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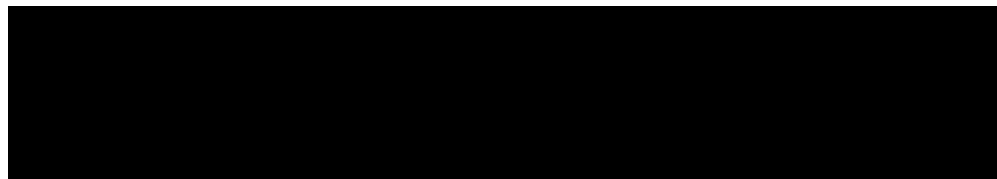
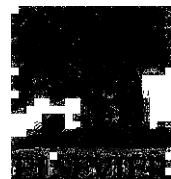
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The intergenerational conflict over the provision of public education[☆]

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ABSTRACT

We study the intergenerational conflict over the provision of public education. This conflict arises because older households without children have weaker incentives to support the provision of high quality educational services in a community than younger households with school-age children. We develop an overlapping generations model for households in a system of multiple jurisdictions. This model captures the differences in preferred policies over the life-cycle. We show that the observed inequality in educational policies across communities is not only the outcome of stratification by income, but is also determined by the stratification by age and a political process that is dominated by older voters in many urban communities with low quality of educational services. The mobility of older households creates a positive fiscal externality since it creates a larger tax base per student. This positive tax externality can dominate the negative effects that arise because older households tend to vote for lower educational expenditures. As a consequence sorting by age can reduce the inequality in educational outcomes that is driven by income sorting.

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1. Introduction

A fundamental premise of modeling competition among local jurisdictions is that households make their location decisions taking account of the quality and tax costs of local public goods and services.¹ Most recent research has focused on the provision of local public education. Since the demand for public education and the willingness to support high quality education at the ballot box is at least partially determined by income, households with higher income tend to locate in communities with higher expenditures and housing prices. This stratification of households by income is one important causal mechanism that supports large differences in the quality of public education

provided by communities and school districts within many metropolitan areas in the U.S.² However, it is not the only mechanism.

The same logic that suggests households sort based on income implies that households will sort based on age since preferences for local public education are largely determined by the presence of school-age children. A household's consumption of local public education begins when its first child enters kindergarten and ends when its last child leaves high school. Younger households with school-age children have strong incentives to vote for high levels of educational expenditures. In contrast, older households with children that have graduated from high school have preferences for lower tax and spending policies. These differences in preferences over preferred education policies give rise to a generational conflict in local public good provision that is played out at the ballot box within many communities in the U.S. This generational conflict may be more important in understanding persistent differences in access to educational opportunities than sorting by income.

Mobility of households not only affects the identity of the pivotal voter, but also the magnitude of the tax bases in each community. Older households not only vote at the ballot box, but also vote with their feet by relocating to communities that better fit their needs.

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¹ This hypothesis, first proposed by Tiebout (1956), has been the subject of extensive formal modeling and empirical analysis.

² Much recent empirical work has focused directly on the extent to which households stratify based on differences in the quality of local public goods. See, for example, Epple and Sieg (1999), Epple et al. (2001), Bayer et al. (2004), Bajari and Kahn (2004), Sieg et al. (2004), Urquiola (2005), Ferreyra (2007), and Ferreira (2009).

74 These incentives to relocate must be balanced against potential moving
75 costs. The mobility of young and old households then implies that
76 the age composition of the voting population, the identity of the deci-
77 sive voters, and the tax base are endogenous in each community.
78 Communities with low educational spending will tend to attract a
79 disproportionate share of older households that prefer low property
80 taxes and relatively inexpensive housing. As a consequence, older
81 households tend to be in the majority in poorer, urban communities
82 with low educational expenditures. Younger households with chil-
83 dren dominate at the ballot box in suburban communities with high
84 levels of expenditures. The inequality in educational policies is, there-
85 fore, not only the outcome of stratification by income, but is influ-
86 enced by stratification by age and a political process that is dominated
87 by older voters in many urban communities with low quality of
88 educational services.

89 But, in contrast to sorting by income, the effects of sorting by age
90 on inequality in educational outcomes is not obvious. While older
91 households tend to vote for lower expenditures, they also provide a
92 positive fiscal externality since they increase the tax base in most
93 school districts while not adding to the cost of providing education.
94 If this positive tax externality dominates the negative effects that
95 arise because older households tend to vote for lower educational
96 expenditures, then sorting by age can partially off-set the inequality
97 in educational outcomes that is driven by income sorting.

98 The main contribution of this paper is then that we combine an
99 overlapping generations model with a multiple jurisdictions model
100 in a tractable way to study the generational conflict in local public
101 good provision.³ Our model captures four important dimensions by
102 which households differ: income, moving cost, age, and family struc-
103 ture. Income is clearly a key factor influencing a household's ability
104 and willingness to pay the housing price premium to live in a commu-
105 nity with high quality public services. Moving costs, both financial
106 and psychic, are important factors in the decision process. In addition
107 to transactions costs, relocation often entails costs associated with
108 moving away from friends, neighbors, and familiar surroundings
109 and the associated costs of becoming established in a new neighbor-
110 hood. While financial costs will typically be roughly proportional to
111 house value, psychic costs are likely to exhibit greater variation across
112 households. Finally, our model also captures the fact that relocation
113 incentives vary over the life cycle. These incentives are largely driven
114 by the presence or absence of children at home at various points
115 during the life cycle.

116 In our model, adults live for two periods and thus can live in at
117 most two different locations. We define the stationary equilibrium
118 of our model. Our modeling approach allows us to characterize im-
119 portant properties of an equilibrium without relying on functional
120 form assumptions or numerical analysis. One important property of
121 residential sorting is that many community pairs that could be chosen
122 over the life cycle are strictly dominated by other pairs in equilibrium.
123 Restricting our attention to community pairs in the relevant choice
124 set, we can order lifetime community-choice plans by a composite
125 local public good measure and can provide conditions that guarantee
126 that households strictly across these plans by wealth conditional on
127 moving costs in equilibrium. Old households have weak incentives
128 to move to a community that has higher levels of public good provi-
129 sion than the community chosen when young. We show that this
130 conjecture is correct if the relative weight placed on the local public

³ Benabou (1996a, 1996b, 2002) and Fernandez and Rogerson (1998) innovate by introducing an overlapping generation approach to study fiscal competition. In their models, young individuals do not make any decisions. Hence, there is no generational conflict in voting over expenditures. An alternative interpretation of their models is that households live one period, but have altruistic preferences. Households care about local educational expenditure since they affect the human capital accumulation of the next generation. In our model, there are two generations that vote and make locational decisions at the same time. This is necessary to capture the conflict over public good provision that arises in this structure.

131 good is higher when young than when old. Older households that re-
132 locate do not “move up.” This equilibrium property then generates a
133 household sorting pattern in which older households tend to be in
134 the majority in communities with lower expenditures and younger
135 households are in the majority in communities with higher levels of
136 expenditures. Households will thus not only sort by wealth, but also
137 by age. Based on the characterization of household sorting by wealth
138 and age, we can then characterize the intergenerational conflict that
139 arises at the ballot box. We show that the median-income voter will
140 almost never be the decisive voter in any community in our model
141 as communities adopt different tax and expenditure policies in
142 equilibrium.

143 Based on our theoretical characterization of equilibrium we can
144 also develop an algorithm that can be used to show that equilibria
145 exist for reasonable parameterizations. Moreover, we can gain addi-
146 tional insights into the quantitative properties of our model. We com-
147 pute equilibria in which a reasonable fraction of households relocates
148 to a different community when old in equilibrium. This property of
149 equilibrium is consistent with evidence on turnover in local housing
150 markets. This finding has important implications for the political
151 decisions made in the communities. We find that older households
152 that move in equilibrium tend to have higher levels of lifetime
153 wealth. As a consequence, the mobility of older households creates
154 a positive fiscal externality since it creates a larger tax base per stu-
155 dent in lower quality communities. This positive fiscal externality
156 can dominate the negative effects that arise because older households
157 tend to vote for lower educational expenditures. Lower mobility costs
158 tend to increase the importance of the fiscal externality increasing
159 expenditures in poor communities and lowering expenditure in
160 richer communities. In contrast to sorting by income, sorting by age
161 leads to a decrease in inequality in educational outcomes.

162 Recent empirical evidence supports the elements of our model.
163 Harris et al. (2001) use district level educational expenditure data,
164 while controlling for Tiebout bias, and provide evidence that the el-
165 derly have relatively weak support for expenditure. Farnham and
166 Sevak (2006) provide evidence of Tiebout sorting driven by empty-
167 nest status, and also find that the extent of such sorting is reduced
168 by school finance equalization policies and other factors. Fletcher
169 and Kenny (2008) find support for median-voter choice of local
170 schooling expenditure, with the best fit having the elderly opposing
171 increased expenditures. Brunner and Ross (2010) use voter behavior
172 data from two referenda in California that would change the super-
173 majority needed to pass local school bond measures, with the second
174 referendum passing, and find evidence of elderly opposition to
175 schooling expenditures. Reback (2010) provides additional evidence
176 of weak preferences for expenditure among the elderly, including
177 those 55 to 64 (in contrast to earlier research), while taking account
178 of “circuit breaker policies” that reduce tax costs to those 65 and up.

179 The rest of the paper is organized as follows. Section 2 develops
180 our theoretical model and defines equilibrium. Section 3 establishes
181 key properties of our equilibrium. Section 4 introduce a parametrized
182 version of our model and examines the quantitative properties of our
183 model. Section 5 offers conclusions.

184 2. An OLG model with multiple jurisdictions

185 We develop an overlapping generations model with multiple
186 jurisdictions to study the generational conflict over the provision of
187 education.⁴

188 Consider a closed economy in which activity occurs at discrete
189 points of time, $t = 1, 2, \dots$. The economy consists of J communities. At

⁴ Our theoretical model builds on previous work by Ellickson (1973), Westhoff (1977), Epple et al. (1984), Goodspeed (1989), Epple and Romer (1991), Nechyba (1997), Fernandez and Rogerson (1996), Benabou (1996a, 1996b), Durlauf (1996), Fernandez and Rogerson (1998), Glomm and Lagunoff (1999), Henderson and Thisse (2001), Benabou (2002), Rothstein (2006) and Ortalo-Magne and Rady (2006).

190 each point of time, each community provides a local public good g ,
191 which is financed by a property tax with rate denoted τ .⁵ Each com-
192 munity has a fixed supply of land, and thus a supply of housing ser-
193 vices that is not perfectly elastic.⁶ Let p_{jt}^h denote the net rental price
194 of a unit of housing services in community j in period t . We assume
195 competitive housing markets and:

196 **Assumption 1.** Housing is owned by absentee landlords. Housing
197 supply in community j is stationary and given by $H_j^s(p_{jt}^h)$, a non-
198 decreasing continuous function.

