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The Race to the Suburb: the Location of the Poor in a Metropolitan Area

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THE LOCATION OF THE POOR IN A METROPOLITAN AREA

by

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ABSTRACT

We provide an explanation for the stylized fact that poor households are concentrated in the inner city of most U.S. metropolitan areas. We consider a metropolitan area with an inner city surrounded by a suburb and two income classes. Using numerical simulations, we show that two equilibria typically exist: one in which the inner city has a majority of poor households and the other in which it has a majority of rich households. We argue that the growth path selects the former equilibrium because rich households “jump” to the suburb before poor households “spill” into the suburb. In addition, the model provides an explanation for gentrification: at large metropolitan populations, population growth causes rich households in the city to live in areas previously inhabited by poor households.

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1. INTRODUCTION

In most U.S. metropolitan areas poor households are concentrated in the inner city. For example, Glaeser et al. (2000) report "the well-documented fact that within U.S. metropolitan areas, the poor generally live in the central cities and middle-income households generally live in the suburbs." At first glance this is somewhat surprising as the concentration of jobs in the inner city and the higher cost of commuting time for rich households might be expected to lead rich households to outbid poor households for the locations closer to the metropolitan center. This paper uses the growth path of the metropolitan area to explain the paradox. In addition it provides an explanation for gentrification in the inner city.

The "monocentric city" model of Alonso (1964) Mills (1967) and Muth (1961, 1969) adds land demand to the simple model of commuting cost in an early attempt to explain the concentration of the rich in the suburbs (leaving the poor in the inner city). All jobs are considered to be located at the metropolitan center. When deciding where to live, a household is considered to trade-off commuting costs and land prices. If a household buys a house at a location closer to the metropolitan center, it spends less time commuting and this advantage is

Estimates of the income elasticity of land demand do not support the equilibrium with rich households being concentrated in the suburbs. Wheaton (1977) estimates that the income elasticity of land demand is statistically indistinguishable from the income elasticity of the commuting cost, so that the Alonso-Mills-Muth model is unable to predict whether it is poor households or rich households who live in the inner city. Glaeser, Kahn and Rappaport (2000) find evidence that the income elasticity of land demand is significantly less than the income elasticity of commuting, so that the monocentric city model predicts that it is the rich households who live in the inner city. Empirically, therefore, this type of sorting on its own cannot be an explanation for the centralization of the poor.

Tiebout's (1956) model of fiscal decentralization stresses that public services are important determinants of where households reside. A household shops over jurisdictions, choosing the jurisdiction which provides his preferred public service level. Tiebout's model is normative as he seeks to establish the efficiency of the resulting equilibrium. However, many authors (e.g., Elickson (1971), McGuire (1974), Berglas (1976a, 1976b), Wooders (1978), Yinger (1982) and Epple et al. (1984, 1993)) have extended the model to consider positive outcomes. These authors show that, because households with different incomes have different demands for the public service, they choose different jurisdictions, or there is sorting by income between jurisdictions. Differences in public service levels are capitalized into land prices.[1]

Tiebout's model is non-spatial. Jurisdictions are viewed as areas of land in a featureless plain so that there is no a-priori reason as to which jurisdiction or which piece of land is inhabited by the poor households. If there are two jurisdictions, labeled the inner city and the suburb, then there are two equilibria: one where the inner city contains the poor households, and another where the suburb contains the poor households. Tiebout's model therefore suggests that households do sort by income between jurisdictions but provides no prediction as to whether the poor households congregate in the inner city or the suburb.

Our view of the topic (as discussed in de Bartolome and Ross (2003, 2004, 2007)) is that commuting costs, land prices and public service levels are all important determinants as to where households locate. In our model, a circular inner city has an exogenous boundary and is surrounded by a suburb. Commuting considerations are present because all households must commute to the central business district which is located at the center of the inner city. In addition, households care about the public service provided by a jurisdiction and its level is determined by voting. The model has two income-classes. Rich households have higher commuting costs per mile than poor households and, consistent with the data, land demand is relatively income inelastic. *Ceteris paribus*, therefore, rich households outbid poor households for land nearer the inner-city's center. In addition, rich households have a higher demand for the public service so that *ceteris paribus* different income groups prefer to live in different jurisdictions. In the spirit of the indeterminacy of Teibout's model, we find two equilibria over a range of metropolitan populations. In one equilibrium, it is the poor households who form the majority in the inner city, voting low public services in that city; in the second equilibrium, it is the rich households who form the majority in the inner city, voting high public services there. What is unexplained in our earlier work is why the equilibrium with poor households forming the majority in the inner city has been selected by most U.S. metropolitan areas. This is the topic addressed by this paper.

