Article

Public Finance Review
2015, Vol. 43(5) 559-585

DOI: 10.1177/1091142114524618
pfr.sagepub.com
SAGE

Land-use Controls, Fiscal Zoning, and the Local Provision of Education

Eric A. Hanushek[1] and Kuzey Yilmaz[2]

Abstract

Considerable prior analysis has gone into the study of zoning restrictions on locational choice and on fiscal burdens, but none addresses the level and distribution of public goods provided under fiscal zoning. Our analysis emphasizes the interplay between land-use restrictions and public good provision, focusing on schooling outcomes. We extend existing general equilibrium models of location and the provision of education so that fiscal zoning can be put into Tiebout choice. Some households create a fiscal burden, motivating the use of exclusionary land-use controls by local governments. We then analyze the market effects of different land-use controls (minimum lot size [MLS] zoning, local public finance with a head tax, and growth restrictions through fringe zoning) and demonstrate how household behavior directly affects the equilibrium outcomes and the provision of the local public good.

Keywords

tiebout model, urban location model, zoning

[1] Hoover Institution, Stanford University, Stanford, CA, USA
[2] Department of Economics, University of Rochester, Rochester, NY, USA

Corresponding Author:
Eric A. Hanushek, Hoover Institution, Stanford University, Stanford, CA 94305, USA.
Email: hanushek@stanford.edu

The primary purpose of local political jurisdictions is the provision of public goods tailored to the needs and desires of their resident populations. In his classic article on the efficiency of local jurisdictions, Tiebout (1956) shows how choice among local areas allows households to sort themselves on the basis of demand for the public good that is provided. But this simple solution breaks down when various realities such as limited numbers of jurisdictions and finance through local property taxes are acknowledged. One important extension of the modeling of residential choice and the provision of various packages of taxes and public goods in the face of these realities has been the introduction of another empirical reality—the existence of various zoning regulations. Zoning constrains the choices of households and alters the equilibrium outcomes, potentially improving the Tiebout equilibrium. By focusing entirely on the locus of taxes and expenditures across jurisdictions, this literature has, however, neglected other important aspects of the residential choices of households. Consideration of these leads to fundamental changes in the equilibrium solutions by households. This article introduces accessibility as a second basic facet of residential location and then highlights how endogenous zoning affects the equilibrium demands for schools, the primary public good offered by local jurisdictions.

In the world of head taxes and large numbers of jurisdictions, Tiebout sorting leads to an efficient revelation of public good demands and thus supports the optimal provision of the public good. Yet, as has long been recognized, the financing of local jurisdictions through the property tax changes this solution. Some taxpayers, by buying less expensive houses within a jurisdiction, can enjoy public expenditures that exceed their contribution to revenues, creating a fiscal burden on wealthier households who must make up for this revenue shortfall. If, however, various zoning devices can be employed, it may be possible to exclude the households that create the fiscal burdens.

Considerable prior analysis has focused on the impact of various zoning restrictions on locational choice and on fiscal burdens. In an influential early article, Hamilton (1975) incorporates endogenous zoning in a model where property taxes finance a local public good, and he shows that zoning allows individuals to separate themselves perfectly by income. Durlauf (1996) considers a dynamic community model in which communities impose a minimum income restriction as a requirement for residence in a community. Henderson (1980) and Epple, Filimon, and Romer (1988) analyze the endogenous choice of zoning regulations in multicommunity models, but they have no public goods. Fernández and Rogerson (1997) study the effect of zoning regulations on allocations and welfare in a two-community model. Recent theoretical work by Calabrese, Epple, and Romano (2007) and Magliocca et al. (2012) provide new theoretical structures and interesting insights. Nonetheless, the prior work on zoning—particularly fiscal or exclusionary zoning—has provided both inconclusive theoretical results and quite inconsistent empirical support of the theory (Evans 1999). The review of the evidence by Quigley and Rosenthal (2005) provides not only a summary of the issues but also ideas on how to resolve the conflicting evidence.

Three important things have been missing from this past discussion. First, it is generally assumed that residential choices are solely a function of the fiscal characteristics of a location. This yields perfect sorting across communities in terms of income and very sharp, and implausible, reactions to changes in the price of local public goods. This conclusion about homogeneous communities, however, conflicts with observations about the nature of US communities. Across the school districts (communities) in the United States, jurisdictions are quite heterogeneous in terms of income (much more so than in terms of race).[1] Moreover, the heterogeneity of households should not be taken as evidence that Tiebout sorting is not going on. A number of authors have looked into parts of this heterogeneity of jurisdictions in Tiebout models, as discussed in the comprehensive review of Epple and Nechyba (2004).[2] For example, Edel and Sclar (1974) consider dynamic adjustment to a long-run equilibrium. Epple and Sieg (1999) and Sieg et al. (2004) consider how heterogeneous tastes will generate mixtures of incomes within jurisdictions, while Epple, Gordon, and Sieg (2010) introduce location-specific amenities. Nechyba (2000) relies on a fixed and heterogeneous housing stock. None has developed an integrated explanation.

Second, while past work has been motivated by the provision of public goods, little is actually said about the outcomes. The demand by households for schooling outcomes drives not only a portion of local residential choice but also determines the spending for schools and the variation across districts. Both spending variations and the resultant achievement differences have themselves been objects of direct public policy interventions.[3]

Third, a limited number of jurisdictions necessarily implies that some households will not have their ideal provision of public goods met. Additionally, restrictions on households such as the exclusionary zoning considered here will not in general move the locational equilibrium to the full Tiebout optimum.

This article addresses each of these issues. It imbeds endogenous zoning within a multifaceted model of locational choice that allows for nonfiscal elements of location. Additionally, it focuses on the most important local public good—schools—and considers how zoning affects the level and distribution of educational outcomes. In the course of this, we can also consider how different forms of taxation affect the analysis.

In order to understand the interactions among these different influences on choices by households when faced with land-use constraints, we need to start with behavior that reflects more than just heterogeneous tastes for public goods. We build upon and extend the general equilibrium model of household location and education spending decisions in Hanushek and Yilmaz (2007, 2013). That model merges the classical urban location models and the Tiebout models of community choice so that the basic urban form is consistent with empirical observations on community heterogeneity. By emphasizing multiple motivations in locational choice and household behavior, this starting point permits new insights into the implications of fiscally motivated land-use controls.

This article focuses on two key issues of exclusionary land-use controls. First, to answer why cities use exclusionary land-use controls, we show how some households impose a fiscal burden on the local government, leading to motivations for excluding some households from a community. Based on the general framework, we can then consider the market effects of exclusionary land-use controls and their distributional implications for both educational outcomes and welfare. The policies considered in the article are minimum lot size (MLS) zoning, local public finance with a head tax, and growth restrictions through fringe zoning that limits city expansion.