199 Let $p = (1 + \tau)p^h$ denote the gross-of-tax rental price of a unit of
200 housing services.

201 There is a continuum of individuals each of whom lives for three
202 periods, one period as a child and two periods as an adult. Thus at
203 each point of time the economy consists of three overlapping gener-
204 ations, denoted child (c), young adult (y), and old adult (o). Each
205 young household has one child who lives at home and attends public
206 school, with per child expenditure g .⁷ Children become young adults
207 and move away from home at the same time that young adults tran-
208 sition to old age. Hence, there are no children in old households. Each
209 young adult is characterized by a lifetime wealth denoted by w and
210 achievement of the household's child, denoted a . The achievement
211 of the child, $a(g)$, is determined by g in the household's community.

212 **Assumption 2.** We assume that achievement $a(g)$ is increasing in g .

213 When young, households have additive time-separable utility. The
214 period utility when young is defined over the quantity of housing
215 services h , child achievement, and young-aged numeraire consump-
216 tion b . The period utility when old is defined over housing services
217 consumed, the local public good, and old-aged numeraire consumption.
218 Period utility when young is denoted $U^y(b, h, a(g))$, and $U^o(b, h, g)$ for
219 an old household. For notational convenience, we write $U^y(b, h, g) \equiv$
220 $U^y(b, h, a(g))$.

221 **Assumption 3.** The current period utility of a young household $U^y(b,$
222 $h, g)$ and the utility function of an old household $U^o(b, h, g)$ are increas-
223 ing, twice differentiable, and concave in (b, h, g) . Lifetime utility of a
224 young household is given by: $U^y(b, h, g) + \beta U^o(b, h, g)$, for common
225 discount factor β .

226 The period utilities of young and old households differ due to the
227 presence or absence of a child, and we impose additional structure
228 on these later. A key feature of our model is that old households
229 have weaker preferences for public expenditures than younger
230 households. In the context of education spending, one can justify
231 weak preferences of old households by appealing to altruism. More-
232 over, older households care about the spill-over effects that arise
233 from educational expenditures. These include lower crime levels
234 and more attractive neighbors in the community.

235 Households choose a community when young and may relocate to
236 another as they enter old age. Moving between communities requires
237 expenditure from wealth on mobility costs, m . We assume that
238 households have heterogeneous mobility costs.

239 **Assumption 4.** The joint distribution of lifetime income and mobility
240 costs at time t , denoted by $F_t(w, m)$, is continuous with support
241 $S = \mathbb{R}_+^2$ and joint density $f_t(w, m)$ with $f_t(\cdot)$ everywhere positive on
242 its support.

Each period of adult life, a household will establish a community
of residence, rent housing, vote on the community property tax, and
consume. The precise timing of choices and household beliefs are
specified below. The level of g in a community each period must
satisfy community government budget balance, for majority choice
of the property tax rate. Letting n_{jt}^y denote the mass of young house-
holds that live in community j in period t , we assume:

Assumption 5. Local government balance prevails each period in
community j .

$$\tau_{jt} p_{jt}^h H_j^s(p_{jt}^h) = g_{jt} n_{jt}^y. \quad (1)$$

Assumption 6. The timing of household choices and household
beliefs, as well as the implications for determination of equilibrium
community variables is given in Fig. 1.

Each period t begins with the type distribution of young adults F_t ,
and equilibrium unfolds in four stages. Households have rational ex-
pectations and anticipate all equilibrium values, while acting as
price takers in housing markets. As households enter adulthood,
they first commit to their young and old-aged community. The com-
mitment to their old-aged community simplifies the voting problem
in Stage 3, as discussed further below. In Stage 2, both young and
old households rent units of housing, and the housing market clears
in each community. In Stage 3, households vote on the tax rate,
with the equilibrium tax rate the Condorcet winner. In Stage 4, cur-
rent period consumption is completed, and young households save
for the future. The achievement levels of children in the community
are established.

When households vote in Stage 3, they take as given current peri-
od housing consumption and the net housing price in their communi-
ty, both already established. Old households anticipate all the effects
on the implied subgames as they contemplate different taxes, specifi-
cally the level of g implied by Eq. (1), the gross housing price, and
their numeraire consumption (as their level of housing consumption
is already fixed). Young households are assumed to take as given the
 (p, g) pair on the equilibrium path in their committed future commu-
nity, while otherwise anticipating equilibrium effects in the current
and future period.⁸ Thus, our equilibrium is not subgame perfect in
that young households do not anticipate changes in (p, g) in their fu-
ture community off the equilibrium path. This myopia assumption
along with the assumption that their future community is commit-
ted permits us to establish the existence of voting equilibrium and
characterize it. It is, of course, of interest to relax such myopia as-
sumptions in future research.⁹ Households do correctly anticipate
all variables on the equilibrium path, and a young household's com-
mitted future community is the optimal community choice as they
enter old age.

Consider the problem of choosing communities of a young house-
hold. Let $d_{jt}^y \in \{0, 1\}$ denote an indicator that is equal to one if a young
household lives in community j at time t and zero otherwise. Similarly
define $d_{jt}^o \in \{0, 1\}$ for old households. Households also determine
consumption choices for housing and the composite private good

⁸ While they take as given the (p, g) pair in their future community, they anticipate the effects on their future period housing and numeraire consumption when they contemplate how their lifetime utility would be impacted by changes in current-period tax rates.

⁹ There are only a few studies that have analyzed voting in a dynamic model. Coate (2010) models forward looking behavior in local elections that determine zoning policies. His is able to adopt a more general approach to voting by adopting an otherwise simpler structure in which there is limited housing choice and heterogeneity, and housing prices are determined by construction costs. Krussell and Rios-Rull (1999) provide a dynamic model of taxation with forward looking voters that relies on numerical solution methods.

⁵ We suppress time and community subscripts when obvious. Subscripts have the obvious ranges unless we state otherwise.

⁶ For example, suppose that housing units are produced by combining land with an elastically supplied factor according to a Cobb–Douglas production function. Then a constant elasticity housing supply function is implied that shifts right with the community's land endowment. See Epple and Romer (1991).

⁷ Since we assume each generation has the same mass, we implicitly assume single parents. We could also assume two parent households that have identical twins. Variation in ability and age of children in a household would add considerable complications to the model.

Period t : $F_t(w,m)$ is given.

	<u>Young Households</u>	<u>Old Households</u>	<u>Communities/Markets</u>
Stage 1:	Commit to communities when young and old, anticipating all continuation equilibrium variables.	Establish old-aged community as committed when young, and bear moving cost if moved from young community.	Community type distributions determined with respect to age and current wealth.
Stage 2:	Rent housing in young community as price taker, anticipating all continuation equilibrium values.	Rent housing as price taker, anticipating all continuation equilibrium values.	Housing markets clear, establishing net housing prices in each community.
Stage 3:	Vote for local tax rate taking as fixed equilibrium (p,g) in old-aged community, otherwise anticipating all continuation equilibrium values.	Vote for local tax rate anticipating all continuation equilibrium values.	Tax and g determined through local budget balance in each community, as well as gross housing prices.
Stage 4:	Save optimally, anticipating all continuation equilibrium values, and consume (h,g,b) .	Consume (h,g,b) exhausting wealth, and then die.	Achievement of young determination in each community.

Fig. 1. Timing of Choices and Household Beliefs.

numeraire. Anticipating the equilibrium values of gross housing prices and the g 's, a young household at date t with characteristics (w_t, m_t) maximizes lifetime utility:

$$\max_{d_{kt}^y, h_{kt}^y, b_{kt}^y, d_{l,t+1}^o, h_{l,t+1}^o, b_{l,t+1}^o} \sum_{k=1}^J d_{kt}^y U^y(b_{kt}^y, h_{kt}^y, g_{kt}) + \beta \sum_{l=1}^J d_{l,t+1}^o U^o(b_{l,t+1}^o, h_{l,t+1}^o, g_{l,t+1}) \quad (2)$$

subject to the lifetime budget constraint

$$\sum_{k=1}^J d_{kt}^y (p_{kt} h_{kt}^y + b_{kt}^y) + \sum_{l=1}^J d_{l,t+1}^o (p_{l,t+1} h_{l,t+1}^o + b_{l,t+1}^o) = w_t - \sum_{k=1}^J \sum_{l \neq k} 1 \{d_{kt}^y = d_{lt}^o = 1\} m_t \quad (3)$$

and residential constraints:

$$\sum_{k=1}^J d_{kt}^y = 1 \quad (4)$$

$$\sum_{l=1}^J d_{l,t+1}^o = 1$$

where $1\{\cdot\}$ is an indicator function.¹⁰ The last two constraints in Eq. (4) impose the requirement that the household lives in one and only one community at each point of time. Also, w_t is the present value of lifetime income, thus assuming perfect capital markets.¹¹ Finally, we have abstracted from discounting of future prices just for simplicity of exposition.

It is often convenient to express this decision problem using an indirect utility (or value) function. Given a household with wealth, w , moving cost, m , and community choice k when young and l when old, we can solve for the optimal demand for housing and other goods in both periods. Substituting these demand functions into the

lifetime utility function yields the indirect utility function, which can be written:

$$V_{kl}^y = V(w - \delta_{kl} m, g_k, p_k, g_l, p_l) \quad (5)$$

where $\delta_{kl} = 1$ if $k \neq l$ and zero otherwise. Similarly, the indirect utility function of an old household that occupied community k when young and is occupying community l when old is:

$$V_{kl}^o(w_n^o, g_l, p_l) = \max_{h_l} U^o(w_n^o - p_l h_l, h_l, g_l) \quad (6)$$

where $w_n^o = w - \delta_{kl} m - p_k h_k^y - b_k^y$.³²⁹

Define the set of young households living in community j at time t as follows:³²²

$$C_{jt}^y = \{(w_t, m_t) | d_{jt}^y = 1\} \quad (7)$$

The number of young households living in community j at time t is given by:³²⁶

$$n_{jt}^y = \iint_{C_{jt}^y} f_t(w_t, m_t) dw_t dm_t \quad (8)$$

Similarly define the set of old households living in community j at time t as follows:³³⁰

$$C_{jt}^o = \{(w_{t-1}, m_{t-1}) | d_{jt}^o = 1\} \quad (9)$$

The number of old households living in community j at time t is given by:³³⁴

$$n_{jt}^o = \iint_{C_{jt}^o} f_{t-1}(w_{t-1}, m_{t-1}) dw_{t-1} dm_{t-1} \quad (10)$$

In this model all households are renters. Housing demand functions $h_t^y(\cdot)$ and $h_t^o(\cdot)$ can be derived by solving problem Eq. (2).³³⁸

¹⁰ Though all the choice variables in problem (2) are not actually chosen simultaneously, the solution variables do conform to the timing and beliefs of Assumption 6. For example, the planned value of old-aged housing consumption $h_{l,t+1}^o$ that solves (2) conforms to the equilibrium choice.

¹¹ Abstracting from uncertainties and liquidity constraints are obviously strong assumptions that should be relaxed in future research.

¹² We can express C_{jt}^y as the finite intersection of measurable sets that are defined by boundary indifference conditions. Hence C_{jt}^y is measurable.

