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A MODEL OF MULTIPLE DISTRICTS AND PRIVATE SCHOOLS: THE ROLE OF MOBILITY, TARGETING, AND PRIVATE SCHOOL VOUCHERS

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ABSTRACT

This paper presents a multi-district model that can be calibrated to data reflecting housing market conditions, public school finance mechanisms and private school markets. Simulations are undertaken to investigate the impact of private school vouchers. Households that differ in both their income and in the ability level of their children choose between school districts, between neighborhoods within their school district, and between the local public school or a menu of private school alternatives. Local public school quality within a district is endogenously determined by a combination of the average peer quality of public school attending children as well as local property and state income tax supported spending. Financial support (above a required state minimum) is set by local majority rule. Finally, there exists the potential for a private school market composed of competitive schools that face production technologies similar to those of public schools but that set tuition and admissions policies to maximize profits. In this model, it is demonstrated that school district targeted vouchers are similar in their impact to non-targeted vouchers but vastly different from vouchers targeted to low income households. Furthermore, strong migration effects are shown to significantly improve the likely equity consequences of voucher programs.

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1. Introduction

Persistent frustration with the perceived low quality of public education, exacerbated by concerns over the inherently unequal levels of public school quality across school districts, has caused policy makers, courts and researchers to investigate modifications and alternatives to the current public school system. One idea that has received increasing academic and public attention is that of private school vouchers, with proponents arguing that the competitive pressures of voucher programs would cause improvements in the efficiency of the public school system while at the same time addressing equity concerns if vouchers can be targeted to low income households or low income school districts.[2] But aside from a few limited experiments in some US cities, our experience with vouchers in the US remains virtually nonexistent.[3] This limits the amount of information researchers can derive from standard empirical analysis in that it forces them to rely on only *current* (non-voucher induced) differences in competition (Hoxby (1994)). Despite important suggestive results, such work may not anticipate all the impacts from a large scale policy such as the voucher policies currently under discussion. At the same time, theoretical models of school finance are also limited in that they often either focus on only one particular aspect of the general equilibrium school finance problem, or they are too rich and complex to yield crisp predictions.

It is for this reason that there is great potential for simulation approaches which combine empirical evidence from household choices between school districts with rich but complicated

[2] The most prominent of these experiments is taking place in Milwaukee where a limited number of vouchers are targeted to low income households (see Rouse (1998) for early evidence on they impact). For other instructive discussions and references, see Levin (1992).

[3] Other countries, such as Chile, have more experience with vouchers, but it is unclear how much we can learn from these experience for US policy given the very different cultural factors (Carnoy and McEwan (1997)).

theoretical models. This combination allows for a narrowing of the relevant parameter space in general equilibrium models that would otherwise be of little predictive value. Careful calibration combined with thorough sensitivity analysis can then lead to simulations that offer a first order approximation of likely impacts of private school vouchers under different assumptions about factors we currently have little evidence on. Such an approach can serve to clarify the nature and magnitude of the general equilibrium forces that are likely to emerge under vouchers and to guide empirical research in searching for more information on important factors that we know too little about.

It is this research strategy that I employ here. Specifically, I attempt to explore the impact of voucher policies on the distribution of educational opportunities across school children by tracing each policy's likely impact on household choices within a general equilibrium multi-community economy. The theoretical model that is employed has several unique features: (i) each school district can be composed of multiple types of neighborhoods that may differ in house quality and local neighborhood amenities and externalities; (ii) households, who differ in income and child ability, jointly choose between school districts, neighborhoods within districts and public and private schools; (iii) school quality is determined by a combination of peer quality within the school and per pupil spending, and peer quality is determined by both parental and child characteristics; (iv) both local property and state income taxes are used to fund public schools, with local property taxes resulting from a public choice process; and (v) private schools seek to maximize profits by setting tuition and admissions policies in a competitive environment. The first of these features is particularly useful in that it allows for imperfect Tiebout sorting of the type we observe in the data for most school districts, while the remaining features lend themselves to calibration in other dimensions.

