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INEFFICIENCIES FROM METROPOLITAN POLITICAL AND FISCAL DECENTRALIZATION: FAILURES OF TIEBOUT COMPETITION

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ABSTRACT

We examine the welfare effects of provision of local public goods in an empirically relevant setting using a multi-community model with mobile and heterogeneous households, and with flexible housing supplies. We characterize the first-best allocation and show efficiency can be implemented with decentralization using head taxes. We calibrate the model and compare welfare in property-tax equilibria, both decentralized and centralized, to the efficient allocation. Inefficiencies with decentralization and property taxation are large, dissipating most if not all the potential welfare gains that efficient decentralization could achieve. In property tax equilibrium centralization is frequently more efficient! An externality in community choice underlies the failure to achieve efficiency with decentralization and property taxes: Poorer households crowd richer communities and free ride by consuming relatively little housing thereby avoiding taxes.

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1. Introduction.

The analogy between competition among firms in providing private goods and Tiebout (1956) competition among jurisdictions in providing local public goods is central to the economic study of local public finance. The basic idea is that household mobility will induce jurisdictions to provide efficient mixes of local public goods and taxes, or they will fail to attract residents. While we confirm that decentralized provision with head taxes is potentially efficient, this paper focuses on departures from efficiency in the realistic case of property taxation. Given property taxation, we ask whether decentralized multi-community provision increases welfare at all relative to centralized provision. Thus, we compare multi-community equilibrium to the centralized alternative with one community, a single property tax rate, and uniform local public good provision. While the environment is one where potential welfare gains from *efficient* Tiebout provision are present, we show quantitatively in a realistically calibrated model that the multi-community property-tax equilibrium not only fails to achieve potential welfare gains, but either leads to small average welfare losses or wipes out the potential gains. The multi-community equilibrium entails three inefficiencies: standard housing consumption distortions from property taxation; voting distortion in the choice of property taxes; and a jurisdictional choice externality, where relatively poorer households free ride on richer households in suburbs by buying small houses to avoid taxes. We can as well quantify the several inefficiencies, and we identify the jurisdictional choice externality as the inefficiency that prevents realization of potential Tiebout sorting gains.

The focus of the paper is on gauging the extent of departures from efficiency in Tiebout equilibrium. A rich theoretical model is needed to seriously quantify efficiency effects of Tiebout provision. We build on the model developed in Epple and Platt (1998), assuming mobile households differing by income and a taste parameter and assuming continuous variation in housing consumption. Household utility depends on numeraire consumption, housing consumption, and the level of the local congested public good (e.g., per student educational expenditure). The economy, which we think of as a metropolitan area (MA), is characterized by an aggregate housing supply function that can be derived from a neoclassical housing production function with the MA's given land area and other elastically supplied factors as inputs. The baseline "centralized equilibrium" to which we do comparisons assumes the MA is one jurisdiction, where households first buy housing and then vote for a single property tax, the proceeds financing uniform provision of the local public good. We compare this baseline equilibrium to allocations where the MA is divided geographically into an exogenous number of communities, each with given land area and thus housing supply having positive elasticity. Using the centralized equilibrium as the baseline permits us to quantify welfare gains from *efficient* decentralized provision to which we compare welfare gains/losses of *equilibrium* decentralized provision with property taxation.

Purely theoretical analysis permits insights into the normative properties of the allocations we study, but quantification, including resolution of trade offs, requires the development of a computational counterpart model. We first examine an efficient Tiebout allocation for the given number of communities. We show theoretically that planner-determined head taxes used to finance community levels of the local public good would implement an efficient Tiebout allocation with mobile households. This generalizes Oates's (1972) celebrated decentralization theorem to the present model and, especially, to allowing mobility. We find an efficient Tiebout allocation in our computational version of the model, and compute the compensating variation gains relative to the centralized property-tax equilibrium. These gains are substantial, equal to 2.67% of mean household income in our preferred calibration. This computation then determines the potential gains from Tiebout sorting.

We then turn to the multi-community property-tax equilibrium. Here households first purchase housing in a community/jurisdiction. They then choose their jurisdiction property tax rate by majority vote, the proceeds of which are used to provide the jurisdiction's public good. Our findings regard cases when an income-stratified equilibrium exists, i.e., when a Tiebout-type equilibrium arises.[1] Such equilibria arise for realistic parameter values when standard single-crossing restrictions on preferences are imposed.[2] While the Tiebout-type equilibrium permits households with heterogeneous incomes and preferences to sort into communities and consume differing levels of the local public good, the three inefficiencies noted above prevent realization of all potential gains of Tiebout provision relative to the centralized equilibrium. Computing the compensating variation, we find average welfare losses!

By computing allocations that remove one or more of the inefficiencies in the multi-community property tax equilibrium, we can delineate the relative effects of the three

[1] These equilibria are also stratified by the preference parameter for the local public good.
[2] The model will generally have a non-stratified equilibrium with communities that are clones as well, and multiplicities of stratified equilibria are possible. We then select the equilibrium that is most realistic, as detailed below.

inefficiencies. We find that the jurisdictional choice externality underlies the failure to realize efficiency gains. Relatively poorer households crowd richer jurisdictions to consume more of the local public good and free ride by consuming little housing thereby avoiding property taxes. To demonstrate that this crowding is the key inefficiency, we compute the allocation where households are *assigned* to communities as in the efficient (head-tax) Tiebout allocation, but then vote for property taxes, this allocation removing the jurisdictional choice externality but retaining the other two inefficiencies. Here 80% of the potential welfare gains from efficient Tiebout provision arise. The finding that it is free riding by relatively poorer households that explains the lack of welfare gains is counterintuitive (at least to us) because one might think that free riding would be most inefficient in the baseline centralized equilibrium where everyone lives in the same jurisdiction. However, when relatively richer communities arise that have high expenditures on local public goods in the Tiebout equilibrium, the efficiency costs of free riding rise.

We examine robustness of our findings by varying parameters in the computational model. Our finding of losses or negligible welfare gains in the property-tax Tiebout model is fairly robust, though parameter variations that curtail free riding lead to welfare gains. For example, sufficiently inelastic housing supplies in jurisdictions imply the price of housing services rises precipitously as households crowd the suburbs, increasing the cost of "free" riding on richer households' high property tax payments. Most interesting is that increasing the number of jurisdictions by more subdivision of the MA does *not* reverse the welfare losses we find in our preferred calibration, at least up to 100 jurisdictions, which covers the empirically relevant range. The logic is that, as long as free riding is feasible, the key inefficiency persists; and the efficiency costs of free riding need not decline with the number of communities for the same reason losses arise as soon as one goes from one to multiple communities.

A vast literature on Tiebout-type equilibria exists. The theoretical inefficiencies that we identify are known.[3] On the purely theoretical side, our contributions are to characterize the efficient Tiebout allocation in the Epple-Platt model and to provide a characterization of the

[3] The idea that the "poor chasing the rich" can be associated with a departure from efficiency in Tiebout economies is well known. Theoretical contributions framing the efficiency issues include Wildasin (1980), Boadway (1982), Brueckner (1983), Gordon (1983), Wilson (1997), and papers discussed in the text. Fernandez and Rogerson (1996) show policies that induce wealthier households to move into the poorest jurisdiction can be Pareto improving. Benabou (1996) nicely delineates equity and efficiency effects theoretically in Tiebout economies. Surveys of the literature are provided by Epple and Nechyba (2004), Ross and Yinger (1999), Rubinfeld (1987), and Scotchmer (2002).

jurisdictional choice externality that arises in property tax equilibrium in this setting. Our main contribution is, however, quantification of inefficiency effects in this rich and fairly realistic setting, while showing extreme efficiency costs of the jurisdictional choice externality for realistic parameter values.

Very few papers have pursued the quantification of Tiebout efficiency effects. Bradford and Oates (1974) provide a very influential estimate of welfare *gains* from decentralization. They focus on education as the key service provided by local governments, and they compare decentralized to centralized provision. *Assuming efficient decentralized provision*, they estimate a welfare loss from centralization equal to 50% of the population-weighted sum of the absolute changes in expenditures that arises from equalization of expenditures under centralization. Their model is much simpler than ours, but the most important difference from our main analysis is their assumption of efficient Tiebout provision.[4] Fernandez and Rogerson (1998) investigate the differences in human capital accumulation between a decentralized and a centralized economy in a model without taste differences. They find that centralization is beneficial from the perspective of human capital accumulation in a steady state. Using their household utility function and calibration of it, we find the static welfare difference between the centralized and decentralized allocations to be approximately zero.[5] Thus, we confirm our finding of gross inefficiencies in decentralized equilibrium using an independently specified model. More recently, Brueckner (2004) compares Tiebout equilibrium with taxation of mobile capital to the centralized alternative and shows by simulation that welfare can be higher or lower in the Tiebout equilibrium. Brueckner's focus is on the trade off from inefficient tax competition for mobile capital, the focus of the tax competition literature, and the gains from matching levels of public goods to diverse preferences. Our research differs in several important ways. The tax we investigate is on (immobile) housing, so the fundamental inefficiency in Brueckner's analysis is not present here. Brueckner's Tiebout sorting is efficient in that a community forms for every

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[4] In an appendix on robustness of our findings (http://public.tepper.cum.edu/facultydirectory/FacultyDirectoryProfile.aspx?id=54), we relate our analysis to Bradford and Oates in more detail. There we perform in our model the welfare calculation that is analogous to that done by Bradford and Oates, and obtain a welfare gain from decentralization that is remarkably close to theirs. This finding highlights that the differing conclusions that we obtain in this paper about the welfare effect of decentralization are not due to differences with respect to the potential gains from decentralization. Rather, we find that the inefficiencies associated with the current institutional structure, which relies on property taxation, dissipate those potential gains.

[5] In our appendix on robustness (see the previous footnote) more detail on the Fernandez and Rogerson (1998) model is provided along with our related calculations.

preference type, while we treat community boundaries as given with an infinite number (continuum) of different types and households then select their preferred community.[6]

As the largest single local government expenditure, education has been a particular focus of analysis of provision regimes, with contributions by Benabou (1993, 1996), deBartolome (1990), Epple and Romano (2003), Fernandez and Rogerson (1996), Ferreyra (2007), and Nechyba (1999, 2000). None of these papers undertakes the welfare comparisons we do here.

Section 2 presents the theoretical model and associated positive and normative properties. The quantitative analysis is presented in Section 3. We calibrate a computational model and show that welfare losses from Tiebout provision are a real possibility. Here we identify the main source of inefficiency, an externality in choice of jurisdiction in which to reside. Section 4 concludes, including a bit more discussion of the related literature.

2. Theoretical Analysis.

a. Elements of the Model. Our intent is to examine the allocative efficiency of multi-jurisdictional or Tiebout provision of a congested local public good in a metropolitan area under property taxation. We examine the efficiency of Tiebout provision relative to the alternative of single-jurisdictional provision, where in the latter the metropolitan area is a single jurisdiction with all residents facing the same property tax rate and level of provision of the public good.[7] We will also study efficient provision regimes that vary with respect to feasible policies (e.g., tax instruments), providing other benchmarks to which we compare the Tiebout equilibrium. The model is an archetypical model of a metropolitan area with property taxation, originally presented in Epple and Platt (1998). We now describe the model, followed by discussion of its virtues for the task at hand.

Households have a utility function over numeraire consumption x, housing consumption h, and the level of the local public good g measured in dollars. Households differ by endowed income y and a taste parameter α, with the latter measuring taste for the local public good as clarified below. The joint distribution on household type (y,α) is continuous and given by F(y,α), with joint density function f(y,α) assumed positive on its support $S \equiv [\underline{\alpha}, \overline{\alpha}] \times [\underline{y}, \overline{y}] \subset R^2_+$.

[6] Another, mainly empirical, literature examines the consequences of centralization versus decentralization for growth. See Brueckner (2006) for a theoretical analysis and for references. For analysis of welfare effects in community models with local income taxation, see Goodspeed (1995) and Schmidheiny (2006).

