j)] \\
\Omega^j &= (g^j)^\beta \alpha^\alpha (1-\alpha)^\alpha (p^j)^{-\alpha} [r^f + r^j]
\end{aligned}$$

The value of Lemma 1 is that for given policies (P^j, g^j, r^f) and housing price p^j , whether already set or anticipated, utility is a simple linear form in the “composite public goods” (Ω^j, Γ^j) and income.

Moreover, it is implied that higher income households have a relative preference for Γ^j , with linear indifference curves $V(\Gamma^j, \Omega^j, y) = \text{const.}$ in the (Ω^j, Γ^j) plane and that satisfying single crossing in income. Higher income households are willing to give up more Ω^j for Γ^j at any (Ω^j, Γ^j) ; the indifference curves flatten as income rises. As one can see by inspection of (8) or (9), higher income households are more averse to income taxes, while lower income households place a higher relative value on lump-sum positive income transfers. Note, though, that the converse of the latter is that higher income households have a relative preference for a local lump sum tax (i.e., $r^j < 0$).¹⁹ Aversion to property taxes is implied by (5) and that $w'(p^j) < 0$, keeping in mind p^j increases with t^j .²⁰ This simple form of the indirect utility function plays a central role in all the propositions that follow.

3.2 Jurisdictional Majority Choice Equilibrium. The first proposition regards majority choice equilibrium of local policies in the J jurisdictions, or the continuation equilibrium of the model at the beginning of Stage 3. To characterize and understand this continuation equilibrium, define jurisdiction j 's government budget constraint (GBC^j) as the locus of values of (Ω^j, Γ^j) as policies (m^j, t^j, r^j) vary over their feasible values. Along a GBC^j , m^f and initial household location are given (pre-determined), with (g^j, p^j, r^f) satisfying (2)-(6) for anticipated relocations by community j residents as the local policy vector varies.

We write the locus as $GBC^j(\Gamma^j, \Omega^j; m^f) = 0$. Figure 2 shows an example of a GBC .

A voter in jurisdiction j has preferred policy that solves:

$$\begin{aligned}
(10) \quad & \text{MAX}_{\Gamma^j, \Omega^j} y\Gamma^j + \Omega^j \\
& \text{s.t. } GBC^j(\Gamma^j, \Omega^j; m^f) = 0
\end{aligned}$$

The main result here is:

¹⁹ Ω^j is negative if community j has a lump sum tax that is higher than the federal income transfer r^f .

²⁰ Aversion to property taxes assumes a non-zero housing supply elasticity so that market-clearing p^j increases with the property tax, i.e., that housing suppliers do not bear the full incidence of a property tax.

Proposition 1. For any m^f , majority choice equilibrium of policy exists in each jurisdiction j , and an equilibrium policy in jurisdiction j is a preferred policy of the median income household residing there.

Proof of Proposition 1. To make the argument, first assume that when voting every resident of jurisdiction j does not *itself* plan to relocate for any policy in jurisdiction j , though anticipating all others' relocations under the utility taking assumption. Then, using the single-crossing property of the indirect utility function, a standard argument implies the results in the Proposition regardless of the shape of the GBC.²¹ We must argue that this pseudo-equilibrium continues to be the majority choice equilibrium when mobile voters contemplate their own relocation whenever optimal. No one household's relocation choice affects the GBC, so the GBC is the same as in the pseudo-equilibrium. The pseudo-equilibrium is in fact an equilibrium, for the following reason. All those in the majority that vote against any alternative policy to the candidate equilibrium policy in the pseudo-equilibrium would continue to do so allowing them to move if they prefer. Obviously, any in this majority would continue to vote against an alternative policy if they would not relocate under the alternative policy. If they would relocate, then they anticipate lower utility than in the candidate equilibrium. This follows because their initial community choice maximizes utility among the policies that arise in equilibrium in all communities (by the no-move property of equilibrium on the equilibrium path). Thus, all in the majority would continue to prefer the candidate equilibrium policy and vote against the alternative. Thus, the candidate equilibrium policy continues to garner a majority against all other policies and is therefore an equilibrium.

To complete the proof we must show that only a preferred choice of the median income household in the community is a majority choice equilibrium. Again, first assuming no voter contemplates their own moving when voting, the single-crossing property implies a preferred choice of the median income household is majority preferred to any other feasible policy (on or below the GBC). But since no one relocates in equilibrium and relocating out of equilibrium implies lower utility than in equilibrium, the majority preference for a median income household's preferred policy over any other is sustained. ■

Given household sorting and m^f , equilibrium in any jurisdiction is generically unique since the preferred policy of a median income household is generically unique. This follows since the equilibrium is a tangency between the median income household's indifference curve and the GBC (see Figure 2), and multiple tangencies between the GBC and the given indifference curve will not arise generically as the GBC depends on the entire population of the community.

While dependent on the assumed form of the utility function, the generality of existence of the community majority choice equilibrium bears emphasis. In particular, equilibrium will exist regardless of

²¹ See, e.g., Epple and Romer (1991).

the shape of the GBC, thus regardless of the incomes of households that make up the community and the federal income tax rate. Existence depends only on the single-crossing property of the indifference curves. Likewise, exogenous restrictions on tax rates (e.g., a property tax limit) or on tax forms (e.g., disallowance of a local lump-sum tax) would not disrupt Proposition 1 because such restrictions only affect the GBC.

Corollary to Proposition 1. For any m^f and restrictions on local taxes, majority choice equilibrium of policy exists in each jurisdiction j , and an equilibrium policy in jurisdiction j is a preferred policy of the median income household residing there.

Proposition 1 essentially generalizes Proposition 2 in CER (2015) to inclusion of a federal income tax.²²

3.3 Household Sorting. Now we develop the main result about household sorting in Stage 2, assuming community differentiation arises. In equilibrium entering Stage 2, households anticipate the equilibrium values of (Γ^j, Ω^j) , $j = 1, 2, \dots, J$. Households optimally select a community that maximizes $V(\Gamma^j, \Omega^j, y)$. The main result here is stated next.

Proposition 2. Assume $\Gamma^J > \Gamma^{J-1} > \dots > \Gamma^1$ and all communities are occupied. Then: (i)

$\Omega^J < \Omega^{J-1} < \dots < \Omega^1$; (ii) those with income on (y_{j-1}, y_j) select community $j = 1, 2, \dots, J - 1$, where $y_0 = y_{\min}$ and $V(\Gamma^j, \Omega^j, y_j) = V(\Gamma^{j+1}, \Omega^{j+1}, y_j)$, $j = 1, 2, \dots, J - 1$; and those with income $y > y_{J-1}$ select community J .

Proof of Proposition 2. (i) If $\Omega^j \geq \Omega^{j-1}$ for any communities j and $j-1$, then everyone would prefer community j to $j-1$, and $j-1$ would attract no residents. (ii) Using (i), this follows by a simple single-crossing argument using that higher income types have flatter indifference curves in the (Ω, Γ) plane. ■

When differentiated communities arise, income stratification across communities arises, with higher Γ communities attracting richer income strata.²³ Intuitively, richer voters reside in communities

²² We write “essentially” because we make the above-described “utility taking” assumption about relocation expectations here, while CER (2015) makes a Nash assumption.

²³ Gravel and Oddou (2014) provide necessary and sufficient conditions on the utility function or on the implied demands for public goods such that income segregation obtains in a Tiebout model with multiple public goods, taxation of income and housing, and frictionless household mobility. Their focus is on stratification, assuming exogenous tax rates and public good levels. While the tax rates and public good levels in our model – which can be regarded as the federal lump-sum subsidy/tax and the local public good – are endogenous in our analysis, their results can be applied to household sorting in Stage 2 of our analysis. This is because we assume the no-move equilibrium and, on entering Stage 2, tax and public good levels are either set or anticipated (and unaffected by any one voter’s choice of community). As Gravel and Oddou show, their key condition can be presented as demand for any one public good being monotonic in the price of private good consumption, which is satisfied in our model. With multiple public goods, they show that additive separability of the utility function is also necessary for

with lower local income tax and lower lump-sum transfer (or higher lump-sum tax). Richer households also, though, value higher g by more. The threshold y_j households are indifferent between communities j and $j+1$, and equilibrium is unaffected by where they reside due to atomism of households. We illustrate these equilibria in the next section.

3.4 Majority Choice of the Federal Income Tax. The next proposition provides sufficient conditions for existence of a majority choice equilibrium of the federal income tax rate, given continuation equilibrium exists for all m^f . Given satisfaction of the conditions, equilibrium in the entire model exists. We confirm existence computationally in well-motivated cases below. If multiple continuation equilibria exist for any given m^f , then we assume the equilibrium selection discussed above.²⁴ Number the J communities so that $\Gamma^J > \Gamma^{J-1} > \dots > \Gamma^1$ in all continuation equilibria. Let y_m denote median income in the population, and let m_m^f denote the median income type's preferred federal income tax. Let $k \leq J$ denote the number of the community that the median income type chooses to reside in the continuation equilibrium with $m^f = m_m^f$.

Proposition 3. m_m^f is a majority choice of the federal income tax rate if: (i) y_{\max} and all y_j , $j = k, k+1, \dots, J'-1$, are worse off in any continuation equilibrium with $m^f > m_m^f$; and (ii) y_{\min} and all y_j , $j = 1, 2, \dots, k-1$, are worse off in any continuation equilibrium with $m^f < m_m^f$.

Comment: Recall that y_j denotes an income type that is indifferent between residing in communities j and $j+1$. The number of y_j values in the conditions of Proposition 3 depends on J and k . In the main cases we examine below, $J=3$ and the median income household resides in community 2, i.e., $k=2$. Then there is one value of y_j in Condition (i), the household indifferent between residing in communities 2 and 3, and one value of y_j in Condition (ii), the household indifferent between residing in communities 1 and 2.

Proof of Proposition 3. Refer to Figure 3. It shows the values of the composite public goods in community k and in community $k+1$ in the candidate equilibrium, assuming a community $k+1$ exists. It also shows the equilibrium indifference curve of the median income household (I_{y_m}), the equilibrium

stratification, which our utility function does not satisfy. The difference is that one of the two public goods, namely the federal lump-sum subsidy/tax, is uniform across the local jurisdictions in our model, which makes this separability unnecessary. Rather than using their approach in Stage 2, we have employed the single-crossing condition on the composite public goods, which we use not just to show stratification, but to develop majority choice results. See also Gravel and Thoron (2007) and Biswal, Gravel, and Oddou (2013) for related analyses.