The overall approach of this paper differs most dramatically from many previous studies on vouchers in that it considers the private/public school choice faced by parents as part of a larger choice problem and therefore draws particular attention to the importance of considering mobility and migration when designing school finance policies in general and private school voucher policies in particular. In retrospect, it seems surprising that, despite the widespread acknowledgment that variances in public school quality play a large role in shaping the current location choices of households (and vice versa),[4] little attention has in fact been given to the possibility that state wide voucher programs might cause significant changes in residential location patterns by severing the strong link between place of residence and school quality. In previous work (Nechyba (1999)), however, I employed a simpler and more theoretical version of the model utilized in this paper to suggest that general equilibrium Tiebout effects can be important when vouchers are introduced into stylized state school systems. The clear forces emerging in the model are quite basic: As vouchers are introduced into the multi-community economy, private schools form in low income communities to serve middle to high income immigrants who move to take advantage of lower house prices. Only if housing of sufficiently high quality is not available or if large negative neighborhood externalities exist in the low income communities will private schools emerge elsewhere first.[5]

Given this basic insight, I focus here more sharply on the potential of residential mobility to change the way we think about voucher policies by employing a richer and more realistic model than

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[4] See Nechyba and Strauss (1998) and references therein for empirical evidence of the impact of public schools of residential location choices. Lankford and Wyckoff (1997) provide further compelling evidence on the importance of parental choices in changing segregation patterns.

[5] While the empirical evidence on private school formation is quite sparse, the basic observation that private schools are likely to appear in low quality districts conforms strongly with the available empirical evidence from California which experienced a dramatic rise in the number of private schools after the *Serrano* court decision and the passage of Proposition 13 in the late 1970's (Downes and Greenstein (1997)).

that used previously and by embedding a state finance system that mirrors one that is actually in practice. I then focus on three different types of state financed voucher programs: (i) a general voucher that can be used by anyone choosing to send their child to private school; (ii) a voucher program targeted only to low income households; and (iii) a voucher program targeted to low income/low public school quality districts. These vouchers programs are demonstrated to have quite different impacts depending on the degree of mobility of households.

The remainder of the paper proceeds as follows: Section 2 briefly reviews some of the relevant literature and presents the motivating intuition for this paper, and Section 3 lays out the model and calibration formally. Section 4 defines the three different voucher programs and reports simulation results under different assumptions of mobility, and Section 5 concludes.

2. A Brief Look at the Prior Literature[6]

As mentioned in the introduction, most prior models of vouchers have focused mainly on the public/private schooling dimension of choice, but not on the jurisdictional and neighborhood dimensions. Early approaches in this tradition have yielded the following powerful insight: Assuming that private schools discriminate on ability and "skim the cream" off the public system, a classic tradeoff may arise: on the one hand, vouchers may cause peer quality in public schools to decline, while on the other hand public school quality may improve due to competitive pressures on an inefficient public system. An emphasis of the latter effect essentially encompassed Friedman's (1962)

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[6] No attempt is made here to review the entire literature on school finance or school competition. Instead, due to space considerations, a few recent highlights are provided. For more extensive reviews, see many of the cited articles, as well as a recent comprehensive survey by

original argument, and the tradeoff between these effects was formalized by Manski (1992),[7]. Unfortunately, however, we still have little empirical evidence regarding the relative magnitude of these forces under large scale vouchers.[8]

For this reason, more recent theoretic and simulation approaches have taken the Friedman/Manski insight as given while attempting to focus on other aspects of the problem.[9] Epple and Romano (1998), for instance, forgo attempting to model or quantify the degree of productive inefficiency in public schools and instead focus on inefficiencies that arise from peer externalities. Their interesting results suggest that, if private schools can observe peer externalities and are able to discriminate in their tuition policies, profit maximizing behavior on their part leads to an internalization of these externalities and results in an improvement of efficiency in the school sector.[10] Furthermore, low income/high ability children might benefit in a voucher system as private schools seek to purchase their peer quality with sizable scholarships, while low income/low ability children

[7] Manski (1992) himself suggests that, from a policy perspective, the cream skimming effect is likely to outweigh the competition effect and is thus critical of vouchers. For a recent critique of some of the normative analysis, see Moe and Shotts (1996). Some other recent approaches have also been critical of the notion that vouchers might improve school quality when public schools are efficient (see, for example, Rangazas (1997)).

[8] See Hoxby (1994) for evidence relating existing private school concentrations to public school performance and Hoxby (1998) for a discussion of how existing evidence can be interpreted as generally positive in regard to competitive effect on public schools, and see Witte (1992) for a recent suggestion that little can be inferred from previous evidence. Also, see Evans and Schwab (1995), Neal (1997) and Figlio and Stone (1997) for somewhat differing evidence regarding Catholic school performance.