To determine which equilibria is likely to be selected, we simulate the city's growth by considering an increase in the metropolitan population in the presence of a fixed boundary between the inner city and the suburb. Poor households are the majority in the metropolitan population. When the population is small, the equilibrium has all households living in the inner city; poor households, forming the majority, vote a low level of the public service. As the population increases, the edge of urban development moves outwards towards the inner-city's boundary and city rents increase . While there is still some undeveloped land in the inner city, some rich households "jump" to the suburb to form a new jurisdiction with a high public service. This establishes rich households as the majority in the suburb. Further growth in the metropolitan population leaves this configuration in place: rich households congregate in the suburb leaving poor households in the inner city.

Other authors have provided possible explanations as to why the poor are concentrated in the inner cities. LeRoy and Sonstelie (1983) suggest that it may be a consequence of the introduction of the automobile. In their model, car travel is faster than public transportation but is also more expensive - initially therefore cars were bought by rich households allowing them to move out of the inner city. Glaeser et al. (2000) suggest that the reason lies in public transportation. In their model, public transportation is favored by high population density and is therefore located in the inner city. Poor households use public transportation to commute and hence they locate in the inner city where the public transportation is. Brueckner and Rosenthal (2006) suggest that the reason lies in the housing stock: richer households live in the suburbs because they are attracted by the newer housing stock there.

Although "the poor generally live in the cental cities and middle-income households generally live in the suburbs" (op. cit.), sorting is incomplete. As is well-known, inner cities contain many middle-income households and the suburbs contain many poor households. In our earlier papers we showed how capitalization supports an equilibrium in which both income classes live in both jurisdictions (“income-mixing”). In this paper we show that, in this equilibrium configuration, population growth causes the boundary between the rich and poor households in the inner city to move outwards so that areas which were previously inhabited by poor households become inhabited by rich households - a process which is descriptively similar to the “gentrification” observed in many U.S. cities since the 1990s.

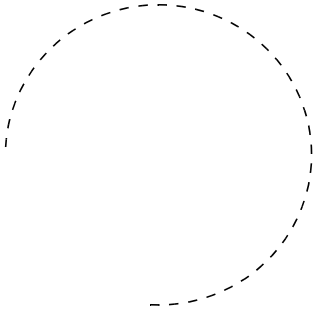
The purposes of this paper are essentially positive. We therefore want a model which is simple enough to show the underlying forces and yet rich enough to capture the important institutional details.[2] Our main simulation has local government financing itself using both a property tax levied on homes and a residence tax, where the latter is used to represent non-residential sources of revenue (viz. the property tax levied on business, the sales tax and intergovernmental grants). However, our main focus is on establishing the growth path of the metropolitan area in the presence of commuting forces, land demand and public service differences; the property tax - by shifting the tax burden from poor households to rich households - affects the incentives of households when choosing where to locate. Therefore, to establish that our results are not due to the property tax *per se*, we rerun the simulations with the residence tax being the only source of local revenue. The movement of rich households to the suburb is maintained.

Because we are comparing different equilibria, it is difficult to use a calculus-based methodology. We therefore use a computable general equilibrium model. We also use a very simple utility function so that the intuition is highlighted. The paper is structured as follows:

Sections 2 and 3 present the theoretical model; Section 4 presents the simulation structure; Section 5 discusses the calculated equilibria, the selection of the equilibrium and gentrification; and Section 6 concludes.

2. THE MODEL

2.1 Spatial overview



an exogenous jurisdictional boundary of radius B. In the city there may be undeveloped land, so that the limit of development has radius X:

$X < B$: there is undeveloped land at the edge of the city;

$X = B$: there is no undeveloped land in the city.

The city is surrounded by a suburb, labeled S. The outer jurisdictional boundary of the suburb is sufficiently distant that all households live in the city or in the suburb; the outer limit of development in the suburb is a circle of radius Y. Our interest is in how households of differing incomes distribute themselves across the metropolitan area as the metropolitan population grows.

2.2 Basic Analytic Structure

An household lives in a jurisdiction j ($j \in \{C, S\}$) and obtains utility from consuming c units of a privately-provided numeraire good, from consuming l units of land, from consuming h units of housing capital and from g^j units of a public service provided by the jurisdiction. For ease of calculation, we consider a utility function which is linear in the numeraire and additively separable in its arguments:

,

In this description, households differ in their tastes for land, housing capital and the public service, and their tastes vary systematically with endowed income.[3]

Each household has a fixed time endowment which he can use either for working or for commuting to the metropolitan center. His endowed income M is his income if he spends no time commuting or if he lives at the metropolitan center. If he lives at distance z from the metropolitan center, his income is reduced by the opportunity cost of the commute. The time spent commuting is proportional to z and the opportunity cost of a unit of his time is proportional to M, so that in this case his commuting cost is $kM z$ (where k is a constant). There is the possibility of a lump-sum transfer T to all households. Hence his income available to buy the numeraire good, to buy land and housing capital and to pay taxes is $M - kMz + T$.