[7] The single jurisdiction regime is commonly referred to as "centralized provision" in the literature on education finance, so we also employ this terminology.

Let U = U(x,h,g; α) denote the household utility function, strictly quasi-concave, increasing, and twice continuously differentiable in (x,h,g). Further restrictions on U are discussed below.

Under Tiebout provision, the metropolitan area (MA) is divided into J jurisdictions, each with non-decreasing housing supply function $H_s^j(p_s^j)$, where p_s^j denotes the net-of-tax or supplier price of housing, and j = 1,2,…,J henceforth unless indicated otherwise. We assume absentee housing owners who supply housing competitively, but we account for their rents in our welfare calculations.[8] We assume absentee housing owners because it is most standard and simplest.

Equilibrium is determined in three stages. First, households purchase a home in a jurisdiction. Second, they vote in their jurisdiction for a property tax that is used to finance the local public good. Last, the local public good is determined from local governmental budget balance, and households consume (although their housing consumption is determined in the first stage). The local public good is "fully congested," meaning per household consumption equals total taxes divided by the number of households. Households have rational expectations, thus anticipate all continuation equilibrium values.[9]

In the comparison centralized equilibrium, the MA constitutes one jurisdiction with housing supply that is the usual aggregation of the J housing supplies in the Tiebout case. Here households first purchase housing in the MA, and then vote for an MA-wide property tax taking housing consumption as given. Last, a uniform level of the local public good is determined by the MA balance budget condition and households consume.

While the model is fairly simple, it is tractable and leads to a rich set of predictions about household sorting, housing prices, tax rates, and provision levels in Tiebout equilibrium. The model's tractability also permits clarification of the efficiency issues that arise in the Tiebout setting, as well as their quantification. The model has also been estimated and shown to fit well the data (Epple and Sieg, 1999; Calabrese, Epple, Romer and Sieg, 2006).

Before beginning the formal development, some key assumptions and abstractions of the model warrant explanation. The best application is to the provision of public education. The

[8] One interpretation is that the MA is divided into jurisdictions with fixed amounts of land, and land is combined with elastically supplied factors to produce units of housing. Then the "absentee housing owners" could just as well be absentee land owners. In Section 3, we provide a specific example of this.

[9] This specification conforms to the case sometimes called "myopic voting," because households take as given residences, housing consumption, and the supplier price of housing when voting, which are all established in the first stage. We examine this case because it is historically the most studied case in the literature. We show in an appendix on robustness (see footnote 5) that the welfare loss we find from Tiebout sorting *increases* with other standard specifications of the timing of choices and thus voter beliefs that may be more appealing.

congestion assumption is the standard one in the analysis of the provision of public education, while clearly some economies in provision of education arise in reality. We wish, however, to abstract from making assumptions about these economies, while also examining the efficiency of Tiebout provision in a setting where it has the most potential to produce efficiency gains. We show efficiency losses (frequently) arise under Tiebout provision relative to the centralized equilibrium, losses that would be greater if there were economies of scale.[10] We also assume no commuting costs as in the standard Tiebout modeling.[11] Again, the existence of commuting costs would favor centralized provision simply because separate jurisdictional provision only has the potential to constrain efficient household location. Our model also abstracts from potential productivity gains under multi-jurisdictional provision induced by residents being attracted to lower-cost providers or from other competitive mechanisms, which would argue for multiple jurisdictions. But our intent is to focus strictly on allocative efficiency simply because this is of interest in its own right. Moreover, the centralization that we examine need not rule out separate localities that receive the same per household allocation and then provide the local public good. Productivity gains could then be realized in both equilibrium regimes we study. Thus, the possibility of productivity gains from multiple local providers is an independent issue from the question of allocative efficiency.

b. Positive Properties of Equilibrium. The results in this subsection draw together and unify, with some minor generalizations, results from the literature. We need to describe the model and positive properties of the equilibria we study before the normative development in Section 2c, which is new. Preferences are assumed to satisfy some single-crossing restrictions concerning how preferences for the public good vary with income and household type, which underlie household sorting across jurisdictions in Tiebout equilibrium. We describe determination of equilibrium and relate two propositions that collect key elements of it.

To provide a formal description of equilibrium in the Tiebout case, begin with the third stage. Let $f_j(y,\alpha)$ denote the density of household types living in jurisdiction j, t_j the property tax rate, and $h_j(y,\alpha)$ housing consumption of household (y,α), all of which are given in the third

[10] If the publicly provided good is a pure public good that can be consumed by everyone in the MA, then obviously an efficient allocation has one (quality) level of provision consumed by all residents To engender the efficient quality would require non-distortionary taxation efficiently determined. One can consider a variety of cases between purely public and fully congested publicly provided goods. For example, parks are reasonably assumed to be congested, but not perfectly so. Multiple parks that are geographically dispersed in a MA might be efficient. As in this paper, one might compare decentralized multi-jurisdictional provision to centralized provision, with multiple tax and park quality levels in the former case versus a single tax level with uniform park qualities in the latter case.

[11] See deBartolome and Ross (2003,2004) for analysis that integrates commuting costs into a Tiebout model.

stage. The gross housing price (p_j), local public good level (g_j), and household numeraire consumption are determined in the third stage, satisfying respectively:

$$p_j = (1+t_j)p_s^j, \tag{1}$$

$$g_j\int_S f_j(y,\alpha)dyd\alpha = t_j p_s^j H_s^j(p_s^j), \tag{2}$$

and

$$x = y - (1+t_j)p_s^j h_j(y,\alpha), \tag{3}$$

where p_s^j is also given, established in the first stage.[12] Obviously, the third stage values exist and are unique for any vector of predetermined variables.

Now consider the second, voting, stage. Substitute (1) into (3), and then (3) into the utility function and write indirect utility of household (y,α) as a function of (p_j, g_j):

$$V(p_j, g_j; y, \alpha) = U(y - p_j h_j(y,\alpha), h_j(y,\alpha), g_j; \alpha). \tag{4}$$

When voting on the property tax rate, households maximize V(·) while correctly anticipating that (p_j, g_j) will satisfy (1)-(2), taking as given $(f_j(y,\alpha), h_j(y,\alpha), p_s^j)$.[13] Suppress the j indicator and compute the slope of an indifference curve of V = constant in the (g,p) plane:

$$\left.\frac{dp}{dg}\right|_{V=const.} = -\frac{V_g}{V_p} = \frac{U_g/U_y}{h(y,\alpha)}; \tag{5}$$

where the arguments in the numerator of the right-hand side of (5) are the same as in the right-hand side of (4). We make the following "single-crossing assumptions" with respect to indifference curves in the (g,p) plane.

$$\frac{\partial\left(\left.(dp/dg)\right|_{V=const.}\right)}{\partial y} > 0; \tag{SRI}$$

and

$$\frac{\partial\left(\left.(dp/dg)\right|_{V=const.}\right)}{\partial \alpha} > 0. \tag{SRα}$$

[12] Because households will correctly anticipate all equilibrium values, a negative numeraire will never arise in equilibrium.

[13] Since the supplier price of housing is established in the first stage and the model is one period, voters do not take account of capital gains or losses on their homes when voting. See Epple and Romer (1991) for a method of instilling such gains/losses in such a model. They show that incentives to increase redistributive taxes are curtailed if these effects are taken into account.

Assumption SRI, "slope rising in income," means that the willingness to trade an increase in housing price for higher g rises with income. Intuitively, from the right-hand side of (5), one can see that this corresponds to cases where the marginal value of g rises faster with income than does housing demand. [14] The intended nature of the taste parameter is embodied in Assumption SRα. For given income, higher-α households are also more willing to trade an increase in housing price for increased g.

Proposition 1 summarizes key properties of the voting stage, with properties illustrated in the panels of Figure 1.

Proposition 1: Assume that $V(p_j,g_j;y,\alpha)$ is twice continuously differentiable and strictly quasi-concave in (p_j,g_j) for $(p_j,g_j) > 0$. Assume also the Inada condition that $V_g \to \infty$ as $g \to 0$. Then:

a. Majority voting equilibrium exists and is unique.

b. The equilibrium is the preferred choice of households (y,α) on the downward sloping locus $y_j^m(\alpha)$ satisfying:

$$\int_{\underline{\alpha}}^{\bar{\alpha}} \int_{\underline{y}}^{y_j^m(\alpha)} f_j(y,\alpha)dyd\alpha = .5N_j; \tag{6}$$

$$N_j \equiv \int_{\underline{\alpha}}^{\bar{\alpha}} \int_{\underline{y}}^{\bar{y}} f_j(y,\alpha)dyd\alpha. \tag{7}$$

c. Households living in community j with (y,α) to the "northeast" ("southwest") of the $y_j^m(\alpha)$ locus in the (α,y) plane prefer a higher- (lower-) than equilibrium tax.

Parts (b) and (c) of Proposition 1 are from Epple and Platt (1998). Part (a) shows that the necessary conditions for voting equilibrium presented in Epple and Platt (1998) are sufficient for existence and uniqueness of voting equilibrium. A proof of Proposition 1 is available on request from the authors. Figure 1A depicts in household type space the locus of median preference voters in jurisdiction j, $y_j^m(\alpha)$. The $y_b^{ji}(\alpha)$ loci in Figure 1A partition the (α,y) plane into jurisdictions and are discussed below. Figure 1B depicts the optimum of a median preference voter, which occurs at a tangency of an indifference curve (V = const.) and the community budget constraint (2), with (1) used to substitute out t_j.

[14] Epple and Sieg (1999) and Calabrese, Epple, Romer, and Sieg (2006) provide evidence supporting this assumption.

An example that satisfies the conditions for Proposition 1 is the CES utility function: $U = [\beta_x x^\rho + \beta_h h^\rho + \beta_g(\alpha) g^\rho]^{1/\rho}$, with $\rho < 0$ and $\beta_g'(\alpha) > 0$. We employ this utility function in our computational analysis in Section 3.

Now consider the first-stage household choices and the implications for the full (three-stage) equilibrium. Households choose jurisdictions and housing consumption in this stage. Since households correctly anticipate all equilibrium values, their housing consumption satisfies ordinary demand, which we denote by h_d. Thus a household that chooses to live in jurisdiction j consumes housing:

$$h = h_d(p_j, g_j, y, \alpha) \text{ for all } j \text{ and } (y, \alpha). \tag{8}$$

Given jurisdictional choices, housing market clearance in community j determines the supplier price of housing:

$$\int_S h_d(p_j, g_j, y, \alpha) f_j(y, \alpha) dy d\alpha = H_s^j(p_s^j); \tag{9}$$

where p_j satisfies (1) for correctly anticipated t_j.

To determine choice of jurisdiction, find indirect utility

$$\tilde{V}(p_j, g_j; y, \alpha) = U(y - p_j h_d(p_j, g_j, y, \alpha), h_d(p_j, g_j, y, \alpha), g_j; \alpha). \tag{10}$$

Households choose among the J jurisdictions to maximize $\tilde{V}$, correctly anticipating equilibrium (p_j,g_j), $j = 1,2,\ldots,J$. We use a '~' to indicate the indirect utility function relevant in the first stage, which allows housing to vary optimally with (p,g,y,α). Using that h_d maximizes $U(\cdot)$, the slope of $\tilde{V}$ = constant in the (g_j,p_j) plane is of the same form as the slope of V = constant:

$$\left.\frac{dp}{dg}\right|_{\tilde{V}=\text{const.}} = -\frac{\tilde{V}_g}{\tilde{V}_p} = \frac{U_g / U_y}{h_d}; \tag{11}$$

but evaluated at the same argument values as is utility on the right-hand side of (10). We make the analogous single-crossing assumptions on $\tilde{V}$ as SRI and SRα, which we reference as $\widetilde{\text{SRI}}$ and $\widetilde{\text{SR}\alpha}$. The two pairs of single-crossing assumptions are closely related, and, for example, both pairs hold in the CES example of the utility function above if $\rho < 0$.