We present a baseline model of a monocentric city that contains two school districts whose households differ in income and tastes that reflect the value of accessibility, lot size, and public amenities (education) of a location. An absentee landlord holds an auction at each location in which households bid for that location. Each jurisdiction provides education, which is financed through property taxes on residential land. Property taxes are determined by majority voting. Households can move without cost between jurisdictions. In equilibrium, communities are heterogeneous, and some households impose a fiscal burden on the local government.

With this structure, we conduct policy experiments with different types of exclusionary land use and then assess the outcomes in terms of the level and distribution of education. Having a more realistic model of urban structure proves to be especially important in this analysis. Public services are tied to specific locations and communities, but locations also differ in their accessibility and in their housing prices. Ignoring these aspects of location introduces a distortion in the analysis of policy alternatives, leading to very different conclusions from those in simpler models. While exclusive communities can improve their educational quality through land-use controls on entry, they impose a cost of increased overall variation in educational quality across the area.

A General Model of Residential Location

This analysis builds on the simplest structure that can provide heterogeneous communities that illustrate the fundamental behavioral trade-offs essential to understanding the impacts of land-use constraints. The model is a modification of the monocentric city model of locational choice in which all job opportunities are offered by firms located at the Central Business District (CBD). Firms employ skilled and unskilled workers who get paid wages that depend on skill. Wages are exogenously given, and skilled workers (s) receive a higher wage than unskilled workers (u); that is, $w_s > w_u$. As in any other monocentric city models, the city is assumed to have a radial transportation system. Additionally, we divide the city evenly into two school districts of the same size, labeled North School District and South School District. Each school district raises local property taxes to finance their public schools. Thus, locations differ by three attributes: accessibility, the property tax rate, and quality of education.

The more common depiction of a monocentric city that has a circular central city surrounded by a donut shaped suburban ring is problematic for our analysis.[4] This standard circular structure of cities implies that all locations at any given distance from the employment center are served by a common school district, making it difficult to see the separate influences of location and school quality. Additionally, there are empirical reasons to consider alternative depictions. The circular city is more of an analytical description than a realistic portrayal of American cities. The variety of cities that result from natural boundaries such as lakes, rivers, and mountains or from historical development patterns makes the stylized "von Thunen pattern" more a simplifying device than an accurate generalization of city structures (see Rose 1989). While it is possible to correct estimation of density gradients for missing quadrants (see Mills [1972] or Rose [1989]), the simple depiction fails in a significant number of metropolitan areas.[5] Our simple city structure here is seen, for example, in Minneapolis and St. Paul, where a river divides two jurisdictions (and two school districts). This structure is not meant as a portrayal of any specific area, however, but instead is employed as the simplest way to illustrate how accessibility and public goods interact in determining the locational equilibrium. The characterization of a two-city metropolitan area also permits highlighting the implications of a limited range of jurisdictional alternatives within a Tiebout model.

Each household has one working member and one child attending to a public school in her school district.[6] On top of heterogeneity in wages, we introduce additional heterogeneity by allowing households to place a different valuation on education: some value education more, while some value it less. Thus, we have four different types of households in the city: skilled low valuation households (SL), skilled high valuation households (SH), unskilled low valuation households (UL), and unskilled high valuation households (UH).

A household $i \in \{\text{SL, SH, UL, UH}\}$ with a residence r miles off the CBD in school district $j \in \{n, s\}$ enjoys education of quality q_j provided to her child; lot size $h > 0$, which proxies residential quality;[7] (numeraire) composite commodity $c > 0$; and leisure $l \in [0, 24]$. For the calibration, our time frame is a day, and hence the household's problem is formulated over a day. Household preference is given by a Cobb–Douglas utility function $U(\alpha_i, \eta_i; q, h, c, l) = q_j^{\alpha_i} h^{\eta_i} c^{\gamma} l^{\delta}$, where $\alpha_i \in \{\alpha_H, \alpha_L\}$ is the taste parameter for education and $\eta_i \in \{\eta_H, \eta_L\}$ is the taste parameter for lot size for high education valuation (H) and low education valuation (L) households.

The working member of household i commutes once a day to a workplace at the CBD. The pecuniary and time costs of commuting are $a/2$ dollars and $b/2$ hours per mile, respectively.[8] Then, household i faces the following budget constraint

$$c_j(r) + (1 + \tau_j)R_j^*(r)\, h_j(r) + w_i l_j(r) = Y_i(r) = 24w_i - (a + bw_i)r, \quad (1)$$

where $Y_i(r)$ is the household's income net of transportation costs, τ_j is the property tax rate, and $R_j^*(r)$ is the equilibrium rent per unit of land.

In each community, the amount of taxes paid by a household depends directly on the lot size (h), so that a household with a small lot pays less in taxes than a household with a large lot even though both households receive the same public goods (education, as defined subsequently). To deal with the fiscal disparities, one school district, say the one in the south, introduces a zoning regulation that sets a minimum lot size (MLS) per household in residential land use, $\bar{h}_m$. The aim of this policy is to eliminate the smallest houses, that is, the ones imposing the largest fiscal burdens on the other residents. The school district sets the MLS by majority voting. We can define the bid rent function of household i, which shows the household's willingness to pay given a fixed utility level. With the MLS zoning, the problem that a household in the south must solve is given by

$$\psi(r; u_i, q_j, \tau_j) = max_{h,c,l}\left\{\frac{Y_i(r) - c - w_i l}{(1+\tau_j)h} | U(\alpha_i, \eta_i; q, h, c, l) = u_i\right\} \text{subject to } h \geq \bar{h}_m. \tag{2}$$

Then, the bid rent and bid max lot size function under MLS regulation is given by

$$\psi_j^i(r) = \begin{cases} \frac{k_i^{1/\eta_i}}{(1+\tau_j)w_i^{\delta/\eta_i}} q_j^{\alpha_i/\eta_i} Y_i(r)^{\frac{\eta_i+\gamma+\delta}{\eta_i}} u_i^{-1/\eta_i} & \text{if } r \geq r_m \\ \frac{Y_i(r) - \left(1+\frac{\gamma}{\delta}\right) w_i \left(\frac{\delta}{\gamma w_i}\right)^{\frac{\gamma}{\gamma+\delta}} \left(\frac{u_i}{q_j \alpha_i \bar{h}_m \eta_i}\right)^{\frac{1}{\gamma+\delta}}}{(1+\tau_j)\bar{h}_m} & \text{if } r < r_m \end{cases}, \tag{3}$$

and

$$h_j^i(r) = \begin{cases} \frac{\eta_i}{(\eta_i+\gamma+\delta)(1+\tau_j)} \frac{Y_i(r)}{\psi_j^i(r)} & \text{if } r \geq r_m \\ \bar{h}_m & \text{if } r < r_m \end{cases}, \tag{4}$$

where $k_i = \frac{\eta_i^{\eta_i}\gamma^\gamma\delta^\delta}{(\eta_i+\gamma+\delta)^{(\eta_i+\gamma+\delta)}}$ is a constant, r_m is the effective constraint distance that is determined by the intersection between the lot size curve, $h(\cdot)$, and the horizontal line, $\bar{h}_m$. (household i in the north solves the same problem with, $\bar{h}_m = 0$). Since the lot size curve is increasing in distance, the household is constrained such that $h = \bar{h}_m$ whenever $r < r_m$, and the bid rent function for household i becomes a linear and decreasing function in r. Otherwise, it is a nonlinear decreasing function. With this MLS, there are some households in the south that would like to locate on a smaller lot closer to work but cannot.