The jurisdiction provides the public service g^j. The production of the public service shows constant returns to jurisdiction size, and the cost of providing a unit of the public service to a resident is s (units of numeraire per resident).[4] Most U.S. local governments finance public services using a property tax levied on homes, a property tax levied on businesses, a sales tax and intergovernmental grants. We model this "mixed" revenue structure by each jurisdiction financing a fraction λ of its cost of the public service using a property tax on land and housing capital levied at tax rate t^j, and financing the remaining fraction $1 - \lambda$ using a residence tax. In our main simulation we consider $\lambda = .4$ to be a good approximation to current U.S. practice. However, our focus is on sorting between jurisdictions based on differences in commuting cost, land demand and public services, and the use of the property tax introduces additional incentives (relative to the residence tax). First: rich households spend more on their homes than poor households so that, in jurisdictions in which both income classes reside, rich households pay a

2.3 Rents and sorting within a jurisdiction

At equilibrium, a household of income *M* achieves utility . Denote the bid of a

ASSUMPTION: the income elasticity of land demand is less than unity: $l/M \, \partial l / \partial M < 1$.

The rent paid at any location is the highest bid-rent of all households at that location or the rent schedule *r(z)* in the jurisdiction is the envelope of the bid-rent functions. A household locates at the point where his bid-rent curve touches the envelope, or

$$\frac{\qquad}{\qquad} \qquad . \tag{2}$$

schedule $r(z)$ is the envelope of the bid-rent curves.[6] Rich households are outbidding the poor households for the locations closer to the metropolitan center because the benefit to them of the saved commuting is greater. Households of income M_2 locate on the inside of the jurisdiction and households of income M_1 locate on the outside of the jurisdiction, or income decreases as

2.4 Sorting between jurisdictions

A household chooses to live in the jurisdiction in which he achieves the greatest utility. If households of the same income live in both jurisdictions, they must achieve the same utility in each jurisdiction: any commuting or fiscal gain the households achieve in one jurisdiction is exactly balanced by the higher rent they have to pay. If both jurisdictions are inhabited but no households of income M live in one jurisdiction, then rents in that jurisdiction are such that a household of income M cannot increase his utility by moving into that jurisdiction. If a jurisdiction is uninhabited, the household calculates the utility he would achieve by moving into the jurisdiction by assuming that the rent he would pay is the reservation rent of land (see below) and that, by moving, he would become the majority so that the public service level he would experience would be his desired public service level.[8]

2.5 Model closure

The public service in each jurisdiction is set by majority voting; households vote myopically, taking the rent schedule and the jurisdictional population as given.[9]

In our simulations, there is an equal number of poor and rich households. This has the advantage of ensuring that, if both jurisdictions are occupied, one has a majority of poor households and one has a majority of rich households. The division of the population into two income classes is of course artificial and, understanding that the U.S. income distribution is skewed towards poor households, we assume that, in the case of tied voting (a situation which arises when only the city is inhabited), the voted outcome is the outcome desired by poor households.

The model is closed by assuming:[10]

1. The number of households in the metropolitan population, N, is exogenous. N is considered to be a continuous variable.
2. The reservation price of land is r_0. The rent at the limit of development in the suburb (Y) is therefore r_0 . If the city contains undeveloped land ($X < B$), the rent at the limit of development (X) is r_0. If all the city's land is developed ($X = B$), the rent at the city's side of the jurisdictional boundary is at least r_0.
3. The average rent paid by all households is returned to households as the lump-sum transfer T. [11]

3. GROWTH: SUBURBANIZATION AND GENTRIFICATION

We now consider the growth of the metropolitan population in order to explain why poor households tend to be concentrated in the city and gentrification. Our presumptions are:

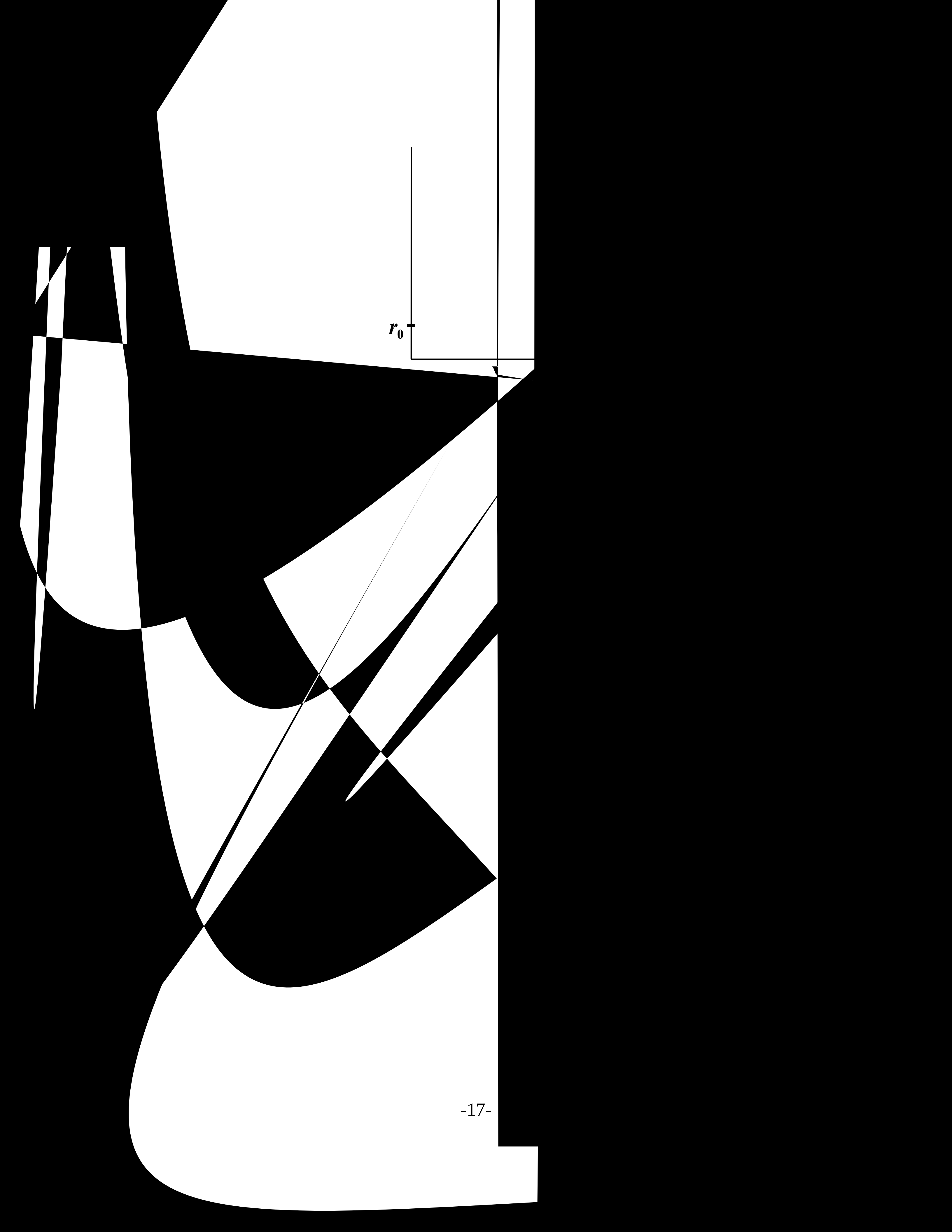
(1) Equilibrium configurations. As the metropolitan area grows, the equilibrium configuration at each point in time resembles a static equilibrium for the contemporaneous population level.

(2) Continuity. As the metropolitan population grows from N to $N + \Delta N$, the equilibrium configuration changes from one static equilibrium to another static equilibrium. The new static equilibrium at population $N + \Delta N$ is one which can be reached from the pre-existing equilibrium (associated with population N) by marginal changes in the limits of development X and Y and in the within-jurisdiction boundaries between the

> income classes x and y (if such an equilibrium exists). Only if there is no such "adjacent" equilibrium is there large-scale migration between the jurisdictions.

Historical metropolitan populations were very small. All households lived in the city and the city had undeveloped land ($X < B$) . We describe this equilibrium configuration as the "single region inhabited by rich households. Therefore, in interpreting the figures, we can use the slope of the rent schedule to infer the income of a household living at a location: a flat (steep) rent schedule implies that poor (rich) households live at that location.[12] For example, interpreting Figure 3: moving in from the jurisdictional boundary, initially there is an undeveloped region; at the limit of development (*X*) the rent is the reservation value r_0 ; then the rent schedule is relatively flat indicating that these locations are inhabited by poor households; at the class boundary *x* the rent schedule steepens indicating that the locations, which are closer to the metropolitan center than *x*, are inhabited by rich households.

As the metropolitan population grew, the limit of development in the city moved outwards and eventually such growth led to the development of a suburb. One income class became the majority in the suburb, leaving the other income class to become the majority in the city. Presumption (2) implies that whichever income class became first established in the suburb retained its majority in the suburb, leaving the other income class to retain its majority in the city.[13] Thus, to predict which equilibrium configuration is selected - with poor or rich households


r_0

the jurisdictional boundary. The dashed line in Figure 4(a) illustrates the new instantaneous configuration which now has some poor households inhabiting the suburb.