Summarizing, an equilibrium arises if the following conditions are satisfied: In each community j, (p_j,g_j) satisfy (1) and (2). Household numeraire consumption satisfies (3). The tax rate in each community is the majority choice, where households maximize $V(\cdot)$ when voting. Housing consumption satisfies ordinary demand, (8), and the supplier price of housing in each community satisfies housing-market clearance (9). Residential choices maximize $\tilde{V}(\cdot)$.

There are two types of equilibria that can arise. Our interest is in Tiebout-type equilibria with differences among jurisdictions in levels of provision of the public good and with at least some households having a strict preference for their choice of jurisdiction. Thus, assume for now that $g_i \neq g_j$, for all jurisdictions $i \neq j$. Proposition 2 summarizes key characteristics of such equilibria:

Proposition 2: Tiebout equilibria with jurisdictions numbered such that $g_1 < g_2 < \ldots < g_J$:

a. Have ascending bundles: $p_1 < p_2 < \ldots < p_J$.

b. Are stratified by income and the taste parameter: For given α, if a household with income y_i resides in a higher-numbered jurisdiction than a household with income y_j, then $y_i \geq y_j$ with equality for at most one income level. For given y, if a household with taste parameter α_i resides in a higher-numbered jurisdiction than a household with taste parameter α_j, then $\alpha_i \geq \alpha_j$ with equality for at most one value of α.

c. Exhibit boundary indifference and strict preference for non-boundary households: Households that exist with income level $y_b^{ji}(\alpha)$, $i > j = 1, 2, \ldots, J-1$, for whom:

$$\tilde{V}(p_j, g_j; y, \alpha) = \tilde{V}(p_i, g_i; y, \alpha) = \underset{k=1,2,\ldots,J}{Max}\ \tilde{V}(p_k, g_k; y, \alpha) \qquad (12)$$

form a boundary in the (α,y) plane that partitions residents between communities j and i (see Figure 1A). Households on a boundary are indifferent between their chosen residents while all other residents strictly prefer their residential choice.

Versions of these results are in the literature (see, e.g., Epple and Platt (1998)), and we just outline the logic here. Proposition 2a must hold to have anyone choose a lower numbered community. Proposition 2b follows from the single-crossing assumptions $\widetilde{SRI}$ and $\widetilde{SR\alpha}$. Proposition 2c follows from continuity of utility in its arguments. Typically, a boundary will be between communities j and j+1, but we cannot rule out that, for some α, no types will choose a community (implying, e.g., a boundary might be between j and j+2 for some α). Note that Proposition 2b implies that boundaries will be downward sloping.

Existence of Tiebout equilibrium in the three-stage model is not guaranteed, but is not unusual.[15] We provide computed examples below. Multiplicity of Tiebout equilibria can arise if housing supplies differ across jurisdictions. In the case of two jurisdictions having different

[15] Restrictions on preferences and technology sufficient for existence in the analogous model with no taste variation are developed in Epple, Filimon, and Romer (1984, 1993).

housing supplies, then either might be the lower-g and poorer jurisdiction. With J jurisdictions each with different housing supply, then J! Tiebout equilibria can arise, where any jurisdiction would be the poorest, any of the remaining the second poorest, and so on. A non-stratified equilibrium always exists in the model as well. Suppose, for example, that each jurisdiction has the same housing supply. Suppose, further, that households choose jurisdictions in the first stage such that $f_j = f/J$ for all y. Then the continuation equilibrium values are the same in each jurisdiction; the jurisdictions are clones. In turn, the initial residential choices are equilibrium ones since the households are indifferent to their community. These non-Tiebout equilibria do not require the same housing supplies; initial residence choices can be adjusted so that the same (p,g) values arise in each jurisdiction. There are also mixed equilibria generally where proper subsets of jurisdictions are clones, these acting like one jurisdiction in a fully stratified equilibrium. Such equilibria are unstable when a Tiebout sorting equilibrium exists (see, e.g., Fernandez and Rogerson, 1996). We study here fully stratified Tiebout equilibrium (i.e., with g different in every jurisdiction), obviously in cases where such an equilibrium exists.

The comparison centralized equilibrium assumes the metropolitan area is one jurisdiction, with housing supply that is the usual aggregation of the jurisdictional housing supplies in the Tiebout case. Equilibrium is determined analogously to the above, but with no alternative jurisdictions to choose from in the first stage and with one vote of the entire population over the tax rate, followed by consumption and provision of the public good. From above, it follows that a centralized equilibrium exists and is unique. Obviously, no matching of varied preferences to public goods arises in the centralized case. Our interest is in the welfare comparison of the centralized equilibrium to the Tiebout equilibrium, when the latter exists.[16]

c. Efficiency Considerations. In this sub-section, we examine efficiency issues theoretically. We focus initially on the social welfare problem and characterize efficient allocations. Solving this problem is of interest for several reasons. First, the characterization of efficiency is of intrinsic interest. Second, the solution permits us to compute efficient allocations and then quantify the potential efficiency gains from multi-jurisdictional provision relative to the single-jurisdictional equilibrium. When we compute an efficiency loss from equilibrium Tiebout provision, it is of interest to compare the loss to the feasible gains from household sorting. We will see that an efficient allocation can be implemented using head taxes while not using

[16] Note that the centralized equilibrium values correspond to those in the decentralized non-stratified (clone) equilibrium discussed in the previous paragraph, so one can interpret the comparison this way as well.

property taxes. The third virtue of examining the social welfare problem is that we can easily modify the analysis to examine a *constrained* social welfare problem where only property taxes are permitted. The solution of this social welfare problem serves to identify the key inefficiency that arises in the Tiebout property tax equilibrium.

(i) The Planner's Problem. We first solve the planner's problem and characterize Pareto efficient allocations. Let $\omega(y,\alpha) > 0$ denote the weight on household (y,α)'s utility in the social welfare function and $\omega_R > 0$ the same for the absentee housing suppliers.[17] Let $r(y,\alpha)$ denote the planner's monetary transfer to household (y,α) and R the total transfer to the housing suppliers. The social planner is permitted to levy in community j both a head tax T_j and a property tax (t_j), the former necessary to obtain efficiency as we show. It is again convenient to work with an indirect utility function. Let:

$$V^e(p_j, g_j, y + r(y,\alpha) - T_j, \alpha) \equiv \max_h U(y + r(y,\alpha) - T_j - p_j h, h, g_j; \alpha), \tag{13}$$

where the solution to the maximization problem in (13) is given by $h_d(p_j, y+r(y,\alpha)-T_j, g_j, \alpha)$, recalling that $h_d(\cdot)$ denotes ordinary housing demand. Finally, let $a_j(y,\alpha) \in [0,1]$ denote the proportion of households (y,α) assigned by the planner to community j.

Pareto efficient allocations solve the social planner's problem:

$$\max_{r(y,\alpha), a_i(y,\alpha), R, T_i, t_i, p_i, g_i} \sum_{i=1}^{J} \{ \int_S \omega(y,\alpha) V^e(p_i, y + r(y,\alpha) - T_i, g_i, \alpha) a_i(y,\alpha) f(y,\alpha) dy d\alpha \\ + \omega_R (R/J + \int_0^{p_i/(1+t_i)} H_s^i(z) dz) \}, \tag{14}$$

s.t. $$R + \int_S r(y,\alpha) f(y,\alpha) dy d\alpha = 0, \tag{15}$$

$$\int_S h_d(p_i, y + r(y,\alpha) - T_i, g_i, \alpha) a_i(y,\alpha) f(y,\alpha) dy d\alpha = H_s^i(p_i/(1+t_i)), \; i = 1,2,...,J, \tag{16}$$

$$T_i \int_S a_i(y,\alpha) f(y,\alpha) dy d\alpha + \frac{t_i p_i}{1+t_i} H_s^i(p^i/(1+t_i)) = g_i \int_S a_i(y,\alpha) f(y,\alpha) dy d\alpha, \; i =,1,2,...,J, \tag{17}$$

$$a_i(y,\alpha) \in [0,1] \text{ and } \sum_{i=1}^{J} a_i(y,\alpha) = 1 \; \forall (y,\alpha). \tag{18}$$

The social planner chooses balanced-budget transfers ((15)), taxes and balanced-budget levels for the local public goods ((17)), and assigns households to communities ((18)) so as to maximize the social welfare function. We also write the problem requiring competitive housing provision ((13) and (16)). Requiring competitive provision of housing and *local* budget balance may seem to impose some second-best requirements on the "efficient" allocation. However, as

[17] We assume housing suppliers have quasi-linear utility functions and the social planner treats them all the same.

discussed below, these impositions are consistent with first-best Pareto efficiency.[18] A solution to the problem is Pareto Efficient for any social welfare weights ($\omega(y,\alpha),\omega_R$). If a Pareto improvement were feasible relative to any solution, then the objective function would increase with the change, a contradiction. As the social weights are varied, alternative Pareto efficient allocations are determined. The latter follows since as one moves along the Paretian frontier, the gradient changes, which serve as social welfare weights corresponding to the particular Pareto efficient allocation. If the utility possibilities set is convex, then all Pareto efficient allocations are a solution to the problem for some set of weights.[19] Note, too, that $r(y,\alpha) = R = 0$ will arise in the solution to the planner's problem for some weights ($\omega(y,\alpha),\omega_R$), this no-transfer case being most naturally compared to the market equilibrium allocation.

To solve the problem, write the Lagrangian function:

$$L = \sum_{i=1}^{J}\left\{\int_S \omega V_i^e a_i f dy d\alpha + \omega_R (R/J + \int_0^{p_i/(1+t_i)} H_s^i dz)\right\} +$$
$$\sum_{i=1}^{J}\lambda_i[(T_i - g_i)\int_S a_i f dy d\alpha + \frac{t_i p_i}{1+t_i}H_s^i] + \sum_{i=1}^{J}\eta_i[\int_S h_d a_i f dy d\alpha - H_s^i] + \Omega[R + \int_S r f dy d\alpha]; \tag{19}$$

where λ_i, η_i, and Ω are multipliers, we have suppressed arguments of functions, V_i^e is notation indicating that V^e has arguments corresponding to community i, and constraint (18) is taken account of below. The first-order condition on ($r(y,\alpha)$,R) can be written:

$$-\Omega = \sum_{i=1}^{J}\omega U_1^i a_i + \sum_{i=1}^{J}\eta_i \frac{\partial h_d^i}{\partial y} a_i = \omega_R \ \ \forall (y,\alpha); \tag{20}$$

where U_1^i is the partial derivative of U with respect to its first argument and the superscript indicates evaluation of the function at community i values. (We continue to use such notation below.) Let:

$$MSV_i(y,\alpha) \equiv L_{a_i f} = \omega V_i^e + \lambda_i[T_i - g_i] + \eta_i h_d^i \tag{21}$$

denote the marginal social value of assigning a measure $a_i f(y,\alpha)$ of household type (y,α) to community i, which equals the first variation in the Lagrangian with respect to type (y,α).[20] Now taking account of (18), the optimal household assignment criterion can be written[21]:

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[18] We treat the housing supplies to jurisdictions as a technological constraint. That is, we do not allow jurisdictional lines to be redrawn, which would effectively permit trading of housing between jurisdictions. Depending on one's perspective, the solution might then be regarded as second best. In Section 3, we will also compute the efficient allocation that allows each household to occupy their own jurisdiction.

[19] If the constrained utilities possibilities set is not convex, then one can still find all Pareto Efficient allocations as extrema of the planner's problem. Some solutions would be local minima of the problem but would satisfy the same (first-order) conditions we derive below. See Panzar and Willig (1976).