The land-use pattern that arises in equilibrium is determined by the relative steepness of bid rent functions of the four different household types. Analytically, it is not possible to find the spatial order, and we rely on numerical methods to find it. In general, a steeper equilibrium bid rent curve corresponds to an equilibrium location closer to the CBD. It is worth pointing out that since each household type has a two-piece bid rent function, each with a different slope, household i_1 can have a steeper bid rent than household i_2 on one piece while the steepness order is reversed on the other piece.

We assume a competitive land market (Alonso 1964) in which households bid for land and absentee land owners offer land to the highest bidder. A landlord may rent land to any of four different types of households or leave it for agriculture. When the latter occurs, the landlord gets a fixed bid of r_a. Formally,

$$R_j^*(r) = \max_{i \in \{\mathrm{SL, SH, UL, UH}\}} \psi_j(r), \tag{5}$$

$$t_j^*(r) = \mathrm{argmax}_{i \in \{\mathrm{SL, SH, UL, UH}\}} \psi_j(r), \tag{6}$$

where $t_j{}^*(r)$ $j \in \{n, s\}$, is a function showing the equilibrium occupant of a location at distance r in school district j. We assume that our city is closed, and thus, the population of each household type is exogenously given. Formally,

$$\int_{t_n^*(r) = i} \frac{\pi r}{s_n^i(r)} dr + \int_{t_s^*(r) = i} \frac{\pi r}{s_s^i(r)} dr = \overline{N}_i \ \forall i \in \{\mathrm{SL, SH\,, UL\,, UH}\}. \tag{7}$$

The population constraints implicitly assume that the land market clears in school district $j \in \{n, s\}$. Each school district raises property taxes to finance its public school. Assuming local governments run a balanced budget, we have

$$e_j = \tau_j \frac{\int_{R_j^*(r) > r_a} R_j^*(r) \pi r \, dr}{N_j}, \tag{8}$$

where N_j is the population, and e_j is the expenditure per pupil on schools in district j. Note that the integration is done over residential property and hence agricultural land is not part of the tax base.

Characterizing the quality of education has proved difficult. Here, to maintain comparability with the prior literature, we emphasize only educational spending, which can be interpreted as either actual quality of the schools or simply perceived quality. Prior literature has shown that it is difficult to characterize school quality when the outcome is measured by student performance.[9] At the same time, households clearly use spending as a proxy for school quality and factor that into their locational decisions. Thus, we take a positivist view of school quality as it affects consumer behavior. In prior work, we have also considered the role of peer groups in the production function for schools (Hanushek and Yilmaz 2007, 2013). However, that formulation unduly complicates the analysis here without yielding additional insights. Under most formulations, it will reinforce the basic fiscal forces involved, and we wish to show the operation of these forces in the simplest fiscal model.

The perceived quality of education in community j is given by a production function

$$q_j = c_1 e_j^{c_2}, \tag{9}$$

where $c_1, c_2 > 0$ and $c_2 < 1$ are constants. Notice that the production function is concave, implying diminishing marginal returns to expenditure per pupil. The property taxes are determined by majority voting in each school district. Then, household i at distance r in school district j's preferred tax rate is given by the following problem

$$\max_{\tau_j} \frac{k_i}{R_j^*(r)^{\eta_i}(1+\tau_i)^{\eta_i} w_i^{\delta}} q_j^{\alpha_i} Y_i(r)^{\eta_i+\gamma+\delta} \text{ subject to } q_j = c_1 e_j^{c_2}$$

$$e_j = \tau_j \frac{\int R_j^*(r) > r_a \, R_j^*(r) \pi r \, dr}{N_j} \tag{10}$$

The preferred tax rate for household i is, then, $\tilde{\tau}_i = \frac{c_2\alpha_i}{\eta_i - c_2\alpha_i}$. Note that the preferred tax rate is independent of income and is a function of the household's valuation of education.

Events unfold in the following order: at the beginning of each period, myopic households make their residential choice decisions with the expectation that the last period's education and property tax packages would prevail in the current period. Once they move in, they are stuck. They vote for the next period property tax rate in their school district. As a result, the quality of education in their school district is determined. At the beginning of the next period, events start over again.

Definition: An equilibrium is a set of utility levels u_i^*, $i \in \{\text{SL, SH, UL, UH}\}$, market rent curves $R_j^*(r)$ $j \in \{n, s\}$, quality of education and property tax rate pairs (q_j, τ_j), $j \in \{n, s\}$, and equilibrium household type functions $t_j^*(r)$, $j \in \{n, s\}$ such that

- utility, maximizing households choose a location (i.e., a school district and commuting distance) along with lot size, leisure, and composite commodity.
- households and farmers bid for land at each location. The absentee landlord offers land to the highest bidder.
- regardless of their location or school district, households of the same type attain the same utility level.
- education is produced through a production function based on expenditure and is financed through local property taxes on residential land. The property tax in each school district is determined by majority voting.
- labor and land markets clear.
- the local government budget balances in each school district.

Calibration of the Urban Economy

As shown in Table 1, the model is calibrated to match some key stylized facts of a typical skilled high valuation (SH) household and a typical US middle-size city. In order to provide a base case for consideration of land-use restrictions, we begin with no zoning restriction $(\overline{h}_m = 0)$ in either district.

The hourly wages for unskilled and skilled workers are calibrated as $w_u \approx 10$ and $w_s \approx 18$, respectively. These number are obtained from the fact that in the United States, average weekly hours of persons working full-time is about 40 hours and the average annual earnings of high school and college graduate workers in 1997 are \$22,154 and \$38,112, respectively.[10]

Then, the share of leisure in the household's budget is $\frac{\delta}{\eta_H+\gamma+\delta} \approx 0.76$. The data on average annual expenditures of some selected MSAs suggest that a household spends about one-fifth of its income on shelter. Therefore, the budget share of composite commodity and land are set to be $\frac{\gamma}{\eta_H+\gamma+\delta} = (1-0.76) \times 0.8 \approx 0.19$ and $\frac{\eta_H}{\eta_H+\gamma+\delta} = (1-0.76) \times 0.2 \approx 0.048$, respectively. Moreover, recall that the preferred tax rate for household i is given by $\tilde{\tau}_i = \frac{c_2\alpha_i}{\eta_i - c_2\alpha_i}$. Clearly, we have two possible preferred tax rates, one for high valuation and another for low valuation households. The one for high (low) valuation type is set to be about 2.2 percent (1.5 percent).[11] These values are sufficient to permit calibration of α_H, α_L, η_H, η_L, γ, and δ.