¹³ Expressions (8) and (10) make use of the fact almost every household of a given type makes the same community choice.

339 Below we introduce subscripts t to indicate the dependence of hous-
 340 ing demands on prices young and old households confront during
 341 their life.¹⁴ Aggregate housing demand in community j at time t is
 342 then defined as the sum of the demand of young and old households:

$$H_{jt}^d = H_{jt}^y + H_{jt}^o \quad (11)$$

343 where

$$H_{jt}^y = \int \int C_j^y h_{jt}^y(w_t, m_t) f_t(w_t, m_t) dw_t dm_t$$

$$H_{jt}^o = \int \int C_j^o h_{jt}^o(w_{t-1}, m_{t-1}) f_{t-1}(w_{t-1}, m_{t-1}) dw_{t-1} dm_{t-1}$$

346

347 Using Assumption 5, the housing market in community j is in
 348 equilibrium at time t if:

$$H_{jt}^d = H_j^s(p_{jt}^h) \quad (12)$$

349

350 Our absentee housing ownership assumption is imposed primarily
 351 for simplicity. The alternative would be to assign property rights over
 352 land. Households would then obtain revenues from rental income.
 353 The income effects from this would be very minor. This alternative
 354 would, however, significantly complicate the public choice problem
 355 for households who happen to live where they own land.¹⁵ We
 356 avoid the additional complexity by assuming absentee owners of
 357 land.

358 The property tax and thus local public good is chosen by majority
 359 vote with the described voter beliefs, subject to (1). A majority voting
 360 equilibrium is a public good level weakly preferred by at least half the
 361 community population in pairwise comparisons to all other feasible
 362 levels.¹⁶

363 We are now in a position to define formally an equilibrium for our
 364 model.

365 **Definition 1.** An equilibrium for this economy is defined as an allocation
 366 that consists of a sequence of joint distributions of wealth and
 367 moving costs, $\{F_t(w, m)\}_{t=1}^{\infty}$, a vector of prices, taxes and public
 368 goods denoted by $\{p_{1t}, \tau_{1t}, g_{1t}, \dots, p_{jt}, \tau_{jt}, g_{jt}\}_{t=1}^{\infty}$, consumption plans for
 369 each household type, and a distribution of households among commu-
 370 nities, $\{C_{jt}^y, \dots, C_{jt}^o, \dots, C_{jt}^o\}_{t=1}^{\infty}$, such that:

- 371 1. Households maximize lifetime utility and live in their preferred
 372 communities.
- 373 2. Housing markets clear in every community at each point of time.
- 374 3. Community budgets are balanced at each point of time.
- 375 4. There is a majority voting equilibrium in each community at each
 376 point of time.

377 The last component of our model deals with the intergenerational
 378 income transmission process. We make the following assumption.

379 **Assumption 7.** A child's human achievement a_t , starts as a young adult
 380 with lifetime wealth w_{t+1} .

$$\ln w_{t+1} = q(a_t, w_t, \epsilon_{t+1}) \quad (13)$$

381 where ϵ_{t+1} denotes an idiosyncratic shock. The dependence of chil-
 382 dren's income on parental income, w_t , captures intergenerational in-
 383 come persistence. Moreover, we assume that $q(\cdot)$ is increasing in all
 384 three elements for $w_t > 0$, but that $q(a_t, 0, \epsilon_{t+1}) = -\infty$.

A stationary equilibrium for our economy is then defined as 387
 follows. 388

Definition 2. A stationary equilibrium is an equilibrium that satisfies 389
 the following additional conditions: 390

- 391 1. Constant prices, tax rates and levels of public good provision, i.e. 391
 for each community j , $p_{jt} = p_j$, $\tau_{jt} = \tau_j$, and $g_{jt} = g_j \forall t$. 392
- 393 2. A stationary distribution of households among communities, i.e. 393
 for each community j , we have $C_{jt}^o = C_j^o$ and $C_{jt}^y = C_j^y \forall t$. 394
- 395 3. A stationary distribution of household wealth and moving costs, 395
 i.e. $F_t(w, m) = F(w, m) \forall t$. 396

3. Properties of equilibrium 397

3.1. Existence and uniqueness of equilibrium 398

An element of existence of equilibrium of the model is existence of 399
 voting equilibrium in Stage 3. We have: 400

Proposition 1. Given residential commitments, a voting equilibrium 401
 exists in all communities. 402

Proof of Proposition 1. Consider a community j which is character- 403
 ized by a pair of housing price and public good provision (p_{jt}, g_{jt}) . 404
 Combining the equation relating net and gross housing prices, $p_{jt} = p_{jt}^h$ 405
 $(1 + \tau_{jt})$, and the community budget constraint Eq. (1), we obtain: 406

$$p_{jt} = p_{jt}^h \frac{g_{jt} n_{jt}^y}{H_{jt}^s} \quad (14)$$

Given our timing assumptions, all variables in this expression except 408
 (p_{jt}, g_{jt}) have been determined prior to voting. Thus the set of feasible 409
 alternatives yields a linear relationship between the choice of g_{jt} and 410
 the resulting gross-of-tax housing price p_{jt} . 411

In each community j , there are two types of voters, young and old. 412
 Given the correct beliefs of each voter about feasible alternatives in 413
 Eq. (14), we can characterize each voter's decision problem and 414
 thus characterize the voter's behavior. 415

First consider an old household that has chosen to live in commu- 416
 nity j after living in community i when young. The household's old 417
 age income is given by $w_{nt}^o = w_{t-1} - p_{it-1} h_{it-1}^y - b_{it-1}^y - \delta_{ij} m_{t-1}$. 418
 The household's budget constraint when old is given by: $w_{nt}^o = p_{jt} h_{jt}^o +$ 419
 b_{jt}^o . Let h_{jt}^o be the amount of housing the household has chosen. The 420
 quantity h_{jt}^o is then fixed at the time that voting occurs. Substituting 421
 the community budget constraint that prevails at the time of voting 422
 into the voter's budget constraint, we obtain: 423

$$w_{nt}^o = p_{jt}^h h_{jt}^o + \frac{g_{jt} n_{jt}^y}{H_{jt}^s} h_{jt}^o + b_{jt}^o \quad (15)$$

The voter's utility function is $U^o(g_{jt}, h_{jt}^o, b_{jt}^o)$. At the time of voting, 424
 all elements of the preceding budget constraint and utility function 425
 have been determined except (g_{jt}, b_{jt}^o) . Quasi-concavity of the utility 426
 function (Assumption 3) and convexity of the budget constraint 427
 imply that the voter's induced preference over g_{jt} is single-peaked 428
 (Denzau and Mackay, 1976). 429

Next consider a young voter that lives in community j at t and 430
 plans to live in community k in $t + 1$. The development is analogous 431
 to that for old voters, and we thus summarize briefly. At the time of 432
 voting in community j , this household will have purchased housing 433
 h_{jt}^y . The budget constraint of the young voter is then: 434
 435

$$w_t = p_{jt}^h h_{jt}^y + \frac{g_{jt} n_{jt}^y}{H_{jt}^s} h_{jt}^y + b_{jt}^y + p_{kt+1} h_{kt+1}^o + b_{kt+1}^o + \delta_{jk} m_t \quad (16)$$

¹⁴ Housing demand when young and old solve (2) and thus depend on the vector
 $(p_{jt}^y, g_{jt}^y, p_{jt}^o, g_{jt}^o, p_{jt+1}^o, g_{jt+1}^o)$. Since these variables are predictable, we use the subscript t
 to indicate this dependence, thus greatly simplifying notation.

¹⁵ Since households are atomistic and thus no one household affects voting equilibri-
 um, residential choices would not be affected by land ownership.

¹⁶ Given Eq. (1), it is equivalent to describe voting as over the local public good or
 property tax.

The young voters utility function is: $U^y(b_{jt}^y, h_{jt}^y, g_{jt}) + \beta U^o(b_{kt+1}^o, h_{kt+1}^o, g_{kt+1})$. At the time of voting, the community tax base, H_{jt}^y/n_{jt}^y , and the voter's housing consumption, h_{jt}^y , have been determined. The voter takes current and future prices (p_{jt}^h, p_{kt+1}) and future government provision, g_{kt+1} , as given. Quasi-concavity of the voter's utility function, $U^y + \beta U^o$, and convexity of the budget constraint then imply that induced preferences over g_{jt} are single-peaked (Slutsky, 1975).

The existence of a voting equilibrium follows from single-peakedness of preferences of all voters. Q.E.D.

In general, the pivotal voter will not be the voter with median income. Indeed, there will often be more than one household type that is pivotal. For example, a wealthy old household and a poor young household may both be pivotal, both having the same most-preferred tax rate and expenditure level. Voting equilibrium will be unique if the density of the preferred level of the public good is positive in the vicinity of its median, which we consistently find in our computations.

We do not have a general proof of existence of stationary equilibrium in the model. However, we compute stationary equilibrium "exactly" in realistically calibrated versions of the model. Computation of equilibrium entails performing numerical integration and setting tolerance levels for convergence. Thus, equilibrium is "exact," conditional on a degree of numerical accuracy. We have implemented the algorithm in GAUSS using quadrature techniques and in C using Monte Carlo integration. Both programs yield almost identical results for the set of equilibria reported in the paper.¹⁷ Based on our computational and sensitivity analysis, we can conclude that equilibria exist and can be computed up to arbitrary degrees of numerical accuracy.

With respect to uniqueness of stationary equilibrium, there are three issues. First, as is common in multi-community models, equilibrium typically exists with communities that are ex post identical. These "non-Tiebout" equilibria are uninteresting and easily rejected empirically (see, e.g., Epple and Sieg, 1999). We analyze sorting equilibria here. Second, the non-convexities in the model associated with community choice preclude use of standard techniques to establish uniqueness of sorting equilibria. Last, the endogeneity of the income distribution in stationary equilibrium may not be unique.

While there are several sources of potential multiplicity, we find in our computational analysis that stationary (sorting) equilibria are robust. When we perturb an equilibrium that we have computed, the algorithm converges back to the original equilibrium. These computational experiments suggest that equilibrium is at least locally unique. We do not, however, have a formal proof of uniqueness of sorting equilibrium.

3.2. Equilibrium with Household Sorting

We need to show that the equilibrium of this model captures the generational conflict in voting over local public good provision. We will show that older households tend to be in the majority in communities with low quality of educational services. Young households tend to dominate in communities with higher quality of education. We derive this result in a sequence of propositions. First, we characterize residential sorting patterns. We then provide sufficient conditions to establish the result that older households only move down in the quality hierarchy if they move at all. We then consider the implication of the residential sorting patterns for the age composition of communities and the resulting voting majorities.

Upon entering adulthood, young households choose an initial and an old-age community of residence, correctly anticipating housing prices and local public good provision. Let k and l denote, respectively, the initial and old-age communities, $k, l \in \{1, 2, \dots, J\}$. If $k \neq l$, then the

household bears moving cost with present value of m . We adopt the convention of numbering the communities so that $g_{j+1} > g_j$. Since households correctly anticipate g 's and p 's, gross housing prices will also ascend with the community number.