[20] This is scaled by $f(y,\alpha)$ just to be comparable across types.

$$a_i(y,\alpha)\begin{pmatrix} =0 \\ \in[0,1] \\ =1 \end{pmatrix} \text{ as } MSV_i(y,\alpha)\begin{pmatrix} < \\ = \\ > \end{pmatrix} Max_{j\neq i}\, MSV_j(y,\alpha)\ \forall (y,\alpha). \tag{22}$$

To write out the remaining first-order conditions, let:

$$N_i \equiv \int_S a_i(y,\alpha) f(y,\alpha) dy d\alpha \text{ and } \varepsilon_s^i \equiv \frac{H_s^{i\prime}}{H_s^i}\frac{p_i}{(1+t_i)} \tag{23}$$

denote respectively the number of residents of community i and the elasticity of housing supply. We have:

$$L_{t_i} = 0 \rightarrow -\omega_R + \lambda_i(1-t_i\varepsilon_s^i) + \frac{1+t_i}{p^i}\eta_i\varepsilon_s^i = 0; \tag{24}$$

$$L_{T_i} = 0 \rightarrow -\int_S \omega U_1^i a_i f dy d\alpha + \lambda_i N_i - \eta_i \int_S \frac{\partial h_d^i}{\partial y} a_i f dy d\alpha = 0; \tag{25}$$

$$L_{g_i} = 0 \rightarrow \int_S \omega U_3^i a_i f dy d\alpha + \eta_i \int_S \frac{\partial h_d^i}{\partial g_i} a_i f dy d\alpha - \lambda_i N_i = 0; \tag{26}$$

and

$$L_{p_i} = 0 \rightarrow \frac{1+t_i}{H_s^i}\left[\eta_i \int_y \frac{\partial h_d^i}{\partial p^i} a_i f dy d\alpha - \int_y \omega U_1^i h_d^i a_i f dy d\alpha\right] + t_i\lambda_i(1+\varepsilon_s^i) - \frac{\eta_i(1+t_i)\varepsilon_s^i}{p_i} + \omega_R = 0. \tag{27}$$

We restrict attention to cases where it is efficient to have *differentiated communities* as in Tiebout allocations. By differentiated communities, we mean allocations having assignments with $a_i(y,\alpha) = 1$ for some community i for almost every household (see (21) and (22)). Alternative allocations have households of the same type live in multiple communities as when communities have the same set of types. Whether differentiation is optimal depends on the utility weights in the social welfare function. Essentially, we want to compare equilibrium allocations *with differentiation* to efficient allocations that entail differentiation.

First we confirm what is very intuitive: The social optimum will have no property taxation, just head taxes. More to our purposes, unilateral household choice of residence with an efficiently chosen head tax would be consistent with the efficient allocation. We will then go on to examine the second-best problem assuming only property taxes are allowed, which helps to clarify the inefficiencies in the Tiebout property-tax equilibrium.

[21] If the middle line of (22) characterizes the solution for a household y, then the summation constraint in (18) comes into play. However, we will focus on cases where this does not characterize the optimum, as discussed below.

Proposition 3: In an efficient differentiated allocation: (a) $t_i = \eta_i = 0$ and $T_i = g_i$; *(b)* g_i *satisfies the community Samuelsonian condition; and (c) households are assigned to the community where* V_i^e *is at a maximum.*

Proof of Proposition 3: (a) First we show that $t_i = \eta_i = 0$. *From (20) and that the allocation is differentiated:*

$$\omega U_1^i + \eta_i(\partial h_d^i / \partial y) = \omega_R \quad \text{for all households } (y,\alpha) \text{ assigned to community } i. \tag{28}$$

Multiply through (28) by $a_i f$ *and integrate to obtain:*

$$\int_S \omega U_1^i a_i f dy d\alpha + \eta_i \int_S \frac{\partial h_d^i}{\partial y} a_i f dy d\alpha = N_i \omega_R. \tag{29}$$

Then (29) and (25) imply:

$$\lambda_i = \omega_R. \tag{30}$$

Also (30) and (24) imply:

$$t_i \omega_R = \frac{\eta_i(1+t_i)}{p_i}. \tag{31}$$

Since $\omega_R > 0$, *if* $t_i = 0$, *then* $\eta_i = 0$ *and the reverse. Now we show that* $t_i \neq 0$ *implies a contradiction. Multiply through (28) by* $h_d^i a_i f$ *and integrate to obtain:*

$$\int_S \omega U_1^i h_d^i a_i f dy d\alpha = \omega_R H_s^i - \eta_i \int_S \frac{\partial h_d^i}{\partial y} h_d^i a_i f dy d\alpha; \tag{32}$$

where we have substituted the housing market clearance condition ((16)). Now substitute from (30), (31), and (32) into (27) to get:

$$\eta_i \left\{ \frac{1+t_i}{H_s^i} \left(\int_S \frac{\partial h_d^i}{\partial p_i} a_i f dy d\alpha + \int_S \frac{\partial h_d^i}{\partial y} h_d^i a_i f dy d\alpha - \frac{1+t_i}{t_i p_i} H_s^i \right) + \frac{1+t_i}{p_i}(1+\varepsilon_s^i) - \frac{1+t_i}{p_i}\varepsilon_s^i + \frac{1+t_i}{t_i p_i} \right\} = 0.$$

This simplifies to:

$$\frac{\eta_i}{H_s^i} \left\{ \int_S \left(\frac{\partial h_d^i}{\partial p_i} + \frac{\partial h_d^i}{\partial y} h_d^i \right) a_i f dy d\alpha \right\} = 0. \tag{33}$$

The term in parentheses in the integrand in (33) is the slope of the compensated demand for housing and is then negative. Hence, the integral term is negative, implying $\eta_i = 0$. *This contradicts (31), so it must be that* $t_i = \eta_i = 0$.

Since $t_i = 0$, $T_i = g_i$ *by local budget balance (i.e., (17)).*

(b) Using $\eta_i = 0$, substitute from (25) into (26). Then use that ωU_1^i *equals a constant from (28) to obtain the Samuelsonian condition for a congested public good:*

$$\int_S \frac{U_3^i}{U_1^i} a_i f dy d\alpha = N_i. \quad (34)$$

(c) Using the results in part (a), (21) and (22) imply that a household is optimally assigned to the community where V_i^e is maximized. ■

It is straightforward to confirm that the same results obtain if the planner also assigns housing consumption to each household and if the government budget constraint is economy-wide, rather than local. Regarding the former, households would, of course, be assigned the level of housing demanded. Regarding the latter, direct income transfers permit the government to accomplish the same set of utility levels as would also allowing transfers across jurisdictions. The reason we have specified the problem imposing competitive housing consumption and jurisdictional budget balance is because we want to impose these requirements in the second-best analysis that follows, and then we can easily use the preceding equations.

A key implication of Proposition 3 is that if head taxes are set in communities to provide the local public goods optimally, then household choice of communities would be socially optimal. Unilateral choice of community would lead households to choose the community where V_i^e is at a maximum, which, by Proposition 3c, is efficient. Likewise, competitive provision of housing is efficient. The non-distorted price of housing and the head tax efficiently price access to communities. No externalities in community choice arise in this case.[22]

Proposition 3 can be viewed as a generalization of the celebrated decentralization theorem of Oates (1972). Our framework follows Oates in assuming no spillovers from the local public goods, costs of provision the same for the centralized as for the decentralized case, and uniform provision under centralization.[23] Our result extends Oates's theorem by permitting

[22] If housing supplies differ across communities, then there are generally multiple local maxima of the social planner's problem. Consider the two-community example, and suppose community 1 has larger housing supply than community 2. The efficient allocation might have either community the relatively more wealthy community; suppose community 2 is richer at the global maximum. Then there exists a local maximum of the social welfare function where community 1 is richer, and the corresponding (second-best) optimal head taxes would induce unilateral community and housing choices consistent with this local maximum. An appendix, available from the authors on request, provides more detail on this issue. We return to this issue in Section 3, when it becomes relevant to computations.

[23] See Oates (1999, 2006) for a detailed discussion of the assumptions underlying the theorem.

households to be mobile and by establishing that optimally chosen head taxes can achieve the efficient decentralized allocation when households are mobile.

Now we examine the planner's problem assuming head taxation is not allowed. The planner's optimum with property taxation identifies an externality in community choice that we will show computationally to underlie the efficiency loss we find in Tiebout equilibrium in realistic calibrations. Set $T_i = 0$ everywhere above and drop the first-order condition describing the efficient choice of T_i, i.e., (25). With $T_i = 0$, the other first-order conditions remain valid.[24] Of course, t_i will be positive here and is optimally chosen by the planner, but we will also discuss later the alternative where t_i is suboptimal. From (21), setting $T_i = 0$, now $MSV_i(y,\alpha) = \omega V_i^e - \lambda_i g_i + \eta_i h_d^i$. Expression (22) continues to describe optimal assignments using the latter value of MSV_i. Household choice of a jurisdiction, rather than jurisdictional assignment by the planner, would now be associated with an externality, and its character is the focus. The value of what we call the "jurisdictional choice externality (JCE)" of household (y,α) in jurisdiction i is given by:

$$JCE_i(y,\alpha) \equiv -\lambda_i g_i + \eta_i h_d(p_i, y + r(y,\alpha), g_i, \alpha). \tag{35}$$

From the expression for MSV_i, we see that $JCE_i(y,\alpha)$ equals the social value of assignment to community i of household (y,α) in excess of the household's own (socially weighted) utility. Thus $JCE_i(y,\alpha)$ measures the social benefit or cost imposed on others when household (y,α) locates in jurisdiction i. To simplify the analysis, we now assume that housing demand is independent of g_i, as arises in the specification we analyze numerically below.[25]

To convey the main results here, we introduce a bit more notation. Let:

$$\tau_i(y,\alpha) \equiv \frac{t_i p_i h_d(p_i, y + r(y,\alpha), \alpha)}{(1+t_i)}, \tag{36}$$

which equals household (y,α)'s tax payment in jurisdiction i. Let $h_c(\cdot)$ denote a household's compensated demand function for housing, and define:

$$\theta_i \equiv \frac{(1+t_i)\varepsilon_s^i}{(1+t_i)\varepsilon_s^i - \int_S \frac{\partial h_c^i}{\partial p_i} \frac{p_i}{H_s^i} a_i f dy d\alpha}. \tag{37}$$

Observe that $\theta_i \in [0,1]$, where the integral term in the denominator of θ_i is the elasticity of the compensated demand. We have:

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[24] We continue to study cases with differentiated communities at the solution to the planner's problem.

[25] We will also indicate what changes if housing demand does depend on g_i.

Proposition 4: (a) The jurisdictional choice externality in the planner's solution satisfies:

$$JCE_i(y,\alpha) = -\lambda_i[g_i - \tau_i(y,\alpha)\theta_i]; \tag{38}$$

with

$$\lambda_i = \frac{\int_S \omega U_3^i a_i f dy d\alpha}{N_i} > 0, \tag{39}$$

(where U_3^i is the derivative of utility with respect to g_i).

(b) $JCE_i(y,\alpha) \to -\lambda_i g_i$ *as* $\varepsilon_s^i \to 0$; $JCE_i(y,\alpha) \to -\lambda_i(g_i - \tau_i(y,\alpha))$ *as* $\varepsilon_s^i \to \infty$.

(c) $JCE_i(y,\alpha)$ is negative for all households in community i with housing demand below the mean.

Proof of Proposition 4: (a) Substitute from (24) and (32)into (27) to obtain:

$$\eta_i = -\lambda_i \frac{t_i p_i \varepsilon_s^i}{\frac{p_i}{H_s^i}\int_S \frac{\partial h_c^i}{\partial p_i} a_i f dy d\alpha - (1+t_i)\varepsilon_s^i}. \tag{40}$$

Substituting (36), (37), and (40) into (35), yields (38). Expression (39) follows from (26) using our assumption that housing demand is independent of g_i, and the value of λ_i is obviously positive.[26]

(b) These results follow trivially from (38) and the definition of θ_i (i.e., (37)).