Based on the cost of owning and operating an automobile, the pecuniary cost per mile was 53.08 cents in 1997. Assuming a commuting speed of 15 miles per hour within the city, the pecuniary and time costs of commuting per round trip mile are set to be $a = \$1$ and $b = 0.13$, respectively. In equilibrium, the endogenous urban fringe distance is targeted at about 12 miles in both school districts. The population of the city is set to be 1,500,000 households, which implies approximately a population density of 3,132 households per square mile.[12] Approximately 40 percent of the total population is assumed to be skilled worker households. Moreover, 25 percent of skilled households are assumed to be low valuation households. As for the unskilled households, 75 percent are low valuation households.

The agricultural rent bid r_a is set to be \$6,844 per acre per year. The parameters of the education production function are set to be $c_1 = 1.6$, $c_2 = 1.12$, so that property tax rate and quality of education packages are consistent with property tax rate and quality of education packages in school districts that generate the desired population distribution across the city.

Table 1. Calibration Parameters.

Parameter	Value	Parameter	Value
α_H	0.02	η_H	0.048
α_L	0.017	η_L	0.051
γ	0.19	δ	0.74
a	\$1	b	0.13
w_s	\$19	w_u	\$10
c_1	1.6	c_2	1.12

Table 2. Benchmark Distribution of Population and School Quality.

	North	South
School quality	11.5	15
Tax rate	1.5%	2.2%
Distribution of households		
Skilled low	8.6	1.4
Skilled high	9.5	20.5
Unskilled low	28.3	16.7
Unskilled high	2.2	12.8

Unconstrained Locational Decisions

Due to the presence of a radial transportation system, households of each type form a concentric ring, or zone, within each of the two school districts around the CBD, and zones for all household types are ranked by the distance from the city center in the order of steepness of their bid rent functions in equilibrium. The benchmark equilibrium without land-use constraints in our simple model has one school district catering to generally higher income households that have a high valuation on education and the other meeting the demands of lower income families. Nonetheless, given the trade-offs between access and the taxes-public good bundle, both communities have a mixture of all household types.

The results for the benchmark equilibrium are shown in table 2 and figures 1 through 3. Our results are quite consistent with the residential pattern observed in the United States. In both cities, households with higher incomes typically locate farther from the CBD, occupying larger dwellings than households with lower income households. Moreover, for each income group, those with high valuation of education live closer to the CBD than do those with low valuation of education. This outcome is natural, since those

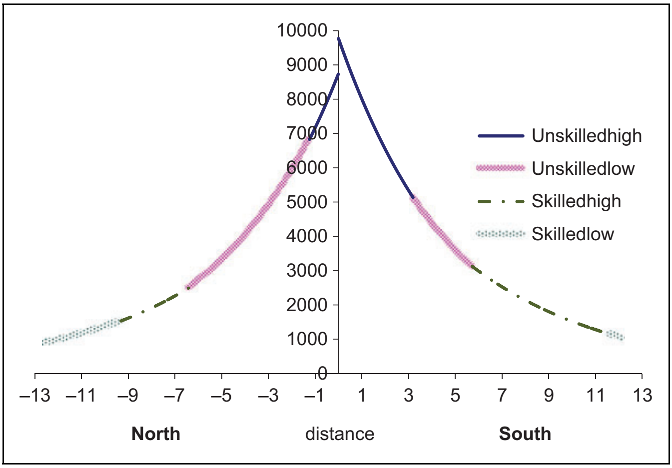

Figure 1. Monthly gross rent per acre with no land-use restrictions.

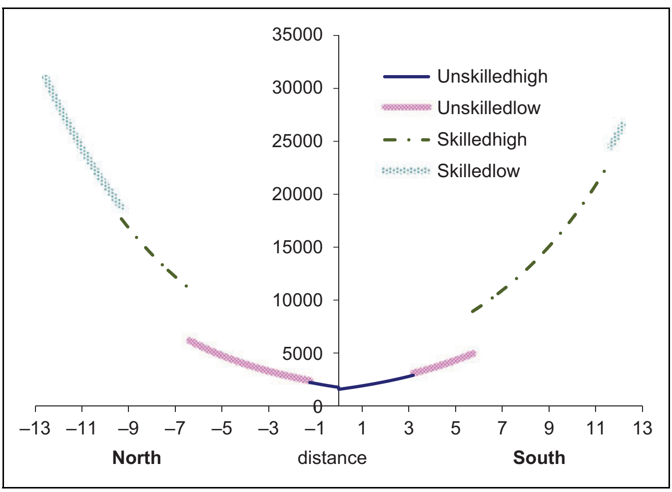

Figure 2. Lot size (square foot) with no land-use restrictions.

with low valuation of education implicitly value lot size high—and thus want to live farther out where land is cheaper.

These patterns are shown for the two districts in figures 1 and 2. (Note that the labeling of the two cities is arbitrary in this benchmark without

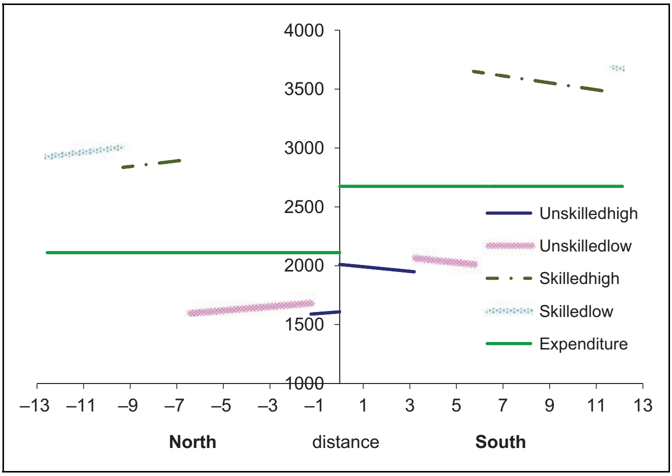

Figure 3. Annual tax per capita with no land-use restrictions.

land-use constraints). The price of land varies across locations with distance due to commuting costs, as in a standard urban location model. The North School District follows the same general pattern, although the rents at any given distance from the CBD will be lower because of the lower school quality (discussed subsequently). Across school districts, the quality of education and property taxes differ, and in equilibrium each type of household is indifferent to living in either school district. This difference in rents across school districts is simply the capitalization of accessibility and differing quality of education.

The school districts are heterogeneous in both income and tastes, and all types are present in both school districts (table 2).[13] The table gives the distribution of households by school district as a percentage of the total population in the metropolitan area. This heterogeneity of school districts is the result of the two components of a location: access to employment and school quality. All households of a given type in terms of income and tastes for education are happy with their residential location in equilibrium, but some of each type will end up purchasing more access and less schooling in trading off the two at equilibrium prices. This aspect of the model introduces a realism that is important in judging policy alternatives that differentially affect the two school districts.

