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SCHOOLS AND LOCATION: TIEBOUT, ALONSO, AND GOVERNMENTAL FINANCE POLICY

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Abstract

Many discussions of school finance policy fail to consider how households respond to policies that change the attractiveness of different residential locations. We develop a general equilibrium model that incorporates workplace choice, residential choice, and political choice of tax and expenditure levels. Importantly, we consider multiple workplaces, a fundamental feature of today's metropolitan landscape. This basic model permits investigating how accessibility and public goods interact in a metropolitan area. The model is used to analyze two conventional policy initiatives: school district consolidation and district power equalization. The surprising conclusion is that school quality and welfare can fall for all families when these restrictions on choice are introduced.

1. Introduction

A unique feature of the U.S. education system is the high degree of both funding and control granted to local governments. As a result, school choice is inextricably tied to residential location decisions. This organization has been lauded for its responsiveness to individual demands and for the

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potential of increased school accountability. On the other hand, it also introduces potential inequities by tying funding decisions to local ability to pay. These conflicting views have made debates about school financing a regular item on both legislative and judicial agendas in the United States. This debate, however, has generally neglected how individual behavior conditions the outcomes of policy initiatives.

The complexities of analyzing the interaction of location and schooling are well known. When local citizens control taxing and spending decisions and when the quality of schools depends on the peer group, school quality is an endogenous outcome that depends on aggregate individual choices. With local funding of schools through a property tax, housing prices and the tax base also become endogenous. Importantly, government policy decisions about school funding can change the attractiveness of residential locations, setting off household moves and altered housing prices. Finally, residential location, while responsive to school quality, is also strongly influenced by job location and journey to work. Developing simple characterizations of locational decisions, even in the absence of schooling choices, has proved difficult when realism about decentralized employment is considered.

With a few exceptions, analysis of school finance policies has generally ignored one or more of these features of household choices of schools and homes. As a result, typical partial equilibrium analyses of policy alternatives for school finance and operations are likely to be misleading in terms of both levels of educational outcomes and their distribution.

This paper integrates the essential features of schools and location. In a general equilibrium framework, heterogeneous families (in terms of income and tastes) seek out an optimal residential location and workplace based on commuting costs, wages, and school quality. They also vote on local taxes, yielding variations in school spending that, along with peer influences, produce variations in school quality. The general equilibrium aspects, when multiple jurisdictions and decentralized employment are introduced, are especially important, because housing prices vary with demand and with governmental policy.

This model is used to illustrate the potential impacts of two alternative school finance policies designed to increase the equity in schooling by reducing the reliance on local property taxes. First, district power equalization—a commonly proposed remedy for unequal tax bases that relies on variable matching grants—is put into the general equilibrium framework where families react to the altered locational advantages. Second, district consolidation and full state funding for school districts are considered from the perspectives of school outcomes and of individual welfare.

We find that the resulting impacts of school finance policy are very different than commonly discussed. Relying on our parameterizations (and a variety of sensitivity analyses surrounding these), both of these policies can actually reduce welfare for *all* households regardless of income or taste for schooling. Full state funding does narrow educational disparities by incomes,

but it does so at the cost of lowered achievement for all students. Additionally, these policies set in motion a series of adjustments that significantly change housing rents and support for schools.

The next section places our work into the context of existing research. We then provide the theoretical formulation for our basic model. This model is calibrated for a benchmark case that provides the basis for evaluating the impact of significant changes in the financing of schools. The policy changes, while within the range of observed governmental decisions, are large enough that the general equilibrium nature of the problem cannot be ignored—and indeed that is the motivation for this work.

2. Existing Strands of Literature

A specific residential location has multiple attributes including a specific quality of housing, a set of amenities, and varying ease of access to employment locations. Depending on the particular analytical focus, most existing research on residential choice has simplified the modeling by following one of two traditional approaches: urban residential location models and Tiebout models of community choice. Urban location theory focuses on the trade-off between accessibility and space,[1] while Tiebout models of community choice concentrate on local public goods and how households vote with their feet to find the community that best satisfies their preferences.[2] de Bartolome and Ross (2003) and Hanushek and Yilmaz (2007) suggest that combining the two modeling perspectives may provide a more realistic portrait of urban location. Nechyba (2003), taking a different route, develops a general equilibrium model that is calibrated on pre-existing heterogeneity of income and housing. A review of alternative modeling approaches is provided by Epple and Nechyba (2004), Nechyba (2006), and Hanushek and Yilmaz (2011).[3]

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[1] The pioneer of this approach was Alonso (1964) with his simple but instructive model of the land market, modeling later followed by a great deal of theoretical and empirical work by Muth (1969), Mills (1972), Kain (1975), and others. (See the reviews in Straszheim (1987) and Fujita (1989)).

[2] This literature has evolved from the central insight of Tiebout (1956) and builds upon the analytical framework developed in Ellickson (1971). The most influential studies from this approach have been conducted by Epple, Filimon, and Romer (1984, 1993), who have also introduced politics into the model. See also the additions by Epple and Romano (1998, 2003) and the review by Ross and Yinger (1999).

[3] In a recent paper, Epple, Gordon, and Sieg (2010) take a different approach to merging location models and Tiebout models. They consider equilibrium of households and housing suppliers in a metropolitan area and develop a set of sufficient conditions that justify estimation of multicommunity equilibrium models while ignoring intracommunity variation in amenities. Empirically they view each parcel as having a single amenity value that combines travel times to the center of the city (Pittsburgh) and specific high school attendance zone.

The objective of this paper is construction of a model with sufficient richness to capture the basic reality of urban spatial structure and the key elements of governmental policy interventions.[4] We build on our prior work that developed a general equilibrium model of household location and school demand in a model with centralized employment that has two competing school districts (Hanushek and Yilmaz 2007).

Here, we move to consideration of multiple workplace centers with three separate school districts. Among other things, this exercise incorporates a fundamental empirical feature of today's urban landscape, i.e., the importance of suburbs and of their heterogeneity.[5] In 1940, 32.8% of the U.S. population lived in central cities of metropolitan areas, with less than half that many (15.8%) in suburban areas; by 2000, 30.3% lived in central cities while fully half of the U.S. population was found in suburbs (Hobbs and Stoops 2002). Moreover, looking at a constant set of metropolitan areas, Kim (2007) notes that central cities began declining absolutely in population after 1950 as population density gradients flattened significantly. These changes in the spatial structure of metropolitan areas paralleled the decentralization of business and industry. While centralized employment and undifferentiated suburban locations are convenient and tractable from a modeling perspective, they lack realism in describing current metropolitan areas.