(c) This follows from (38) since $\theta_i \in [0,1]$ and g_i equals the tax payment of the household in community i with average housing consumption. ■

The main implication is that an *equilibrium* allocation with property taxation, where households *choose* communities, will have too many households selecting jurisdictions with high g's, especially poorer households (assuming housing demand is normal). Intuition suggests, and (38) confirms, that the JCE will be proportional to the difference between the value of the service the household consumes (g) and the tax paid *by that household.* The "tax paid" by a household equals the tax "shifted forward," $\tau\theta$. In the limit with perfectly elastic housing supply ($\theta = 1$), a household's consumption of housing corresponds to new production, and taxes are effectively collected from the household in proportion to housing consumption. In this case and assuming an income elasticity of housing demand equal to one, households with income above (below) the community average and thus housing consumption above (below) the average exert a positive

[26] If housing demand depends on g_i, then a sufficient condition for λ_i to be positive is that housing demand is non-increasing in g_i. The remaining results in Proposition 4 are as stated.

(negative) externality. At the opposite extreme with housing supply elasticity equal to 0 (and thus θ=0), every household's consumption of housing displaces that of other households in the community, and taxes to cover consumption of g are fully absorbed by the absentee housing owners. Here every household exerts a negative externality proportional to g in the community.[27]

In contrast to the case with efficient head taxes, note from (40) that the multiplier (η) on the housing-market clearance condition is positive except when the housing supply elasticity is 0. This is because the gross housing price inefficiently deters housing consumption and is not enough to deter poor households from moving into high-g communities. Requiring housing consumption in excess of demand could then improve efficiency.[28] If the tax t_i is inefficient (i.e., is not chosen by the planner), one finds that[29]:

$$\eta_i = \frac{t_i\left[\int_S \omega U_1^i h_d^i a_i f dy d\alpha - (1+\varepsilon_s^i)\frac{H_s^i}{N_i}\int_S \omega U_3^i a_i f dy d\alpha\right]}{\int_S \frac{\partial h_c^i}{\partial p_i} a_i f dy d\alpha + t_i \int_y \frac{\partial h_d^i}{\partial p_i} a_i f dy d\alpha - \frac{(1+t_i)\varepsilon_s^i H_s^i}{p_i}}. \tag{41}$$

Now η_i can be positive or negative. This is because g_i might be over-provided (conditional on using property taxation) and then limiting housing consumption would reduce this distortion.

The efficiency analysis reveals three inefficiencies that will arise in a Tiebout property tax equilibrium. The fact that the constraint on the housing market clearance condition is generally binding under property taxation ($\eta \neq 0$), implies that this taxation is inefficient. Property taxation distorts housing market consumption in the usual way with competitive housing markets Second, the property tax rate and thus g in each jurisdiction will not be chosen

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[27] In light of the preceding, it is tempting to conclude that the aggregate loss from the JCE is highest when the elasticity of housing supply is zero. However, the aggregate loss associated with the JCE depends not only on the externality created by a household's location choice, but also on the number of households who make location choices that depart from the efficient allocation. That number will tend to be smaller when the housing supply elasticity is low than when it is high, for the following reason. Consider two communities, one of which is poor, the other wealthy. As households move from the poor to the wealthy community, the housing price in the wealthy community rises more rapidly when the housing supply elasticity is low. Similarly, the price in the poor community falls more rapidly when the supply elasticity is low. These price effects limit the extent to which location choices depart from the optimum. Hence, when the housing price elasticity is low (high), the externality from a poor household that chooses the wealthy community is high (low), but the number of households whose location deviates from the optimum is low (high). The net effect of a change in the housing price elasticity is then ambiguous. We find computationally that welfare rises as the housing supply elasticity falls for low and intermediate elasticity values (see Section 3).

[28] See Calabrese, Epple, and Romano (2007) on residential zoning that improves efficiency.

[29] This is found by solving the planner's problem with t_i exogenous, hence suppressing condition (24). We continue to assume that T_i must be 0.

by a planner in equilibrium, rather will be the majority choice.[30] Third, having property taxation rather than (efficient) head taxation will imply a jurisdictional choice externality as we have seen.[31] We have highlighted this externality in the analysis because it is less obvious and because we will show that it is the major cause of the welfare losses we find in Tiebout equilibrium.

3. Computational Analysis

We specify and calibrate a computational model that illustrates the tendency for decentralization to be inefficient. The computational model also permits us to delineate the magnitudes of the three sources of inefficiency. We describe the baseline model, clarify our measurement of efficiency, present the main findings, and examine robustness.

a. Specification and Calibration of the Model. Household utility is assumed to be CES:

$$U=[\beta_x x^\rho + \beta_h h^\rho + \beta_g g^\rho]^{1/\rho}, \tag{42}$$

with the taste parameter α equated to β_g. We must calibrate the metropolitan area (MA) income distribution, the distribution of the taste parameter, the number of jurisdictions, and the parameters of the utility function and housing supply functions.

We assume constant elasticity housing supply function in each jurisdiction. Such a housing supply function arises if units of housing are produced competitively by combining a jurisdiction's inelastically supplied land L_j with an elastically supplied factor q according to constant-returns production function: $h = L^\gamma q^{1-\gamma}$, $\gamma \in (0,1)$. Specifically, then

$$H_s^j = L_j \left(p_s^j\right)^{\frac{1-\gamma}{\gamma}} \left(\frac{1-\gamma}{w}\right)^{\frac{1-\gamma}{\gamma}}, \tag{43}$$

where w is the given price of input q. The quantity of housing available at given housing price then varies across jurisdictions proportionately to their land endowment. In our baseline calibration, we assume five local jurisdictions in the MA – a large city and four smaller suburbs that have equal area. The total land supply in the MA is normalized to 1. The city is assumed to

[30] See Bergstrom (1979) for analysis of majority choice and efficiency.

[31] The above-discussed multiplicity of Tiebout equilibria when jurisdictions have different housing supplies implies another type of inefficiency can arise. These equilibria differ with respect to the stratum and size of the population that occupies each community. Efficiency generally entails grouping households with similar demands for local public goods in the same community. With variation in the "size" of communities it is also relatively efficient to match community sizes to sizes of groups with similar demands for the local public good . One of the Tiebout equilibria will do a better job of accomplishing this size matching. Thus, the other Tiebout equilibria then suffer from the additional inefficiency of "poor size matching." We will study the Tiebout equilibrium that is most empirically relevant in our computational analysis, placing the poorest stratum in the largest jurisdiction, which we interpret as the central city.

have 40% of the total land area and each of the suburbs 15%. We assume that the city is the poorest jurisdiction (see footnote 31). The jurisdictions are numbered from poorest to richest: Hence, $L_1 = .4$, and $L_2 = L_3 = L_4 = L_5 = .15$, where L_j equals community j's land share. The parameter γ equals the share of land inputs in housing in our model. Based on the empirical evidence (see the discussion in Epple and Romer, 1991), we set $\gamma = ¼$. Note from (43) that this implies a housing supply elasticity equal to 3.[32] Parameters in the baseline calibration are reported in Table 1.

The distribution of MA income is calibrated using data from the 1999 American Housing Survey (AHS).[33] Median income reported by the AHS is $36,942. Using data for the 14 income classes reported by the AHS, we estimate mean household income to be $54,710. These values and our assumption that the income distribution is lognormal imply $\ln y \sim N(10.52,.785)$.

We assume that $\beta_g = \alpha$ follows a lognormal distribution. We calibrate its variance so that the across jurisdictional income variation in the baseline Tiebout equilibrium we compute equals 25% of the MA variance in income.[34] Using annual data for the Boston metropolitan area, Epple and Sieg (1999) found that the across-jurisdiction share of the variance of income was on the order of 15%. Annual incomes are a noisy measure of permanent income, however, leading to an overstatement of within-jurisdiction income variance as shown by Davidoff (2005). He estimates the across jurisdiction share to be 28% in the Boston MA. Hence, we have opted for a value closer to Davidoff's estimate, specifically 25%. The implied standard deviation of β_g is approximately given by: SD $[\beta_g] = .000932$. Note that this implies substantial income mixing within jurisdictions.

The remaining parameter values are ρ, β_x, β_h, and $E[\beta_g]$ from the utility function (42), and w from the housing supply function (43). The remaining calibration is based on the single jurisdictional equilibrium for simplicity. First, we set $\beta_x = 1$, a normalization. While less obvious, w is also a "free parameter," which we also then set equal to 1. To see this, note from

[32] This housing supply elasticity is within the range of estimates for new housing, though estimates vary substantially. See Dipasquale (1999), Blackley (1999), and Somerville (1999). Dipasquale and Wheaton (1992) estimate the long run rental housing supply elasticity to be 6.8. Other estimates also find a higher elasticity than 3 (see Mayer and Sommerville, 2000, and Epple, Gordon, and Sieg, 2010).

[33] http://www.census.gov/hhes/www/housing/ahs/99dtchrt/tab2-12.html

[34] A standard decomposition of the variance of income yields: $VAR[y] = VAR[\bar{y}_j] + \sum_{j=1}^{J} \varphi_j VAR[y_j]$; where y_j denotes income in jurisdiction j, $\bar{y}_j$ its mean, and φ_j is the proportion of residents in jurisdiction j. Thus we calibrate so that $VAR[\bar{y}_j]/VAR[y] = .25$.

(43) that the housing supply function for the MA is: $H_s = \left(w\right)^{\frac{\gamma-1}{\gamma}}\left(p_s\right)^{\frac{1-\gamma}{\gamma}}\left(1-\gamma\right)^{\frac{1-\gamma}{\gamma}}$, and this is the only place that w appears in the model. For any γ, changing w is equivalent to changing the units of measurement of housing. No equilibrium values relevant to utilities then vary with w.

The values of $E[\beta_g]$, β_h, and ρ are set so that in the single jurisdictional equilibrium the median voter chooses t = .35, the net-of-tax expenditure share on housing equals .20, and the price elasticity of housing is very close to -1. A t = .35 implies a tax rate on property value that is realistic, on the order of 2.5% to 3.0%.[35] The expenditure share on housing of .20 is in the range of values estimated in the literature (see Hanushek and Quigley (1980)). Likewise, the housing market literature indicates a price elasticity close to -1.[36] The implied values of $E[\beta_g]$ and β_h are, respectively, 0.094 and .356. We set ρ = -.01, which implies a price elasticity of housing demand equal to -.993, while also implying SRI and existence of a Tiebout equilibrium when there are multiple jurisdictions.[37]

b. <u>Measuring Welfare</u>. We treat the centralized property-tax equilibrium as the status quo and use (the negative of) aggregate compensating variation in moving to the Tiebout property tax equilibrium as our welfare measure. Let $U^c(y,\alpha)$ denote utility of household (y,α) in the centralized equilibrium and $U^T(y,\alpha)$ utility in Tiebout equilibrium. Let v(y,α) denote compensating variation, defined in $U^c(y,\alpha) = U^T(y+v,\alpha)$. Let $CV = \int_S v(y,\alpha)f(y,\alpha)dyd\alpha$ denote aggregate household compensating variation. Let $R^c = \sum_{j=1}^{J}\int_0^{p_s^c} H_s^j(p)dp$ denote housing rents in the centralized equilibrium, where p_s^c denotes the net housing price. Let $R^T = \sum_{j=1}^{J}\int_0^{p_s^j} H_s^j(p)dp$ denote housing rents in the Tiebout equilibrium. Compensating variation of the absentee landlords is given by: $R^c - R^T$. We report $W^T = -[CV + R^c - R^T]$ as our welfare measure, while also typically reporting the components, aggregate consumer welfare (-CV) and housing rents (R^T-R^c). The negative of compensating variation is reported, so a positive value indicates a gain

[35] Observed property tax rates are typically expressed as a percent of property value. In our model, rates are expressed as a percentage of annual implicit rent. Employing the approach of Poterba (1992), Calabrese and Epple (2006) conclude that tax rates on annualized implicit rents can be converted to rates on property values using a conversion rate on the order of 7% to 9%. Thus, our annualized rate of .35 translates to a tax rate on property value on the order of 2.5% to 3%, which is the order of magnitude of observed property tax rates.

[36] See Rosen (1979), Hoyt and Rosenthal (1990), and Rosenthal, Duca, and Gabriel (1991). Hanushek and Quigley (1980) obtain somewhat more inelastic estimates.