²⁴ Proposition 3 that follows does not require this selection criteria, but only that there is some selection criterion that is common knowledge among households.

indifference curve of y_k , and the equilibrium indifference curve of a household with income $y' \in (y_m, y_k)$. We argue that Condition (i) implies any households with incomes in the range $[y_m, y_k]$ would vote against any values of $m^f > m_m^f$. Obviously this holds for $y = y_m$, since m_m^f is y_m 's preferred federal income tax. Any value of m^f implies a continuation equilibrium with a set of community choices and corresponding composite public good pairs (Ω^j, Γ^j) , $j=1, 2, \dots, J$. All these points, for any $m^f > m_m^f$ must lie below I_{y_m} in Figure 3, or the preference of the median income type is contradicted. Condition (i) implies all these points must also lie below I_{y_k} , or the assumed preference of y_k is contradicted. Obviously, y_k votes against any increase in m^f . From Proposition 2, all those with income on (y_m, y_k) reside in community k in the candidate equilibrium, and so their equilibrium indifference curve goes through (Ω^k, Γ^k) , with slope between that of I_{y_m} and I_{y_k} . Thus, one can see that any of these household would also vote against any $m^f > m_m^f$.

Storing the latter result for the moment, now suppose instead that there is no community $k+1$, i.e., the median income household in the candidate equilibrium resides in the community with the highest Γ . Then, by Proposition 2, the highest income household y_{\max} resides in that community, and has flatter equilibrium indifference curve through (Ω^k, Γ^k) than does y_m . The graph of this is analogous to Figure 3 but with the equilibrium indifference curve of y_{\max} replacing that of y_k and with no point $(\Omega^{k+1}, \Gamma^{k+1})$. Using Condition (i), a parallel argument to that in the latter paragraph implies all those with income on $[y_m, y_{\max}]$ would vote against any federal income tax increase, which is a majority.

Now return to the previous case where a community $k+1$ exists in the candidate equilibrium. There are two possibilities. One is where there is no community $k+2$, i.e., community $k+1$ has the highest Γ in the candidate equilibrium. Then y_{\max} lives in community $k+1$, and one can use Condition (i) and the equilibrium indifference curves of y_k and y_{\max} to make the parallel argument as in the previous paragraph to show that all those with income $[y_k, y_{\max}]$ would vote against any increase in the federal income tax rate. Again, using the earlier result, a majority then vote against any increase in the federal income tax. In the second case there exists another community $k+2$, with $\Gamma^{k+2} > \Gamma^{k+1}$. Using Condition (i) and the indifference curves of the indifferent households y_k and y_{k+1} , one can make the parallel argument that all those with income on $[y_k, y_{k+1}]$ would vote against any increase in the federal income tax. Making this argument successively until all communities with higher Γ than Γ^k implies a majority would vote against a federal income tax increase.

An analogous argument using Condition (ii) shows that a majority consisting of households with income below y_m vote against any federal income tax decrease, completing the proof. ■

The conditions in Proposition 3 are fairly intuitive and can be applied. Regarding intuition, one would expect relatively higher income households to be averse to federal income tax increases, and the reverse for relatively lower income households, keeping in mind revenues are used for a lump-sum income transfer. Proposition 3 pins down a (small) finite subset of households such that, if the latter preferences hold, the preference of the median type is an equilibrium. Regarding application, we use these conditions to confirm equilibrium in non-trivial cases in the next section.

While the proof uses the single crossing property of the indirect preferences over composite public goods, *it bears emphasis that this is not a standard single crossing argument*. In the standard single crossing argument for existence of majority choice equilibrium, any policy alternative leads to the same point in the relevant policy space determining utility for *every* voter. This is not the case here. Rather, a policy (m^f) leads to a set of outcomes, namely (Ω^j, Γ^j) , $j=1, 2, \dots, J$, over which voters choose. Generally, voters choose different alternatives in the set. Single crossing itself is enough to imply majority choice equilibrium in the standard application, e.g., as in Proposition 1 above. Here, we must further show that a small subset of voters oppose federal income tax changes. This can also be framed as requiring some restrictions on the composite good choice sets among locations as the federal income tax varies. We provide this alternative form of the Proposition in the on-line appendix. *The theoretical argument for existence of majority choice equilibrium is new to our knowledge* and has potential to be applied in other public choice problems with stages of choices.

4 Quantitative Model

4.1 Model Calibration. To show existence and develop more specific implications about the features of equilibrium, we specify and calibrate a quantitative model. 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.

As noted above, we assume a Cobb-Douglas utility function: $U(g, h, b) = g^\beta h^\alpha b^{1-\alpha}$, with parameters that satisfy the homogeneity assumption required of (1). We choose 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%²⁵ and the fraction spent on local public goods would be 9%, which is approximately the share of

²⁵ The share of aggregate income spent on housing of 20% is in the range of values estimated in the literature.

GDP spent on local public goods.²⁶ This yields $\alpha = 0.21978$ and $\beta = 0.098901$. The expressions for the implied indirect utility function and composite goods were provided above in (9).

To calibrate the housing supply functions, we assume price taking housing producers combine the community's 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, a community's housing supply is given by a constant elasticity supply function:²⁷

$$(11) \quad H_s^j(p^j) = L^j \cdot (p_h^j)^{\frac{1-\mu}{\mu}} \left(\frac{1-\mu}{p_w} \right)^{\frac{1-\mu}{\mu}}, \quad \varepsilon_H = \frac{1-\mu}{\mu};$$

where L^j is the land area of community j as a proportion of total (developable) land area in the economy (normalized to 1), μ is the ratio of non-land to land expenditure in the production of housing, ε_H is the housing supply elasticity, and p_w is the price per unit of non-land factors. 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. Since the choice of p_w does not affect equilibrium variable values that impact households' relative utilities, we choose it so that $\left(\frac{1-\mu}{p_w} \right) = 1$ when $\varepsilon_H = 3$. This implies $p_w = 3/4$.²⁸

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.²⁹ These values imply $\ln y \sim N(10.805, 0.791)$.

To calibrate the income tax distortion function, we assume for simplicity that $\omega(m^f + m^j) \equiv \omega$ is constant. We then compute a value of ω that produces an empirically relevant equilibrium for a single community model ($J = 1$), which we refer to as the "Unitary State." Of course, in this Unitary State equilibrium, the median income household is pivotal on all the policy variables, namely (m^f, t^j, r^j, m^j) , which imply the values of (r^f, g^j, p^j) . It can be shown that since m^f only finances r^f , the pivotal voter is indifferent between combinations of m^f and m^j such that $m^f + m^j = m^*$, and combinations of r^f and r^j such that $r^f + r^j = r^*$, where m^* is the pivotal voter's optimal income tax rate and r^* is the pivotal voter's optimal lump-sum grant. That is, the Unitary State equilibrium can be characterized by one m and one r .³⁰ Using the 2010 U.S. Census, we calculate aggregate household income of \$7,865,744 million. Total U.S.

²⁶ Data for this approximation are from the 2008 *Statistical Abstract* Tables 442 and 645 for 2004.

²⁷ See Epple and Zelenitz (1981). This derivation is also provided in the on-line appendix.

²⁸ The choice of p_w does not affect equilibrium relative utilities because the percentage of income households spend on housing is independent of the price of housing, given the adopted utility function.

²⁹ U.S. Census Bureau, 2011, Table H-6 from Historical Income Tables.

³⁰ This result will be provided upon request.

Federal Income tax receipts in 2010 were \$898,549 million.³¹ Hence, we estimate the average 2010 household income tax rate as 11.4%. Given the other calibrated parameters, we then find the ω such that the equilibrium has $m = 11.4\%$. This implies $\omega = 0.2471$. The first column of Table 1 reports key variable values of this Unitary State computational equilibrium, which are the same as in CER (2015). We report the equilibrium population proportion (n), property tax rate (t), the income tax rate (m), the lump-sum income transfer (r , or lump-sum tax if negative), and the per capita expenditure on the public good (g).³² The equilibrium has a positive lump-sum income transfer of \$9,415, with \$7,438 financed by the income tax rate and the remainder financed by part of the proceeds from the property tax rate. The positive transfer results because the pivotal voter has lower income than the mean, implying an income tax price to finance a transfer less than 1, but with the transfer limited by the tax distortion. Property taxes not contributed to the transfer finance the local public good, with expenditure of \$4,799 per capita. Part of the incidence of the property tax falls on the absentee housing suppliers, but higher housing rents as taxes rise curtail property taxation chosen by the pivotal voter. The property tax rate of 85% may appear very high, but this is a tax rate on services (rent), not value.³³ Using Poterba's (1992) conversion, a .85 tax on rent translates to a .09 tax on value.³⁴ This equilibrium will be used as the baseline case in examining the positive and normative impacts of multi-community federal systems.

In computation of federal systems with multiple local communities, we assume the number of local jurisdictions is $J = 3$. The idea is to have a central city and two suburbs. We must calibrate the land areas. As mentioned above, 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. To resolve this multiplicity, we designate the largest community to be the city and assume it is the poorest jurisdiction.³⁵ 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 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

³¹ Budget of the U.S. Government, Fiscal Year 2015, Historical tables, Table 2.1 Receipts by Source: 1934-2019.

³² The income tax rate can be described as the federal or local rate or their sum, and we report it as the federal rate in the tables for the Unitary State cases. To be clear, the total rate ($m^f + m^l$) is 11.4%. We do the same for the lump-sum transfer.

³³ To save space, we do not report equilibrium housing prices, but these are available on request.

³⁴ 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. Letting z denote the "user cost factor" and W the value of housing, the equilibrium rental rate of housing equals its user cost, according to: $p_h = z \cdot W$. 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.

³⁵ DeBartolome and Ross (2002) provide a dynamic analysis that predicts the relative wealth of the city as compared to the suburbs.

in the baseline federal system computational equilibrium, we constrain the city's population to 40% of the total population, while assuming the population shares in the two suburbs to be equal and thus 30% each. In addition, in our calibration, we assume full household mobility ($\rho(y) \equiv 1$), and we constrain any local lump-sum taxes (r^j) to be less than 5% of the total expenditure on public goods (g^j) in a community. We do not assume a constraint on local lump-sum grants should the pivotal voter in a community find this optimal. Given these assumptions and constraints, and the other already calibrated parameter values, the baseline federal system computation results in the city having 67.45% of the land area, the poor suburb having 20.59% of the land area, and the rich suburb having 11.96% of the land area.