3. A Model with Decentralized Employment and Public Goods

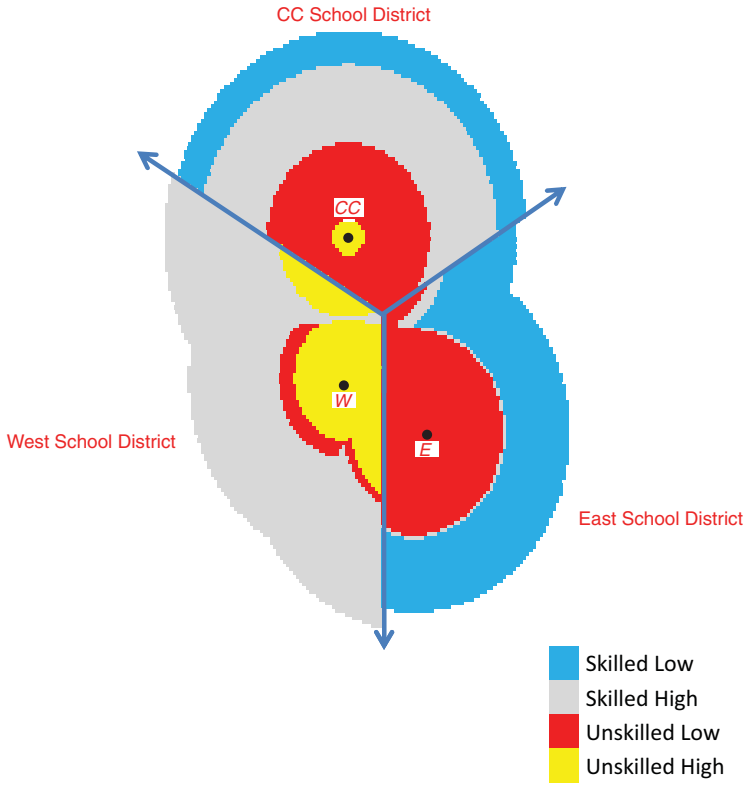
We begin with a flat featureless plane that has three exogenously determined jurisdictions and employment centers.[6] This metropolitan area is a stylized representation of the many cities on water boundaries such as Chicago, Cleveland, or New Orleans.[7] A Central City (CC) is bordered on one side by two competing suburban workplaces, namely the West Suburban Center (W) and the East Suburban Center (E). (see Map 1). This

[4] This analysis concentrates on the long-run equilibrium for the residential location of households. As such it ignores any of the short-run dynamics or of the interactions with the macroeconomy; cf. Leung (2004).

[5] See, for example, the discussion of patterns of American cities in Glaeser and Kahn (2001, 2004). The incorporation of decentralized employment into urban modeling is explored in depth in White (1976, 1999).

[6] Note that a complete general equilibrium analysis would have endogenous determination of employment location and wages. While incorporating these elements into our analysis would be extremely difficult, we also do not believe that they would materially affect our results. Specifically, while households are likely to act relatively quickly to altered attractiveness of specific locations, core employment would be expected to adjust more slowly to specific funding changes.

[7] As Rose(1989) points out, half of the 40 most populous metropolitan areas were bound by the Pacific Ocean, Atlantic Ocean, the Gulf of Mexico, or the Great Lakes.



Map 1: The spatial distribution of housholds in equilibrium 1.

jurisdictional structure permits disentangling accessibility and school quality in ways that are not possible in simple cities of concentric rings. Firms are located at points, take up no space, and have no taxable property.[8] Each jurisdiction also contains a school district (named after its employment center).

Labor market. We concentrate on residential and schooling choices and take wages as exogenous. At each workplace (l), there are both high wage jobs (paid to skilled workers, s) and low wage jobs (paid to unskilled workers, u). (All skilled workers are perfectly substitutable, as are all low wage workers). Wages of both skilled and unskilled workers vary across suburban centers depending on their locations relative to the Central City. Suburban wages are less than their counterparts in the CC (i.e., $w_s^{CC} > w_s^{E} > w_s^{W} \gg$

[8] Note that ignoring the impact of commercial and industrial property on the tax base ignores an important feature of local finance (see Ladd 1975, Fischel 2006), but it would not change the qualitative nature of our results.

$w_u^{CC} > w_u^{E} > w_u^{W}$), because of the wage gradient induced by the lesser need to commute and the larger and cheaper houses around these places.[9]

Households and preferences. One member of each household works and makes all the economic decisions in the house. Each household has one pupil attending school, although the crucial element is that all children in a household attend the same school district. Households place different values on the quality of education a jurisdiction provides. Some value education more (high-valuation types, H), some less (low-valuation types, L). Therefore, we have four different types of households in the city $i \in \{SL, SH, UL, UH\}$. The different valuations could reflect differences in inherent tastes or could be induced by underlying differences in family size. A low-valuation household may, for example, be a household with no children at home, but it nevertheless recognizes that school quality is still relevant because it will be capitalized into rents and housing values. The metropolitan area is closed in the sense that there is a set population of each of four types of households.

The preferences for a type i household is represented by a Cobb–Douglas utility function given by $U(\alpha_i, \eta_i; q, s, z, t) = q_j^{\alpha_i} s^{\eta_i} z^{\gamma} t^{\delta}$, where $\alpha_i + \eta_i + \gamma + \delta = 1$, q_j is the quality of education in community j$\in$ {CC, W, E}, $s > 0$ is the lot size, $z > 0$ is the numeraire composite commodity, and $t \in [0, 24]$ is leisure. $\alpha_i \in \{\alpha_H, \alpha_L\}$ is the taste parameter for education[10] and, $\eta_i \in \{\eta_H, \eta_L\}$ is the taste parameter for lot size.[11]

Accessibility and budget constraint. Consider a type i household who is trying to decide where to work and live. The area has a dense radial transportation system from each workplace, and the worker of every household commutes daily from his residence to his workplace. But a household could have a residence differing from his/her workplace. For instance, a household commuting to his/her workplace in the CC could reside in West School District due to a better education, tax advantages, or less commuting distance. There is both a time and Euclidean distance component to the commuting

[9] In locational models, the wage gradient is frequently derived after the residential price gradient is found. A complete model would, however, simultaneously solve both the household and employer locational problem along with rents and wages—a task beyond our capacity. Fujita and Thisse (2002) discuss polycentric cities where the employment centers' locations are determined endogenously. In our model with exogenous wages and employment, the rent gradient adjusts to wages, because wages will enter into the value of accessibility.

[10] Important contributions on segregation by income and taste were provided by Berglas (1976) and Scotchmer and Wooders (1987).