In our baseline model, table 2 shows that the South School District provides the best education and is the school district of choice for a disproportionate share of high valuation households, whether of high- or low-income (skill) level. This better education does come with a higher price tag, namely, higher property taxes than in the North School District, but this is the majority vote equilibrium of the households.

Following Hamilton (1975), we have concentrated on property taxes to fund our local education, as consistent with US school finance.[14] Figure 3, the derived tax bill for different households in two school districts, vividly shows the issue of fiscal burden. The use of a property tax implies a low tax liability for households in small houses (small lots), but a high tax liability for households in big houses. As shown in figure 3, the annual spending of about \$2,700 in the South School District is met with an annual tax liability of a small house of about \$2,000 but a corresponding liability of \$3,600 for each household in a big house. The households with the larger houses are effectively subsidizing the education of those with smaller houses. This observation identifies powerful incentives for school districts to regulate the development of new land.

The fiscal disparities by households imply that there are large incentives in the south district to exclude low-income households with their lower consumption of quality housing. Also, the exclusionary incentives in the south are greater than in the north, where school quality and fiscal burdens are less. The fiscal disparity exists in the north but is less with poor households paying about \$1,650 in taxes to support a school expenditure of about \$2,100. A majority of the residents in the north are low-income households. Further, they attract a disproportionate share of high-skilled households who have a low valuation of schooling. The predominance of low-income and low-valuation households in the north implies that the majority does not want to raise school spending in the North School District and would not want to exclude low-income residents.

For the rest of the article, we study the impact of some alternative land-use policies on the efficient provision of education and how successful they are in terms of excluding households that would impose a fiscal burden on the government. In all the cases, we consider situations where the south imposes controls, while the north does not.

Land-use Controls

We use this expanded locational choice model to analyze how a local government can exclude households by some land-use controls. We consider alternative kinds of restrictions (which may or may not be permissible for use by any given school district, depending on state laws): zoning, lump

Table 3. Equilibrium Distribution of Population and School Quality under Minimum Lot Size Zoning in the South.

	North	South
School quality	10.6	17.5
Tax rate	1.5%	2.2%
Distribution of households		
Skilled low	10	0
Skilled high	3.4	26.6
Unskilled low	32.3	12.7
Unskilled high	6.1	8.9

Note: MLS = minimum lot size.

sum taxation, and growth restrictions through fringe zoning. Each land-use control is designed by the south in an attempt to exclude those imposing a fiscal burden on the high-income residents. The key questions relate to the effectiveness of each kind of control and the implications for household location and school quality.

MLS Zoning

At the benchmark equilibrium, the South School District determines the MLS per household in residential land use, $\bar{h}_m$ by majority voting. We assume each household votes for its optimal unconstrained house size as an MLS. If a larger lot size were chosen, it would be constrained in housing consumption and would end up with a lower utility level. On the other hand, a lower MLS (than its optimum) would decrease property tax revenues, would introduce households that bring a fiscal burden, and would lead to a lower quality of schools. As a result of the voting outcome, the South School District requires poor households in small houses to consume at least $\bar{h}_m = 4,428$ square feet.

In equilibrium, the South School District continues to provide a better education, but there are significant locational changes compared to the benchmark case. A summary of the new equilibrium outcome is found in table 3 and figures 4 through 6. All skilled low valuation and nearly one-third of UH from the South School District now find that it no longer best serves their demands. Most of the SH now reside in the south, which has become an exclusive city with fewer residents and higher average income. Many of the UL previously in the south stay in the south, but most of them as well as all UH and a small portion of skilled high households are now

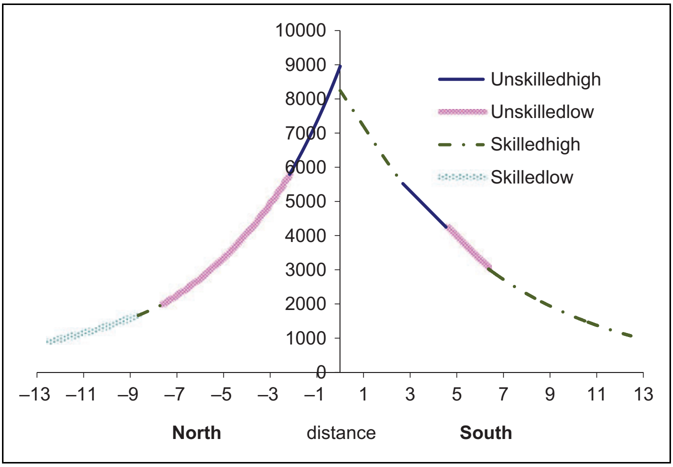

Figure 4. Monthly gross rent per acre with minimum lot size zoning.

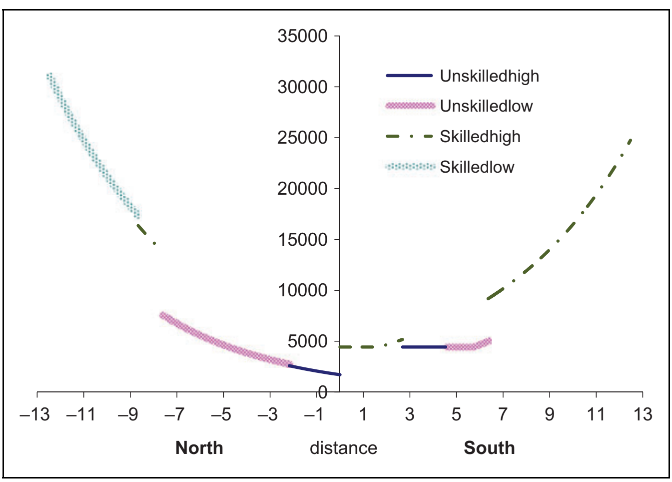

Figure 5. Lot size (square foot) with minimum lot size zoning.

forced to consume an amount of land, $\bar{h}_m$, that is greater than the bid max lot size without such a regulation. Thus, some fiscal burden of low-income households remains in the south, but it is considerably reduced by the exclusionary zoning.

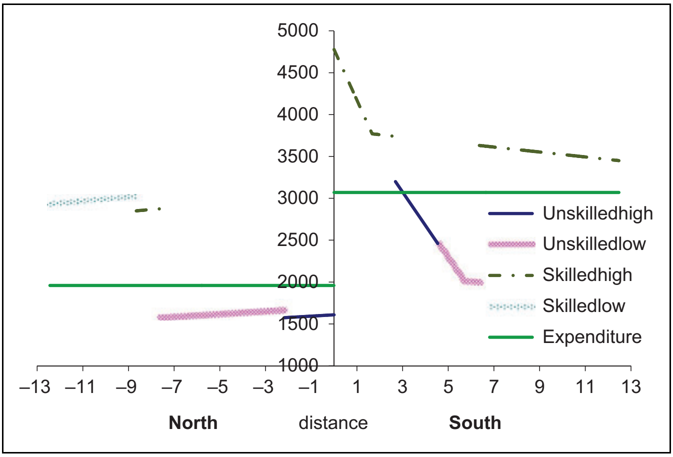

Figure 6. Annual tax per capita with minimum lot size zoning.