4.2 Computational Findings.

4.2.1 Positive Analysis. The second through fifth columns of Table 1 report equilibrium values for four multi-community specifications, with the positive results in the upper part of the table and normative values in the lower part. In this Table, all households are mobile. We first discuss the positive values. Though we view the third column as the preferred case because it limits local lump-sum taxation (and which we used to calibrate the land areas), we first discuss the second column of the table, the federal model with no limits on taxes. *A key finding is that equilibrium exists.* To our knowledge, we are the first to find equilibrium with majority choice with two tiers of government and heterogeneous households. We have proved equilibrium holds generally beginning in Stage 3 (Proposition 1). Using the sufficient conditions for overall equilibrium in Proposition 3, we are able to write and execute a program that confirms satisfaction of these conditions and identifies equilibrium.³⁶ Numerous examples with existence are provided as we continue the discussion.

A specific property of the equilibrium that bears emphasis is that no redistribution nor income taxation arises in the local jurisdictions, though substantial federal income taxation and redistribution arises, more than in the Unitary State. Local taxation, which finances the local public goods, combines local lump-sum taxation and property taxation. We will see that no or very limited local redistribution and no or very limited local income taxation arise as we consider alternative cases (e.g., with tax limits). This contrasts with the findings of BMV (1998) and GC (2011). They show that in spite of the adverse effects on the tax base of local income taxation (a horizontal externality), local redistribution arises in a federal system due to a vertical externality that part of the burden of local income taxation is born by other jurisdictions as federal tax collection is reduced from the distortion of local taxation. What differs here? In BMV and GC the effective federal and local policy makers have similar redistribution

³⁶ The program is outlined in the on-line appendix.

incentives, facing the same tax bases (income distributions) and as if they have the same incomes,³⁷ their incentives differing somewhat due to the local decision maker's failure to account for the aforementioned externalities. The key difference in our model is that the effective federal and local policy makers, i.e., the relevant pivotal voters, have different incomes and face different tax bases, as a result of the equilibrium income sorting and endogenous determination of the local pivotal voters. The equilibrium has income stratification, with the poorest 71.6% living in the city, the middle-income 23.0 % living in the poorer suburb, and the richest 5.4% living in the rich suburb. In this column and in most of the examples we present, the local pivotal voter has income below the local mean income, implying some incentive to redistribute locally, but this incentive is relatively weak and largely (or completely) offset by the income tax distortion.³⁸ The on-line appendix provides theoretical analysis that confirms this. Note that the vertical externality in BMV and GC is present here, reinforcing the incentive to employ local income taxation. But it still does not occur. One might also expect that the mobility of households, i.e., the horizontal externality, is what underlies no or limited local income taxation: Local redistribution would attract (repel) poorer (richer) households that are mobile, lowering the tax base.³⁹ The lack of local redistribution is not, however, driven by this in our model. We know this because the same outcome arises as mobility is reduced, even to when only 1% of households are mobile. This is shown in Tables 2 and A1, which we discuss shortly. To our knowledge, we are the first to clarify that local income sorting that can result in a federated economy is sufficient to curtail local incentives to redistribute, independent of household potential to subsequently flee jurisdictions that impose significant redistribution.

Column 3 of Table 1 reports equilibrium values for our preferred case, the federal system with local lump-sum taxes constrained to not exceed 5% of expenditure on the local public good. One can see in Column 2 by comparing the lump-sum taxes to the per capita expenditures on the local public goods that lump-sum taxation is the predominant form of local finance in the suburbs (i.e., in richer communities) if allowed. In fact, local jurisdictions in the U.S. generally do not seem to have the authority to impose lump-sum taxes.⁴⁰ However, Hamilton (1975) argued some time ago that zoning

³⁷ Their models do not specify decision makers, rather specify the federal and local objective functions that determine policies. The federal and local objective functions instill a redistribution incentive and are the same except that the local objective function only weighs utilities of local residents.

³⁸ In Table 1 and the other tables, the community percentage is bolded if the median income is above the mean, these few cases implying no local incentive to redistribute using an income tax. For home renters, an incentive to employ property taxation to redistribute arises because partial incidence of the tax is on the absentee housing suppliers.

³⁹ The likelihood that mobility would limit the scope for local distribution was noted in early writings, including Stigler (1957) and Oates (1972). We should note that there is a counter-incentive to repel rich households, in fact all households, to keep down the equilibrium housing rents.

⁴⁰ Local taxing authority in the U.S. varies by state, with some federal constitutional restrictions. The disallowance of local lump-sum taxes we claim in the text is implicit in 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

restrictions on housing consumption combined with a property tax can provide a substitute for local lump-sum taxation. Building on this idea, we (2007) showed the near equivalence of political equilibrium with local lump-sum taxes to that with property taxes and minimum housing quality restrictions in a model with multiple jurisdictions. This provides an argument for the legitimacy of considering lump-sum taxes even in the presence of legal barriers, but the near equivalence breaks down when property taxes would also be enacted to appropriate housing supplier surplus as arises in the present model. More research is needed here.⁴¹ We take the position that a small amount of local expenditure might effectively be financed by lump-sum taxation, specifically assuming 5%.⁴²

We provide a graphical illustration of the workings of the model following initial community choice using the city from our preferred case in column (3) of Table 1. Figure 4 shows the government budget constraint for the city. Utility is increasing as the composite public goods increase so no voter would want policies that would lead to an outcome on the upward-sloping part of the GBC. As shown in Figure 3, voter indifference curves become flatter as income rises. Hence, as voter income rises, the voter's most-preferred point on the GBC moves upward to the left.

In Figure 5, we illustrate how city government policies most-preferred by voters change as voter income increases. The horizontal axis in each graph in Figure 5 is the income percentile of the voter. In equilibrium, 40% of the voter population lives in the city. Hence, the maximum value on the horizontal axis is .4. The pivotal voter has median income, and hence is at the middle of the horizontal axis, the 20th income percentile. The equilibrium policy choice is thus the preferred policy of that voter. From the left panel of Figure 5, we see that low income voters would opt for a very high local income tax rate, on the order of 20 percent, and a property tax rate of 65%.⁴³ As voter income rises, the preferred income tax rate declines rapidly while the preferred property tax rate rises by a relatively modest amount. The right panel of Figure 5 shows that the preferred total local per capita spending does not change much as voter income increases, but the mix of preferred spending changes very markedly. As voter income rises, the preferred

employer rather than the employee's residence. It is an interesting legal question as to whether use of local lump-sum taxes would satisfy federal law. Federal law requires that taxes are nondiscriminatory, but whether local lump-sum taxes would be legally discriminatory is unclear.

⁴¹ We have seen that with multiple tax instruments, renter households combine lump-sum taxes and property taxes, the latter due to incidence on housing suppliers. If lump-sum taxes are unavailable but minimum housing consumption can be required, renter households would face a trade off in undoing appropriation of housing supplier producer surplus if using minimum housing consumption requirements to approximate lump-sum taxation. In our 2007 paper, we did not consider multiple tax instruments so this trade off did not arise.

⁴² To be clear, the choice of 5% is arbitrary, just a low amount. The essential findings carry over for other "low amounts." Note, however, that shutting down completely lump-sum taxation causes existence problems unless we modify the utility function.

⁴³ Recall that this is the tax rate on annualized rent. As we noted earlier, the analysis by Poterba (1992) suggest that annualized property tax rate should be multiplied by approximately .11 to convert to a rate on property value.

amount of local redistribution declines rapidly, and the preferred level of spending on the local public good increases rapidly.

The implications of the variation in preferred voter policy for city population and housing prices are shown in Figure 6 (holding constant utilities if other communities are selected). We saw in Figure 5 that poor voters prefer a high income tax rate to support high local redistribution and low local public good spending. The left panel of Figure 6 shows that, if these policies were adopted, only a small fraction of the metropolitan population would choose to locate in the city. As voter income rises, preferred policy becomes increasingly attractive to higher income households, and more households choose to locate in the city. The vertical line in the left panel of Figure 6 illustrates that the preferred policy of the voter at the 20th income percentile attracts 40% of the metropolitan area population, the equilibrium allocation being the preferred policy of that voter. The right panel of Figure 6 illustrates the effect of preferred voter policies on housing prices. As voter income rises and the associated preferred policies attract more households to locate in the city, housing demand rises, bidding up the gross-of-tax housing price. Net-of-tax housing prices rise as well, inducing higher housing supply.

Returning to the equilibrium analysis, comparing Columns 2 and 3 of Table 1, note that limiting lump-sum taxation implies a “less stratified” equilibrium, with the city less populated and poorer but then with more populated and less elite suburbs. A small amount of local redistribution occurs in the city and a very small amount in the poorer suburb, with a low income tax of 2.14% in the city. The pivotal voter in the city is quite poor and has income slightly above the mean, choosing a tax package that deters richer households to keep down the rental price of housing. The federal income tax drops by about 3%, and less redistribution takes place overall. Property taxes rise everywhere substantially to finance the local public good, not surprisingly given the loss of potential tax revenues from the lump-sum tax and the reluctance to tax income. Some of the proceeds of the property tax are used to finance the small redistribution in the city and the smaller yet redistribution in the poorer suburb. *It bears emphasis that, when lump-sum taxes are limited, we find the property tax rather than the income tax to be the local tax of choice.* This is driven by the relatively higher distortion from income taxation, especially as it is atop federal income taxation. If we let the distortion parameter (ω) decline, there is a little more local income taxation, but federal income taxation rises very substantially.⁴⁴ Empirical support for these findings is provided in Section 5. Further comparing Columns 2 and 3, we see that limiting lump sum taxation results in a decline in the levels of the local public good in all communities, but the declines in the local values are somewhat misleading as the sorting changes imply the economy per capita average level of local public

⁴⁴ This analysis is in the on-line appendix.

good consumption declines by only \$241 (e.g., the rich suburb has many more households consuming a relatively large amount).