[9] One notable exception is the political and institutional analysis offered by Chubb and Moe (1990).

[10] More precisely, the distribution of students across private schools in the absence of free public schools is shown to be efficient *if* the number of private schools is efficient. Since this number is exogenous in ER, only constrained efficiency is guaranteed. Caucutt (1997) presents a different model in which she allows for the number of private schools to emerge endogenously and is able to prove a first welfare theorem in the absence of public schools. Schwab and Oates (1991) demonstrates that, just as private schools may internalize peer group externalities through pricing, more activist public schools could accomplish the same by charging low peer quality students higher taxes.

would be worse off due to the exit of high ability children from public schools. In an extensions of their approach (Epple, Newlon and Romano (1997)), it can further be demonstrated that public schools may be able to use "tracking" within public schools as one tool to compete with private schools by raising school quality internally for high ability children. However, the model assumes a single public school district and thus abstracts away from issues related to school district choice.

Several recent efforts have begun to analyze multi-community models.[11] DeBartolome (1990) uses a two community model with peer effects to point out inefficiencies from voting when voters ignore the impact of migration. More recently, Fernandez and Rogerson (1996) also use a simple two community model (without peer effects) to investigate redistributive state policies in the presence of migration and find that policies which raise the fraction of wealthy residents in poor communities tend to be welfare enhancing. This conclusion is mirrored in some of the results presented in Nechyba (1999). Finally, Epple and Romano (1995) introduce multiple communities into their framework but do not focus on vouchers.

The nature of the additional effect of voucher induced migration is, of course, neither mysterious nor difficult to model. Suppose, for example, that a continuum of households with identical preferences but different incomes separate into two public school districts in the absence of vouchers (and that none of the households chooses private schooling). Further suppose that the two communities are identical in every way, and that the housing in each community is identical and exogenously given. Under certain conditions, an equilibrium in such a model will entail a separation of households into these communities by income, with the higher income community imposing higher

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[11] Other notable paper investigating different aspects of vouchers in a single community setting include Glomm and Ravikumar (1995) and Hoyt and Lee (1996).

property taxes and funding better schools.[12] Furthermore, the tax inclusive price of housing in the wealthy community must be higher than that in the low income community (to prevent low income households from moving into the community with the better public schools). Now suppose a state funded voucher program was instituted in this two community world. In the absence of mobility, it is then ambiguous whether private schools will arise first in the poor or the wealthy community: If public schools are sufficiently good in the wealthy community and sufficiently bad in the poor community, then the highest income household in the poor community would be the first to utilize the voucher. Otherwise, the highest income household in the wealthy community would be the first to choose private schools and thus give rise to private schools in the wealthy community. Under full mobility of households, however, high income households in the wealthy community would never simultaneously choose private schools *and* stay in the wealthy community in which the tax inclusive price of housing is higher. Thus, private schools would unambiguously arise in the poor community, either because of local demand or because of demand from immigrating households.

While a simple model of the kind outlined above can therefore illustrate basic migration forces, it helps us little in determining whether such forces are likely to be of empirical relevance given the much richer environment into which vouchers would be introduced. In particular, available housing is not identical across communities, neighborhood amenities other than public schools are important in location choices, and neighborhood externalities may inhibit mobility. We therefore now turn to the exposition of a richer model, calibrate it, and investigate the likely magnitude of migration and general equilibrium effects from the introduction of private school voucher programs.

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[12] Note that this is just a simplification of the familiar Epple, Filimon and Romer (1993) model in which housing is not exogenous.

3. The Model

As mentioned above, the theoretical model on which this paper's simulations are based is an extension of Nechyba (1999) which builds a private school market into a well defined local public goods economy first explored in Nechyba (1997a). It takes as given the boundaries that divide a fixed set of houses into school districts and places no a priori restrictions on the mix of house and neighborhood qualities within and across these boundaries. This allows the model to accommodate the empirically important possibility of the coexistence of rich and poor "neighborhoods" within a single school district.[13] Each household is endowed with a house (which can be sold at the market price), a parental income level and an ability level for its one child. The parental income level combined with the child's ability determine the child's peer externality within a school, and a school's quality is determined by the interaction of the average peer quality of children within that school and per pupil spending. A child is therefore assumed to impact his peers in two ways: first, through his parents' income level and second through his own ability. The former of these captures the fact that parental involvement and monitoring of schools increases in household income (see, for example, McMillan (1998)), while the latter captures spillovers within the classroom. Parents take endowments as given and choose (i) where to live, (ii) whether to send their child to the local public or a private school, and (iii) how to vote in local elections determining the level of public school spending. A more formal exposition of these elements of the model follows.