[11] The normalization of the parameters to sum to one is important for the model (i.e., $\alpha_H > \alpha_L$ and $\eta_H < \eta_L$). In this formulation, a high-valuation household demands less land than a low-valuation household and a high-valuation type prefers a higher property tax rate. It leads to high-valuation households to have steeper bid-rents than low-valuation households, or for high-valuation households to live closer to the employment centers than low-valuation households of the same wage. In equilibrium, it leads to more of the skilled high-valuation households living in the district with a better education, raising the rents and the peer group there.

cost. Formally, commuting requires $a/2$ dollars per mile and $b/2$ hours per mile.[12] The time endowment for the household is 24 hours. The budget constraint of the household with a workplace l and school district j, at a location (x,y) on the xy plane is given by

$$z_{ijl}(x, y) + (1 + \tau_j)R(x, y)s_{ijl}(x, y) + w_i^l t_{ijl}(x, y) = Y_i^l(x, y) = 24w_i^l - \left(a + bw_i^l\right) r_l(x, y), \quad (1)$$

where r is the Euclidean distance to workplace l, τ_j is the property tax rate, $R(x, y)$ is the equilibrium rent per unit of land at the coordinate (x,y) on the map, that is paid to a landlord for his land in community j. Notice that this formulation suggests that households sell all available time to employers and buy back some leisure at the prevailing market wage rate.

Land Market. Following Alonso (1964), we assume a competitive land market in which households bid for land and absentee land owners offer the land to the highest bidder. For any given location, nondevelopment is an option and the land is left for agricultural use if the households cannot outbid the agricultural use, which has a fixed bid of r_a.

We can view any household's problem as a trade-off problem, in which there are four basic factors: workplace, accessibility, space (lot size), and public goods (education). In making a residential choice, a household must weigh all four factors appropriately, yet must also meet the budget constraint. So the household has to sacrifice one factor, say space, for another factor, say accessibility. In equilibrium, the advantages and disadvantages at different workplaces, and school districts/locations are capitalized into prices and identical households obtain the same utility level regardless of their district of residence. The bid-rent function captures this feature and allows us to calculate rents at different locations/workplaces/school districts. In a standard way, we can define the bid-rent function of the household, which shows the household's willingness to pay for a residence at a location holding utility at a fixed level as:[13]

$$\Psi(l, j, r, u_i, q_j, \tau_j) = \max_{s,z,l} \left\{ \frac{Y_i^l(r) - z - w_i^l t}{(1 + \tau_j)s} \mid U(l, j, r, \alpha_i, \eta_i; q, s, z, t) = u_i \right\}, \quad (2)$$

$$= \frac{k_i^{1/\eta_i}}{(1 + \tau_j)\left(w_i^l\right)^{\delta/\eta_i}} q_j^{\alpha_i/\eta_i} Y_i^l(r)^{\eta_i+\gamma+\delta/\eta_i} u_i^{-1/\eta_i}. \quad (3)$$

[12] We need a nonzero pecuniary cost of commuting (i.e., $a \neq 0$) to have a steeper bid-rent curve of the rich than that of the poor.

[13] In the explicit formulation, $k_i = \frac{\eta_i^{\eta_i}\gamma^\gamma\delta^\delta}{(\eta_i+\gamma+\delta)^{(\eta_i+\gamma+\delta)}}$.

In any school district, identical households occupy rings (sometimes truncated or distorted or even absent) originating from three workplaces in equilibrium. Within each school district, the four types of households with three different workplaces each and farmers bid for land. Since we have three workplaces, there are $4 \times 3 \times 3 = 36$ different household-by-residence-by-workplace outcomes (i.e., bid-rent curves). As shown in Map 1, in equilibrium, the land allocated to households with the same workplace and agricultural land form disjoint sets and partition the school district.[14] Importantly, in a school district, the bid-rent functions originating from a workplace can be ordered by their relative steepness. In any school district, we numerically find that the spatial order is independent of workplace where it originates, poor (high-valuation) households have a steeper bid-rent curve than rich (low-valuation) households, yielding a spatial ordering of households of Unskilled High, Unskilled Low, Skilled High, and Skilled Low as we move away from any generating employment center in school district j.[15] It is important to note that in a school district, as a result of either bidding or the school district boundaries or the interaction with the other rings originating from a different workplace, some rings for a given type could be absent or some rings could even be truncated/distorted in equilibrium.

In equilibrium, if type i households are present in more than one school district or workplace, they should get the same utility wherever they are so that nobody has an incentive to switch workplace, school district, location, or consumption pattern. We can identify the equilibrium location (both residential and workplace) of households and equilibrium market rents, once we know the households' utilities. Since we have a closed city, the equilibrium utility levels are found by the population constraints.

Taxes and schools. Our real interest is to examine the interaction of school quality and location. For most interesting analyses, we must turn to a general equilibrium model. From a household's point of view, each jurisdiction is characterized by the quality of education and property tax rate pair (q_j, τ_j) it provides. Education in community $j \in \{\text{CC, W, E}\}$ is financed through property taxes on residential land. Each jurisdiction's local government spends all tax revenue on education. Then, the government budget constraint in school district j is

$$e_j = \tau_j \bar{R}_j = \tau_j \frac{\int_{(x,y)\in j} \int_{R(x,y)>r_a} R(x, y)\, dx dy}{N_j}, \tag{4}$$

[14] Note that Map 1 gives the equilibrium location of households in the baseline case that also involves school tax and quantity as discussed below. An appendix is available upon request from the authors, that contains a detailed discussion of the computational details among other things.

[15] Alonso (1964) and Muth (1969) discuss the possibility of alternative ordering of income groups by distance.

where N_j is the population, e_j is the expenditure per pupil, and $\bar{R}_j$ is the tax base per pupil in school district j. Note that the agricultural land does not pay any property taxes (i.e., integration just considers land with prices $R(x, y) > r_a$).

Characterizing the relationship between the quality of education and the expenditure on schools has proven difficult (Hanushek 2003). Here, we emphasize the interaction of peers and spending in determining quality.[16] Specifically, we characterize quality as being determined by:

$$q_j = \phi_j \left(N_L^j, N_H^j \right) e_j, \tag{5}$$

where N_L^j and N_H^j are the number of low educational valuation and high educational valuation households in school district j, respectively.[17] The peer group effect function, $\phi_j(\cdot)$, which has a natural interpretation of determining the efficiency of spending, is given by

$$\phi_j \left(N_L^j, N_H^j \right) = c_1 + c_2 \exp\left(-c_3 \frac{N_L^j}{N_H^j} \right), \tag{6}$$

where c_1, c_2, and $c_3 > 0$ are constants. Notice that the function is convex and decreasing in its argument. Moreover, ϕ_j, the efficiency of schools in jurisdiction j, is increasing in high-valuation households and decreasing in low-valuation households. The value of the peer group effect is between c_1 and $c_1 + c_2$. Two arguments can be made to justify this kind of peer group effect. The first argument is based on the classical peer-group effect: the more my neighbor knows, the more I can learn from him. The second argument is that high-valuation households are more involved in how schools operate such as taking a part in the schooling process as board members or simply continuously watching over school decisions. This involvement is presumed to lead to a more efficient use of resources.