We now place some restrictions on the form of the household utility function that greatly facilitate the analysis.

Assumption 8. The utility function

$$U^a(b, h, g) = u_g^a(g) + u^a(b, h), a \in \{y, o\}, \tag{17}$$

is separable and $u^a(b, h)$ is homogeneous of degree ψ .

Define $V_{kl}^y = V^y(g_k, g_l, p_k, p_l, \tilde{w})$ as the indirect lifetime utility of a young household choosing residential plan kl , where $\tilde{w} = w - \delta_{kl}m$ is lifetime wealth adjusted for any moving cost. Given Assumption 8, we show in Appendix A that the indirect utility of a young household can be written as:

$$V_{kl}^y = G(g_k, g_l) + \tilde{w}^{-\psi} W(p_k, p_l) \tag{18}$$

with G an increasing function of (g_k, g_l) and W a decreasing function of (p_k, p_l) .

The optimal residential choice plan of young adults maximizes V_{kl}^y over (k, l) taking anticipated p 's and g 's as given. It is also convenient to adopt a notation in which locational choices can be characterized by a single index subscript i . Let $i \in I_{kl}, I_{kl} = \{kl | k, l = 1, 2, \dots, J\}$, indicate a residential plan. Let $P_i \equiv -W(p_k, p_l)$ for $i = kl$, which we refer to as the composite price of residential plan i . Note that P_i is increasing in (p_k, p_l) . Using this definition, we have that indirect utility from residential plan i is given by:

$$V_i^y = G_i - (w - \delta_i m)^{-\psi} P_i, \tag{19}$$

where $G_i \equiv G(g_k, g_l)$ for $i = kl$. As a final step, let $T \equiv m/w$ denote proportional moving costs and again rewrite indirect utility using type-dependent price P_i^T .

$$V_i^y = G_i - w^{-\psi} P_i^T; \tag{20}$$

where

$$P_i^T \equiv \begin{cases} P_i & \text{if } i \text{ does not move } (k = l) \\ P_i(1 - T)^{-\psi} & \text{if } i \text{ moves } (k \neq l) \end{cases} \tag{21}$$

Household type (w, T) then chooses a residential plan i to maximize V_i^y in Eq. (20) taking $(G_i, P_i^T), i \in I_{kl}$, as given.

Household choices then satisfy the following three properties:

- (P1) Indifference curves $V_i^y = \text{const.}$ in the (G_i, P_i^T) plane are linear with slope $w^{-\psi}$.
- (P2) Indifference curve satisfy single crossing, with "slope increasing in wealth (SIW)."
- (P3) $dP_i^T/dT > 0$ for $k \neq l$; choices with moving are effectively more expensive as m rises.

Properties (P1)–(P3) are intuitive and simply confirmed. (P1) will greatly simplify the analysis that follows. The single crossing property in (P2) means that the indifference curves defined in (P1) cross at most once, and with slopes increasing in wealth. (P2) and (P3) are keys to the character of sorting over communities over the life cycle.

With J communities, there are J^2 residential plans that could feasibly be chosen. Using properties of the choice problem, we can develop restrictions on the set of plans that are actually chosen and then develop an algorithm for mapping household types into their equilibrium residential plans. Let $B^0 \equiv \{G_i, P_i^T | i \in I_{kl}\}$ denote the set of bundles, corresponding to residential plans, that are feasible for households with $T = m/w$. Let H^T denote the convex hull of B^0 and let $B^0(T)$ denote the set of residential plans (G_i, P_i^T) on the lower boundary of H^T .

¹⁷ A version of the GAUSS program is available on our web site for other researchers who wish to replicate our results.

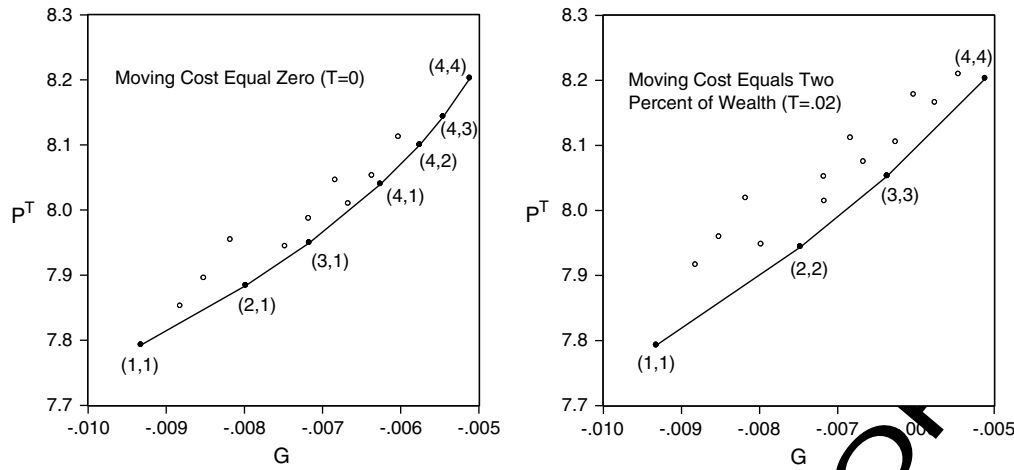


Fig. 2. The Relevant Choice Set.

555 Formally, $\underline{B}^0(T)$ is defined:

$$\underline{B}^0(T) \equiv \{ (G_i, P_i^T) \in B^0 \mid \text{no distinct } (\tilde{G}_i, \tilde{P}_i^T) \in H^T \text{ exist with } \tilde{G}_i \geq G_i \text{ and } \tilde{P}_i^T \leq P_i^T \} \quad (22)$$

556 Fig. 2 shows two examples from some of our computational
557 analysis of these concepts for a case with $J=4$.

558 We make the following assumption:

559 **Assumption 9.** A T exists that prohibits moving in equilibrium for all
560 wealth types.

561 We then have the following main result that characterizes the
562 relevant choice set:

563 **Proposition 2.** Households with relative moving cost T chosen in equilibrium
564 all residential plans in $\underline{B}^0(T)$. As a consequence, we have:

- 565 (i). Non-moving residential plans chosen by households with a prohibitive
566 T comprise the set of all non-moving residential plans chosen in equilibrium
567 by any households.
- 568 (ii). Moving plans chosen by households with the minimum T comprise the set of all moving residential plans chosen in equilibrium
569 by any households.

570 The proof of Proposition 2 and the remaining propositions are
571 collected in an appendix.

572 To see informally what underlies these results refer to Fig. 2. For
573 given T , one can use (P1)–(P3) and draw indifference curves for a
574 wealth type in the relevant panel. The household chooses the plan
575 where the southeasternmost indifference curve touches the choice set.
576 Wealth can vary from 0 to ∞ , and an indifference curve has
577 slope w_k^e . Hence, for every residential plan in that T -types choice
578 set, there will be a wealth type w choosing that residential plan.
579 Parts (i) and (ii) are confirmed by examining the effects of varying
580 T on the convex hull of a T type's residential plans. In particular, bundles
581 (G_i, P_i^T) do not vary with T for non-moving plans, but P_i^T increases
582 with T for moving plans.

583 We can also show that equilibrium satisfies an “ascending bundles”
584 property and is characterized by a conditional wealth stratification
585 property. Let $J_e \leq J^2$ denote the number of residential plans
586 chosen by any household.¹⁸ Number these plans $1, 2, \dots, J_e$ such that
587 $G_1 < G_2 < \dots < G_{J_e}$.

¹⁸ Later we show that $J_e < J^2$ under reasonable restrictions.

Proposition 3.

- 591 (i). Ascending bundles: Given two residential plans chosen in equilibrium
592 by a household with T satisfying $G_i > G_j$, then $P_i^T > P_j^T$.
- 593 (ii). Conditional Wealth Stratification: For given T , if $w_2 > w_1$ and
594 a household with wealth w_2 chooses plan with G_i and household
595 with wealth w_1 chooses plan with G_j ($j \neq i$), then $i > j$.

596 These results can be confirmed using the properties of the optimal
597 residential choice set and the indifference curves of young
598 households.

599 Note that the subset of the J_e plans chosen by different T types
600 varies. Fig. 3 shows an example with $J=4$ from our computational
601 analysis of the equilibrium partition of young households by type
602 (w, T) across residential plans kl . In this example, only five of the
603 residential plans entailing moving arise in equilibrium. There are
604 four no-moving plans and thus $J_e = 9$.

605 In our computational analysis below, we adopt the following life-
606 time utility function:

$$U = a + \frac{1}{\rho} [\alpha_h h_k^\rho + \alpha_b b_k^\rho + \beta_g g_l^\rho + \beta_h h_l^\rho + \beta_b b_l^\rho], \rho < 0; \quad (23)$$

607 and the following achievement function: 608

$$a = \frac{\alpha_g}{\rho_a} g_k^{\rho_a}; \quad (24)$$

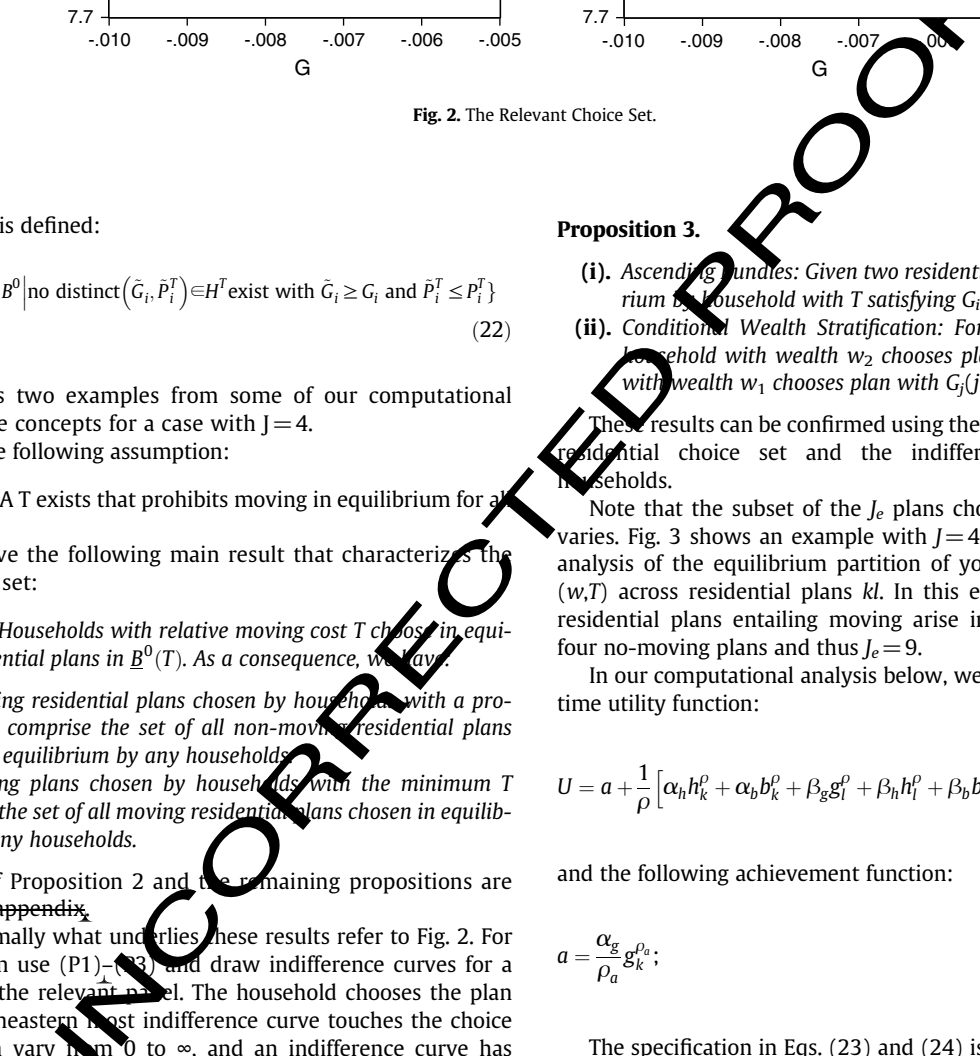
609 The specification in Eqs. (23) and (24) is a variant of a CES speci-
610 fication that satisfies our general assumptions and is tractable while
611 retaining substantial flexibility. If $\rho = \rho_a$, the standard CES case arises.
612 Note that discounting of future values is impounded in the β 's.