[37] A ρ = 0 implies a Cobb-Douglas utility function and a price elasticity of demand for housing exactly equal to -1. In this case, SRI fails and an equilibrium with Tiebout sorting does not arise.

from Tiebout sorting. We measure the welfare effect of going from the centralized equilibrium to the efficient allocation the same way.

c. Findings. Table 2 summarizes the welfare effects in the baseline calibration, comparing the Tiebout property-tax equilibrium and efficient allocation to the centralized property-tax equilibrium. The proportion of the population that is worse off relative to the centralized equilibrium and the welfare changes, averaged over resident households and for housing absentee owners are reported. The first column shows the welfare effects of going from the centralized property tax equilibrium to the Tiebout property tax equilibrium. We see that 63% of the resident population is worse off in the Tiebout allocation, with a per capita welfare loss equal to $51.20. The middle rows parcel the loss between the housing suppliers ("Change in Rents") and MA residents. Note that '-CV' equals the per capita (negative) compensating variation since the population is normalized to 1. While the welfare loss is small (.09% of mean income), a potential welfare gain from instead moving to an efficient allocation equals $1,459 (2.67% of mean income), as reported in the second column. This column provides the same welfare measures, but values for moving from the centralized property tax equilibrium to an efficient allocation. This "efficient allocation" is the local maximum of the social welfare problem assuming no transfers and with the poorest stratum of the population living in the large community.[38]

Before we dissect the welfare effects in the baseline case, consider Figure 2. Figure 2 shows the per capita welfare effect of moving to the Tiebout property tax equilibrium as a function of the number of jurisdictions, for three values of the housing supply elasticity. We vary the number of jurisdictions by subdividing the suburbs, always keeping each suburb with the same, but smaller, land area, and maintain the land area in the city equal to 40%. For the moment, examine the middle (solid) curve with $\varepsilon_s = 3$, the baseline value. It is perhaps surprising that the welfare loss we find in the baseline calibration is *not* due to our restriction to 4

[38] To be comparable to the decentralized property tax equilibrium, we have computed welfare effects in Column 2 of Table 2 for the efficient allocation conditional on the poorest segment choosing the largest community. As discussed in footnote 22, when housing supplies differ, there can be multiple "efficient" head-tax allocations that vary with respect to which income segments are assigned to the variably sized communities. More formally, these "efficient allocations" are local maxima of the social welfare problem. We have also computed the most efficient allocation that could possibly result which, given the no congestion assumption, is equivalent to treating g as a private good, produced in a competitive market with constant cost. This would be like the efficient head tax allocation if every household lived in their own community. The average welfare gain from this allocation relative to the centralized Tiebout equilibrium equals $1682. Because we find a gain of $1459 from the 5-community efficient allocation (Column 2 of Table 2), 86.7% of the latter value, we can infer that our restriction to 5 communities and focus on this local maximum of the social welfare problem does not bias our analysis.

suburbs, and in fact the per capital welfare loss rises slightly as the number of jurisdictions increases. To understand this finding and all our computational results, we return for now to the baseline calibration with 5 jurisdictions, and examine the welfare effects in more detail.

Table 3 reports positive and normative properties of five allocations for the baseline parameters, with positive elements in the upper part of the table and normative elements in the lower part. The second and third columns are exactly the same allocations reported respectively in the first and second columns of Table 2, but now including detail on positive properties of these allocations. Understanding positive properties of the allocations is crucial to understanding the welfare effects as well as being interesting in their own right. The first column of Table 3 reports the positive properties of the benchmark single jurisdiction property tax equilibrium. Ignore the last two columns of Table 3 for the moment.

Positive properties of the allocations reported in Table 3 are the gross housing prices, proportions of community residents, property-tax rates (when applicable), and per household local public good expenditures. The reported normative properties are exactly as in Table 2. The first column reports positive values for the single-jurisdiction equilibrium. It has a gross price of housing services equal to $17.13, a property tax rate on those services of 35%, and uniform provision of g of $3,830, these values driven by the calibration as discussed above. The second column reports values for the Tiebout property-tax equilibrium. It is income- and taste-stratified and supported by ascending housing prices, although the property tax rates vary little and are very close to that rate in the centralized equilibrium. Because these tax rates apply to substantially different housing expenditures, the public good levels vary substantially. The equilibrium population proportions (the N_i's) closely match the land allocations to the jurisdictions. We have already seen there is a per capita welfare loss relative to the single-jurisdiction equilibrium of about $51.

With respect to positive economic variables, what is most notable about the efficient allocation (third column), as compared to the property-tax Tiebout allocation, is that the efficient allocation is much more stratified: In the efficient allocation, the central city has 70% of the population, while the most elite suburb has only 3% of the population, these in spite of the same land allocation and thus housing supplies as in the Tiebout property-tax equilibrium. Along the same lines, the g's rise much more rapidly as one moves up the hierarchy in the efficient allocation. Recall that these are financed by community head taxes in the efficient allocation so there are no property taxes to report. The reason that housing prices rise along the hierarchy in the property tax equilibrium, but not so in the efficient allocation, is that housing prices are bid up as poorer types move into richer jurisdictions in the property-tax equilibrium, while head taxes limit this behavior in the efficient allocation.[39]

To delineate the sources of the welfare losses that arise in Tiebout property-tax equilibrium, we calculate two other allocations. Recall, three inefficiencies arise in Tiebout equilibrium: First, property taxation distorts housing consumption with the usual deadweight loss. Second, majority choice of the tax rate conforms to the choice of the median-preference households in a jurisdiction, which generally differs from the choice that would maximize average welfare. Third, externalities arise in household choice of jurisdiction.

The second, majority voting inefficiency, is generally believed to be small in these models. To verify this here, we compute multi-jurisdictional equilibrium with majority choice of a head tax. Equilibrium is determined precisely as in the multi-jurisdictional property-tax model, but voting is over a local head tax that fully finances the local public good. Versions of Propositions 1 and 2 apply to this variation of the Tiebout sorting model.[40] Values for this equilibrium are shown in Column 4 of Table 3. The head taxes are, of course, equal to the levels of public good provision.[41] Comparing Column 4 to Column 3, one sees that the allocation is very close to the efficient allocation. The per capita welfare gain of $1,447 relative to the single-jurisdictional equilibrium is 99.2% of the potential welfare gain from household sorting. Thus, we conclude that voting bias is a minor effect and does not explain why the property-tax equilibrium fails to induce welfare gains.

The welfare loss in the Tiebout equilibrium is then largely attributable to property taxation and the jurisdictional choice externality rather than voting bias. To delineate these effects, we *assign* households to jurisdictions as arises in the efficient allocation, but then let them vote for a local property tax to finance the public good. Hence, this allocation essentially removes externalities from household choice of jurisdiction, while retaining the two other distortions—the property tax distortion and the voting bias. This is not an equilibrium allocation because some households would prefer to move. The associated values are reported in Column 5

[39] Recall that the efficient allocation is derived by assigning households to communities, but the assignments are consistent with individually optimal community choice (Proposition 3c).
[40] The ascending bundles property trivially regards the head tax, not the housing price. Since the head tax is a deterrent to moving into a jurisdiction, housing prices can decline across jurisdictions as the level of the public good ascends as we find between jurisdictions 2 and 3 in column 4 of Table 3.
[41] Because the calibration of income begins at 0, some households in the poorest jurisdiction cannot afford to pay the $1765 head tax. The proportion of the population is negligible, so we simply ignore this.

of Table 3. This allocation generates an average welfare gain of $1,183 relative to the single jurisdiction property tax equilibrium, or 81% of the potential $1,459 potential gain.

We conclude that the jurisdictional choice externality is the main cause of the welfare loss we find. Relatively poor households crowd into richer jurisdictions to consume high levels of the public good, while free riding on richer households that pay more in taxes and on the absentee land owners that absorb tax payments. This free riding is evidenced by the markedly higher percentages of households that live in the suburbs in the Tiebout property tax equilibrium (see Column 2 of Table 3) than in the efficient allocation (see Column 3 of Table 3). To see this free riding more clearly, Figure 3 compares the partition of household types in the efficient allocation and in the decentralized property-tax equilibrium. Those above the upper most dashed curve reside in the highest-g community (i.e., that numbered 5) in the efficient allocation; those between the latter curve and the next upper most dashed curve comprise the residents of the second highest-g community 4 (i.e., that numbered 4); etc. The solid curves likewise delineate the residents of the 5 communities in the Tiebout equilibrium. We have measured income and the taste parameter in percentiles in Figure 3, so the area of a community residential space equals the community population. For example, the area above the upper most dashed curve equals 3% of the total area (equal to N_5 in Table 3 for the efficient allocation), while the area above the upper most solid curve equals 16% of the total area (equal to N_5 in Table 3 for the multi-jurisdiction property-tax equilibrium). The comparative partitions in Figure 3 demonstrate that poorer households crowd the richer communities in the property-tax equilibrium relative to the efficient allocation. The fundamental explanation for the welfare loss in Tiebout property tax equilibrium is that the resulting sorting of households is inefficient; it is not stratified enough.

To illustrate the free riding in the property-tax Tiebout equilibrium yet another way, we order households within jurisdictions by their tax payments (or housing consumption) and compute the tax payments of the 10th and 90th percentile households, as well as the mean. These tax payments are shown in Table 4 for the cases of the multiple jurisdiction property tax equilibrium (top 5 rows) and for the single jurisdiction property tax equilibrium (bottom row). Moving up the wealth hierarchy of jurisdictions in the former case, we see increasing differences between the mean and 10th percentile payments, ($1304, $2013, $2519, $3295, $5396), indicating that free riding worsens as one moves up the jurisdictional hierarchy.[42] The bottom

[42] One might alternatively compare the payment of the 10th percentile payer to the 90th percentile payment. There are various ways to make this point.

row indicates substantial free riding as well in the single jurisdictional equilibrium, but of magnitude lower than results in the elite suburbs in the multiple jurisdictional case.

The lack of Tiebout sorting gains in property tax equilibrium is counterintuitive even though we are in a second-best economy so that "anything can happen." Because the poor free-ride on the rich in the centralized equilibrium as well, it would seem that some degree of sorting would lessen this externality. But carving the MA into jurisdictions entails limiting within jurisdiction housing supplies, which intensifies the externality losses as the relatively poor crowd relatively rich jurisdictions. Moreover, the free riding that takes place in richer jurisdictions is on higher levels of expenditure on the local public good. Given property taxation, the analysis indicates that Tiebout sorting needs to be limited for realization of welfare gains.[43]

It is interesting to examine further the distribution of welfare effects. Table 5 reports welfare effects by household type for both the move to the efficient allocation (upper panel) and to the Tiebout property-tax equilibrium (lower panel), again with the single jurisdiction property-tax equilibrium as the baseline. Specifically, the table entries are the within cell average welfare change as a percentage of household income. For example, the upper-left corner cell in the lower table with value .12 means that households with the lowest decile of both the taste parameter and income gain in welfare an average of .12% of their income in moving to the Tiebout property-tax equilibrium. Consider first the upper panel. We know from Table 2 that households gain on average $810 in going to the efficient allocation, though 74% are worse off.[44] Rich households gain and poor households lose, regardless of their tastes for the public good. Rich households gain because they obtain a preferred level of the public good and because the free riding that arises in the single jurisdiction property-tax equilibrium is eliminated. Poor households lose in spite of their more efficient consumption level of the public good because they no longer can free ride. Thus an equity-efficiency trade off arises in moving from decentralized provision with property taxes to an efficient Tiebout regime. These welfare effects are very large for many.

From the lower panel of Table 5, we see that the average losses that result from decentralized property tax provision are not evenly distributed either, though the effects are

[43] One might argue that the explanation points to a misallocation of housing to jurisdictions. But this is essentially the same as saying that a misallocation of households to jurisdictions arises, which is the better perspective for given jurisdictional housing supplies. More importantly, the problem does *not* go away by redrawing jurisdictional boundaries (see our robustness analysis). Access to jurisdictions must be limited beyond that caused by housing prices.