The property taxes are determined by majority voting in each school district. Following Epple, Filimon, and Romer (1983, 1984, 1993), we assume that voters are myopic in the sense that they do not consider that their decision about (q_j, τ_j) will influence land prices, populations, efficiency of the

[16] The empirical studies suggest that the effect of the peer group depends on the characteristics of a household. The earlier studies suggested that the effect is greatest for low ability (valuation) children. In the structure of Epple and Romano (1998), the peer group affects the educational achievement of the household and the extend of the effect depends on positively on the student's ability. We have a more neutral effect in the effect of the peer group on quality.

[17] This structure would produce qualitatively similar results if the peer effects depended on the relative concentrations of the different income groups. A similar formulation is found in Benabou (1993), which looks at the efficiency and investment aspects of residential segregation.

schooling system, etc.[18] Their vote will reflect their tax preferences (τ_j) that come from maximizing indirect utility as in:

$$\max_{\tau_j} V(.) = \frac{k_i}{R(x, y)^{\eta_i}(1+\tau_j)^{\eta_i}\left(w_i^l\right)^{\delta}} q_j^{\alpha_i} Y_i^l(r)^{\eta_i+\gamma+\delta} \tag{7}$$

subject to

$$q_j = \phi_j(.)e_j \tag{8}$$
$$e_j = \tau_j \bar{R}_j.$$

Because of the Cobb–Douglas utility function, solving this problem yields a very simple form of the preferred tax rate for type i household with a workplace l and residence at (x,y), $\tilde{\tau}_i = \frac{\alpha_i}{\eta_i - \alpha_i}$.[19] The preferred tax rate is a direct function of the household's valuation of the importance of schooling. This leads to the special property that, for a given majority, the expenditure per pupil is directly proportional to the average rent in the district.

Timing of Decisions. The timing of events would be as follows: At the beginning of each period, households make workplace and school district/location 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 for the period. They vote for the property tax rate in their school district of residence. The public good and tax rate package might be different from what they expected, but they have chosen the community for that period. At the beginning of the next period, they update their expectations and events start over again.

DEFINITION: *An equilibrium is a set of workplace, a school district, a location, lot size, leisure, and composite commodity for each household, utility levels, quality of education, and property tax rate for each school district, market rents at any location, the spatial distribution of households over workplaces, and school districts such that:*

- *Given wages, rents, taxes, and quality of education across school districts, households pick a workplace, a school district, a location, lot size, leisure, and composite commodity to maximize their utility.*
- *An absentee landlord owns the land and holds an auction at each location. The land at a location is developed for the highest bidder if the highest bid exceeds the fixed nonurban purpose bid, agricultural rent. Otherwise, it is not developed.*
- *The city is a polycentric city, and jobs are offered by firms located at the CC or two subcenters. Wages in the workplaces are exogenously determined. The*

[18] For a model of voters with perceptions of capitalization and capital gains, see Yinger (1982, 1985).

[19] It is implicitly assumed $\eta_i > \alpha_i$. This assumption also guarantees the single peaked preference requirement for the existence of majority voting equilibrium.

Table 1: Calibration parameters

Parameter	Value	Parameter	Value
α_H	0.019	η_H	0.048
α_L	0.017	η_L	0.050
γ	0.187	δ	0.747
a	\$1.10	b	0.1 hours
w_s^{CC}	\$18.30	w_u^{CC}	\$10.70
w_s^{W}	\$17.60	w_u^{W}	\$10.30
w_s^{E}	\$17.90	w_u^{E}	\$10.50

city has a dense radial transportation system around workplaces. Households commute to workplaces. Commuting has both pecuniary and time costs.

- *We have identical treatment of identical households. Regardless of their residential location, workplace, or school district, households of the same type attain the same utility level.*
- *The metropolitan area is a closed city and contains three school districts, each of which operates its own schools.*
- *The local public good, education, is produced through a production function defined by peer characteristics and school spending, where spending is financed through local property taxes on residential land as determined by majority voting in each school district.*
- *Labor and land markets clear.*
- *The local government budget balances in school districts.*

3.1. Calibration

The central parameter values for the functional forms used in the model follow those displayed in Table 1. These parameters relate the equilibrium choices of households to relevant aggregate statistics. Recall that the household spends $\frac{\eta_H}{\eta_H+\gamma+\delta}$, $\frac{\gamma}{\eta_H+\gamma+\delta}$, and $\frac{\delta}{\eta_H+\gamma+\delta}$ percent of his net income $Y(r)$ on land, the composite commodity, and leisure, respectively.[20] U.S. average weekly hours of persons working full time are about 40 hours,[21] and the average annual earnings (for individuals 18 years old or more) is \$22, 154 for high school educated workers and \$38, 112 for college graduate workers in 1997. These figures suggest the hourly wages in the CC for unskilled and skilled workers should be calibrated as $w_u \approx \$10.70$/hour and $w_s \approx \$18.30$/hour, respectively. The wages at the suburban center are

[20] For the calculations we begin with the skilled, high-valuation type (*SH*).
[21] The statistical facts, unless otherwise indicated, come from the Statistical Abstract of the United States, 1998.

lower so that a higher fraction of jobs are located at the CC (46.7%).[22] The share of leisure (nonwork time) in the household's budget is $\frac{\delta}{\eta_H+\gamma+\delta} = 1-\frac{40w_s}{24\times 7\times w_s} \approx 0.762$. The data on average annual expenditures of some selected metropolitan statistical areas suggest that a household spends about 20% of his income on shelter. Therefore, we set the budget share for the composite commodity and land as $\frac{\gamma}{\eta_H+\gamma+\delta} = (1-0.762)\times 0.8 \approx 0.1904$ and $\frac{\eta_H}{\eta_H+\gamma+\delta} = (1-0.762)\times 0.2 \approx 0.0476$, respectively. Recall that the preferred tax rate for a type i household is given by $\tilde{\tau}_i = \frac{\alpha_i}{\eta_i-\alpha_i}$ and we had two possible preferred tax rates, one for high-valuation and another for low-valuation type households. The one for high (low) valuation type is set to be about 1.7% (1.1%) of the value of a house, which is the present value of rents generated by the house annually. These relationships provide sufficient information by which to calibrate α_H, α_L, η_H, η_L, γ, δ.

Since the most common practice of commuting in the United States is by car, pecuniary commuting cost per round trip mile is based on the cost of owning and operating an automobile. In 1997, pecuniary cost per mile was 53.08 cents, suggesting a pecuniary commuting cost of $a = \$1.10$ per round trip mile. Assuming the commuting speed is 20 miles per hour within the city, the time cost of commuting per round trip mile is set to be $b = 0.1$ hours per mile.