Motivated by the passage of property tax limits in some jurisdictions in the U.S., we also consider the equilibrium with the same limit on local lump-sum taxes and with property taxes restricted to be no higher than 35%, which, recall implies a much lower limit of about 3.2% on property value using the Poterba conversion. This restriction on property taxes is in the range of observed property tax rates in the U.S., which vary between about 0.2% and 4.5% of home value.⁴⁵ Also, 46 states do limit property taxes, the exceptions being Connecticut, Hawaii, New Hampshire, and Vermont. Rate limits impose maximum rates on jurisdictions (e.g., counties, municipalities, and school districts) and apply to property market value.⁴⁶ Maximum authorized property tax rates range from 0.5 percent (Kentucky) to 5% (Michigan) of property value.⁴⁷ Hence, this 3.2% limit we impose is also within the range of actual property tax limits. Equilibrium values with this property tax limit are reported in Column 4 of Table 1. Stratification is very similar to the previous case. Property taxes are at the bound in each local jurisdiction. A moderate local income tax of 3.62% arises in the city, with per capita revenues of \$882 split between financing a small local redistribution (\$500) and the rest put toward financing the local public good. No local redistribution takes place in either suburb, though a small income tax arises in the poorer suburb to help finance the local public good there. Both suburbs have lump-sum taxation, with the rich suburb at the bound. Local public good levels decline given the restrictions on tax instruments and the reluctance to tax income, especially in the suburbs.⁴⁸ Property taxation still dominates local finance. The federal tax increases a little as the pivotal federal voter (i.e., median income household) anticipates less (negative) redistribution in his community, the poorer suburb.

Ignoring the fifth column for the moment, which is mainly of interest for its normative implications, consider the effects of reducing mobility. Table 2 presents equilibrium values as in Table 1 for the several policy regimes but assuming one-half of each income type are mobile ($\rho(y) \equiv .5$), i.e., can costlessly relocate jurisdictions after their initial choice and local voting. Table A1 in the appendix presents the same with only 1% of each income type mobile (i.e., with $\rho(y) \equiv .01$). The main point is that the same fundamentals carry over, i.e., little or no local redistribution and little or no local income taxation. Focusing on the case of 50% mobility, considering the main cases of interest in Columns 2,3,

⁴⁵Siniavskaia, 2016.

⁴⁶Tax Policy Center Foundation, Urban Institute and Brookings Institution, *Tax Policy Center Briefing Book, State (and Local) Taxes*, <http://www.taxpolicycenter.org/briefing-book/what-are-tax-and-expenditure-limits>

⁴⁷Advisory Commission on Intergovernmental Relations, 1995(a). *Tax and Expenditure Limits on local Governments*. Washington, D.C.

⁴⁸The economy per capita local public good consumption equals \$4,244 in this case, as compared to \$6,273 in the previous case with just the local lump-sum tax constrained. These per capita consumption levels for all cases are available from the authors.

and 4, observe that in only the two cases with lump-sum taxation restricted does any local redistribution arise and only in the city. For example, with just a restriction on local lump-sum taxation (Column 3), city residents obtain a locally financed lump-sum redistribution of \$695, financed by a small local income tax just below 1% and with some of the proceeds from the local property tax. Imposing also the property tax ceiling of 35% (Column 4), the city lump-sum redistribution drops to just \$263. The income tax rises in the city to 2.82%, but about half of the proceeds from it are used to help finance the local public good given the property tax limit. The only other case of any local income tax is in the latter case in the poorer suburb, but with all the proceeds from the 1.65% local income tax supplementing provision of the local public good. The lack of local redistribution carries over to the case of virtually no mobility (see Table A1): With only 1% mobile, in none of the cases we examine is there any local redistribution. With both the local lump-sum tax and property tax restrictions, small local income taxes arise, but to help finance the local public goods. *We can infer that the potential for relocation is not the explanation for limited or no local redistribution.* As we have discussed, it is the weak incentive to redistribute locally resulting from income stratification that explains this finding.

Restricting mobility does have some other equilibrium effects. Sorting is a bit different, but not much. Interestingly, the federal income tax rate rises some, e.g., from 11.7% to 13.5% as mobility drops from 100% to 50% for the case with just the restriction on the local lump-sum tax (Columns 3 in Tables 1 and 2). The higher federal income tax discourages local income taxation because it exacerbates the income tax distortion. However, the net effects yield higher income redistribution as mobility is reduced.

4.2.2. Normative Analysis. We return to the case of 100% mobility with a normative focus. Using the unitary state as the baseline, we measure welfare as the sum of average EV plus the change in housing rents, the latter since we have absentee housing owners. Refer to the lower entries in Table 1. Note that in all cases either the welfare effect on households and housing owners is the same sign, or the effect on households dominates. In any case, we report both effects (i.e., we report EV and EV plus housing rents). We also report the income range that is worse off with the regime change, and, in Figure 4, graph EV as a function of income. As seen in Column 2 of Table 1, the federal system with no tax restrictions leads to an average welfare gain, but a large majority of poorer households (82.3%) are worse off. Average welfare rises because of the efficiencies from Tiebout-type sorting, also with relatively efficient taxation, in particular heavy reliance on local lump-sum taxes. Local lump sum taxes are efficient both because they are non-distortionary and because they induce relatively efficient household sorting, the latter because they efficiently price community access in as much as they equal the cost of the local public good (see, e.g., Calabrese, Epple, and Romano, 2012). Direct redistribution is a little higher in the federal equilibrium than in the unitary state, but all those in the city in the former regime (71.6%) consume

substantially less of the local public good, implying a net welfare loss for them.⁴⁹ In short, there is an equity-efficiency trade off in this comparison.

Examining Columns 3 and 4 of Table 1, one sees that in the cases of the federation with the lump-sum tax restrictions, welfare is lower than in the unitary state and either everyone or almost everyone is worse off! This finding generalizes the main result in Calabrese, Epple, and Romano (2012). In the latter, we show that Tiebout equilibria that restrict local taxes to property taxes are inefficient. We show that this is explained by inefficient sorting that results, which increases the costs of free riding in consumption of local public goods, to the determinant of almost everyone. This is shown by demonstrating that directly restricting access of poorer households to richer jurisdictions, with otherwise equilibrium choices (e.g., majority choice of local property taxes), produces welfare gains. The inefficient sorting and consequences for free riding more than offset the classic Tiebout gains from better matching local public goods to preferences. The welfare losses we find here generalize this finding in two ways. The present model also has a central government, not presents in our 2012 paper. Second, choice of local property taxation is here endogenous, i.e., in these cases local income taxation is an option, while we assumed only property taxation in the 2012 paper.

Consider last the equilibrium in Column 5 of Table 1. This is a Tiebout equilibrium, with no central government, and with no restrictions on the local tax instruments.⁵⁰ We study such equilibria in CER (2015). Observe that this is the most efficient allocation, which means that having a central government with power to redistribute is inefficient. It is natural to compare this equilibrium to that in Column 2, with the latter adding the federal government to the Tiebout equilibrium. One can see that the equilibria are quite similar (e.g., sorting is close), the key difference just being the federal income tax and associated redistribution in the federal case. Creating scope for central government to redistribute lowers efficiency and also hurts the rich and upper middle class. However, poorer households, specifically those with income below \$52,150 are better off in the case with the federal government. Introducing the federal government entails, again, an equity-efficiency trade off.

⁴⁹ The housing price in the city in the federal equilibrium is lower than in the unitary state, so this effect pulls for gains to the poorer households.

⁵⁰ To compare our findings on redistribution to Epple and Romer (1991), another model variation we have considered is that with no central government and with the restriction on local lump-sum taxation. Epple and Romer (1991) find significant local income redistribution in a one-tiered multi-community Tiebout model that assumes local property taxation. Our model with no central government, limited lump-sum taxation, and 100% mobility is most similar, though it allows local income taxation in addition to property taxation. Nevertheless, we obtain substantially less local redistribution than Epple and Romer (1991). The explanation is that our model has a local public good whereas Epple and Romer (1991) does not. In our equilibrium, provision of the local public good increases the distortion if property taxes are to be increased to provide local redistribution, and hardly any results. Nor are income taxes used due to their distortion. We confirm this logic by showing that local redistribution increases as the weight on the local public good in the utility function declines. This analysis is available on request.

Another normative perspective, presented in Figure 5, shows the distribution of “generalized consumption” in the policy regimes, which we define to equal expenditure on private goods plus consumption of the local public good. We omit the federal regime with both of the tax limits just to reduce clutter. One can see that, relative to the unitary state (this distribution included in the graph), the two federal regimes and the pure Tiebout regime (no central government) have a greater proportion of households with very low generalized consumption, with the Tiebout regime the least equitable in this regard. The federal regime with restricted lump-sum taxation has the most households with generalized consumption above \$83,387.⁵¹ One might expect the federal regime with no tax restrictions and the pure Tiebout regime would have the largest group with very high generalized consumption, but the substantial lump-sum tax in the rich suburb in these regimes curtails very high consumption by other than the very rich. One can also see that the pure Tiebout regime has the widest generalized consumption distribution followed by the federal regime with limited lump-sum taxation.

All the normative comparisons are qualitatively analogous in the cases of restricted mobility, as can be seen in Tables 2 and A1.

4.2.3. Housing Owners. We have so far assumed households rent housing. Housing owners will have weaker incentives to tax property, so it is of interest to examine whether home ownership alters our main findings, especially the reluctance to employ local income taxes. To investigate this, we adapt the home-ownership specification in CER (2015) to the present model. We assume all households are owners, or, otherwise, existence issues arise. Refer to Figure 1. Stage 1 is the same. Stage 2 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 5 of quality/quantity h , at agreed upon price per unit of h . The contract may be renegotiated in Stage 5 when housing is actually built and consumed. The price in the contract must equal the ultimate equilibrium supplier housing price (p_h^j) since all agents have rational expectations, but it is convenient to have different notation for the equilibrium contract price, p_{h1}^j . Stages 3 and 4 are the same as with renters. While no capital gains or losses arise on the equilibrium path, relocation by mobile households 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 5, 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

⁵¹ The \$83,387 is the minimum generalized consumption among residents in the richest suburb in this regime, at the rightward jump in the distribution (see Figure 5). In the cases with multiple communities (i.e., other than the unitary state), jumps in the distribution occur at community boundary incomes, but, in the cases with significant lump-sum taxation, they are not very apparent.

suppliers are just as well off under the buy-out, and owners are better off.⁵² 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 commitment to home ownership implies full incidence of property taxes falls on buyers. For tractability, we maintain the utility taking assumption regarding how a voter assesses utility in other jurisdictions of movers.