[13] At the same time, however, the assumed exogeneity of the housing stock and neighborhood effects and the fixed nature of the political boundaries make the model ill suited for explaining either the evolution of observed intradistrict neighborhood structures or the formation of political jurisdictions. Instead, the model seems most appropriate for analyzing policy issues for a relatively stable and developed urban/suburban economy.

3.1. *Community Structure*

The set of houses is represented by the unit interval N=[0,1].[14] A fixed school district and neighborhood structure

$$C = \{C_{dh} \mid C_{dh} \cap C_{d'h'} = \varnothing \ \forall\ (d,h),(d',h') \in D \times H \text{ s.t. } (d,h) \neq (d',h') \text{ and } \cup_{d \in D, h \in H} C_{dh} = N\}$$

is imposed on this set and partitions it into a set of house/neighborhood types $H=\{1,\ldots,h,\ldots,H\}$ spread over a set of school districts $D=\{1,\ldots,d,\ldots,D\}$. C_{dh} is then the set of houses of type h located in district d, or the set of houses in "neighborhood h" of community d. The calibrated computable general equilibrium (CGE) version used in this paper sets H=5 and D=3. This implies the existence of 15 different neighborhoods spread over 3 school districts, where the measure of houses in district d is denoted $\mu(C_d)$, and the measure of houses in neighborhood h of district d is $\mu(C_{dh})$.

The school districts in the CGE model are assumed to be of equal size (i.e. $\{\mu(C_1), \mu(C_2), \mu(C_3)\} = \{1/3, 1/3, 1/3\}$) and are intended to be representative of low income, middle income and high income school districts in the suburbs of New York City. Using 1990 School District Data Book (National Center for Education Statistics (1995)) and Census (Bureau of the Census (1992)) data from all districts in southeastern New York, school districts were divided into three categories by median household income such that each category ended up with roughly equal numbers of households. Table 1 gives summary statistics for each class of districts. Furthermore, each district in the CGE model is divided into five equally sized neighborhoods. From price data on houses in the various district types I am able to infer neighborhood quality parameters that enter directly into utility functions by a process described in detail in Section 3.6. For now I simply note that this calibration

[14] More precisely, the set of houses is defined as part of a measure space (N,N,μ) where μ is taken to be the Lebesgue measure. All subsets referred to are henceforth assumed to be measurable.

translates a near-continuum of house qualities observed for each district type into 5 discrete quality intervals (neighborhoods) of equal sizes. More precisely, one fifth of all houses in district d are assigned the house/neighborhood quality of the median house observed in the data for that district and are labeled houses of neighborhood type h=3. Similarly, neighborhoods 2 and 4 represent "somewhat below average" and "somewhat above average" house qualities respectively, and one fifth of all houses within district d are assigned quality levels corresponding to those observed at the 30^{th} and 70^{th} quality percentile for that district type. Finally, neighborhoods 1 and 5 represent the worst and best houses in a particular district, and one fifth of all houses in district d are assigned the quality level observed for the houses in the 10^{th} and 90^{th} percentile (respectively). Note that because I employ price data to calibrate house qualities within districts, I capture both characteristics of the houses and characteristics of the neighborhoods in one measure. Thus, the model allows for both neighborhood externalities and amenities as well as house qualities to determine the character of neighborhoods within school districts. In the simulations below it will then be assumed that these quality levels are fixed once the benchmark (no voucher) equilibrium has been fully calibrated, and that migrations of households do not change neighborhood qualities. However, I will argue in the conclusion that, if anything, this biases the model against the results I report in Section 4.

3.2. *Endowments and Preferences*

Households in the model are endowed with income, a house, a child with some exogenous ability level, and preferences over the consumption set. Both the income and the house endowment, however, can be viewed as private good endowment, except that the value of the house endowment is endogenous.