613 Substituting the achievement function into the utility function, we
614 obtain:

$$U = \left[\frac{\alpha_g}{\rho_a} g_k^{\rho_a} + \frac{\beta_g}{\rho} g_l^\rho \right] + \frac{1}{\rho} [\alpha_h h_k^\rho + \alpha_b b_k^\rho + \beta_h h_l^\rho + \beta_b b_l^\rho], \rho < 0; \quad (25)$$

615 After some manipulation one obtains indirect utility: 616

$$V_i^y = G_i - (w - \delta_i m)^\rho P_i; \quad (26)$$



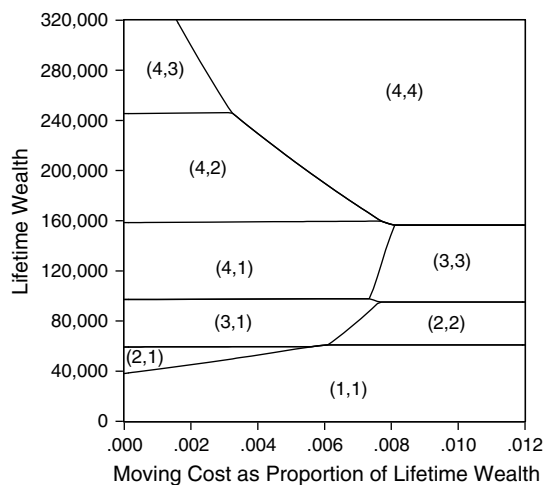


Fig. 3. Residential Plans in Equilibrium.

622 where:

$$\begin{aligned}
 p_i &= -\frac{1}{\rho} z_{kl}^{-\rho} \left[\alpha_h \left(\frac{\alpha_b}{\alpha_h} p_k \right)^{-\frac{\rho}{1-\rho}} + \alpha_b + \beta_h \left(\frac{\alpha_b}{\beta_h} p_l \right)^{-\frac{\rho}{1-\rho}} + \beta_b \left(\frac{\alpha_b}{\beta_b} \right)^{-\frac{\rho}{1-\rho}} \right]; \\
 z_{kl} &= \left[p_k \left(\frac{\alpha_b}{\alpha_h} p_k \right)^{-\frac{1}{1-\rho}} + 1 + p_l \left(\frac{\alpha_b}{\beta_h} p_l \right)^{-\frac{1}{1-\rho}} + \left(\frac{\alpha_b}{\beta_b} \right)^{-\frac{1}{1-\rho}} \right]; \\
 G_i &= \left[\frac{\alpha_g}{\rho_a} g_k^{\rho_a} + \frac{\beta_g}{\rho} g_l^{\rho} \right].
 \end{aligned}
 \tag{27}$$

624 and where we have again used the notation that residential plan
625 $i = kl$.

626 Keeping in mind that $\rho < 0$, one can see that all the properties of
627 the preceding more general case are satisfied. In particular the com-
628 posite public good G_i is increasing in the g 's and the composite price
629 P_i is increasing in the p 's.

630 Restricting the relative values of the parameters of the utility func-
631 tion, we can provide conditions such that no household will move
632 when old to a community with higher g .

633 **Assumption 10.** The utility function satisfies the following param-
634 eter restrictions:

$$\alpha_g (\alpha_h / \alpha_b)^{1/(\rho-1)} > \beta_g (\beta_h / \beta_b)^{1/(\rho-1)} \text{ and } \rho_a > \rho.
 \tag{28}$$

635 Hence we have the following important result that impacts the
636 age distribution within communities.

639 **Proposition 4.** No household will choose a community with higher (p, g)
640 pair when old than when young in a stationary equilibrium.

641 The willingness to pay a higher housing price to live in a commu-
642 nity with higher g increases with the coefficient on g in the period
643 utility function and decreases with the coefficient on housing. While
644 the presence of children when young indicates that both $\alpha_g > \beta_g$ and
645 $\alpha_h > \beta_h$ are to be expected, the condition of Proposition 4 implies
646 that the relatively stronger preference for g when young outweighs
647 the relatively stronger preference for housing so that moving to a
648 higher (p, g) community when old would not result.

649 We have characterized the residential sorting patterns by age that
650 are generated by our model. We can explore the implication of these
651 sorting patterns for collective choices. As we have shown, one key im-
652 plication of our model is that older households do not want to move
653 up the community hierarchy after the children graduate from high
654 school. These sorting implications suggest that older households

will be in a majority in poor communities with low educational ser- 655
vices and younger households will dominate in communities with 656
high levels of education services. We formalize this intuition in this 657
section. 658

There will be at least some mobility in equilibrium: 659

Proposition 5. Consider the set of communities $j > 1$ that are chosen by 660
young households with zero moving costs. Some households will move 661
down from these communities in equilibrium. 662

Proposition 6 then characterizes potential voting majorities in 663
equilibrium. 664

Proposition 6. The young will be in the majority in the highest g com- 665
munity, and the old will be in the majority in at least one lower g com- 666
munity, necessarily so in the lowest g community. 667

Note that the first result follows since some households will 668
move out of community J as they enter old age and no such households 669
will move in (by Proposition 4).¹⁹ The second result follows from the 670
first result and that Proposition 5 implies some households will 671
necessarily move into the lowest g community as they enter old age 672
while none will move out (again by Proposition 4). 673

4. Quantitative properties of equilibrium 674

The quantitative analysis has two objectives. First, we show that 675
equilibria of the model exist and can be computed for reasonable 676
specifications of the model.²⁰ Second, we show that the model can 677
generate equilibria that are broadly consistent with many quantita- 678
tive facts that we observe in the data. In particular, the model can 679
generate household sorting patterns by income and age among the 680
set of communities that are broadly consistent with our empirical 681
characterization of household sorting observed in the Boston metro- 682
politan area. The computed equilibria are also consistent with the ob- 683
served mobility patterns if we use relatively low mobility costs. These 684
are meaningful exercises despite the fact that equilibrium may not be 685
unique. 686

4.1. Parameterization and calibration 687

In our quantitative analysis we restrict attention to models with 688
four communities. To implement the algorithm, we must fully specify 689
the model, choosing functional forms and assigning parameter values. 690
First, we assume that the community housing supply has constant 691
elasticity θ and is given by 692

$$H_{jt}^s = [p_{jt}^h]^\theta
 \tag{29}$$

Thus we assume that the four communities have the same housing 693
supply function and in this sense are of “equal size.” We set the sup- 694
ply elasticity, θ , equal to 3.²¹ 695

We then calibrate the eight parameters of the utility function as 696
follows. We set $\rho_a = \rho$ as explained below, leaving 7 parameters. 697
The strategy is then to set parameters to match predictions of the 698
baseline model to empirical estimates of expenditure shares and 699
demand elasticities. The α 's and β 's are set so that equilibrium predic- 700
tions approximately conform to empirical values of: (i) relative 701
expenditure of lifetime wealth while young versus old; (ii) the hous- 702
ing expenditure shares while young and old; (iii) proportional expend- 703
iture on local public goods; and (iv) a constant share of expenditure 704
on the numeraire good while young and old. Since the ordinality of 705
706
707

¹⁹ Some zero moving cost households will choose community J while young since some of them have arbitrarily high wealth.

²⁰ Appendix B presents an algorithm that can be used to compute equilibria.

²¹ This is consistent with empirical evidence as discussed in detail in Epple et al. (forthcoming).

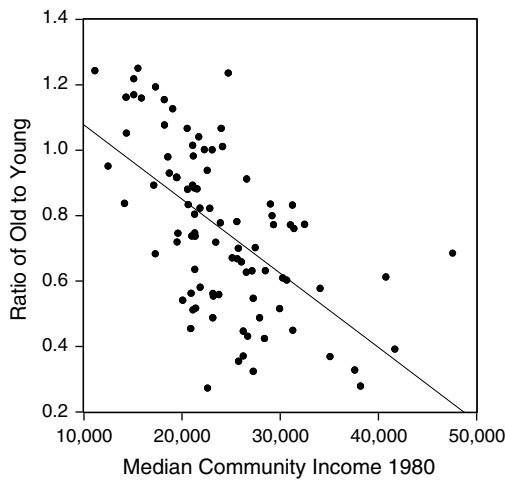


Fig. 4. Ratio of Old to Young Households by Community in 1980.

708 utility makes one parameter free, calibrating to the latter five conditions
 709 pin down the α 's and β 's. We employ data from the Consumer
 710 Expenditure Survey to obtain the shares in (i) and (ii), treating the
 711 data as if it pertains to a single cohort moving through the life cycle.
 712 We take households aged 35–44 as typical of young households in
 713 our model, and households aged 65–74 as typical of old households
 714 who have relocated. Households spend 60% of lifetime wealth when
 715 young and 40% when old. Approximately 26% of expenditures at
 716 each life stage are for housing services.

717 While we have emphasized education as a key factor influencing
 718 household location choices, we include in local government expenditure
 719 the other components that potentially influence location choice
 720 in estimating (iii); specifically expenditures for public safety (police
 721 and corrections), fire, sanitation, health, transportation, debt expense,
 722 and government administration. These totaled \$901.8 billion in 2004.
 723 Personal income in 2004 was \$9,731 billion, implying local government
 724 expenditure equal to 8.7% of income. Of this total, \$474 billion
 725 (52.5%) was for education.²² Using this strategy, we obtain $\alpha_y = 0.096$,
 726 $\beta_h = 0.053$, $\alpha_g = 0.075$, $\beta_g = 0.028$, $\alpha_b = 1.00$, and $\beta_w = 0.57$. We then
 727 choose $\rho = -.4$ as this yields price elasticities between $-.7$ and $-.8$
 728 for all goods.