The only difference in the primitive equations (i.e., (2)-(7)) is that $y[1 - (1 + \omega(m^f + m^j))(m^f + m^j)]$ is replaced for non-movers everywhere by $y[1 - (1 - \omega(m^f + m^j))(m^f + m^j)] + (p_h^j - p_{h1}^j)h_d(y, p^j)$, where we assume households contract for their equilibrium preferred level of housing initially.⁵³ While no capital gain/loss arises in equilibrium, the potential for a gain or loss will have a marked effect on equilibrium policies. In particular, in contemplating the effects of voting on the property tax, the capital gains/losses that arise out-of-equilibrium make owners relatively averse to property taxation. As shown in the on-line appendix, indirect utility is modified to be:

$$(12) \quad \begin{aligned} V(\Gamma_o^j, \Omega_o^j, y) &= y \cdot \Gamma_o^j + \Omega_o^j; \\ \Gamma_o^j &\equiv v(g^j) \cdot [1 - (1 + \omega(m^f + m^j))(m^f + m^j)] \cdot [1 + (p_h^j - p_{h1}^j)G(p^j)] \cdot w(p^j); \\ \Omega_o^j &\equiv v(g^j) \cdot r^j \cdot [1 + (p_h^j - p_{h1}^j)G(p^j)] \cdot w(p^j); \\ &\text{where } G'(p^j) < 0. \end{aligned}$$

The analysis and above propositions for the case of renters' carries over to the owners' case with Γ_o^j and Ω_o^j everywhere replacing respectively Γ^j and Ω^j .

Turning to the computational analysis, we use the same calibration for a cleaner comparison to the renters' case, and we focus on the case with all households mobile. For tractability in the computational analysis, we assume households consider only their own capital gains/losses and that their housing contracts are voided if they relocate.⁵⁴ Table 3 summarizes positive and normative properties of

⁵² 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.

⁵³ 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.

⁵⁴ The first part of this simplification means that voters do not anticipate income effects of others' capital gains or losses off the equilibrium path. The second simplification means that voters do not realize capital gains or losses if they relocate, again off the equilibrium path, this consistent with the utility taking assumption (though not to suggest this is realistic).

equilibrium in the same policy regimes as in Tables 2 and 3, but omitting the case with no central government (available from the authors). Equilibrium exists in all the cases presented here, so we again find equilibrium in interesting cases. The Unitary State Case is presented in Column 1 and the federal case with no tax restrictions in Column 2. Comparing these respectively to Columns 1 and 2 of Table 1 for renters, a salient effect is lower property tax rates, with the exception of the richest suburb in the federal cases. The property tax rate is, however, quite low in the latter cases. No local redistribution arises in the federal case with owners, and local property taxes are 0 in each jurisdiction. The federal income tax rates change little. Considering restrictions on local taxes, existence of equilibrium fails if the local lump-sum tax level is severely restricted. We then examine the case with local lump-sum taxes restricted to be no higher than 20% of expenditure on the local public good, where equilibrium exists. Equilibrium values for owners with just this restriction in the federal system are presented in Column 3 of Table 3. For comparison, the equilibrium with renters and the same restriction is presented in Column 5. No local redistribution results with owners. A small property tax (1.88%) arises in the richer suburb, which helps to finance the local public good there. Property tax rates are lower in the city and in the richer suburb in the owners' case, though somewhat higher in the poorer suburb with owners. The federal income tax is about the same. Imposing the property tax rate restriction (Column 4), lowers the property tax to the bound in the city and poorer suburb, induces small local income taxes, and leads to less of the local public good provided in these two jurisdictions.

The normative comparisons and interpretations are the same as with renters. Restricting mobility has similar effects to doing so with renters, and, in particular, does not lead to local redistribution.⁵⁵ In short, all the main qualitative results regarding renters carry over to owners.

5. Discussion.

Here we discuss our results in light of empirical evidence. We also discuss our modelling assumptions and provide some perspectives. Our main applied findings are that households sort locally by income, redistribution is conducted primarily at the central level of government, and local taxation is financed mainly by property, rather than income, taxes (assuming lump-sum taxation is constrained). We also have shown that income stratification is sufficient to curtail local redistribution, i.e., that “mobility” to escape or exploit local redistribution is unnecessary to obtain this. A criticism is that mobility is necessary to obtain income sorting so that mobility is crucial to the finding of limited local redistribution. We agree, but this misses our point. It is that, given income sorting, further moving options are (largely) irrelevant to the finding. It is a different logic that existing income sorting curtails the incentive to

⁵⁵ This analysis is available from the authors, as well as the analogues to Figures 4 and 5.

redistribute rather than the adverse effects on the tax base from relocations that local redistribution would induce. The latter is central to explaining limits on local redistribution in equilibria without income stratification, while not so if such stratification is present.

As such, the model is of more relevance to economies with income sorting among local jurisdictions, especially multi-jurisdictional metropolitan areas. Regarding empirical support, Epple and Sieg (1999), for example, provide evidence of income stratification in the Boston Metropolitan Area. Although most local jurisdictions in the U.S. do not impose a local income tax, 4,943 jurisdictions in 17 states, or approximately 13% of all local jurisdictions do so tax. As mentioned above, the local income tax rates that arise in our model are within the range of empirically observed rates, which range from 0.1% to almost 4.0%. In addition, in general local income taxes are levied by the central cities of metropolitan areas and not by suburban jurisdictions. Of the 17 states that have local income taxes, eight of them each have a total of 3 or less jurisdictions with income taxes, and almost all of these particular jurisdictions are central cities in metropolitan areas. If suburbs in a metropolitan area do impose income taxes, the rates for the most part are less than their central city's. For instance, almost 60% of the local jurisdictions that impose income taxes are in Pennsylvania and most of these 2,621 jurisdictions impose income taxes not exceeding 2%. The six cities that impose higher rates (Philadelphia 3.98%, Scranton 3.4%, Pittsburgh 3%, Wilkes-Barre 2.85%, and Reading 2.7%) are all central cities in metropolitan areas. In Kentucky, where 218 local jurisdictions impose income taxes, the highest rates are in the central cities of the two major metropolitan areas, which are Louisville 2.2% and Lexington 2.25% (Henchman and Sapia, 2011). All this is broadly consistent with our findings.

However, in other countries with federations and metropolitan areas having multiple jurisdictions, substantial variation in the shares of local taxes is observed. Brulhart, Bucovetsky, and Schmidheiny (2015) provide a wealth of data. In their sample of the 16 OECD countries with the highest degree of fiscal decentralization, five of the six countries where property taxes have the highest share of local taxes are, interestingly, former parts of the British Empire.⁵⁶ But, in 9 of these 16 countries, the local share of income taxes exceeds that of property taxes. For example, the respective shares of income and property taxes in local taxes in Switzerland are 68 and 14 percent. It is of interest to investigate these differences, our model clearly not fitting well everywhere.

Also, many states in the U.S. have significant income taxation, this atop federal income taxation. Income stratification across states is much more limited than within metropolitan areas, likely reflecting more limited mobility among states. The relationship between the federal and state taxation and their redistribution choices would undoubtedly be better modeled as in GC than using our model.

⁵⁶ These are Australia, Canada, UK, US, and New Zealand, with the shares of local property taxation ranging from 72 to 100 percent. Greece has a property tax share of local taxes equal to 75%.

Let us discuss our modelling assumptions. First, we note some major model omissions and challenges in pursuing extensions. Household heterogeneity is only with respect to income and whether a household can relocate. Introducing preference heterogeneity over local public goods or for locations can be expected to induce some degree of income mixing, which would increase incentives for local redistribution. The main challenge in extending our model to have such difference in preferences regards existence of equilibrium. We have not considered taxation of the numeraire, i.e., sales taxes, at either the federal or local level. As discussed in CER (2015), local majority choice of sales taxes does not disrupt local majority choice equilibrium, but it would not arise if households can travel costlessly among local jurisdictions to consume the numeraire. We have not considered a model with frictions in this, which would likely lead to local sales taxes and which are significant in some metropolitan areas around the world (see Bulhart, Bucovetsky, and Schmidheiny, 2015). Federal sales taxation or any other federal taxation is of interest to examine. One might also consider provision of a national public good and/or federal subsidies to local public goods. To the extent a federally provided public good is a substitute for the locally provided public goods, this would weaken incentives to stratify. We think that Proposition 3 can be extended to investigate a greater federal role, though existence is not assured and the problem is challenging computationally. We believe that progress can be made on these various extensions, but are topics for future research.

Another aspect of our model is the timing of choices. We have assumed a one-period model with federal voting, then initial locational choice, then local voting, then relocation, and last consumption. Does this timing make sense? In the context of a one-period model, we have attempted to capture an environment that allows complete sorting, having in mind the long run, but where we can consider mobility frictions in the shorter run. This motivated the early frictionless sorting in the model. Considering alternatives *consistent with this thinking*, we think it makes sense to have consumption last, relocation after local voting, and sorting before local voting. This fixes the order of four of the stages (initial locational choice, followed by local voting, followed by relocation, followed by consumption), but the timing of federal voting vis-à-vis the other stages could be varied. Having federal voting before local voting is consistent with other models (e.g., GC), where the federal decision maker is a Stackelberg leader. This facilitates comparison to other models. This makes sense, too, if federal policy is committed for a longer period of time than local policies, but, of course, this suggests a dynamic model. We feel the best direction for extension is to consider dynamics, but one would still confront timing within periods. Staying in the context of one period, we have thought seriously about moving the stage of the federal vote relative to the other stages. Suppose we assume 100% mobility (i.e., everyone can relocate anytime). If federal voting precedes local voting, the alternative to what we have done is flip Stages 1 and 2 in our model. Equilibrium is the same as in our model. However, this is not so if some cannot relocate. If we

flip Stages 1 and 2, then, when households vote federally, some of them cannot relocate. We think our techniques can be used to investigate this model, but this is a big undertaking. We conjecture that equilibrium will at least sometimes exist and will have similar properties. But this is conjecture! Flipping the order of local and federal voting would also require much work to investigate. Then local voters would consider how their tax choices would affect the federal decision maker (i.e., pivotal federal voter). Our intuition is that this would further curtail the incentive to tax to redistribute locally (since crowding out the federal pivotal voter's incentive increases the local decision maker's cost of redistributing). Again, though, conjecture. Given the scope of pursuing alternatives, we think these are topics for future research. We also believe our current model is reasonable and provides some insights.