The population of the city is set to be 3,000,000 households, which implies approximately a population density of 5185 households per square mile.[23] Approximately, 40% of the total population is assumed to be skilled worker households. Moreover, 30% of skilled households are assumed to be low-valuation types. For the unskilled households, 70% are assumed to be low-valuation types. The agricultural rent bid r_a is set to be \$8897 per acre per year.[24]

The metropolitan area is large, and we have a inelastic supply of residential property in any direction in the metropolitan area. In a rich set up with decentralized workplaces, it is not possible to talk about the uniqueness of equilibrium analytically. We rely on computational methods to find all equilibria.[25]

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[22] Ihlanfeldt (1992) reports that wages decline by approximately 1% per mile of distance from the Central Business District (CBD). Here, we consider distance from the central city employment center.

[23] The median population per square mile of cities with 200,000 or more population was 3546 in 1992. Source: County and City Data Book, 1994.

[24] Parameters of the education production function are set to be $c_1 = 5.819, c_2 = 3.975$, $c_3 = 0.461$, so that (q_j, τ_j) preferences of households in different jurisdictions are consistent with (q_j, τ_j) pairs that induce the underlying population distribution. With these parameter values for peers, a school district of all residents with low (high) valuation has a productivity of 5.819 (9.794), a 68% difference in productivity for the higher peer group.

[25] Computational details are available in an appendix from the authors. With benchmark parameters, we identified two more equilibria in which $q_{CC} > q_E > q_W$ and $q_E > q_{CC} > q_W$.

Table 2: Characteristics of communities in equilibrium

Variable	CC	West	East
Quality of education	40.1	59.9	29.9
Tax rate	1.3%	1.66%	1.3%
Expenditure per pupil per year	$1968	$2273	$1876
Efficiency	7.43	9.63	5.82
Average monthly gross rent per acre	$3815	$4054	$3399
Proportion of high-valuation households	33.8%	91.5%	2%

Table 3: Equilibrium percentage distribution of households across communities

	Residence			
Type/Workplace	CC	West	East	All
Skilled Low: CC	3.6		1.2	4.8
Skilled High: CC	10.4	6.3	0.3	17
Unskilled Low: CC	19.6		0.5	20.1
Unskilled High: CC	1.5	3.2		4.7
Skilled Low: West				
Skilled High: West		6.3		6.3
Unskilled Low: West		2.6	1.0	3.6
Unskilled High: West		11.1		11.1
Skilled Low: East			7.3	7.3
Skilled High: East		4.4	0.2	4.6
Unskilled Low: East		0.6	17.8	18.4
Unskilled High: East		2.1		2.1
	35.1	36.6	28.3	100

3.2. Basic Results

The simulation results for the benchmark model are given in Table 2, Table 3, Map 1, and Figures 1 and 2. In the base model, the West School District is the best in terms of the education it provides, while the East is the worst. The West School District attracts mostly high-valuation type households. These high-valuation households put more pressure on the schools and make their schools more productive and efficient. The East School District is the opposite, attracting households with a low valuation of education and resulting in low-quality schools. The majority voting outcome of tax rates in West (East) School district are the preferred tax rates of high (low) valuation type households. To be precise, tax rates for the West and both the East and CC School Districts are 1.66% and 1.3%, respectively. Average rents

We report the one with the highest welfare due to space considerations. The discussions and findings for the benchmark model remain valid for the other equilibria as well. For the policy experiments, the equilibrium is unique.

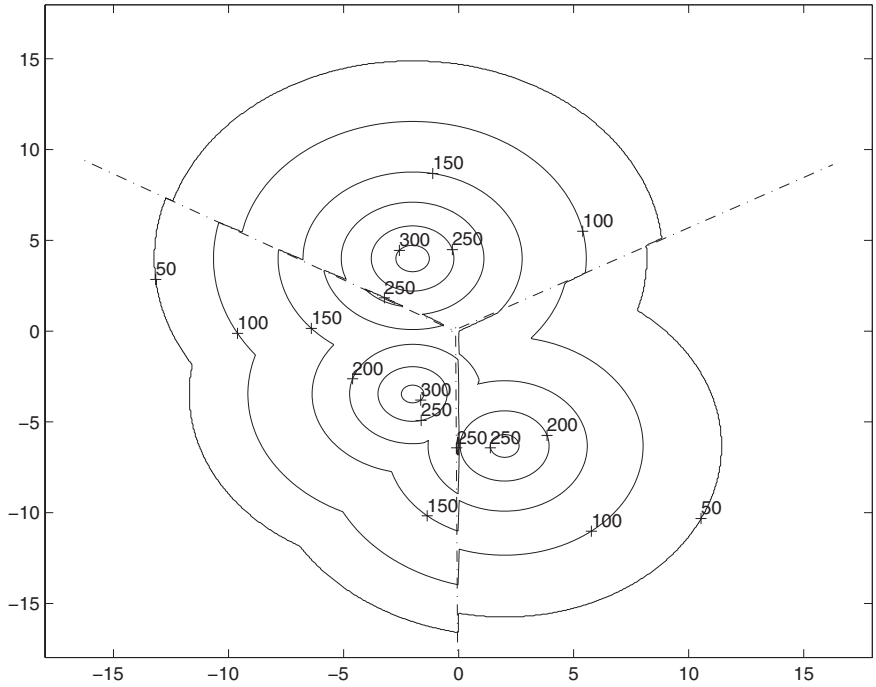

Figure 1: Iso-rent curves for baseline equilibrium.

attain their peak value in the West School District and their lowest value in the East.

The finding seems to be counterintuitive. After all, the east suburban center offers higher wages than the west suburban center, and higher wages are expected to be capitalized into housing prices. However, the quality of education is also capitalized into housing prices, so that what we see is the better education in the West School District leading to the highest housing prices. Moreover, the West School District with the highest property taxes and land prices spends more on education than the other communities in the metropolitan area.

Figure 1 shows iso-rent curves for the metropolitan area. As sites get close to employment centers, we observe a monotonic increase in rents with three local maxima around workplaces. More importantly, we see the capitalization of higher quality of education and higher wages. The rents are higher in the West School District with the best education, compared to the East School District with the worst education. The West School District also provides a much better education than the CC but their rents are almost the same, reflecting the higher wages and greater employment accessibility in the central city.