More precisely, it is assumed that there is one and only one house for each household in the model, and neither multiple residences nor homelessness are allowed. Thus, the unit interval N=[0,1] which represents the set of houses also represents the set of households, and each household is assumed to have one child. Initially, an endowment function z:N→$\mathbb{R}_+$ divides this set of households into a finite set of "income types."[15] The income endowment function chosen for the CGE model creates 10 income types and replicates a discretized version of the actual household income distribution observed for the New York districts used in the calibration . Incomes in the model therefore range from 1 (corresponding to $10,000) to 10 (corresponding to $100,000), and the measure of agents with different levels of income is given by the observed household income distribution in the data. It should be kept in mind that this eliminates from the model extremely poor and extremely wealthy households by truncating the income distribution at 1 and 10. Given that it is likely that such extreme households are often motivated by factors quite different from the middle class (broadly defined), however, this appears to be a minor limitation of the model.

In addition to income, each household is endowed with one house (the value of which is determined endogenously in equilibrium), and each income type is initially spread uniformly across all neighborhoods (in all school districts). Given that this is a static model calibrated to annual data, the "value" of a house is defined as the annualized flow of housing/neighborhood services from that house. Furthermore, it is important to note that, while some low income households are endowed with high quality houses, this does not imply that these low income households actually *live* in high priced houses. Rather, on the way to determining the benchmark equilibrium from which the

[15] The assumption of finiteness of the number of income types is made for technical reasons related to the existence of an equilibrium. These issues are discussed in detail in Nechyba (1997a).

simulations start, households buy and sell houses on the market at market prices. Thus, those low income types that are endowed with a high quality house will not remain in that house in the benchmark equilibrium. The house endowments therefore are just like income endowments except that their value is determined endogenously. In practice, the value of these endowments (i.e. the value of the annual flow of services from these endowments) falls between 0.3 and 2.5 and thus simply serves to smooth out the discretized income distribution. This causes the initial set of 10 income types to become 150 endowment types, where the distribution of the value of the combined income and house endowments now more smoothly replicates the income distribution observed in the New York districts.

Each household $n \in N$ is also assumed to have one child, and ability levels are assigned via a function $a: N \rightarrow \mathbb{R}_+$. In the CGE model, ability levels take on 5 different possible discrete values which are set to correspond in magnitude to parental income levels (which range from 1 to 10).[16] Solon (1992) and Zimmerman (1992) provide a point estimate for the empirical correlation of parental and child income of 0.4 which I use as a proxy for the correlation of parental income and child ability;[17] i.e. I assign the five ability levels in equal measure but distribute them in such a way as to make the correlation between parental income and child ability equal to 0.4. Given the 150 endowment types specified above, this addition of ability levels generates a total of 750 types.

Finally, each household $n \in N$ is assumed to act as one utility maximizing agent with utility

[16] These values are admittedly arbitrary, but sensitivity analysis has shown that changing either the mean or variance of these numbers has little qualitative or quantitative impact on the results presented in this paper.

[17] One can also interpret the correlation between parental and child income of 0.4 as an upper bound on the correlation between parental income and child ability because of the correlation of school quality and parental income. Sensitivity analysis with versions of the model that drive the correlation to 0, however, suggest this makes little difference for the results I report.

function $u^n{:}D\times H\times\mathbb{R}_+^2\rightarrow\mathbb{R}_+$ that takes as its arguments the district and neighborhood the agent lives in, his private good consumption $c\in\mathbb{R}_+$, and the perceived school quality level $s\in\mathbb{R}_+$ enjoyed by the household's child.[18] In principle, few restrictions on utility functions are necessary for the existence of an equilibrium (Nechyba (1997a)), and preferences may vary across household types. Under the assumption of heterogeneous preferences, however, the potential of a large multiplicity of equilibria arises, which is why the CGE model restricts all types to have the same Cobb-Douglas utility function:

$$u^n(d,h,s,c) = k_{dh}\, s^\alpha c^\beta \quad \forall\ n\in N.$$

The determination of s is explored next, and the calibration of $\{k_{dh} | d\in D, h\in H\}$, α and β is described in Section 3.6.

3.3. *Production of School Quality*

Both public and private schools combine per pupil spending with average peer quality to produce the output s that enters the utility functions of the households. A child's peer quality $q(n)$ is jointly determined by his parents' income level and his own ability through a process captured by the function $q(n) = (z(n)^\theta\, a(n)^{(1-\theta)})/7.5$.[19] Thus, as θ increases, the importance of parental income

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[18] The household production literature (Becker (1991)) suggests school quality is only one of the inputs in the production of student achievement, and that others include such factors as parental commitment of time and resources. In light of this, the utility function specified in this model should be viewed as somewhat "reduced form." A more complete model might specify a technology by which child ability combined with school quality and parental inputs produces future consumption, and households care about this future consumption rather than school quality per se. The current reduced form utility function, however, can be derived from the more complete model under certain specific assumptions (see Nechyba (1999)), and none of the main conclusions of this paper change under a more complicated model of preferences and technologies.