In this scenario, as poor households "spill" into the suburb, rich households become the city's majority and they vote a high public service level.[15] The high public service level makes the city less attractive to poor households and some additional poor households leave the city for the suburb, recreating undeveloped land in the city. This would cause a discontinuous change in x, X and Y. If the poor maintained its

4. SIMULATION FRAMEWORK

The analysis of this paper is to simulate the equilibrium structure of a metropolitan area as its population grows. The utility function of a household with endowed income M is specified as:

$$c + AA\,M^{\alpha}$$

Table 1: Assumed elasticities and expenditure shares

	income elasticity	price elasticity	expenditure shares
Land	.4 [a]	-1 [b]	.03 [c]
Housing capital	1.2 [d]	-1[e]	.15 [f]
Public service	0.7 [g]	-0.5 [h]	.09 [i]

[a] Muth (1971) estimates the income elasticity of demand for land as: 0.328.
Straszheim (1975) estimates income elasticity of lot size as: 0.345. Cheshire and Sheppard (1998) use U.K. data and estimate income elasticity of land area to be in range: 1.678 - 3.755 . Glaeser et al (2000) estimate income elasticity of land demand as being in range: 0.1 - 0.4. We use the upper-value of the Glaeser et al. estimate.

[b] The logarithmic dependence of utility on land implies a price elasticity of: -1. This is within the range determined by studies, viz. Muth (1971) estimates the price elasticity of demand for land as: -0.512. Straszheim (1975) estimates price elasticity of lot size as: - 1.072.
King (1976) estimates price elasticity for "site characteristics" (which include land) as: -0.82. Cheshire and Sheppard (1998) use U.K. data and estimate price elasticity of land area to be between -0.804 and -1.533 Gyourko and Voith (2001) use suburban Philadelphian data to estimate the price elasticity as: -1.64.

[c] From National Income and Product Accounts 2000, Table 2.1: the Compensation of Employees is 5783 ($b). From Table 2.5.5: housing expenditures (including imputed rent) is 1006 ($b). We consider this to be "total housing" comprised of housing capital plus land. Therefore expenditure on housing capital plus land as share of "income" is .17.

To determine land value as a share of house value: Muth (1971) estimates that land expenditure as fraction of house price is: 0.18. Gyourko and Voith (2001) find that for the Philadelphia suburbs land as a share of house value is: 0.15. We accept this value.

Therefore land expenditure as a share of income is: 0.15 x 0.17 = 0.03.

Similarly, housing capital as a share of income is: 0.85 x 0.17 = 0.15.

[d] Muth (1971) estimates the income elasticity of housing capital as: 0.778. McMillan (1979) estimates the income elasticity of internal space as: 1.20. Cheshire and Sheppard (1998) use U.K. data and estimate income elasticity of internal space to be in range: 1.592 - 1.751. We use McMillan's estimate as it lies between the other two.

[e] The logarithmic dependence of utility on housing capital implies a price elasticity of: -1. This is within the range determined by studies, viz. Muth
n (1971) estimiates the price elasticity of demand .0009 Tc-0.000Stal as: 0.778.o

[2] From Money Income in the United States 2000, Table A.1: the 25th percentile household income is inferred to be 22 000 ($) and the 75th percentile household income is inferred to be 73 000 ($).

[3] Based on round-trip speed of 20 mph and 8 hour working day.

[4] Glaeser, Gyourko and Saks (2005) report a range of land prices in 21 metropolitan areas of $\$_{2000}$ 0.13-4.1 ($ per sq. ft) or $\$_{2000}$ 5663-178598 ($ per acre); using an annual interest rate of .04, this translates into the rental cost of land being between 226 and 7144 ($ per acre). This range is for the land

Note that, in a departure from our earlier work, we explicitly take account of the fact that only 40% of a city's developed land area is devoted to housing with the remaining land being used for businesses and infrastructure.

5. EQUILIBRIA OF THE METROPOLITAN AREA

In this section we describe the static equilibria as the metropolitan population increases but the city's jurisdictional boundary *B* remains fixed. We focus on the case $\lambda = .4$ because it represents current "average" practice in the U.S; in Section 5 we will consider the cases of $\lambda = 0$ and $\lambda = 1$. There are many potential equilibrium configurations corresponding to which income class forms the majority in the city and whether the city includes one or both income classes, which income class forms the majority in the suburb and whether the suburb includes one or both income classes, and whether there is undeveloped land in the city.[19] Instead of discussing all the possible equilibrium configurations, we present below only the equilibria actually found in our simulations.

5.1 Very small metropolitan populations: *the single city*

The boundaries and populations of equilibria with the "single city" configuration are shown in Table 3. Rents, public service levels, tax rates and average lot sizes are shown in Table 6 in Appendix A.