6. Summary

We have provided a model with two tiers of government, multiple local jurisdictions, households that differ by income with at least some able to move anytime among local jurisdictions, and with majority choice of a redistributive linear income tax at both tiers. In addition, property taxation and lump-sum taxes in local jurisdictions are majority selected, in some cases with limits, the proceeds used to finance a local public good and/or local redistribution. Assuming a household utility function that is homogenous of degree 1 in the numeraire and housing consumption and multiplicative in the local public good, we show theoretically that: (i) an indirect utility function that is linear in income over two composite public goods arises, their values depending on all taxes, the level of the housing price, and expenditure on the local public good; (ii) majority choice of local tax instruments exists given the federal income tax and federal redistribution; and (iii) income stratification across jurisdictions arises assuming equilibrium exists; and (iv) we provide sufficient conditions for determining and confirming majority choice of the federal income tax. We then specify a quantitative model that we use to confirm the latter conditions and explore equilibrium properties. We show equilibrium does exist in a series of examples that vary with respect to the degree of mobility of households, whether there are tax limits, and whether households rent or own housing. The equilibrium has little or no local redistribution and very limited use of local income taxation. The explanation for the lack of local redistribution is weak local incentives to do so, this driven by income sorting and federal redistribution. We show a preference for local property taxation over local income taxation, whether or not households rent or own housing. Normative findings are: (v) assuming local lump-sum taxes are permitted, equilibrium with no central government is more efficient but less equitable than the federal system equilibrium; (vi) the latter federal system is, however, more efficient but less equitable than having just a central government; and (vii) a federal system with highly constrained local lump-sum taxes is inefficient and inequitable relative to having just a central government.

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Figure 1				
Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
All Households Vote on Federal Income Tax	Households Choose Initial Local Jurisdiction	Households Vote Over Local Policy	Mobile Households Costlessly Relocate	Households Consume, Government Budgets Balance, Markets Clear