[19] The function is divided by 7.5 in order to make peer quality similar in magnitude to per pupil spending. This is of no consequence other than that is eases the interpretation of the parameter ρ in the next equation.

increases while that of child ability declines. One possible interpretation of this is that θ represents the degree to which peer effects work through the channel of parental monitoring (which increases in parental income) as opposed to the child's inherent ability. Letting x be equal to per pupil spending and q be equal to average peer quality, household choices are then assumed to be made as if the school production function were accurately described by the constant returns to scale process:

$$s = f(x,q) = x^{(1-\rho)} q^{\rho} \text{ where } 0 \leq \rho \leq 1.$$

Note that so long as $\rho<1$, this implies that additional material resources (x) are viewed by parents as translating directly into gains in school quality. Although the accuracy of this view is challenged in much of the empirical education literature (Hanusheck (1986)),[20] there is overwhelming evidence that per pupil spending *does* affect parental location and voting choices. This evidence dictates that, in any model that seeks to predict policy-induced changes in parental behavior, per pupil spending *must* be perceived by parents to have a marginal product greater than zero. The specification of *f* is therefore intended merely to reflect the fact that both peer quality and per pupil spending affect parental choices. Normative implications of the results, however, depend on how one resolves the puzzle that a large part of academic research suggests a marginal product of per pupil spending close to zero while parents act as if it was quite large.[21] Since different explanations of this puzzle have different

[20] Debate over this continues, as demonstrated by the recent work of Card and Krueger (1992), Betts (1996), Heckman, Layne-Farrar and Todd (1996), Barro and Lee (1997), Hanushek (1998) and Krueger (1998).

[21] There several ways of resolving this puzzle. First, while economists typically quantify school quality with test scores or future wages, parents may define "quality" more broadly to include other aspects of schools (such as music classes, athletic activities, the attractiveness of school buildings, etc.). If so, $\rho<1$ is not inconsistent with the "money does not matter for test scores" result of the Hanushek literature. Second, spending may *appear* not to matter for test scores because, whenever spending falls, parents compensate by engaging more unobservable effort at home (Houtenville (1996)). In that case, parents would care about spending despite the empirical observation that spending is uncorrelated with test scores. Third, Lazear (1999) argues persuasively that, if class size is determined endogenously and peer quality matters in the sense that disruptive students are particularly damaging, then it will appear that class size does not matter when in fact it does.

normative implications, the reader is left to make his own judgements regarding the actual importance of x in relation to q, and simulation results will report x and q alongside s.[22] (This is also one of the reasons I forego a detailed welfare analysis using utility functions in the simulations that follow.) The calibration of the parameter ρ is left to Section 3.6.

3.4. *Public School Equilibrium*

Before defining an equilibrium formally, the public choice process that determines average public school spending in district d (x_d) must be specified. Let $\eta \subseteq N$ be the subset of households that choose to send their children to public school. Then per pupil spending in district d is

$$x_d = (t_d P(C_d) + AID_d)/\mu(\eta \cap J_d),$$

where t_d is the local property tax rate in district d,[23] AID_d is the total state aid received by district d, and $P(C_d) = \sum_{h \in H} \mu(C_{dh}) p(C_{dh})$ is the local property tax base. This base varies with the endogenously determined house price function $p: D \times H \to \mathbb{R}_+$ that gives rise to an equilibrium house price vector $p \in \mathbb{R}_+^{DH}$ and thus assigns a unique price to each house type in each district. The formula underlying

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[22] While many studies focus on the impact of spending on both educational quality and on parental choices, few papers investigate the impact of peer effects on either of these variables. Again, for purposes of the present analysis, the precise nature of peer effects is secondary as parental beliefs are more important. It seems quite plausible, therefore, that parents view schools with higher income parents and higher ability children as better schools. The specification of peer effects in the function *f* is, however, consistent with the general empirical findings of Henderson, Mieszkowski and Sauvageau (1978) who suggest that peer effects are equally important for high income and low income students. Summers and Wolfe (1979), on the other hand, find (in a different setting) that less able students benefit from more able peers but high ability students are not affected by the presence of low ability student, while Evans, Oates and Schwab (1992) cast doubt on much of this literature by demonstrating that, in the case of teenage pregnancy and school dropouts, evidence of peer effects vanishes as endogeneity problems are taken into account. But, more recent cross country evidence is again generally supportive of the importance of peer effects (Toma (1996), Zimmer and Toma (1997)), although the literature is far from settled on appropriate functional forms. For an excellent demonstration of the empirical difficulties involved in measuring peer effects, see Manski (1993), and for a recent survey supportive of using peer averages, see Moreland and Levine (1992). Lazear (1999) recently presented a different view of peer effects in which extremes rather than averages matter.