The spatial location pattern seems at first glance to be puzzling, but it is readily explained. As a result of lower rents and increased accessibility in the north, all SL move to the north. As a result of higher rents and a high MLS requirement, both unskilled high and UL were outbid by SH at locations closer to the CBD. Recall that the bid rent function for a household has two pieces: one piece where it is unconstrained and consumes a lot size bigger than MLS and another piece where she is constrained and consumes the MLS. At locations closer to the CBD, we see the constrained portion of a skilled high valuation household's bid rent curve. Aside from the presence of SH around the CBD, the rest of the spatial order is not surprising.

To explain the increasing amounts of annual tax liability of SH at locations closer to the CBD in figure 6, recall that they consume the MLS and their tax liability increases toward the CBD due to increasing land prices. This result is different from Hamilton (1975). In a given school district, both land consumption and tax liability differ across household types, while Hamilton finds that every household in a given school district consumes the same amount of housing in equilibrium and pays the same amount of property taxes.

By extension, it is clearly possible to form a school district in the south containing just skilled high valuation households by sufficiently raising the MLS requirement level. This would make it unattractive for the UL, who would then prefer the north.

Table 4. Equilibrium Distribution of Population and School Quality under Head Taxes in the South.

	North	South
School quality	9.2	15
Property tax rate	1.5%	0%
Distribution of households		
Skilled low	6.2	3.8
Skilled high	0.3	29.7
Unskilled low	45	0
Unskilled high	14.5	0.5

Head Taxes

The commonly analyzed simple Tiebout model finances the local public goods with a constant tax for all individuals in a school district. Given the homogeneous nature of each district in the standard Tiebout model, the constant, or head, tax does not have much impact. In our model, however, the heterogeneity of districts in terms of income and equilibrium land consumption implies that the property tax and the head tax will operate quite differently.

As should be clear, a head tax would eliminate the fiscal burden.[15] We consider the possibility of applying a flat tax in the South School District, which is concerned with the presence of the households that impose fiscal burdens on the local government under the property tax. We analyze the implications of setting the head tax in the south at the expenditure per pupil in the benchmark.

As a result of the new policy, almost no unskilled workers wish to reside in the south (see table 4). A few additional SL move to the south, compared to the baseline, because of the increased accessibility from the south. But, with the fall in average property values in the north, the quality of schools declines in the north, again compared to the baseline. In total, fewer people now find the south to be an attractive residential location compared to the baseline, and its population is less.

Growth Restrictions

An alternative land-use policy frequently pursued is simply to deny new development within a city, thus making it more exclusive. For our modeling, we consider (urban) fringe restrictions that residences beyond a certain

Table 5. Equilibrium Distribution of Population and School Quality after Reduced Fringe Distance Zoning in the South.

	North	South
School quality	11.9	14.5
Tax rate	1.5%	2.2%
Distribution of households		
Skilled low	10	0
Skilled high	12.6	17.4
Unskilled low	27.2	17.8
Unskilled high	3.3	11.7

radius, r_f, from the city center as a means of constraining growth.[16] Here, r_f is chosen to be ten miles. In order to reduce the fiscal burden of the baseline, this policy would have to drive out unskilled households. This would happen if the land that is available for residential allocation in the south is smaller, allocated to the highest bidder, and skilled households can afford to bid more. In the new equilibrium, however, it is not so clear. As shown in table 5, the quality of education falls in the south compared to the baseline. All SL move to the North School District, fewer high valuation households reside in the south, and more UL live in the South School District. This policy is not effective at excluding households that impose a fiscal burden on the local government. Once again, skilled households subsidize unskilled households, and the problem of fiscal burden in the south remains.

To understand the failure of such fringe zoning, recall that the spatial allocation of households is determined by the relative steepness of bid rent curves. In the model, poor households have a steeper bid rent curve, and they reside in locations closer to the CBD, leading to the failure of this policy to exclude the "right" households.

Implications for School Quality

All the land-use control policies were motivated by reducing the fiscal transfers within a subset of the jurisdictions. A particularly interesting aspect of these policies is their implications for the level and distribution of schooling. Specifically, by ending up with a different distribution of households, some of whom are constrained by the land-use policies, the political support for schools changes in the two districts. Within each district, the combination of majority voting on tax rates and the heterogeneity of households within the districts means that a number of households

Table 6. Quality of Education across Districts under Various Land-use Control Regimes.

	School quality			
	Benchmark	MLS zoning	Head tax	Reduced fringe
North	11.5	10.6	9.2	11.9
South	15	17.5	15	14.5
Area mean	13.3	14	12.1	13.2

Table 7. Quality of Education across Household Types under Various Land-use Control Regimes.

	Average school quality			
Household type	Benchmark	MLS zoning	Head tax	Reduced fringe
Skilled residents	13.4	15.2	14	13
Unskilled residents	13.2	13.1	9.2	13.2
High valuation families	14.1	16.1	13.1	13.6
Low valuation families	12.6	12.2	9.6	12.8

typically are trading off school quality for accessibility and housing prices—and the educational outcomes will depend on the mix of households in the different communities.

We first look at the results for school quality by school district, as summarized in tables 6 and 7. In general, the jurisdiction imposing land-use controls can maintain as high or higher school quality for those households remaining in the district. However, the quality in the other school district (north) tends to decline. The resulting average quality of schools may or may not decline, but uniformly the spread in quality across districts consistently increases.

With MLS zoning, the gains in school quality in the south district are sufficient to offset the declines in the north so that average school quality increases. With the other policies, however, the average quality declines, implying that these land-use controls work against the typical public policy objectives of increasing quality and reducing variance.

Simply looking at the results by city, however, is incomplete, because the equilibrium outcomes of the different policies imply considerable movement across cities. An alternative summary is to investigate the school quality outcomes for the different families in our analysis, denominated by either income or valuation of schooling. Table 7 summarizes how the different types make out in equilibrium after the South district imposes the alternative land-use controls.

The skilled households and the households that highly value schooling do better in terms of school quality with MLS zoning (compared to the benchmark case), and the skilled workers also improve school quality with the head tax. The growth restrictions through reduced fringe zoning lower school quality for both groups. The unskilled and the low valuation residents, who are generally simply reacting to the policies of the south, find that their school quality generally decreases—although any change is minimal with the reduced fringe zoning.