729 Our algorithm requires that we specify an initial distribution of
 730 household income. We approximate the initial income distribution
 731 using a log-normal. In 2005, U.S. mean and median incomes were
 732 \$63,344 and \$46,326. These imply that $\mu_{\ln y} = 10.743$ and $\sigma_{\ln y}^2 = .626$.
 733 We treat each of the two periods of adult life in our model as “representative
 734 years.” This implies that wealth equals twice annual income,
 735 $w = 2y$, and hence $\ln(w) = \ln(2) + \ln(y)$. This and the distribution of
 736 $\ln(y)$ imply $\ln(w) \sim N(11.436, .26)$. The mean and standard deviation
 737 of w are then \$112,638 and \$78,018. Calibrating wealth as twice
 738 annual income is convenient in then permitting us to interpret the
 739 equilibrium values of variables as typical annualized values for a
 740 young and an old household respectively.

741 Our achievement function is given by Eq. (24). We assume that
 742 the logarithm of wealth when an adult for a child with achievement
 743 a is given by

$$\ln w_{t+1} = \gamma_p a_t + \gamma_w \ln w_t + \epsilon_{t+1} \quad (30)$$

744 where ϵ_{t+1} is normally distributed with mean μ_ϵ and variance σ_ϵ^2 . To
 745 calibrate the intergenerational income transmission function, we consider
 746 the stationary equilibrium in the one community-case. In stationary
 747 equilibrium, the distribution of wealth is invariant across
 748

Table 1

Cohort Ratios.

1980				
1	2	3	4	5
Community	(55–69)/ (35–49)	(55–69)/ (30–44)	(60–74)/ (35–49)	Model Prediction
1	1.128	1.025	1.155	1.178
2	1.184	1.181	1.231	1.123
3	0.926	0.956	0.910	0.989
4	0.742	0.804	0.683	0.777

749 generations. Moreover, we require that the transmission function
 750 generates an income distribution with mean and variance reported
 751 above. This provides two moment conditions for the four parameters
 752 to be calibrated. The other two moments are obtained using the cor-
 753 relation of parent and child earnings and the elasticity of spending on
 754 educational outcomes. The literature suggests that the correlation of
 755 parent and child earnings is approximately .4 (Solon, 1992).

756 The effect of spending on educational outcomes is more difficult to
 757 establish since there is a lack of agreement in the empirical literature
 758 about the magnitude of this effect. Fernandez and Rogerson (2003)
 759 adopt a utility function that also has education spending entering
 760 the utility function in the same way as our function above. Fernandez
 761 and Rogerson (1998) review evidence regarding the elasticity of earn-
 762 ings with respect to education spending, concluding that the evidence
 763 suggests a range of 0 to .2. We choose an elasticity, .1, in the middle of
 764 this range.

765 We choose parameters of the income transmission function
 766 which, in equilibrium, satisfy the four moment conditions discussed
 767 above. It is then straight-forward to show that there is closed-form
 768 solution that maps the moment conditions into the parameter
 769 estimates. We obtain the following estimates $\mu_\epsilon = 7.11$, $\sigma_\epsilon = .573$,
 770 $\gamma_p = 49.32$, and $\gamma_w = .4$.

771 Next, to calibrate the moving cost distribution, we consider the
 772 empirical age distributions in metropolitan areas. Fig. 4 plots the
 773 ratio of old to young households as a function of median community
 774 income for the 92 municipalities in the Boston SMSA in 1980.²⁴ We
 775 define cohorts representative of our young and old households. For
 776 the former, we choose age 35 to 49 and, for the latter, age 55 to
 777 69.²⁵ We find that the proportion of old to young households is in-
 778 versely related to community income.

779 The plots in Fig. 4 suggest a calibration of the distribution of mov-
 780 ing cost so that our model can replicate the observed age ratios. We
 781 aggregated all communities by income into four groups with popula-
 782 tion proportions approximately equal to those in our four-community
 783 equilibrium. Next, we calculated the ratio of old to young households
 784 in each of these groups. The results are in column 2 of Table 1. One
 785 might argue that households will typically be in the age range 30 to
 786 44 when their first child enters school. Hence, as a second calculation,
 787 we treated the young as cohort 30 to 44. The results are in column 3
 788 of Table 1. It is important to note that the 30 to 44 cohort in 1980 is
 789 substantially larger than the 35 to 49 cohort, the former being heavily
 790 influenced by the baby boom generation. Thus, while we present it for
 791 completeness, the 3rd column is of questionable value for calibration
 792 of our stationary equilibrium. One might also argue that households
 793 do not contemplate relocating until their children have completed

²³ They also review the evidence, concluding that the exponent on expenditure is in the range from 0 to -3 . The value $\rho_a = -.4$ that we have chosen for the other component (ρ) of utility falls within this range.

²⁴ Our plot for 1980 is chosen to precede the pronounced effects of non-stationary changes arising from maturing of the baby boom generation.

²⁵ The metropolitan population in the former cohort is 7% larger than the metropolitan population in the latter. Since our model presumes equal cohort sizes, we increase all community populations in the 55 to 69 cohort by 7%.

²² Sources: Statistical Abstract, 2008, Table 442. Local Governments Expenditure and Debt by State: 2004.

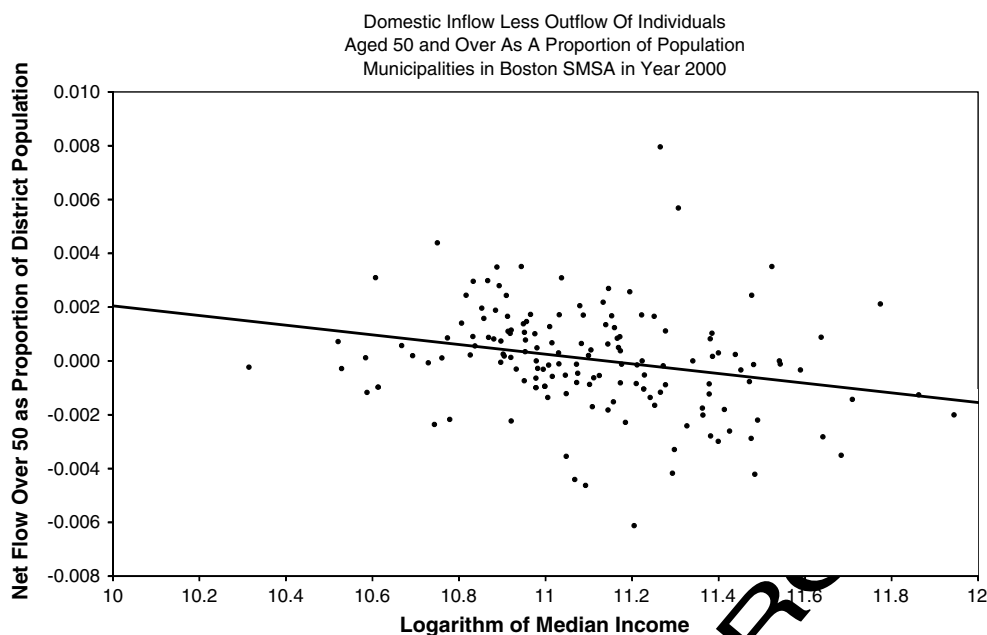


Fig. 5. Domestic Inflow Less Outflow Of Individuals Aged 50 and Over As A Proportion of Population Municipalities in Boston SMSA in Year 2000.

college. Hence, as a third calculation we defined ages 60 to 74 as the old cohort, with results in column 4 of Table 1.

To calibrate moving costs, we take moving costs as a share of income, T , to be log-normally distributed. We chose parameters of our moving cost distribution to generate an equilibrium with cohort ratios roughly in accord with those summarized in columns 2 through 4 of Table 1. With some experimentation, we settled on $\ln(T) \sim N(.00925, .0026)$ with a correlation of $\ln(T)$ and $\ln(w)$ equal to zero. This yields the cohort ratios in column 5 of Table 1.

The age ratios implied by our model are also broadly consistent with observed migration patterns in the Boston Metropolitan area. Migration data are publicly available for municipalities in New England from the year 2000 U.S. Census. We plot in Fig. 5 the net inflow of individuals over the age of 50 among residents in the Boston MA as a percentage of the population for each municipality in the Boston metropolitan area. We find a strong negative correlation with median income. Poorer communities have positive net inflows while richer communities have positive net outflows. These findings are in line with the prediction of our model and provide empirical support for our modeling approach.

4.2. Quantitative analysis of the intergenerational conflict

We now provide a quantitative analysis of the intergenerational conflict over provision of local educational services. Table 2 illustrates two different equilibria with four communities. The lower panel conforms to the model that we have presented. In the upper panel we also consider an equilibrium with a foundation grant for local public good spending that is financed by a given proportional income tax. In the equilibrium with a foundation grant, the proceeds from the income tax revenues finance a constant economy-wide expenditure on g , and jurisdictional property tax revenues provide a local supplement. Since income is exogenous in this model, an income tax is equal to a lump sum tax. For simplicity we assume that an income tax is paid by young adult households and the tax base is total lifetime income. In 2006, state and local government revenues for primary and secondary education were approximately equal. Thus, we choose the foundation grant to equalize state and local expenditures on education. As we noted above, education expenditures are 52.5% of local expenditures. With state funding equal to half this amount in our

calibrated equilibrium, we obtain a foundation grant of \$2,600 per young household. All the properties of the model with no foundation grant carry over with trivial adjustments.²⁶

The potential lack of uniqueness implies that comparative static exercises have to be taken with caution. When we compute the equilibrium with the \$2600 foundation grant, we start with the baseline equilibrium with no foundation. We then compute a sequence of equilibria with increasing foundation grants until we are up to \$2600. We find that the mapping that characterizes equilibrium allocations is continuous in that model parameter. Moreover, we cannot find any other equilibria nearby. These computations suggest that equilibrium is at least locally unique. We cannot, however, rule out that there may exist other equilibria that are not close to the original, baseline equilibrium.

Table 2 reports expenditures, tax rates, and housing prices in the stationary equilibria. First consider the equilibrium with a foundation grant. Expenditures range from \$4,012 in the low income community to \$17,996 in the high-income community. Property tax rates range from 0.124 to 0.366.²⁷ This finding is consistent with the observation that households in the higher income communities prefer much higher levels of expenditures than the threshold level guaranteed by the foundation grant.

We are primarily interested in characterizing the age distribution of households within and among communities. Table 2 also reports the fraction of young and old households in each community. There are more old households in communities 1 and 2 than young households. This ratio reverses for the higher income communities 3 and 4. Households tend to downsize when old and move from communities with high expenditures to communities with low expenditures. These mobility patterns are also reflected in the average lifetime wealth of young and old households in each community. We find that old households that live in a given community have a higher wealth than young households. Old households that move to a lower community typically have a higher lifetime wealth than the household that always live in this community. As a consequence, the mobility of older households creates a positive fiscal externality

²⁶ Lifetime income is lowered by the required taxes and educational expenditure is adjusted up to reflect these revenues.