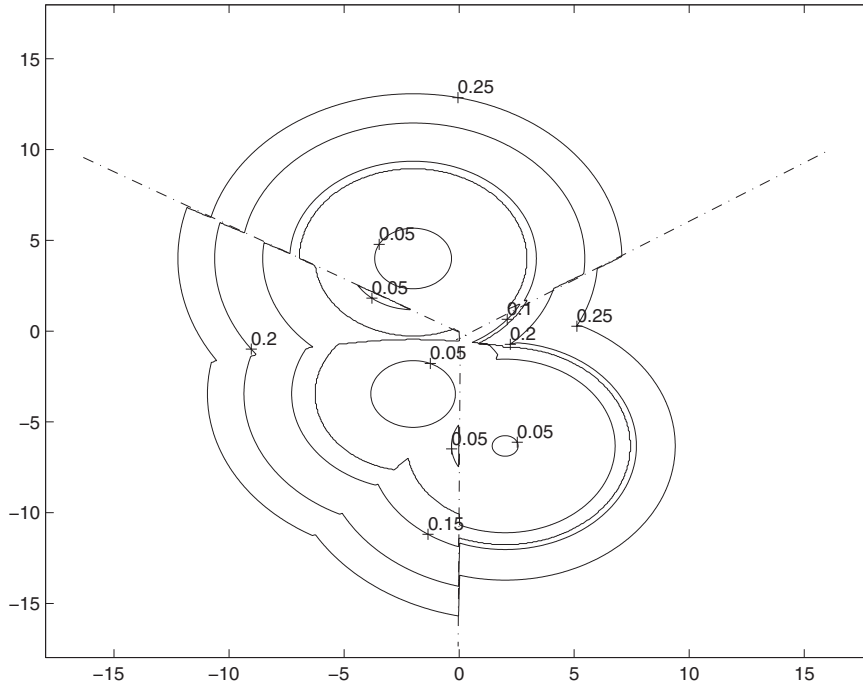

Figure 2: Iso-lot size curves for baseline equilibrium.

The iso-rent rings around the CC center extend to both the West and East School districts, reflecting the presence of in-commuters (see also Map 1). The rings emanating from the CC center in the West School District are different from those in the CC school district. Although households in both rings have a job at the CC center, we see the capitalization of better education and tax package in the West School District. For in-commuters, the rents at locations that are the same distance to the CC employment are highest in the West School District and lowest in the East. There are big jumps in rents as we cross into the West School District from the CC school district. We also see the rings around the East employment center extending to the West School District, showing the presence of households with a job at the East employment center residing in the West School District, again to enjoy a better education.

Map 1 also shows the spatial distribution of households across the metropolitan area in equilibrium. In any school district, the orientation of rings towards a workplace shows the workplace where the ring occupants work. In the central city school district, we have all four types of households with a workplace in the central city and the spatial order is given by Unskilled High, Unskilled Low, Skilled High, Skilled Low as we move away from the CC

workplace. Moreover, in the central school district, we do not see any household with a workplace in the west or east. As we move to the West School District and get away from workplace CC, we see Unskilled High and Skilled High household rings, respectively, with a workplace at the CC. Two types of CC workers (Unskilled Low and Skilled Low) are absent from the West School District, but the spatial order is still valid even in their absence. In the West School District, we also see households with a west workplace, and we see rings in the same spatial order. Skilled Low households with workplace in the west are, however, absent. In the West School District, the scalloped residential pattern also indicates some households with workplace in the east, and the spatial order prevails even though some skilled low valuations with workplace in the east are absent.

Although the central city employs 46.6% of all workers, a much smaller fraction of households, 35.1%, resides in the CC in equilibrium (Table 3). The east suburban center (32.4%) has more workers than the west suburban center (20.7%). The west suburban center can be thought of as a bedroom community with employment concentrated in services for the population. Besides, high-valuation households disproportionately reside in the West School District that provides the best education while commuting to work in the CC ($6.3\% + 3.2\% = 9.5\%$). Also, there are some households (2%) with a job in the CC and residence at the East School District. We do not see any reverse commuters (i.e., residents of the CC getting to and from their workplace at any suburban employment center). Also, note the presence of some households with a workplace at East (West) and residence at West (East), either to commute less or to provide a better education to their children.

Iso-lot size curves are drawn in Figure 2. The pattern is quite similar to iso-rent curves, and similar arguments can be made. The lot size increases monotonically with distance from employment centers and has local troughs at workplaces. Consistent with empirical evidence in the United States, the rich reside in bigger houses away from their workplaces. Once again, we clearly see two effects: Holding distance to workplaces constant, houses in the West School District are smaller than houses in the East and CC School Districts, if those places compared are occupied by the same type of households. This is due to higher rents resulting from the capitalization of better education. Also, observe the rings around the CC extending to the West and East School Districts. In the west, households with a job in the CC accept having a smaller house and/or commute more to provide their children with a better education. Residential densities follow a pattern analogous to rents.

The two suburban areas not only serve very heterogeneous populations but also have very different patterns of school quality and taxes. In fact, the East district provides the worst schools in the area, but this is compensated for by having the lowest rents.

4. Alternative School Finance Policies

Since the late 1960s, courts and legislatures have been concerned with potential inequities in the provision of schooling arising from the differential ability of some districts to raise funds for schools.[26] The focus has been the use of local property taxes to fund schools. The central argument is that differences in the tax base between wealthy and poor districts result in "discrimination on the basis of the wealth of ones' neighborhoods," because wealthy districts could more easily raise funds for schools (Coons, Clune, and Sugarman 1970). Any such funding discrepancies would then lead to poorer schools and lower educational outcomes for poor children. The history of school finance discussions throughout this period involves the interaction of courts and legislatures to move the funding of schools away from local property taxes to some alternative revenue plan (see Murray, Evans, and Schwab 1998, Fischel 2006, and Hanushek and Lindseth 2009).

This section analyzes a series of alternative school finance policies, representing variants of policies that have been discussed or implemented in the recent period of school funding. We start with district power equalization, an alternative funding plan that compensates districts that have a low tax base. Subsequently, we consider full state funding, which in our simplified metropolitan area is fiscally equivalent to district consolidation.

4.1. District Power Equalization

An alternative approach to purely local property taxes is district power equalization.[27] A portion of the funding in many U.S. states is based on a version of this. The central idea is a variable matching grant from the state can be used to equalize the per student revenue yield across varying tax bases for any property tax rate chosen by the district.[28] It explicitly does not call for equal spending among districts, only that all districts are able to realize the same revenues from the same tax effort. (Note that this is not the case in the benchmark, where the CC and the East districts apply the same tax rate

[26] As early as the 1920s, U.S. states were concerned about the differential ability of local communities to fund schools through local taxes, and states generally developed plans to compensate partially for differences in local tax bases. The Strayer–Haig funding plan developed in New York State in the 1920s involved state subsidies that were negatively correlated with the size of the local tax base; Strayer and Haig (1923). The debates about school funding, however, became more intense over the past half century. The modern era of concern about school finance in the states began with the California court case of *Serrano v. Priest* which spread to courts in the vast majority of states.

[27] This was introduced into the debates by Coons, Clune, and Sugarman (1970) and has been a perennial candidate for funding, largely because it was identified as being "wealth-neutral." It is variously called guaranteed tax base, district power equalization, or wealth neutrality.

[28] It is assumed that the state runs a balanced budget in the model.