Metropolitan Population N	Equilibrium Configuration	Boundary between rich and poor in city, x (miles)	Limit of city development X (miles)	Boundary between rich and poor in suburb y (miles)	Limit of suburb development Y (miles)	Number of rich households in city	Number of poor households in city	Number of rich households in suburb	Number of poor households in suburb
7000	single city	1.47	2.04			3 500	3 500		
10 000	single city	1.69	2.38			5 000	5 000		
20 000	single city	2.18	3.18			10 000	10 000		
40 000	single city	2.73	4.19			20 000	20 000		
80 000	single city	3.30	5.42			40 000	40 000		

Table 3: equilibria with the "single city" configuration and $\lambda = .4$

Table 3 shows that, as the metropolitan population increases, x and X move outwards; from Table 6 rents increase and average plot sizes fall.[20]

As rents rise in the city, the suburb becomes increasingly attractive to rich households. At a metropolitan population slightly larger than $N = 80\ 000$ (actually at $N = 80\ 016$), rich households can achieve the same utility in the suburb as in the city: as discussed in Section 3, by moving to the suburb, a rich household can vote a higher public service level, pay a lower rent and avoid paying the transfer to poor households which is implicit in the property tax. If the population increases further, the suburb becomes inhabited with some rich households and the "single city" ceases to be an equilibrium configuration. This occurs while there is still undeveloped land ($X < B$). This establishes our main result: while there is still undeveloped city land, rich households "jump" to the suburb, establishing themselves as the majority there. This leaves poor households as the majority in the city - an equilibrium configuration which is maintained as the metropolitan area continues to grow.

We now present the details of the result by considering the various equilibrium configurations that arise when $\lambda = .4$.

[redacted]

[redacted]tion

move outward. At a critical population slightly above 300 000, all city land is developed and the equilibrium configuration shifts to Configuration B.

With Configuration B: as the population continues to increase, some of the additional rich households locate in the city and some locate in the suburb. In Configuration A, the increasing population of the city was accommodated by the limit of development *X* moving outwards. Now, however, the city is fully developed and hence the increasing number of poor households pushes the class-boundary *x* away from the city’s jurisdictional boundary. Parts of the city which had been inhabited by rich households are now inhabited by poor households. The larger rich population in the city is able to be accommodated in a smaller area because the higher rents induce smaller land plot sizes.

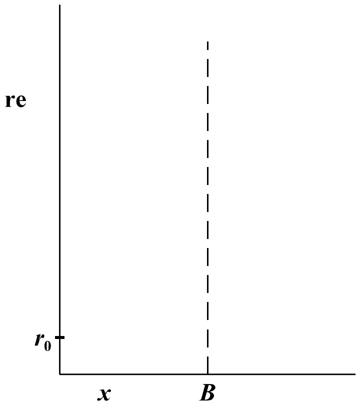
As the metropolitan population further increases, rents continue to rise in the city and at a critical population size, which is slightly above 3 000 000 , poor households are able to achieve the same utility at the edge of the suburb as they achieve in the city. This is Configuration C with both income classes resident in both jurisdictions.

Configuration C is the equilibrium which is discussed extensively in de Bartolome and Ross (2003, 2004, 2007) where it is termed “income mixing”. As the population continues to increase, some “new” poor households locate in the suburb, allowing the class boundary *x* [illegible]

As the metropolitan population increases and the equilibrium configuration changes from Configuration A through Configuration B, the proportion of the city's population which is poor increases. Because the property tax is being partially used to finance the city's public service, the increasing proportion of poor households increases the tax-price of the public service. As shown in Table 7, this causes the public service voted in the city to deteriorate and the city's property tax rate to increase. However, the situation reverses when the configuration changes to Configuration C. With poor households now locating in the suburb, the proportion of the city's population which is poor decreases, lowering the tax-price of the public service and causing the city's public service to "rebound" and the city's property tax rate to decrease.

Rents paid by rich households exceed those paid by poor households but - beyond a

5.3 Equilibria with both jurisdictions occupied: the city having majority of rich households



Configuration E is the analogue of Configuration B. As the metropolitan population continues to grow: some “new” poor households locate in the suburb but all “new” rich households locate in the city, pushing the class boundary *x* outwards. The increasing population in the city is accommodated by the smaller lot sizes induced by the increase in rents. Rich households make up an increasing proportion of the city’s population, increasing the implicit subsidy to each poor household; this keeps poor households in the city and this configuration is maintained at all reasonable metropolitan populations.[21]

Metropolitan Popo5.7 308.46 46.68 0.96002 ran									

5.4 Further discussion of the growth path

Tables 3 and 4 show that the “single city” continues to be the equilibrium configuration until slightly above *80 000* or until $N = 80\ 016$. As the metropolitan population increases beyond $N = 80\ 016$ some rich households locate in the suburb: the equilibrium changes continuously from the configuration of the “single city” to Configuration A (x, X and Y change continuously through the transition). Viewing the metropolitan area’s path as a continuous sequence of static equilibria, rich households “jump” over undeveloped land to the suburb before poor households