²⁷ Note that these tax rates are on rents and not housing values.

Table 2
Quantitative Properties of Equilibrium.

Community	Housing		Government		Populations		Wealth		Voting	
	p	t	g		Fraction young	Fraction old	young	old	Lower g young	Lower g old
<i>Decentralized Equilibrium with \$2600 Foundation Grant: 4 Communities</i>										
1	9.117	0.120	4,012	0.280	0.330	0.280	43,626	55,601	0.058	0.798
2	10.935	0.236	6,959	0.249	0.275	0.275	78,771	89,795	0.001	0.952
3	12.391	0.313	10,406	0.238	0.230	0.230	121,499	125,054	0.017	0.999
4	14.600	0.366	17,996	0.233	0.164	0.164	224,382	249,981	0.152	0.982
<i>Decentralized Equilibrium without Foundation Grant : 4 Communities</i>										
1	9.979	0.429	3668	0.209	0.246	0.246	38,713	49,569	0.059	0.874
2	11.828	0.422	6259	0.242	0.272	0.272	68,958	80,022	0.001	0.945
3	13.334	0.440	9297	0.261	0.258	0.258	107,833	110,407	0.006	0.999
4	15.901	0.428	17099	0.288	0.224	0.224	209,096	226,496	0.119	0.989

868 since it creates a larger tax base per student in poor communities.
869 This positive fiscal externality can at least partially off-set the nega-
870 tive effects that arise because older households tend to vote for
871 lower educational expenditures.

872 Next we turn to a more complete characterization of the voting
873 equilibrium. Table 2 reports the fraction of young and old households
874 that prefer lower expenditures than the equilibrium level for each
875 community. We find the expected strong generational divide in
876 voting patterns. Young households typically prefer higher expendi-
877 ture levels while the vast majority of older household prefer lower
878 expenditure levels. This finding holds for all four communities and
879 is especially pronounced for the high income communities in which
880 almost all old households prefer lower expenditure levels.

881 Comparing the equilibrium with a foundation grant with the one
882 obtained without the foundation grant, we find that the same qualita-
883 tive properties of the equilibrium carry over. However, there are also
884 some pronounced quantitative differences. One obvious consequence
885 of the lack of the foundation grant is that property taxes are uniformly
886 higher since property tax revenues are being substituted for income
887 tax revenues in all communities. On average expenditures in all com-
888 munities are somewhat lower without the foundation grant. Less
889 obvious is the finding that the high income community is larger and
890 thus appears less “selective” under a pure property tax system (see
891 Table 3). There is a stronger incentive to choose a richer community
892 than under a foundation grant system since the latter system provides
893 somewhat higher expenditures in relatively less wealthy communities.

894 Table 3 and Fig. 3 provide some additional insights into the nature
895 of the fiscal externalities that arise due to the mobility of older house-
896 holds. As we have discussed in the previous section, not all possible
897 residential plans are used in equilibrium. For the equilibria in Table
898 2, there are nine residential plans that are optimal for households.
899 These include four plans that involve no relocations and five plans
900 with relocations. Fig. 3 shows the partition of households among
901 the equilibrium residential plans for the case with a foundation
902 grant. No household with moving costs that exceed about 1% of life-
903 time income move as they enter old age. Fig. 2 shows the associated

t3.1 **Table 3**
Quantitative Properties of Residential Plans.

Community	Community	No Foundation Grant		Foundation Grant	
		Young	Old	Population	Wealth
1	1	0.208	38,713	0.280	43,626
2	1	0.002	48,353	0.001	56,096
2	2	0.240	68,975	0.248	78,801
3	1	0.006	75,596	0.011	85,502
3	3	0.255	108,606	0.228	123,195
4	1	0.031	117,577	0.039	133,258
4	2	0.030	169,183	0.026	193,621
4	3	0.003	246,919	0.003	281,539
4	4	0.224	226,496	0.165	249,981

convex hull of optimal plans for $T=.1$ and $T=.02$. Households that
initially choose communities 2 and 3 either stay in these communities
or move to community 1. In contrast, households from community 4
move to all three other communities. We also find that 7% of all
households find it optimal to relocate in the no foundation grant
equilibrium. About 22% of the households that choose community 4
when young move to one of the three other communities as they
enter old age. Fig. 3 illustrates how the choice of residential plans
varies with wealth and moving costs.

Comparing the equilibrium with a foundation grant to the equilib-
rium without a foundation grant, we find similar mobility patterns.
We find that mobility increases slightly as we move to a foundation
grant equilibrium. This is mainly because there are more households
moving from communities 3 and 4 to community 1.

To assess the effects of moving costs on equilibrium, we calculate
equilibrium with very low moving costs (having distributional mean
equal to .16 of the mean in the benchmark equilibrium). Table 4 pre-
sents the results, where we include the benchmark values for ease of
comparison. We find that these changes in the distribution of moving
costs have massive effects. When moving costs are very low, 37%
move over the life cycle as compared to 7% in the benchmark. Exam-
ining the fractions of old and young that make up communities, we
see that the old population dominate in the lowest-g community
and the young dominate in the two higher-g communities. Associated
with this increased relocation, the lowest-g community would in-
crease markedly in household population relative to the benchmark
from 23% to 40%, while the highest-g community would shrink from
having 26% to 15% of the household population.

Most interesting is that the increased relocation would substan-
tially lower the variability in g levels across communities, increasing
public provision in the lowest-g community and lowering public pro-
vision in the highest-g community. Note that there are two effects

t4.1 **Table 4**
The Impact of Moving Costs: Sensitivity Analysis.

Community	g	t	p	Fraction of young	Fraction of old	Voting for lower g max inc young	Voting for lower g max inc old	Tax base
<i>Benchmark Equilibrium (no foundation grant)</i>								
1	3,668	.43	9.98	.208	.246	21026	87993	8549
2	6,259	.42	11.83	.242	.272	38143	165641	14818
3	9,297	.44	13.33	.260	.258	70057	288480	21085
4	17,099	.43	15.90	.289	.224	141451	574949	39898
<i>Low Moving Cost Equilibrium</i>								
1	6,615	.31	11.91	.241	.564	23909	98009	21404
2	8,262	.41	12.69	.245	.264	52182	215439	20280
3	9,963	.49	13.45	.244	.135	91872	376888	20173
4	14,968	.54	15.40	.270	.035	180106	732382	27528

that go in opposite directions. First, older households that move down to cheaper communities have typically weaker preferences for public goods. In Table 4 we also report the maximum income of a young and old household in each community who would vote for lower expenditures than the status quo. Note that the maximum income for older households is typically four times as large as the maximum income for younger households reflecting differences in the valuations of education. The set of pivotal voters in each community thus typically consist of young households that are much poorer than the median income young household and older households that have much more wealth than the typical median old household. While the median voter theorem applies, as demonstrated in Proposition 1, the median voter is clearly not the voter with median income when there is sorting by age.

However, mobility has a second effect since it increases the tax base per student in communities that experience a net-inflow of older households and vice versa. Table 4 also reports the property tax base (average net housing expenditures) normalized by the number of students in the community. While the older households that move to lower- g communities place less weight on g in their utility functions, they are relatively wealthy and increase the tax base per student in poorer communities. In our calibration we find that the effects of increased moving on tax bases outweigh the political economy effects. Facilitating moving of older households has an equalizing effect. Lower mobility costs tend to increase the importance of the fiscal externality yielding higher expenditures in the poor communities. This effect further draws into poorer communities somewhat more wealthy young households, reinforcing higher educational expenditures in those communities. Note that lowering mobility costs increases the young population in the two poorer communities and the reverse in the two richer communities. Our model reveals the importance of considering the general equilibrium effects of life cycle choices in assessing the generational divide in support for public educational expenditure.

5. Conclusions

Understanding the intergenerational conflict over public good provision is an important research area, and there is ample scope for future research. One interesting avenue for future research is to analyze the differences between households with and without children. The presence of households that never have children can be expected to affect the age composition of communities as well as the outcomes that arise from voting over public good levels.

Households without children present do not have strong preferences for public education, but care for a variety of other local expenditures such as police and fire expenditures or welfare and recreational expenditures. Education has the largest expenditure share of all local expenditures, and typically accounts for at least 50% of all local expenditures on our sample of 119 Boston communities. A simple correlation analysis available upon request from the authors suggests that communities with older individuals tend to spend a larger share of resources on police, fire and other safety expenditures. Moreover, these communities also tend to spend a larger share on recreational expenditures. Future research should provide compelling models that explain the composition of expenditure types, and not just the level of expenditures within a system of jurisdictions. Allowing for multi-dimensional voting is, however, a challenging problem.

Another important generalization is introduction of home ownership effects. Home owners with grown children may have an incentive to support high provision of education to maintain property values (Brueckner and Joo, 1991). These incentives depend on the household's beliefs about the way in which quality of public services impacts rental prices or the value of the home. Property owners have different preferences over public good provision than renters since

owners are affected by capital gains or losses that may arise from changes in public policies. The key complication in such a generalization is in characterizing voting equilibrium.²⁸ Introducing ownership into our dynamic framework is a challenging but important task for future research.

6. Uncited reference

Epple and Romano, 1996

Appendix A. Additional proofs

The indirect utility is given by²⁹:

$$\begin{aligned}
 V^y &= \text{Max}_{h_k, h_l} [u_g^y(g_k) + u_g^o(g_l) + u^y(b_k, h_k) + u^o(b_l, h_l)] \\
 &\quad \text{s.t. } p_k h_k + b_k + p_l h_l + b_l \leq \bar{w} \\
 &= G(g_k, g_l) + \text{Max}_{h_k, h_l} [u^y(b_k, h_k) + u^o(b_l, h_l)] \\
 &\quad \text{s.t. } p_k h_k + b_k + p_l h_l + b_l \leq \bar{w}
 \end{aligned}
 \tag{31}$$

where $G(g_k, g_l) \equiv u_g^y(g_k) + u_g^o(g_l)$ is an increasing function of (g_k, g_l) . Since $u^a(b, h)$ is homogeneous of degree ψ , it follows from Theorem I in (Lau, 1970) (p. 376) that the maximand in the lower line of Eq. (31) equals $\bar{W}(\frac{p_k}{\bar{w}}, \frac{p_l}{\bar{w}})$, a function homogeneous of degree $-\psi$ and decreasing in its arguments. Then: $V^y = G(p_k, p_l) + \bar{w}^{-\psi} W(p_k, p_l)$.

Proof of Proposition 2. Households with T maximize V_i^y as defined in Eq. (20)–(21). Since V_i^y is increasing in G_i and decreasing in P_i^T , households choose among the residential plans in $B^0(T)$. Since w ranges from 0 to ∞ , the slope of an indifference curve in the (G_i, P_i^T) plane ranges from 0 to ∞ (Assumption 4) as well, implying all plans in $B^0(T)$ are chosen by some households with T .