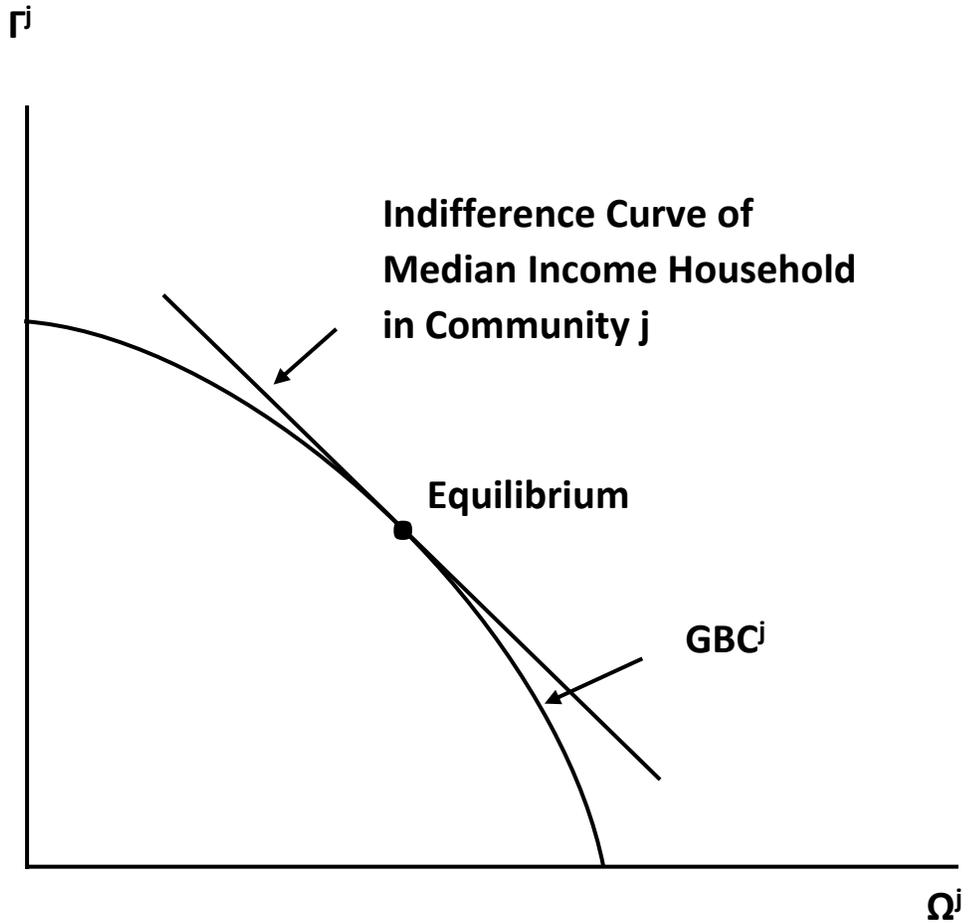


Figure 2: Equilibrium in Community j

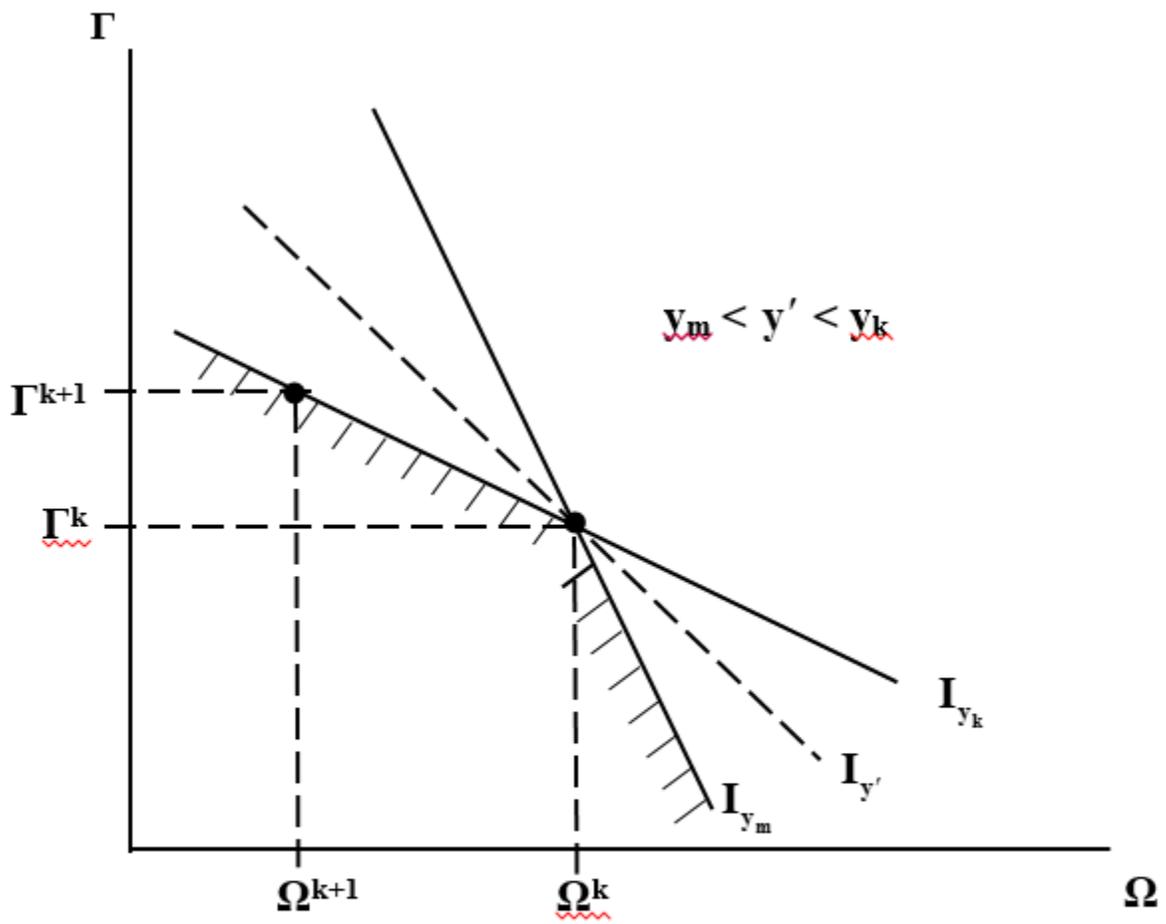


Figure 3

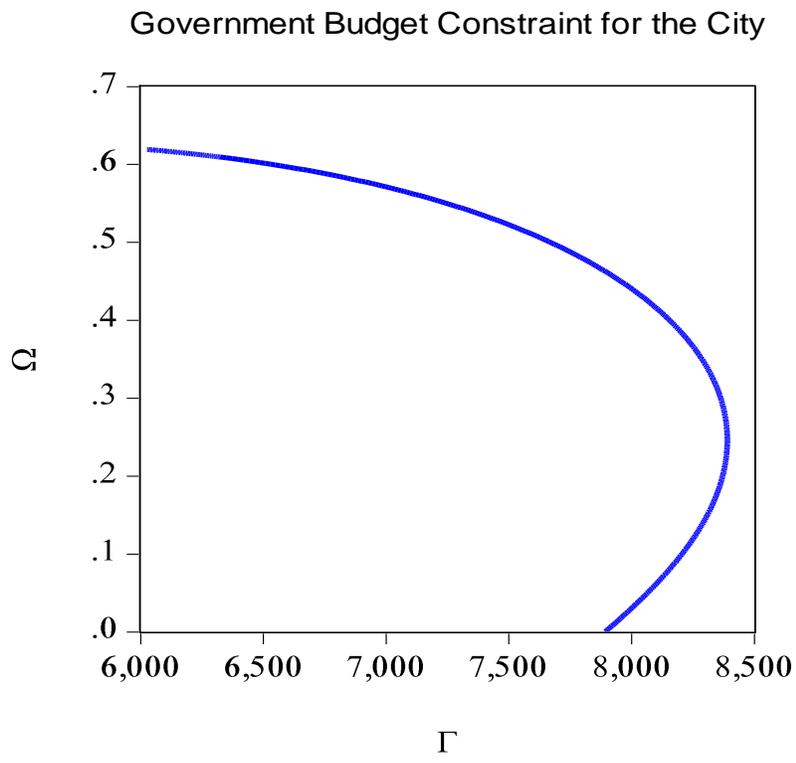


Figure 4

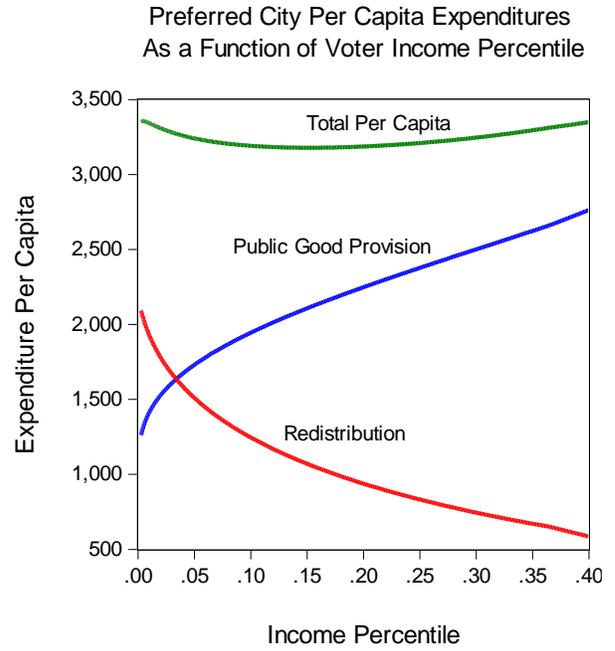
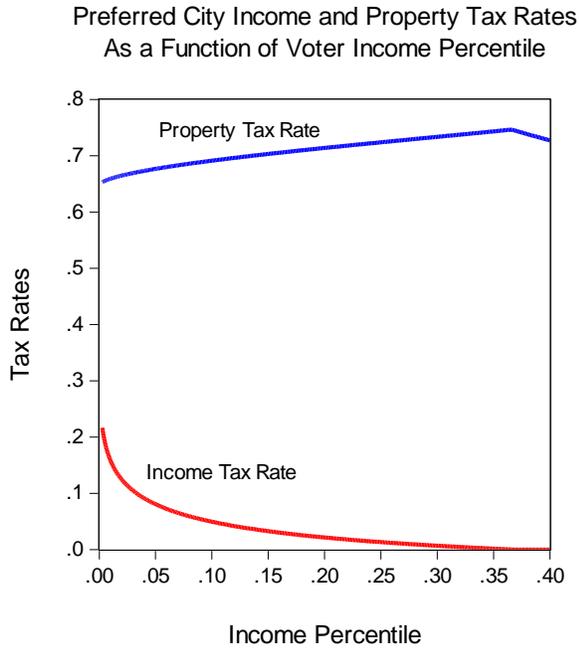


Figure 5

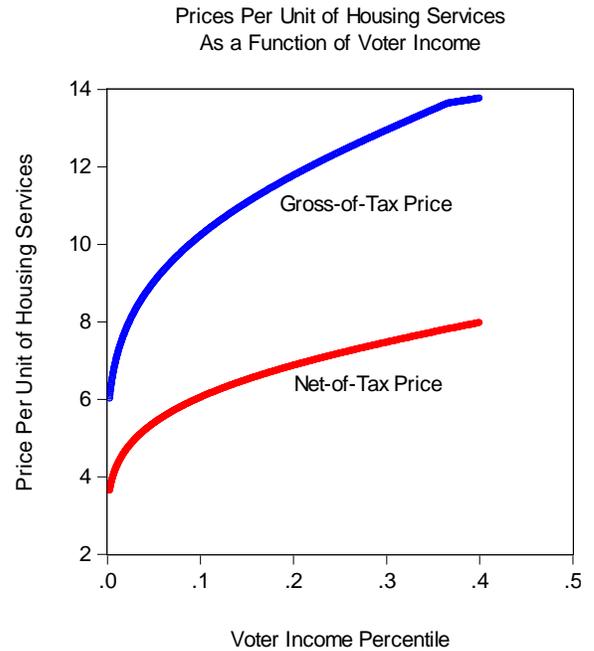
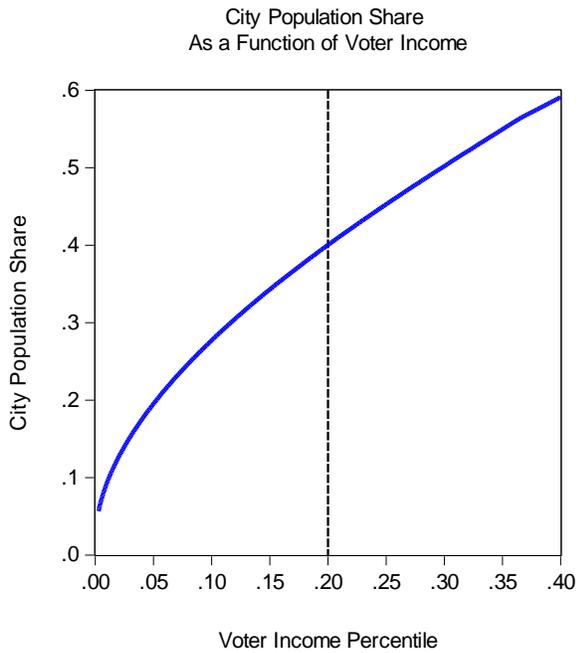