Figure 6 shows that the “single city” is the only equilibrium configuration at small metropolitan populations but it ceases to be an equilibrium configuration when the metropolitan population reaches *80 016.* Between populations of *80 016* and *233 245*, Configuration A is the only equilibrium and hence it is selected when the “single city” equilibrium breaks down. Our assumption about continuity implies that, once this configuration - with the poor being the majority in the city - has been established, it is maintained

A configuration with rich households being the majority in the city (Configuration D) does not exist until the metropolitan population is 233 245. If rich households were forbidden to locate in the suburb, the “single city” would become fully developed and poor households would “spill” into the suburb when the metropolitan population reached 252 480. As indicated in Section 3, as poor households spilled into the suburb, rich households would become the city’s majority. They would vote a high public service in the city, causing additional poor households to locate to the suburb, creating undeveloped land in the city. This would correspond to an equilibrium with the form of Configuration D. Hence, although Configuration D exists as a static equilibrium configuration at populations above 233 245, it cannot be reached from the “single city” until the metropolitan population reaches 252 480 and poor households “spill” into the suburb. This is shown in Figure 6 by the arrow covering the populations for which Configuration D is an equilibrium being dashed for populations between 233 245 and 252 80.

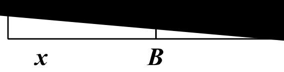
5.5 What is causing the rich to "jump" to the suburb? The pure residence tax.

In our model, rich households "jump" to the suburb before poor households "spill" into the suburb. The net effect of the commuting cost and inelastic land demand is to push rich households towards the city. If jurisdictions financed their expenditures using only a residence tax, the only force pushing rich households towards the suburb would be the fiscal force - by moving to the suburb, a rich household can vote a higher pubic service than is provided by the city. However, the partial use of the property tax introduces additional forces. Implicit in the property tax is a transfer from rich to poor households. Because a rich household "jumping" to the suburb avoids this transfer, this aspect of the property tax reinforces the force pushing the rich household to jump. However the property tax has another aspect which "holds the rich household back." Because it lowers the tax price of the public service to poor households (relative to the pure residence tax), it raises the public service voted in the city which makes the city more attractive to rich households and delays their "jump" to the suburb.

To determine if it is the fiscal effect *per se* which is causing rich households to "jump" (and hence creating cities in which poor households congregate), we reran the simulations using a pure residence tax or setting $\lambda = 0$. The characteristics of the computed equilibria are shown in Appendix B; the characteristics of the "single city" are shown in Table 9.With $\lambda = 0$ the "single city" ceases to be an equilibrium when *N = 44 103* and while there is undeveloped land in the city; at this population a rich household can achieve the same utility whether he locates in the city or in the suburb. With the partial use of the property tax, the "single city" ceased to be an equilibrium when *N = 80 016.* Therefore the primary force causing rich households to "jump" to the suburb is the difference in the public service levels; the property tax, by inducing a higher public service level in the city, delays the "jump".

With $\lambda = 0$ and with both jurisdictions being occupied, the
which poor households are the majority in the city are the same co
in Figure 5; the characteristics of the equilibria at different metropo
in Table 10 in Appendix B. When the metropolitan population exc
configuration is Configuration A, which is reached from the "singl
change in the boundaries x, X and Y.

The property tax raises the after-tax rent and reduces lot siz
property tax or setting $\lambda = 0$ causes the city to fill up faster and the
Configuration B occurs at a lower metropolitan population. In cons
Configuration B to Configuration C: as noted earlier, the property
transfer from rich households to poor households in jurisdictions i
makes it beneficial for poor households to locate in the suburb whe
households. In consequence, removing the property tax or setting


x
B

reached from the “single city” configuration with undeveloped land. The “single city” ceases to be an equilibrium before poor households spill into the suburb (if rich households were forbidden to jump to the suburb, this would occur at $N = 403\ 934$).

5.6. $\lambda = 1$ *and robustness*

Similar results are obtained with $\lambda = 1$ although the details differ. In particular the full use of the property tax causes the public service voted by poor households in the “single city” to rise and delays the “jump” of rich households to the suburb: this now occurs when $N = 132\ 730$. When the “jump” occurs there is still undeveloped city land.[22] With the public service being fully financed by the property tax, the incentive for a poor household to live in a jurisdiction containing rich households is increased: as rich households “jump”, poor households “follow”: x, X, and Y change discontinuously. Hence the configurations of the subsequent equilibria differ from those illustrated in Figure 5.

In our framework, if x, X and Y change discontinuously, any configuration which is an equilibrium configuration can potentially be selected. However, with $\lambda =$, at $N = 132\ 730$, the households living in the city, and rich and poor households living in the suburb.