Conclusion

The provision of educational services in the United States is closely tied to residential location. A range of active governmental policies have been aimed at altering both the level and the distribution of education across school districts, and it is clear that these policy deliberations must consider household reactions to policies and the alternative reasons why household choose a given location.[17] This analysis focuses on the actions of individual communities to restrict the options available to households through exclusionary zoning and thus to improve their local fiscal situation. We embed our endogenous zoning choices within a simple model that recognizes that a given location offers both accessibility to employment and local schools. The quality of schools depends, however, on the preferences of local voters, something that could change in the aggregate with different policies. Putting these basic elements together, we can provide a general equilibrium solution to the household location problem that is useful for policy simulations.

We consider schools that are funded by property taxes. But, with heterogeneous communities, the presence of households purchasing different quality of homes can impose a fiscal burden on the local government, because a household in a small house pays a relatively small amount in taxes compared to school spending. Concerned with the fiscal burden of some households, a local government may try to exclude those households paying less tax than their cost of schooling by means of some exclusionary land-use controls: MLS zoning, lump sum tax, or fringe distance (growth limitation) zoning.

We presume that the district with the highest income, the best school quality, and the largest fiscal discrepancies imposes a given land-use control, while the other district does not. The resulting population distributions under the alternative policies differ substantially from the open market benchmark case. In terms of the quality of education provided, MLS zoning within our parameterization actually increases average quality of education. However, as the mean quality of education increases, so does inequality, measured by the discrepancy in quality across the jurisdictions. The other cases of permitting head taxes or of reduced fringe zoning (growth controls) tend to lower average school quality while also increasing the variance in quality across districts. It is generally true, however, that the upper-income residents, who drive the restrictive zoning, can come out ahead in terms of school quality.

Our theoretical characterization of the equilibrium outcomes is of course dependent upon the specific utility functions and calibration of the model. Alternative calibrations can lead to different results. The important message from our calibrations is, however, that the simplest models of locational choice—ones dependent on just the provision of differing amounts of the local public good—are likely to misstate the locational outcomes and the nature of public good provision. Specifically, models that lead to perfect sorting of households across communities, à la Tiebout (1956), are likely to misrepresent the outcomes that will result from local policy changes. Moreover, the general equilibrium nature of housing decisions means that the actions of households in one jurisdiction spill over into other jurisdictions, leading to changes not only in the structure of housing prices but also in the overall provision of public goods. These can be very significant when there are limited numbers of jurisdictions as in our modeling here.

Acknowledgment

We are grateful to the comments and suggestions of Charles Leung, two anonymous referees, and the seminar participants at the Fed-Philadelphia, at the 2002 Econometric Society North American Summer Meeting, at the Workshop on Macroeconomics, Real Estate, and Public Policy at Koc University, and several conferences.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. See Pack and Pack (1977, 1978), Persky (1990), and Hanushek and Yilmaz (2011).
2. From a different perspective, Ortalo-Magné and Rady (2008) introduce income heterogeneity through housing market price dynamics, where people buy houses at different times (and prices).
3. Hanushek and Lindseth (2009) review and analyze school finance deliberations with an emphasis on court involvement in school finance variations across districts.
4. With a circular city structure, the radial symmetry permits straightforward analytical solutions of location where it is necessary only to trace locational choices along any ray from the employment center. It has also motivated a large number of empirical analysis of urban form that are based on estimating household density functions and price gradients emanating from the center (see, e.g., Mills 1972; Rose 1989; and Kim 2007). See also de Bartolome and Ross (2003) or Cassidy, Epple, and Romer (1989). Note that as demonstrated subsequently, our cities have some similar structure in that there is ‘‘ring-separation'' of different household types within each jurisdiction.
5. Kim (2007) describes a number of situations where the standard depiction does not work including, importantly, the significant numbers of US metropolitan areas with multiple central cities or other anomalies. Bertaud and Malpezzi (2003) also find a number of international cities are inaccurately described by smooth density gradients.
6. For simplicity, public schools are the only means to provide education in our model. We do not consider private schools. See Hanushek, Sarpça, and Yilmaz (2011) for a model with private schools.
7. It is implicitly assumed that each household manages the construction of his house by himself and that lot size indexes the overall quality of the residential services.
8. The pecuniary cost of commuting is an important parameter in the model, without which we cannot find the spatial order of households by income. Empirically, pecuniary costs are not negligible in United States. See Altmann and Desalvo (1981) for an early estimate. Internet sites offer commuting cost calculators that put the 2011 cost per mile at over $1 (see, e.g., http://commutesolutions.org/external/calc.html, accessed December 26, 2011).
9. See Hanushek (1996, 2003) for empirical evidence on achievement production functions.
10. The source of statistical facts we use is the Statistical Abstract of the United States; see US Bureau of the Census (1998).

11. Based on a real interest rate of 2.5 percent, those values are the effective tax rates based on the value of a house.
12. The median population per square mile of cities with 200,000 or more population was 3,546 in 1992 (US Bureau of the Census 1994).
13. Note that there is a trivially different equilibrium where south and north are simply switched. In each case, however, our prior work shows that the solution converges on the same equilibrium, independent of the starting point chosen, when there are no peer effects in the educational production function. See Hanushek and Yilmaz (2007).
14. In 1997, the average expenditure per pupil was 5,923, of which 45 percent comes from local funds (US Department of Education 2004). Our analysis assumes that both cities get equal per student allocations of state and federal funds for education and that is not considered in the household decision making.
15. While head taxes are not common in the United States, they are used partially to finance schools in California. The introduction of a property tax limitation (Proposition 13) effectively sets the property tax rate at a constant across the state. Individual districts may, with voter approval, establish a parcel tax that is the same for all residences in the school district regardless of their value.
16. Note that we think of this as maintaining restrictions on any expansions in the city, as is typical of many European cities. A policy to actually move the fringe in clearly reduces the value of property that was formerly residential and the owners would have to be compensated for such actions. Also, if the fringe moves out, so that the population expands, the new equilibrium can imply a reduced school quality for the South district.
17. See, for example, the early study of Feldstein (1975) on state school finance options. More recent analysis incorporates accessibility into the analysis of governmental policy (Hanushek and Yilmaz 2007, 2013).

References

Alonso, William. 1964. *Location and Land Use*. Cambridge, MA: Harvard University Press.

Altmann, James L., and Joseph S. DeSalvo. 1981. "Tests and Extensions of the Mills-Muth Simulation Model of Urban Residential Land Use." *Journal of Regional Science* 21:1–21.

Bertaud, Alain, and Stephen Malpezzi. 2003. *The Spatial Distribution of Population in 48 World Cities: Implications for Economics in Transition*. Center for Urban Land Economics Research. Madison: University of Wisconsin.

Calabrese, Stephen, Dennis Epple, and Richard Romano. 2007. "On the Political Economy of Zoning." *Journal of Public Economics* 91:25–49.