Figure 6

Figure 7: EV 100% Mobility-Renters

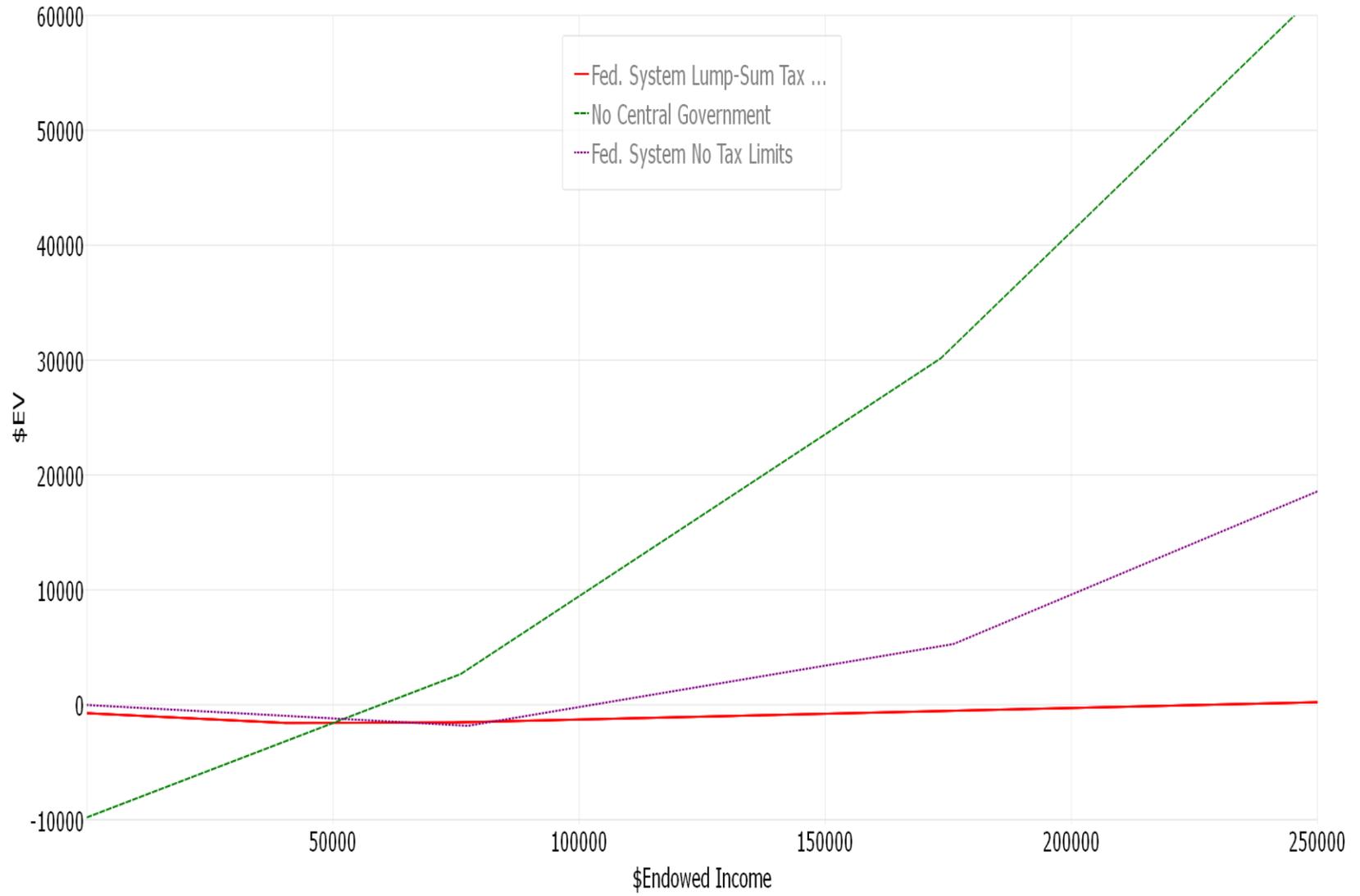


Figure 8: Generalized Consumption PDFS 100% Mobility-Renters

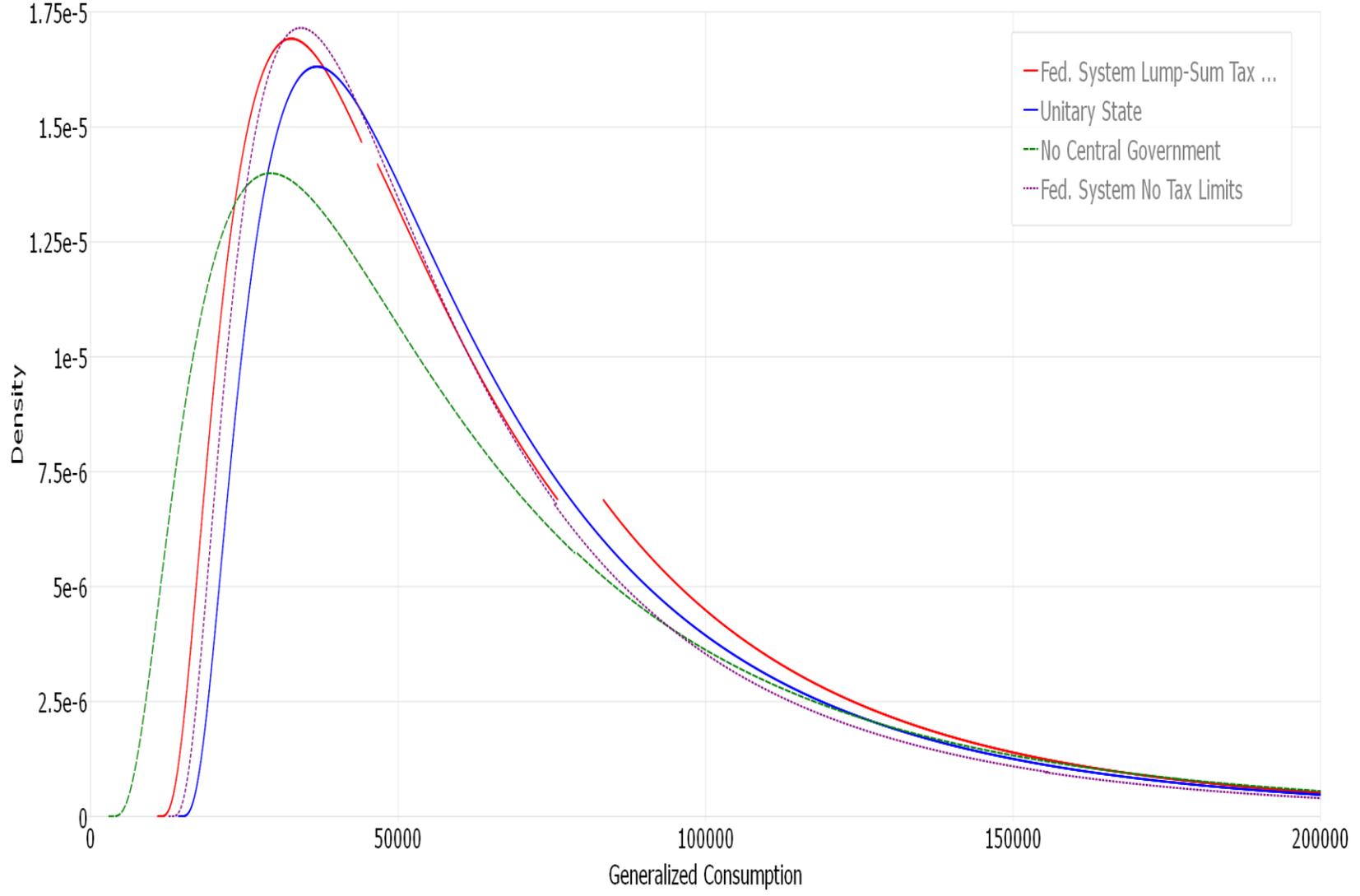


Table 1: Renters' Model w. 100% Mobility*

	<u>Unitary State</u>	<u>Fed. System No Tax Limits</u>	<u>Fed. System Lump-Sum Tax Limits**</u>	<u>Fed. System Local Lump- Sum and Property Tax Limits***</u>	<u>No Central Government</u>
<u>Positive Properties</u>					
n ¹ =	100%	71.6%	40.0%****	41.6%****	70.8%
n ² =	n/a	23.0%	30.0%	28.6%	23.7%
n ³ =	n/a	5.4%	30.0%	29.8%	5.6%
t ¹ =	84.7%	54.0%	71.4%	35.0%	53.1%
t ² =	n/a	15.8%	61.3%	35.0%	17.1%
t ³ =	n/a	4.9%	79.5%	35.0%	6.4%
m ¹ =	n/a	0.0%	2.1%	3.6%	0.0%
m ² =	n/a	0.0%	0.0%	1.9%	0.0%
m ³ =	n/a	0.0%	0.0%	0.0%	0.0%
r ¹ =	n/a	(\$349)	\$939	\$500	(\$378)
r ² =	n/a	(\$7,779)	\$96	(\$69)	(\$8,168)
r ³ =	n/a	(\$22,845)	(\$630)	(\$369)	(\$25,506)
g ¹ =	\$4,799	\$3,500	\$2,248	\$2,031	\$3,276
g ² =	n/a	\$10,549	\$4,500	\$4,187	\$11,424
g ³ =	n/a	\$24,832	\$12,609	\$7,383	\$28,553
m ^f =	11.4%	14.8%	11.7%	12.3%	n/a
r ^f =	\$9,415	\$9,535	\$7,641	\$7,940	n/a
<u>Norm. Props. ****</u>					
EV =	n/a	\$553	(\$1,250)	(\$1,581)	\$3,967
EV+ΔHouse Rents=	n/a	\$1,167	(\$1,182)	(\$965)	\$4,723
Interval Worse Off	n/a	< \$102,800	< \$228,000	All Incomes	< \$59,700
% Worse Off =	n/a	82.4%	97.4%	100.0%	59.5%

*Utility is $g^{-10}h^{.22}b^{.78}$. Economy income lognormal with mean \$67,392 and median \$49,267. Tax distortion parameter $\omega = .247$. Community housing supply elasticities equal 3. Community areas are $L^1 = .675$, $L^2 = .206$, and $L^3 = .120$. Median community income below mean except where community proportion bolded.

** $r^j \geq -.05g^j$, $j = 1,2,3$.

*** $r^j \geq -.05g^j$, $t^j \leq 35\%$, $j = 1,2,3$.

****Median community income exceeds mean.

*****Positive (negative) EV and EV + ΔHouse Rents indicate average welfare gains (losses).

Table 2: Renters' Model w. 50% Mobility*

	<u>Unitary State</u>	<u>Fed. System No Tax Limits</u>	<u>Fed. System Lump-Sum Tax Limits**</u>	<u>Fed. System Local Lump- Sum and Property Tax Limits***</u>	<u>No Central Government</u>
<u>Positive Properties</u>					
n ¹ =	100%	67.7%	43.6%****	44.9%****	66.5%
n ² =	n/a	24.1%	28.1%	27.5%	24.8%
n ³ =	n/a	8.3%	28.3%	27.6%	8.6%
t ¹ =	84.7%	50.7%	71.4%	35.0%	50.2%
t ² =	n/a	22.9%	59.6%	35.0%	24.0%
t ³ =	n/a	16.1%	69.6%	35.0%	17.7%
m ¹ =	n/a	0.0%	1.0%	2.8%	0.0%
m ² =	n/a	0.0%	0.0%	1.7%	0.0%
m ³ =	n/a	0.0%	0.0%	0.0%	0.0%
r ¹ =	n/a	(\$528)	\$695	\$263	(\$515)
r ² =	n/a	(\$5638)	\$(34)	(\$195)	(\$5,830)
r ³ =	n/a	(\$14,804)	(\$590)	(\$338)	(\$16,225)
g ¹ =	\$4,799	\$3,416	\$2,388	\$2,184	\$3,138
g ² =	n/a	\$9,113	\$4,736	\$4,375	\$9,728
g ³ =	n/a	\$20,213	\$11,804	\$7,554	\$22,989
m ^f =	11.4%	14.9%	13.5%	13.7%	n/a
r ^f =	\$9,415	\$9,590	\$8,733	\$8,574	n/a
<u>Norm. Props. ****</u>					
EV =	n/a	\$459	(\$1,295)	(\$1,520)	\$3,828
EV+ΔHouse Rents=	n/a	\$1,031	(\$1,168)	(\$914)	\$4,531
Interval Worse Off	n/a	< \$98,900	All Incomes	All Incomes	< \$58,500
% Worse Off =	n/a	81.1%	100%	100.0%	58.5%

*Utility is $g^{-10}h^{22}b^{78}$. Economy income lognormal with mean \$67,392 and median \$49,267. Tax distortion parameter $\omega = .247$. Community housing supply elasticities equal 3. Community areas are $L^1 = .675$, $L^2 = .206$, and $L^3 = .120$. Median community income below mean except where community proportion bolded.

** $r^j \geq -.05g^j$, $j = 1,2,3$.

*** $r^j \geq -.05g^j$, $t^j \leq 35\%$, $j = 1,2,3$.

****Median community income exceeds mean.

*****Positive (negative) EV and EV + ΔHouse Rents indicate average welfare gains (losses).

Table 3: Owners' Model w. 100% Mobility*

	<u>Unitary State</u>	<u>Fed. System No Tax Limits</u>	<u>Fed. System Lump-Sum Tax Limits**</u>	<u>Fed. System Local Lump- Sum and Property Tax Limits***</u>	<u>Renters' Fed. System Lump-Sum Tax Limits**</u>
<u>Positive Properties</u>					
n ¹ =	100%	79.0%	59.8%	55.8%	51.5%
n ² =	n/a	15.4%	22.8%	24.9%	30.0%
n ³ =	n/a	5.6%	17.4%	19.3%	18.6%
t ¹ =	53.1%	9.3%	43.3%	35.0%	73.7%
t ² =	n/a	2.1%	76.9%	35.0%	53.6%
t ³ =	n/a	8.4%	20.9%	25.7%	85.9%
m ¹ =	n/a	0.0%	0.0%	0.1%	0.0%
m ² =	n/a	0.0%	0.0%	0.5%	0.0%
m ³ =	n/a	0.0%	1.9%	1.2%	0.0%
r ¹ =	n/a	(\$3,099)	(\$594)	(\$502)	\$594
r ² =	n/a	(\$9,400)	(\$1,717)	(\$1,049)	(\$1,267)
r ³ =	n/a	(\$14,871)	(\$2,132)	(\$1,998)	(\$3,596)
g ¹ =	\$4,642	\$3,878	\$2,968	\$2,512	\$2,599
g ² =	n/a	\$9,854	\$8,586	\$5,243	\$6,336
g ³ =	n/a	\$18,366	\$10,659	\$9,990	\$17,981
m ^f =	11.3%	13.9%	14.1%	16.2%	15.0%
r ^f =	\$7,755	\$8,960	\$9,067	\$10,340	\$964
<u>Norm. Props.****</u>					
EV =	n/a	\$568	(\$738)	(\$1,416)	(\$959)
EV+ΔHouse Rents= Interval Worse Off	n/a	\$1,288	(\$626)	(\$1,143)	(\$915)
% Worse Off =	n/a	< \$95,600	> \$27,100	> \$37,400	> \$19,350 < \$302,900
		79.9%	72.4%	63.6%	87.0%

*Utility is $g^{-10}h^{-22}b^{-78}$. Economy income lognormal with mean \$67,392 and median \$49,267. Tax distortion parameter $\omega = .247$. Community housing supply elasticities equal 3. Community areas are $L^1 = .675$, $L^2 = .206$, and $L^3 = .120$. Median community income is less than mean in all cases.

** $r^j \geq -.20g^j$, $j = 1,2,3$.

*** $r^j \geq -.20g^j$, $t^j \leq 35\%$, $j = 1,2,3$.

****Positive (negative) EV and EV + ΔHouse Rents indicate average welfare gains (losses).