The above discussion has considered variation in the tax parameter λ. Our main result - that rich households "jump into" the suburb before poor households "spill into" the suburb - is robust if each of the other parameter values is changed by ± 20%. However, the analysis on gentrification is less robust because, when some parameter values change by ± 20%, Configuration C ceases to be an equilibrium configuration.

6. CONCLUSION

In a monocentric urban model with two jurisdictions - an inner city and a surrounding suburb - there tend to be two equilibria: one in which poor households are the inner city's majority and one in which rich households are the inner city's majority. Our simulation suggests that the growth path of the metropolitan area selects the equilibrium in which poor households are the inner city's majority because rich households migrate to form a new jurisdiction in the in the inner city than in the suburbs. We believe that an important difference between the U.S. and Europe is that in Europe there is less variation in the public service level across jurisdictions and less reliance on the property tax.[24] In our model, if a regional government is introduced which prevents large differences in the public service being established between jurisdictions, rich households have a smaller incentive to “jump” over undeveloped city land to form a new jurisdiction in the suburb. If the allowed difference is sufficiently small, the equilibrium growth path may have poor households “spilling” into the suburb and rich households forming the inner city’s majority. Thus it seems that, by adding a regional government to our model and imbuing it with different powers or roles, we might be able to explain the difference between the U.S. and the European experiences. This is an issue we intend to explore in future research.

APPENDIX B: RESULTS WITH USE OF RESIDENCE TAX ONLY (= 0)N

[redacted]

[redacted]

Metropolitan Population N	Configuration	Boundary between rich and poor in city, x (miles)	Limit of city development X (miles)	Boundary between rich and poor in suburb y (miles)	Limit of suburb development Y (miles)	Number of rich households in city	Number of poor households in city	Number of rich households in suburb	Number of poor households in suburb
7000	D	1.57	2.17		8.01	3 500	3 416		84
10 000	D	1.86	2.27		8.11	5 000	2 511		2 489
20 000	F		2.53		8.41	10 000			10 000
40 000	F		3.35		8.77	20 000			20 000
50 000	F		3.63		8.93	25 000			25 000
80 000	F		4.25		9.37	40 000			40 000
90 000	F		4.42		9.50	45 000			45 000
100 000	F		4.57		9.62	50 000			50 000
150 000	F		5.18		10.18	75 000			75 000
200 000	F		5.62		10.66	100 000			100 000
250 000	F		5.99		11.07	125 000			125 000
300 000	F		6.29		11.43	150 000			150 000
350 000	F		6.55		11.76	175 000			175 000
400 000	F		6.77		12.05	200 000			200 000
500 000	F		7.16		12.58	250 000			250 000
600 000	F		7.47		13.03	300 000			300 000
700 000	F		7.74		13.42	350 000			350 000
800 000	F		7.98		13.78	400 000			400 000
900 000	G		8.00		14.11	450 000			450 000
1 000 000	G		8.00		14.40	500 000			500 000
2 000 000	G		8.00		16.48	1 000 000			1 000 000
3 000 000	G		8.00		17.78	1 500 000			1 500 000
4 000 000	G		8.00		18.74	2 000 000			2 000 000
5 000 000	G		8.00		19.49	2 500 000			2 500 000
10 000 000	G		8.00		21.89	5 000 000			5 000 000
15 000 000	G		8.00		23.33	7 500 000			7 500 000
20 000 000	G		8.00		24.36	10 000 000			10 000 000
25 000 000	G		8.00		25.16	12 500 000			12 500 000
30 000 000	G		8.00		25.82	15 000 000			15 000 000

Table11(a): equilibria when the city having a majority of rich households and = 0

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1. Ross and Yinger (1999) survey this literature.

2. In addition to considering the property tax, the model presented in this paper extends the earlier models by making house size endogenous.

3. We want to stress that, because each household's endowed income M is exogenous, its taste parameters $\alpha(M)$, $\beta(M)$ and $\gamma(M)$ are exogenous.

The reader should note that all households with the same endowed income have the same utility function so that "income-mixing" arises because of differences in tastes between income-classes and not because of differences in tastes between and among income classes (as in Epple and Platt (1998)).

4. For ease of calculation, the jurisdiction is assumed to provide a public service and not a public good. It is straightforward to change the publically-provided good from a public service to a public good.

5. Wheaton (1977) shows that, in the Alonso-Mills-Muth model, the bid-rent curve steepens with income if the income elasticity of land is less than the income elasticity of commuting cost. In our model the income elasticity of commuting cost is unity.

6. For diagrammatic clarity, the bid-rent schedules and the rent schedule are drawn as straight lines. In fact, as the location moves towards the city's center, the higher rents cause lot sizes to fall; this causes the bid-rent curves and the rent schedule steepen.

7. If only one income class resides in the jurisdiction, the bid-rent curve of the other income class lies below the bid-rent curve of the income class which resides in the jurisdiction.

8. In practice, if the incentive existed, a developer might build a development with houses