[44] Welfare effects on housing suppliers are not included in Table 5.

generally small. Low-income, low-taste types and high-income, high-taste types are better off. The former populate the lowest-g community in the decentralized equilibrium and gain due to the lower housing price, while not caring much about the reduced g. The group of winners is smaller, about 10% of the MA population, and reside in the richest jurisdiction in Tiebout equilibrium. In spite of paying higher housing prices, they gain because they value substantially the increased level of g.

d. Robustness Analysis. We examine robustness of our findings by varying key parameters of the model. Consistent with our main finding of free riding as the central inefficiency in Tiebout equilibrium, the theme is that parameter variations that facilitate free riding increase welfare losses from decentralized provision under property taxes and the reverse if this activity becomes more costly.

Most interesting is the effect of increasing the number of jurisdictions. We vary the number of jurisdictions by subdividing the suburbs, always keeping each suburb with the same, but smaller, land area, and maintain the land area in the city equal to 40 percent. Figure 2 graphs the per capita welfare change (including on housing suppliers) in going from one to multiple jurisdictions with property taxation, for three values of the housing supply elasticity. The solid curve is for the baseline elasticity. As we increase the number of jurisdictions up to 100, which subsumes the empirically relevant range, the welfare loss for the baseline elasticity varies by less than two dollars, the loss rising very slightly.[45] One might expect that smaller jurisdictions with smaller housing supplies would drastically curtail free riding and result in welfare gains. While this might happen in the limit, it does not within the empirically relevant range.[46] The intuition is the same that explains why we get losses as soon as multiple jurisdictions come to exist. Keep in mind that the free riding we have identified as the key

[45] Adding jurisdictions beyond 100 is difficult computationally. We have performed this exercise in a simpler version of the model, which is the same except with no taste variation (i.e., SD[β_g] = 0). Here we are able to increase the number of jurisdictions to 500. We find the same welfare loss, which varies by less than \$2 over the range of jurisdictions from 5 to 500.

[46] In an alternative model with a discrete number of households and where households have minimal housing needs (e.g., minimal land), once jurisdictions get small enough that they can only accommodate one household, then the free riding we study would become impossible. Our model has a continuum of households and continuous housing consumption, so it is not clear what happens in the limit. Note that having a discrete number of households is not enough to imply no free riding beyond some number of jurisdictions if housing consumption remains continuous. Even if there are as many jurisdictions as households so everyone could have their own jurisdiction, this does not imply poorer households would not want to move into a richer household's jurisdiction if feasible. An appendix available from the authors shows that free riding incentives can persist with a discrete number of households and equal number of jurisdictions. The implication of empty jurisdictions as households free ride in the latter case implies failure of existence of equilibrium (because richer households would prefer to move to an empty jurisdiction rather than living with a poorer household, etc.). Price taking of housing would become unrealistic, too; e.g., a rich household might easily buy up all land to prevent free riding. These issues warrant more research.

inefficiency, where household escape taxes by consuming relatively little housing, arises in the single jurisdiction equilibrium. While fewer households free ride *within* any jurisdiction as the number of jurisdictions increases, our analysis demonstrates that the overall welfare costs of this free riding does not decline with the number of jurisdictions.[47] So long as *relatively* poorer households can build homes in richer neighborhoods, the welfare costs we identify will be present (see the previous footnote).

Varying γ, the land share parameter in the housing production function, corresponds to varying the housing supply elasticity. We find that increasing the housing supply elasticity facilitates free riding and increases the welfare loss from decentralization, and the reverse for lowering it. For example, relatively inelastic housing supply implies steep increases in housing prices as households crowd the suburbs, this deterring the free riding that is responsible for losses. Figure 2 shows the welfare effect for a very low elasticity ($\varepsilon_s = .1$) and very high elasticity ($\varepsilon_s = 10$) as a function of the number of jurisdictions. In both cases, the welfare effect again remains relatively constant as the number of jurisdictions varies within this range. For the high elasticity, the per capita loss rises substantially, varying between $1,059 and $1,177. To get a sense of the extreme free riding that takes place here, we find that 59% of households live in the richest jurisdiction for the baseline value of 5 jurisdictions. When the elasticity is very low, however, welfare gains result of about $400 per capita.

Table 6 summarizes the effects of the remaining parameter variations we present. In each case, we vary a parameter from the baseline value while maintaining all other values. The rows report the indicated effects relative to the corresponding centralized equilibrium. The CES utility function implies the elasticity of substitution of goods equals 1/(1-ρ). A positive value of ρ violates the single crossing assumptions and multi-jurisdictional equilibrium has clone communities with an allocation equivalent to the centralized case. Hence, we consider further only negative values of ρ. Since ρ = -.01 in the baseline, we just examine smaller values of it. As ρ and thus the elasticity of substitution decline, average welfare gains emerge and increase rapidly. The intuition is that the mechanism whereby the poor free ride on the rich, which entails small housing purchases in richer jurisdictions, becomes less attractive when goods are more difficult to substitute. Simply put, it is more painful for households to curtail their housing consumption. Note, too, that the potential welfare gains from efficient Tiebout sorting rise

[47] It is surprising as well that the welfare effects are essentially invariant to the number of jurisdictions. Apparently, the welfare gains from better matching of public goods to preferences as the number of jurisdictions is increased are always offset by the free-riding effect over the range examined.

rapidly as ρ declines because matching of preferences to goods' bundles has increased value when goods are more difficult to substitute.

Increasing (decreasing) β_h relative to the baseline value of $\beta_h = .356$ leads to smaller (larger) average welfare losses in Tiebout equilibrium. The intuition is very similar to that explaining the consequences of varying ρ. For example, a smaller value of β_h implies housing is valued less, which facilitates the free riding mechanism and results in larger welfare losses.

Finally, we have independently varied the mean and standard deviation of the taste parameter distribution. Increasing the mean leads to a higher welfare loss while also increasing the potential gain. The reverse holds for a decrease. Essentially, the effects that we have found in the baseline case are magnified as g becomes more important to households. Changing the standard deviation of the taste parameter has small effects.[48]

4. Concluding Remarks In this paper, we have computed welfare effects of Tiebout sorting in a rich model with heterogeneity in household tastes and income, variable housing supplies, mobile households, and property taxation. While the presence of inefficiencies in local property tax equilibria is understood, we believe this research provides the most realistic quantification of these effects to date. We also provide a full theoretical characterization of the efficient allocation, which is of interest in its own right. We compare the decentralized equilibrium under current institutional arrangements to an efficient allocation. We find the inefficiencies arising under the existing institutional structure to be substantial, dissipating potential average welfare gains that are substantial. It is surprising to find that the welfare effects run counter to basic intuition concerning the gain from the Tiebout process.

The finding that decentralization as manifest in practice results in average welfare losses has led us to investigate the main source of the inefficiency. We find that the externality in choice of residence is the primary source of loss. Thus, ironically, the mobility that Tiebout emphasized as essential to the realization of potential efficiency gains of decentralization is also the culprit in preventing those gains from being realized under property taxation.

We have emphasized schooling as the primary local public good. Efforts to reduce inequalities in the local public finance of schooling have lead to increased centralization in much of the U.S. (see, for example, Evans, Murray, and Schwab (1998)). Few economists would

[48] One can see in Table 6 that the proportion of losers changes substantially as we vary the standard deviation of β_g, perhaps contradicting the statement in the text. But the gains/losses are very small. In the original version of this paper, we did extensive analysis of the case of no taste variation, and found analogous welfare effects. Thus, it is not taste variation that drives our results.

challenge the notion that those inequalities, arising from Tiebout sorting, have adversely affected poorer households. However, distributional issues aside, we, and we believe most other economists, had believed the Tiebout process to be efficiency enhancing. Our findings suggest the implied concerns about efficiency losses from centralization may not be warranted.

We realize that our analysis abstracts from potentially important elements. Our perspective is that the efficiency analysis of empirical Tiebout equilibrium warrants more research. We very briefly discuss a few issues that might be relevant. In a very influential paper, Hamilton (1975) argued that zoning can overcome the inefficiencies associated with property taxation. In Calabrese, Epple, and Romano (2007), we pursue a theoretical and quantitative analysis of equilibrium residential zoning that supports Hamilton's argument that zoning can serve as a substitute for head taxation. That analysis is, however, in the context of a model in which households differ only with respect to income. Whether such results carry over to an environment with preference heterogeneity is an important open question. However, the empirical relevance of residential zoning is unclear. Evidence on the extent of intra-community household heterogeneity (Epple and Sieg, 1999; Hardman and Ioannides, 2004; Pack and Pack (1977)) and lot size heterogeneity (Epple, 2006) is not supportive of the argument that zoning effectively screens out free riders and thus serves as a good substitute for head taxes.

For the schooling application, the existence of private schools raises the question as to how the relative efficiency of centralized versus decentralized public provision is affected by private market alternatives.[49] Peer effects that operate within schools or neighborhoods are also relevant to alternative policy regimes in as much as the alternatives induce different sorting of households. Extending the analysis of quantification of alternative policy regimes on welfare to the inclusion of peer effects is an interesting topic for more research.[50] Finally, communities provide multiple local public goods. While this increases the potential gains from decentralization, it might heighten the residential choice externality that we find to be so inefficient. A major research challenge in examining this is, of course, finding a satisfactory characterization of political equilibrium when multiple public goods are provided.

This paper does not, of course, refute Tiebout's argument. Rather, it tells a cautionary tale about applying first-best arguments in a second-best environment.

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[49] Nechyba (2003) finds that relatively wealthy households that choose private schools will live in poorer school districts in Tiebout equilibrium, implying more limited household sorting. He finds as well that Tiebout equilibrium increases choice of private schools relative to centralized provision of public schooling. The net effect on welfare of these forces is unclear and of interest to investigate.

[50] The literature on peer effects in education is surveyed in Epple and Romano (2011).

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Table 1: Parameter Values Baseline Model

E[lny]	Var[lny]	β_x	β_h	$E[\beta_g]$	$SD[\beta_g]$	ρ	γ	w
10.52	.785	1.00	.356	.094	.000932	-.01	.250	1.00

Table 2: Welfare Effects of Tiebout Provision in Baseline Model*

	Property Tax Eq. Multiple Jurisdictions	Efficient Allocation Multiple Communities
% of Pop. Made Worse Off	63%	74%
(-) CV	-$0.23	$810
Change in Rents	-$50.97	$649
(-)CV + Change in Rents	-$51.20	$1,459

*Benchmark for comparison is the single jurisdiction property tax equilibrium.

Table 3:
Positive and Normative Properties in Baseline Allocations

Positive Properties*	**Property Tax Eq. One Jurisdiction**	**Property Tax Eq. Multiple Jurisdictions**	**Efficient Allocation Multiple Communities**	**Head Tax Eq. Multiple Jurisdictions**	**Property Tax/Fixed Boundaries Multiple Jurisdictions**
p_1 =	$17.13	$14.26	$13.05	$13.00	$16.64
p_2 =		$16.19	$13.68	$13.62	$17.46
p_3 =		$17.18	$13.61	$13.61	$17.38
p_4 =		$18.39	$13.57	$13.61	$17.34
p_5 =		$20.80	$13.53	$13.71	$17.29
N_1 =	100%	39%	70%	69%	70%
N_2 =		15%	12%	12%	12%
N_3 =		15%	9%	9%	9%
N_4 =		15%	6%	6%	6%
N_5 =		16%	3%	3%	3%
t_1 =	35%	34.88%			35.09%
t_2 =		35.08%			35.31%
t_3 =		35.18%			35.40%
t_4 =		35.30%			35.50%
t_5 =		35.45%			35.59%
g_1 =	$3,830	$1,881	$1,834	$1,765	$1,954
g_2 =		$3,064	$4,625	$4,283	$4,969
g_3 =		$3,850	$6,546	$6,387	$7,034
g_4 =		$5,007	$9,627	$9,299	$10,354
g_5 =		$8,017	$17,373	$15,238	$18,722
Distributional and Welfare Properties**					
% of Pop. Worse Off		**63%**	**74%**	**73%**	**68%**
(-)CV		**-$0.23**	**$810**	**$788**	**$1,237**
Change in Rents		**-$50.97**	**$649**	**$658**	**-$54**
(-)CV + Change in Rents		**-$51.20**	**$1,459**	**$1,447**	**$1,183**

*The p_i 's are gross housing prices, the N_i's are population proportions, the t_i's are property tax rates, and the g_i's are per capital public expenditures.
**Benchmark for comparison is single jurisdiction property tax equilibrium.