Cassidy, Glenn, Dennis Epple, and Thomas Romer. 1989. "Redistribution by Local Governments in a Monocentric Urban Area." *Regional Science and Urban Economics* 19:421–54.

de Bartolome, Charles A. M., and Stephen L. Ross. 2003. "Equilibria with Local Governments and Commuting: Income Sorting Vs Income Mixing." *Journal of Urban Economics* 54:1–20.

Durlauf, Steven N. 1996. "A Theory of Persistent Income Inequality." *Journal of Economic Growth* 1:75–93.

Epple, Dennis, Radu Filimon, and Thomas Romer. 1988. "Community Development with Endogenous Land Use Controls." *Journal of Public Economics* 35:133–62.

Epple, Dennis, Brett Gordon, and Holger Sieg. 2010. "Drs. Muth and Mills Meet Dr. Tiebout: Integrating Location-specific Amenities into Multi-community Equilibrium Models." *Journal of Regional Science* 50:381–400.

Epple, Dennis, and Thomas Nechyba. 2004. "Fiscal Decentralization." In *Handbook of Regional and Urban Economics*, edited by J. Vernon Henderson and Jacques-François Thisse, 2423–480. Amsterdam, the Netherlands: Elsevier.

Edel, Matthew, and Elliott Sclar. 1974. "Taxes, Spending, and Property Values: Supply Adjustment in a Tiebout-Oates Model." *Journal of Political Economy* 82:941–54.

Epple, Dennis, and Holger Sieg. 1999. "Estimating Equilibrium Models of Local Jurisdictions." *The Journal of Political Economy* 107:645–81.

Evans, A. W. 1999. "The Land Market and Government Intervention." In *Handbook of Regional and Urban Economics*, edited by Paul Cheshire and Edwin S. Mills, 1637–1669. Amsterdam, the Netherlands: North Holland.

Feldstein, Martin S. 1975. "Wealth Neutrality and Local Choice in Public Education." *The American Economic Review* 65:75–89.

Fernández, Raquel, and Richard Rogerson. 1997. "Keeping People Out: Income Distribution, Zoning, and the Quality of Public Education." *International Economic Review* 38:23–42.

Hamilton, Bruce W. 1975. "Zoning and Property Taxation in a System of Local Governments." *Urban Studies* 12:205–11.

Hanushek, Eric A. 1996. "School Resources and Student Performance." In *Does Money Matter? The Effect of School Resources on Student Achievement and Adult Success*, edited by Gary Burtless, 43–73. Washington, DC: The Brookings Institution.

Hanushek, Eric A. 2003. "The Failure of Input-based Schooling Policies." *Economic Journal* 113:F64–F98.

Hanushek, Eric A., and Alfred A. Lindseth. 2009. *Schoolhouses, Courthouses, and Statehouses: Solving the Funding-achievement Puzzle in America's Public Schools*. Princeton, NJ: Princeton University Press.

Hanushek, Eric A., Sinan Sarpça, and Kuzey Yilmaz. 2011. "Private Schools and Residential Choices: Accessibility, Mobility, and Welfare." *B.E. Journal of Economic Analysis & Policy: Contributions* 11:article 44.

Hanushek, Eric A., and Kuzey Yilmaz. 2007. "The Complementarity of Tiebout and Alonso." *Journal of Housing Economics* 16:243–61.

Hanushek, Eric A., and Kuzey Yilmaz. 2011. "Urban Education, Location, and Opportunity in the United States." In *Oxford Handbook of Urban Economics and Planning*, edited by Nancy Brooks, Kieran Donaghy, and Gerrit-Jan Knaap, 583–615. Oxford, UK: Oxford University Press.

Hanushek, Eric A., and Kuzey Yilmaz. 2013. "Schools and Location: Tiebout, Alonso, and Governmental Finance Policy." *Journal of Public Economic Theory* 15:829–55.

Henderson, Vernon J. 1980. "Community Development: The Effects of Growth and Uncertainty." *The American Economic Review* 70:894–910.

Kim, Sukkoo. 2007. "Changes in the Nature of Urban Spatial Structure in the United States, 1890-2000." *Journal of Regional Science* 47:273–87.

Magliocca, Nicholas, Virginia McConnell, Margaret Walls, and Elena Safirova. 2012. "Zoning on the Urban Fringe: Results from a New Approach to Modeling Land and Housing Markets." *Regional Science and Urban Economics* 42: 198–210.

Mills, Edwin S. 1972. *Studies in the Structure of the Urban Economy*. Washington, DC: Resources for the Future.

Nechyba, Thomas J. 2000. "Mobility, Targeting, and Private-school Vouchers." *The American Economic Review* 90:130–46.

Ortalo-Magné, François, and Sven Rady. 2008. "Heterogeneity within Communities: A Stochastic Model with Tenure Choice." *Journal of Urban Economics* 64:1–17.

Pack, Howard, and Janet Rothenberg Pack. 1977. "Metropolitan Fragmentation and Suburban Homogeneity." *Urban Studies* 14:191–201.

Pack, Howard, and Janet Rothenberg Pack. 1978. "Metropolitan Fragmentation and Local Public Expenditures." *National Tax Journal* 31:349–62.

Persky, Joseph J. 1990. "Suburban Income Inequality: Three Theories and a Few Facts." *Regional Science and Urban Economics* 20:125–37.

Quigley, John M., and Larry A. Rosenthal. 2005. "The Effects of Land Use Regulation on the Price of Housing: What Do We Know? What Can We Learn?" *Cityscape* 8:69–137.

Rose, Louis A. 1989. "Topographical Constraints and Urban Land Supply Indexes." *Journal of Urban Economics* 26:335–47.

Sieg, Holger, V. Kerry Smith, H. Spencer Banzhaf, and Randy Walsh. 2004. "Estimating the General Equilibrium Benefits of Large Changes in Spatially Delineated Public Goods." *International Economic Review* 45:1047–77.

Tiebout, Charles M. 1956. "A Pure Theory of Local Expenditures." *The Journal of Political Economy* 64:416–24.
US Bureau of the Census. 1994. *County and City Data Book 1994*. Washington, DC: US Department of Commerce.
US Bureau of the Census. 1998. *Statistical Abstract of the United States: 1998*. Washington, DC: US Government Printing Office.
US Department of Education. 2004. *Digest of Education Statistics, 2003*. Washington, DC: National Center for Education Statistics.

Author Biographies

Eric Hanushek is the Paul and Jean Hanna senior fellow at the Hoover Institution of Stanford University. His research spans such diverse areas as the impact of teacher quality, high-stakes accountability, equity, and efficiency in school finance, and class-size reduction along with the role of cognitive skills in international growth and development. He has authored or edited twenty books along with more than 200 articles. He is a distinguished graduate of the US Air Force Academy and completed his PhD in economics at the Massachusetts Institute of Technology.

Kuzey Yilmaz is a visiting professor in the Department of Economics at the University of Rochester. He received his doctorate in economics from the University of Rochester. Much of her research develops general equilibrium models to analyze individual decision making and uses those models to study issues in the finance of schools.