Table 4: Equilibrium characteristics of communities after district power equalization

Variable	CC	West	East
Quality of education	31.8	58	37.3
Tax rate	1.3%	1.66%	1.3%
Expenditure per pupil per year	$1957	$2186	$1993
Efficiency	5.93	9.68	6.83
Average monthly gross rent per acre	$3675	$4044	$3543
Proportion of high-valuation households	11.4%	94.6%	25.3%
Tax (subsidy) rate	(1.5)%	3.4%	(3.1)%

Table 5: School quality with power equalization and consolidation

Average School Quality			
	Benchmark	**Power Equalization**	**Consolidation**
Skilled households	46.2	44.5	41.7
Unskilled households	43.3	42.2	39.3
High-valuation households	54.4	52.4	47.8
Low-valuation households	36.0	35.2	33.9

but collect varying revenues because the capitalization of school quality and location yields varying tax bases).

Table 4 shows the equilibrium outcome of a move to finance through district power equalization. With revenue and spending choices under district power equalization, the West district again disproportionately attracts people who value schooling highly, but the largest impact is a significant fall in quality in the CC schools. The West School District is the most efficient school district, since it is home mostly to high-valuation households. We also see the effect of access and wages on rents. Rents in the East remain below those in the CC, even though the tax rates and school quality are essentially the same.

If we look at the comparisons of school quality in Table 5, we see that the implications for different types of households is not as simple as prior analyses have suggested.[29] In the simple partial equilibrium setting that motivates much of the discussion of school finance policy, equalizing the ability to raise money is typically seen as a way of improving the education of kids from poor families. But, as the table shows, the average quality of schools for the unskilled residents falls—as it does for *all* family types. The range of schooling outcomes across household types narrows but only slightly.

[29] A table that reports the average school quality for the four types: *SL*, *SH*, *UL*, and *UH* yields a similar pattern.

The most severely hit group is skilled high-valuation households who have to share part of the capitalized rents from high school quality with other groups. Nonetheless, each group finds that the postpolicy equilibrium yields poorer schools. There is a slight narrowing of the gap between low-income (unskilled) and high-income (skilled) families, but it comes at the cost of poorer outcomes overall.

A possible explanation lies in the nature of *convex* peer group effect function. In terms of expenditure per pupil, CC and East School Districts are similar. After district power equalization, the average quality of education is lower for any group because the policy causes the composition ($\frac{N_L}{N_H}$) of these two school districts to become more equal. Another possible explanation is through educational expenditures. As shown in Table 4, expenditures are being taxed in the West School District and subsidized in the CC and East School Districts. Hence, the resources are being reduced in the district with the highest peer group, and increased in the districts with a much lower peer groups.

As Feldstein (1975) previously indicated, this program does not sever the relationship between a community's expenditure per pupil and its wealth (here measured by rents). Communities with the same property tax rates, as in our simulation, might end up with different quality of schools, and tax rates also vary by wealth, depending on community composition.

4.2. Full State Funding

One obvious way to reduce the variation in spending (the objective of many court and legislative decisions) is simply to raise the share of spending that is provided by the state. This is precisely the history of school funding, as the state share of educational funding has gone from 30% in 1940 to 40% in 1970 to 50% in 2000 (U.S. Department of Education 2008).[30]

The extreme is full state funding, where all local choice in funding decisions is eliminated. A close relative of full state funding is school district consolidation where taxes and spending are equalized across merging districts.[31]

The two policies are conceptually somewhat different. Full state funding can still work with separate school districts that make their own educational

[30] Note that the federal government currently provides 9% of total revenues (U.S. Department of Education 2008). These revenues are largely distributed in a compensatory manner that will provide larger funding to districts with more poor people. Thus, even with a flat amount of full state funding, there would be variation across districts. States, however, also have compensatory programs that would amplify such variations. Because the federal share has increased since the passage of the Elementary and Secondary Education Act of 1965, the local share of funding has fallen by even more than the rise in state shares.

[31] In fact, the history of U.S. schooling in the 20th century was one of consolidation of districts. At the beginning of World War II, there were over 115,000 school districts, but this fell to less than 15,000 today.

Table 6: The characteristics of communities after school district consolidation

Variable	CC	West	East
Quality of education	51.1	31	34.7
Tax rate	1.3%	1.3%	1.3%
Expenditure per pupil per year	$1936	$1936	$1936
Efficiency	9.63	5.84	6.55
Average monthly gross rent per acre	$4046	$3439	$3516
Proportion of high-valuation households	91%	7.6%	22.4%

decisions, while consolidation assumes both common funding and common administration. Additionally, consolidation does not have to be done at the state level but instead can be done at lower levels such as the county-wide school districts seen in many southern states. Nonetheless, in our metropolitan area analysis we do not distinguish between full state funding and local consolidation. While there has been prior analysis of district consolidation, the implications both for welfare and for school quality remain uncertain.[32]

This section explores the consequences of school district consolidation. The CC, West, and East School Districts are consolidated under the name Greater City School District. For consolidation, however, we require that students attend their neighborhood schools, which follow the boundaries of the prior school districts. Thus, consolidation and full state funding are both modeled as a policy of common spending and tax policy across all of the neighborhoods/districts.[33]

This imposition of common spending does not, however, imply that outcomes are the same. The metropolitan area moves from the benchmark to a new equilibrium, which is described by Table 6. One striking feature of the new equilibrium is that, although all jurisdictions spend the same amount of money on education, they end up with providing different qualities of education. In a significant change from the prior benchmark, the CC School District offers the best education, while the West School District is the worst. What has happened?

Consolidation eliminates the ability of residents to choose the tax-spending policy that they prefer, thus implicitly elevating the role of

[32] The nature of voluntary consolidation (Brasington 1999) and the potential cost savings from school district consolidation (Duncombe and Yinger 2007) have been previously considered. Calabrese, Cassidy, and Epple (2002) analyze consolidation within the context of a political model and suggest that voters as a group are unlikely to support further consolidation, although they suggest the welfare aspects of consolidation are ambiguous.

[33] District consolidation with a common decision structure across all schools in the consolidated district may, for example, employ compensatory schemes to re-direct funds to one or more of the prior (pre-consolidated) districts or it could pursue various "compensatory" assignment policies within the consolidated districts. We do not look at these potential within-district policies.

workplace accessibility in their decision making. The property tax rate prevailing at equilibrium is, not surprisingly, the preferred tax rate of low-valuation households who represent the majority of households. The driving force in the school outcomes is the impact of peers on schooling outcomes, and high-valuation families systematically move together to the more accessible CC district.

It is now useful to put this policy change into perspective. Table 5 summarized the impacts of policy on the school quality across the different groups of the population. Similar to district power equalization, there is a reduction in the outcome gap by income, but it follows from dramatic decreases in school quality. By attempting equalization, the full state funding plan can actually harm school quality. In addition to the reasons pointed out in district power equalization, the reduced expenditures are behind this result because it is "as if" all districts have a majority of low-valuation households voting a low tax rate.