- (i). Obviously all non-moving residential plans chosen by households with the prohibitive T are in the set of chosen residential plans by all households. To confirm that only these non-moving plans are equilibrium ones, observe from Eq. (21) that, since P_i^T is increasing in T for moving plans and independent of T for non-moving plans, lowering T can eliminate but cannot add non-moving plans to $B^0(T)$. From the result in the previous paragraph, it follows that no households with lower T than the prohibitive T will choose an alternative non-moving plan.
- (ii). Let T_m denote the minimum T . (This equals zero under assumption 4, but the result does not require this.) Obviously all moving plans chosen by such households are in the equilibrium set of moving plans. To confirm only such moving plans are in the equilibrium set of all households, suppose household “2” with (w_2, T_2) , $T_2 > T_m$, chooses a moving plan lk in equilibrium that is not chosen by any households with T_m . Consider household “1” with $(w_1, T_1) = (w_2 \frac{1-T_2}{1-T_m}, T_m)$. Note that $w_1 < w_2$. Households 1 and 2 obtain the same level of utility from all moving plans (by Eqs. (20)–(21)). Household 1 obtains lower utility from all non-moving plans than does household 2, since household 1 has lower wealth (and moving costs are irrelevant). But then household 1 would share household 2's preference for moving plan lk , a contradiction. Q.E.D.

²⁸ Owner-occupants who anticipate capital gains and losses when voting have been incorporated in static models (Epple and Romer, 1991), and those investigations reveal that ownership substantially affects voter incentives and equilibrium outcomes. Coate (2011) provides a dynamic analysis of voting over zoning policies when owners take capitalization effects into consideration.

²⁹ The discount factor β is subsumed in the old age utility function with no loss of generality.

1045 **Proof of Proposition 3.** First we show that the plan with $G = G_1$ cor- 1086
 1046 responds to $lk = 11$ and the plan with $G = G_j$ corresponds to $lk = jj$. 1087

1047 The residential plans on the lower boundary of the convex hull of 1088
 1048 all feasible plans corresponds to just non-moving plans for any types 1089
 1049 with T that will never move in equilibrium. Plans $lk = 11$ and $lk = jj$ 1090
 1050 are the endpoints of the lower boundary of the convex hull for all of 1091
 1051 these types. The result then follows from Assumption 9.

- 1052 (i). If $P_j^T \geq P_i^T$, then choice of plan j would contradict maximization 1092
 1053 of V^y (recall Eq. (20)). 1093
 1054 (ii). Using that households choose residential plans to maximize V^y , 1094
 1055 wealth stratification follows from the ascending bundles 1095
 1056 property and SIW. Q.E.D. 1096

1057

1058 **Proof of Proposition 4.** The proof is by contradiction, so suppose a 1097
 1059 household makes such a choice. Then that choice solves the program:

$$\max_{h_k, b_k, h_l, b_l} U = \left[\frac{\alpha_g}{\rho_a} g_k^{\rho_a} + \frac{\beta_g}{\rho} g_l^{\rho} \right] + \frac{1}{\rho} [\alpha_h h_k^{\rho} + \alpha_b b_k^{\rho} + \beta_h h_l^{\rho} + \beta_b b_l^{\rho}] \quad (32)$$

$$s.t. w - m = p_k h_k + b_k + p_l h_l + b_l$$

1060 with $(p_k, g_k) < (p_l, g_l)$. Let:

$$L^* \equiv \left[\frac{\alpha_g}{\rho_a} g_k^{\rho_a} + \frac{\beta_g}{\rho} g_l^{\rho} \right] + \frac{1}{\rho} [\alpha_h h_k^{\rho} + \alpha_b b_k^{\rho} + \beta_h h_l^{\rho} + \beta_b b_l^{\rho}] \quad (33)$$

$$+ \lambda [w - m - p_k h_k - b_k - p_l h_l - b_l]$$

1063 denote the Lagrangian function at the household's optimum, where λ 1110
 1064 denotes the multiplier on the budget constraint. Thus, $V_{kl}^y(p_k, g_k, p_l, g_l) \equiv$ 1111
 1065 $L(p_k, g_k, p_l, g_l)$. Using the latter and Eq. (33), compute, respectively, slope 1112
 1066 of the indifference curves over (p, g) pairs while young and (p, g) pairs 1113
 1067 while old: 1114

$$\frac{dp_k}{dg_k} \Big|_{V_{kl}^y = const.} = - \frac{\partial V_{kl}^y / \partial g_k}{\partial V_{kl}^y / \partial p_k} = - \frac{\partial L^* / \partial g_k}{\partial L^* / \partial p_k} = \frac{\alpha_g g_k^{\rho_a - 1}}{\lambda h_k}; \quad (34)$$

1068 and

$$\frac{dp_l}{dg_l} \Big|_{V_{kl}^y = const.} = - \frac{\partial V_{kl}^y / \partial g_l}{\partial V_{kl}^y / \partial p_l} = - \frac{\partial L^* / \partial g_l}{\partial L^* / \partial p_l} = \frac{\beta_g g_l^{\rho - 1}}{\lambda}; \quad (35)$$

1070 where the last equality in each of Eqs. (34) and (35) uses the Envelope 1115
 1072 Theorem. Using the first-order conditions from Eq. (33), one obtains:

$$h_k = \frac{w - m}{z_{kl}} \left(\frac{\alpha_b}{\alpha_h} p_k \right)^{1/(\rho - 1)} \quad (36)$$

1073

$$h_l = \frac{w - m}{z_{kl}} \left(\frac{\beta_b}{\beta_h} p_l \right)^{1/(\rho - 1)} \quad (37)$$

1076

1077 Substituting Eq. (37) into Eq. (35) and Eq. (36) into Eq. (34) and 1116
 1078 evaluating slopes at a common (p, g) point, one finds that the indiffer- 1117
 1079 ence curve over (p, g) pairs while young are everywhere steeper than 1118
 1080 the indifference curve over (p, g) pairs while old if $\alpha_g (\alpha_h / \alpha_b)^{1/(\rho - 1)}$ 1119
 1081 $g^{\rho_a - \rho} > \beta_g (\beta_h / \beta_b)^{1/(\rho - 1)}$. This condition holds under Assumption 1120
 1082 10.³⁰ In a stationary equilibrium, the (p, g) pairs available in each pe- 1121
 1083 riod of life are the same. 1122

1084 One can then use the relative slopes of these indifference curves to 1123
 1085 show that the young households choice of plan kl implies the 1124

household would prefer to stay in community k when old, a contra- 1086
 1087 diction. (Contact the authors for a more detailed proof.) Q.E.D. 1087

Proof of Proposition 5. Suppose not. Find the lowest numbered 1088
 1089 community $j > 1$ for which no households with 0 moving cost move 1090
 1091 down. We know the poorest households will choose (1,1). Using 1091
 1092 that $g_1 < g_j$ and $p_1 < p_j$ for all communities $1 < j$, from Eq. (27) one can 1092
 1093 see by inspection that $P(1,1) < P(1,j) < P(j,j)$ and $G(1,1) < G(1,j) < G(j,j)$, 1093
 1094 where (i,j) indicates residence plan with j chosen while young and i 1094
 1095 when old. It follows that plan (1,j) is on the lower bound of the convex 1094
 1096 hull of the plans (1,1), (1,j), and (j,j) and plan (1,j) would be preferred 1095
 1097 by some households with 0 moving costs, a contradiction. Now find 1096
 1098 the next higher numbered plan (k,k) , $k > j$, chosen by some 0 moving 1097
 1099 cost households and suppose no households move down from commu- 1098
 1100 nity k . By analogous argument there exists some 0 moving cost house- 1099
 1101 holds that prefer (k,j) to both (k,k) and (j,j) , and there exist some 1100
 1101 households that prefer $(k,1)$ to (k,k) and $(1,1)$. It follows that some 1101
 1102 0 moving cost households would move down from k .³¹ Higher yet num- 1102
 1103 bered communities chosen by 0 moving cost households while young 1103
 1104 must have some downward movers by the same argument. Further, 1104
 1105 by continuity of all the relevant functions, there will exist households 1105
 1106 with arbitrarily small moving costs that move down in each case as do 1106
 1107 the 0 moving cost households (i.e., a positive measure of households 1107
 1108 will so move). 1108

1109 **Appendix B. Computation of stationary equilibria** 1109

Given a stationary distribution of wealth and moving costs, a 1110
 1111 stationary equilibrium in this model is determined fully by a vector 1111
 1112 $(p_j, \tau_j, g_j)_{j=1}^J$. Computing an equilibrium is, then, equivalent to finding a 1112
 1113 root to a system of $3J$ nonlinear equations. For each community, the 1113
 1114 three equations of interest are the housing market equilibrium in Eq. 1114
 1115 (12), the balanced budget requirement in Eq. (1), and the majority 1115
 1116 rule equilibrium requirement. 1116

The full algorithm, therefore consists of an outer loop that searches 1117
 1118 over admissible distributions of wealth and moving costs, and an inner 1117
 1119 loop that computes a stationary equilibrium holding the joint distri- 1118
 1120 bution fixed. The algorithm in the inner loop finds a root of $3 \times J$ dimen- 1119
 1121 sional system of linear equations. More specifically, the algorithm can 1120
 1122 be describes as follows: 1122

1. Fix the joint distribution of wealth and moving costs. 1123
2. Compute equilibrium for that distribution: 1124
 - (a) Given a vector (p_j, τ_j, g_j) we can compute p_j^h from the identity 1125
 1126 $p_j = (1 + \tau_j) p_j^h$.
 - (b) For each young household type $(w, m \epsilon)$, we can compute the 1127
 1128 optimal residential choices for both time periods. Hence we 1127
 1129 can characterize household sorting across the J communities. 1128
 - (c) Given the residential decisions, we can characterize total 1130
 1131 housing demand, as well as total government revenues for 1130
 1132 each community. 1131
 - (d) Given p_j^h , we can compute housing supply for each communi- 1132
 1133 ty, and check whether the housing market clears in each 1132
 1134 community. 1133
 - (e) Given g_j , we can check whether the budget in each communi- 1134
 1135 ty is balanced. 1135
 - (f) For each young household and each old household living in 1136
 1137 community j determine whether the household prefers lower 1136
 1138 expenditures than the status quo and check whether g_j is a 1137
 1139 majority rule equilibrium 1138
 - (g) Iterate over (p_j, τ_j, g_j) until convergence obtains. 1139
 1140 1141 1142

³⁰ Here we are presuming $g \geq 1$. In economies with realistic wealth levels, the pre-
 1143 sumption that equilibrium spending in all communities is more than a dollar per stu-
 1144 dent is innocuous.

³¹ Note that this does not imply every downward moving plan will be followed, but
 1145 that at least one will. For example, if $k = 3$, it could be that every household that prefers
 1146 (3,2) to (3,3) and (2,2) also prefers (3,1) to (3,2). Thus there may not be any house-
 1147 holds that choose (3,2).

- 1143 3. Update the joint distribution of wealth and moving costs using the
1144 law of motion in Eq. (13).
1145 4. Check for convergence of wealth and moving cost distributions.

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