Table 4: Tax Payments in Property Tax Equilibria

		10th Perc.	Mean	90th Perc.	Mean Minus 10th Perc.
Property Tax Eq. Multiple Jurisdictions	**J1**	$577	$1,881	$3,669	$1,304
	J2	$1,051	$3,064	$5,727	$2,013
	J3	$1,331	$3,850	$7,310	$2,519
	J4	$1,712	$5,007	$9,442	$3,295
	J5	$2,621	$8,017	$16,126	$5,396
Property Tax Eq. One Jurisdiction		$833	$3,830	$8,070	$2,997

Table 5

Average Negative Compensating Variation for Efficient Allocation as a Percentage of Average Income

	Income Deciles									
Preference Deciles	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	-19.92	-10.17	-6.76	-4.73	-3.30	-2.20	-1.29	0.27	2.48	7.30
2	-19.98	-10.21	-6.79	-4.77	-3.34	-2.24	-1.32	0.27	2.50	7.35
3	-19.99	-10.23	-6.81	-4.78	-3.35	-2.26	-1.33	0.28	2.51	7.40
4	-19.99	-10.24	-6.82	-4.80	-3.37	-2.27	-1.34	0.29	2.52	7.40
5	-20.03	-10.25	-6.84	-4.81	-3.38	-2.28	-1.35	0.29	2.53	7.42
6	-20.02	-10.26	-6.85	-4.83	-3.40	-2.30	-1.36	0.29	2.54	7.46
7	-20.04	-10.27	-6.86	-4.84	-3.41	-2.31	-1.37	0.30	2.54	7.47
8	-20.05	-10.29	-6.88	-4.85	-3.42	-2.33	-1.38	0.30	2.56	7.47
9	-20.07	-10.31	-6.89	-4.87	-3.44	-2.35	-1.39	0.30	2.56	7.49
10	-20.09	-10.34	-6.93	-4.91	-3.48	-2.38	-1.41	0.31	2.59	7.56

Average Negative Compensating Variation for Tiebout Equilibrium as a Percentage of Average Income

	Income Deciles									
Preference Deciles	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	0.12	0.09	0.07	0.06	0.05	0.04	0.03	0.01	-0.001	-0.02
2	0.08	0.05	0.04	0.03	0.02	0.004	-0.007	-0.02	-0.03	-0.03
3	0.06	0.04	0.02	0.008	-0.002	-0.01	-0.02	-0.03	-0.03	-0.02
4	0.05	0.02	0.007	-0.005	-0.02	-0.02	-0.03	-0.03	-0.03	-0.01
5	0.04	0.01	-0.006	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.002
6	0.02	-0.002	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02	0.01
7	0.01	-0.01	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02	-0.02	0.02
8	-0.002	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02	-0.02	-0.004	0.04
9	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02	-0.01	-0.002	0.02	0.06
10	-0.03	-0.02	-0.02	-0.01	-0.002	0.009	0.02	0.03	0.05	0.09

Table 6: Robustness with Respect to Parameter Values

	Base-Line[*]	Vary ρ			Vary β_h		Vary $E[\beta_g]$		Vary $SD[\beta_g]$	
		ρ =			β_h =		$E[\beta_g]$ =		$SD[\beta_g]$ =	
		–.05	–.1	–1	.3	.4	.09	.10	.000432	.00143
Average Welfare Gain Tiebout Equilibrium	–$51	$39	$275	$3,451	–$163	$10	–$26	–$97	–$72	–$40
Percentage Worse Off Tiebout Equilibrium	63%	0%	0%	0%	100%	0%	0%[†]	96%	86%	39%
Average Welfare Gain Efficient Allocation	$1,459	$1,524	$1,600	$4,061	$1,622	$1,365	$1,387	$1,575	$1,464	$1,461
Percentage Worse Off Efficient Allocation	74%	74%	74%	71%	73%	74%	74%	73%	74%	74%

[*]Baseline parameter values are: $\rho = -.01$; $\beta_x = 1.00$; $\beta_h = .356$; $\gamma = .25$; w = 1.00; $E[\beta_g] = .0940$; $SD[\beta_g] = .000932$; E 1n[y] = 10.52; Var ln [y] = .785.

[†]An average loss results because a loss to land owners outweighs the (very small) gains to households.

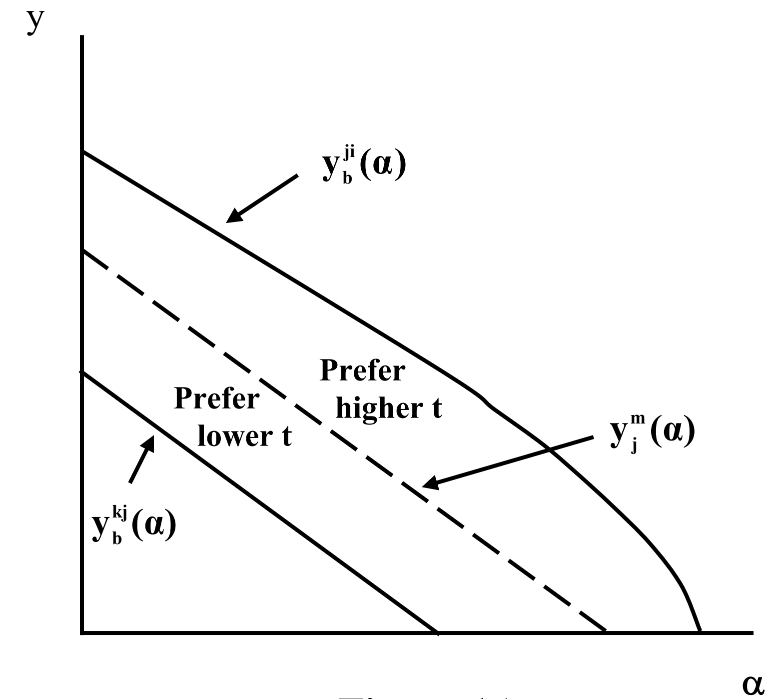

Figure 1A

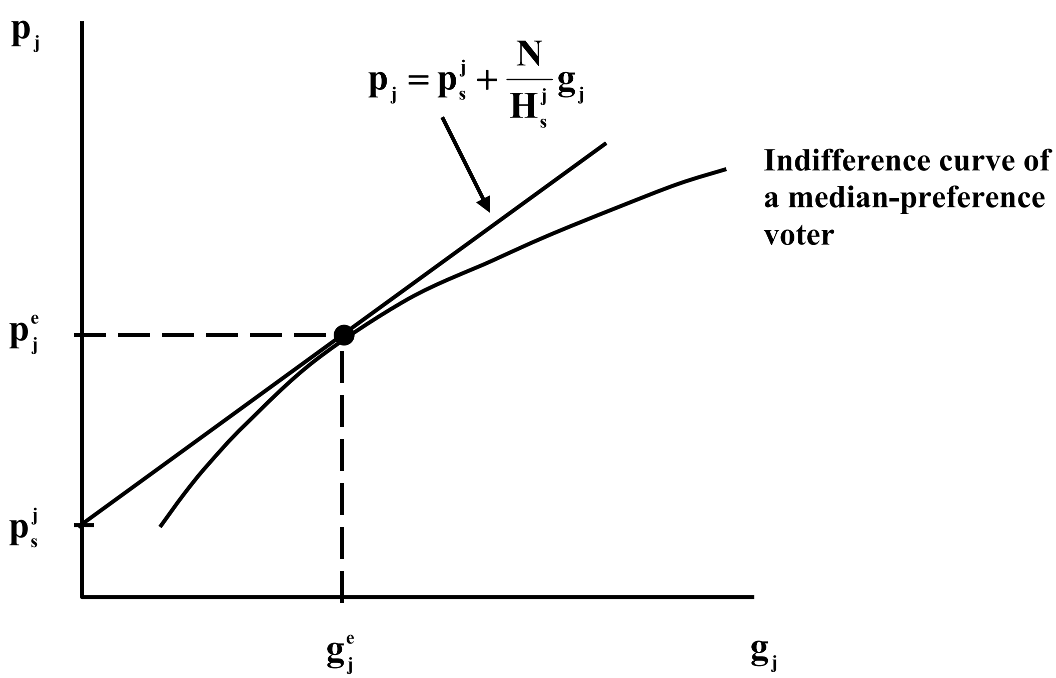

Figure 1B

Figure 2: Per Capita Welfare Effect and the Number of Jurisdictions

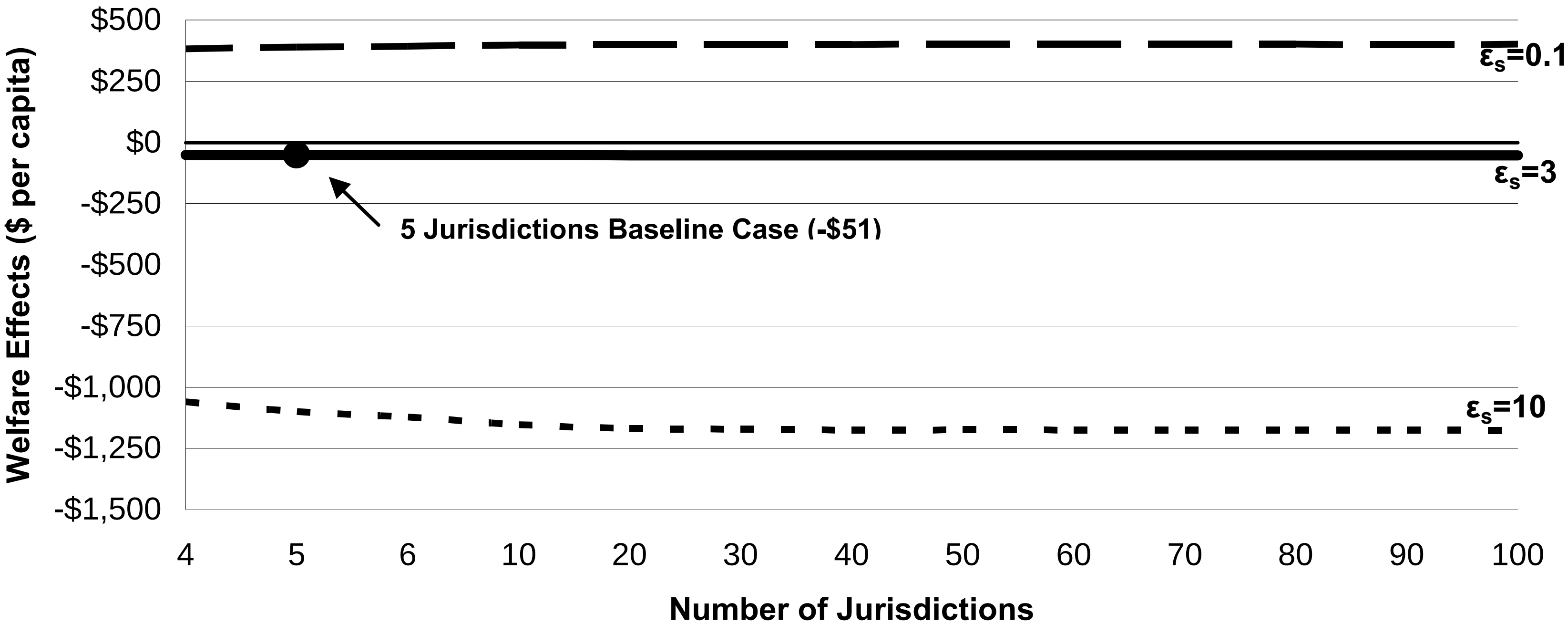

Figure 3: Community Boundaries