4.3. Summary of Welfare Changes

The key to these calculations is that we have covered the most commonly advocated policies. These are not the only approaches, but they are the most relevant for current school finance debates, especially as seen in the courts.[34] The results are striking. First, paralleling the actions of legal cases surrounding school funding, spending, and tax rates are equalized as an objective measure of actions to improve the equity of the system. Second, aggregating across the schools attended by the different groups, we see more equality in educational outcomes *at the cost of lowering the quality of schools for all groups*. The equalization inhibits expressing preferences for education through choice of higher taxes, and everybody ends up in lower quality schools. Indeed, this looks like the results in California following the *Serrano v. Priest* court case. The state largely took over funding of all schools, the level of funding of schools fell (compared to other states), and schools dropped to near the bottom of state rankings on student achievement (Hanushek and Lindseth 2009).

Table 7 summarizes the welfare change of households resulting from the previous analyses of policy alternatives. The impact of constrained choices of consolidation on high-valuation households (both skilled and unskilled) is about a half percent consumption loss. But even the unskilled, low-valuation households are hurt, because rents are driven up from the minimums previously available. We also provide an estimate of the consumption change

[34] Two other potential policies complete the full range of options. First, the state or courts could simply declare equal spending across districts. Second, the state could declare a common tax rate. Neither are entirely realistic options because, with differences in the (capitalized) home values, these policies would not address the tax capacity problem that has motivated much of the discussion to date. See Hanushek and Lindseth (2009).

Table 7: Equivalent consumption gains as a result of governmental involvement

Type	Consolidation	Power Equalization
Skilled High	−0.51	−0.20
Skilled Low	−0.48	−0.20
Unskilled High	−0.57	−0.27
Unskilled Low	−0.44	−0.18
Average Total Change (ATC)	−0.35	−0.24

needed to hold household utility constant after the introduction of the policy. To account for a change in the welfare of the nonresident landlords, the average total change in consumption (ATC), that is the average of consumption changes plus the change in average consumption if all the rent income is returned to residents, is reported equally as the last row in the table.

Although we have ideal conditions for governmental involvement—the presence of peer group effects and the redistributive motives for the government to reduce spending disparities—the welfare implications of the policies that are shown Table 7 are somewhat surprising. Due to distortions that could only be captured by a general equilibrium framework, crippling the Tiebout system by divorcing local property wealth (i.e., the price mechanism) from school spending results in welfare losses for *all* households.[35] The worst policy, in terms of welfare loss, is school district consolidation, but district power equalization does surprisingly bad.

5. Sensitivity Analysis

The equilibrium outcomes reported are clearly based upon specific choices of the functional form and parameters for the key underlying utilities and costs. Without an analytical solution, we cannot get away from this parameter dependency. As a way of assessing the generalizability of the results, we consider varying two key sets of parameters: those related to the peer group effect function and those related to importance of the specific taste parameters.

We start out with the parameter of peer group effect function, c_3 which is effectively an index of the advantage of better peers. We consider a range of many simulations in which we increase/decrease c_3 by 10%, and repeat school district consolidation and district power equalization exercises. Due to space consideration, we just report welfare changes after school district consolidation from some simulations in Table 8. Again, compared to the benchmark, everybody is worse off. Though not reported here, average school quality by income or taste groups reconfirms the previous findings.

[35] Our previous analysis based on the classic monocentric employment model (Hanushek and Yilmaz 2007) also found the consolidation led to generalized welfare losses.

Table 8: Welfare change after district consolidation by c_3 relative to its benchmark value (percentages)

Type/c_3	10% lower	10% higher
Skilled High	−0.17	−0.29
Skilled Low	−0.17	−0.29
Unskilled High	−0.24	−0.33
Unskilled Low	−0.14	−0.23
ATC	−0.12	−0.09

Table 9: Welfare change after consolidation by taste parameters

Type/Taste	$\alpha_L = 0.15, \alpha_H = 0.17$	$\alpha_L = 0.15, \alpha_H = 0.19$	$\alpha_L = 0.17, \alpha_H = 0.21$
Skilled High	−0.02	−0.93	−0.84
Skilled Low	−0.05	−0.91	−0.85
Unskilled High	−0.15	−0.48	−0.31
Unskilled Low	−0.04	−0.42	−0.30
ATC	−0.01	−0.50	−0.35

In these variations, the resulting school quality is lower for everybody. Comparable analysis (not shown) for power district equalization also confirms our previous results. Everybody is worse off after the policy is implemented, and all household income groups or taste groups get a lower quality of education.

Table 9 shows welfare change after consolidation for different taste values considered.[36] Recall that taste values determine the willingness to pay, which in turn effectively set the property tax rate. Again, across the different taste values, everybody is worse off, and the quality of education for income groups by income or tastes is lower. [37]

6. Conclusions

This paper develops a unified treatment of urban location theory and Tiebout models of community choice. More importantly, to portray today's urban structure better, it also takes the model beyond the monocentric city model by introducing decentralized employment locations. The base locational outcomes are more consistent with empirical observation.

From an analytical viewpoint, it is clear that considering multiple jurisdictions with decentralized employment opportunities is important. The

[36] To have utility function parameters adding up to one, the parameter η changes as the parameter α changes while the parameters γ and δ remain constant.

[37] For district power equalization, the welfare change and average quality of education for household groups by income or tastes are very similar, although some do not lose with the policy change.

competition among suburban districts, a fact of today's locational patterns, can only be handled with models such as those outlined here. Additionally, when considering the kinds of significant changes in school finance policies that have occurred frequently for the past 50 years, it is extremely important to consider general equilibrium formulations, because households will adjust to the changed attractiveness of different locations in a metropolitan area.

The richness of this depiction of household locational choices does, however, come at a cost. We cannot be completely general but must rely upon fixed specifications and selected values for key parameters. Our parsimonious models, specific functional forms, and even choice of the geometry of the districts must be important at some level. We have no reason to believe that the results are artifacts of the specific choices, and the sensitivity analysis involving alternative values of key parameters yields similar results as the baseline model. Nonetheless, conclusions about the generalizability of the policy simulations must await further analysis.

We use the model to assess the impact of two central types of reforms in the pursuit of equity in school finance on the quality of education and individual welfare. A significant finding of our paper is that households can be uniformly worse off as a result of commonly pursued governmental involvement. In the baseline, communities establish different levels of education and property taxes, and households "vote with their feet" to choose the optimal bundle. The property tax essentially becomes a fee for education and location. When government policy intervenes, our baseline policy assessments suggest that households may not made better off.

Moreover, with governmental involvement, even though districts might end up with the same expenditure per pupil, they end up providing different levels of education—precisely what is seen across school districts today. Improving the fiscal capacity of schools may be a necessary requirement to improve outcomes, but clearly it is not sufficient to achieve equity of educational opportunity. Operating on just the spending margin might not make the situation better, even when one has specific distributional objectives.

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