[23] Nechyba (1997b) shows that the use of property taxes is the dominant local tax strategy in this model.

AID_d may in principle contain a variety of matching and block grant features which are taken into account by voters as they vote on local tax rates.[24] The CGE model contains state aid levels corresponding to those found in the representative districts in New York in 1990. Throughout the simulations, these aid levels (reported in Table 1) are taken as exogenous (on a per pupil basis). Furthermore, it is assumed that there exists a constitutionally set minimum spending level of 0.6 (which lies below the lowest spending level in the initial benchmark equilibria.) This is to add some realism to the public choice process in that it does not permit majorities who attend private schools to vote for zero spending on public education, and it prevents simulations from finding trivial equilibria in which no public schools exist.

While voters do take into account state aid, they are otherwise assumed to be quite *myopic* - i.e. they take community composition and property values as given when going to the polls. Such voter myopia is technically convenient and thus relatively standard in the literature (see Epple, Filimon and Romer (1993), Dunz (1986), Rose-Ackerman (1979)). In the absence of private schools, a voting equilibrium for a given partition of the population is then obtained relatively easily as myopic preferences over local tax rates are single peaked (Nechyba (1997a)). For expositional purposes I therefore define a full equilibrium in two steps: First I specify a *public school equilibrium* under which private schools are prohibited, and then I proceed to expand the definition to an *actual equilibrium* that includes endogenously generated private schools. While the *actual* equilibrium must specify a list $\{J,t,s,p,\eta\}$ that includes a partition of households into districts and neighborhoods J, local property tax rates $t\in\mathbb{R}_+^D$, local public school qualities $s\in\mathbb{R}_+^D$, house prices $p\in\mathbb{R}_+^{DH}$ and a

[24] Nechyba (1996, 1999) demonstrates that the specific form of state aid formulae may indeed have large impacts on the nature of equilibria in the context of this model.

specification of the sub-set of the population that attends public rather than private schools $\eta \subseteq N$, the *public* school equilibrium artificially forces η=N.

<u>Definition</u>: A *public school equilibrium* is a list {J,t,s,p,η} such that

(1) $\mu(J_{dh})=\mu(C_{dh})\ \forall\ (d,h)\in D\times H$ (every house is occupied);

(2) Property tax rates t are consistent with majority voting by myopic residents;

(3) $s_d=f(x_d,q_d)$ for all d $\in D$, where $x_d=(t_dP(C_d)+AID_d)/\mu(\eta\cap J_d)$ (budgets balance) and $q_d=((Z(\eta\cap J_d))^{\theta}\ (A(\eta\cap J_d))^{(1-\theta)})/7.5$;[25]

(4) At prices p, households cannot gain utility by moving (market clearing); and

(5) η = N; i.e. everyone attends public school.

The theoretical properties of this type of equilibrium are explored in detail in Nechyba (1997a) where it is demonstrated that, under relatively weak assumptions, such an equilibrium is guaranteed to exist. Furthermore, with sufficient variation in mean house quality across districts, the equilibrium assignment of agents across neighborhoods and communities is unique (Nechyba (1997a, 1999)).[26]

3.5. *Actual Equilibrium (including private schools)*

Here, however, the focus is explicitly on the policy consequences of state voucher programs *in the presence of private alternatives* to public schools. Therefore, the definition of a public school

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[25] $Z(J_d)=\int_{Jd} z(n)\,dn$ and $A(J_d)=\int_{Jd} a(n)\,dn$ are the average income and the average ability level (respectively) of the population assigned to district d.

[26] Without variation in housing quality, such uniqueness does not happen. Consider, for example, the case in which house qualities are identical across all communities and all neighborhoods. Then there is nothing in the structure of the model that tells us which district will contain the high income households. With sufficient variation in housing quality, high income households will always end up in high quality communities and uniqueness is obtained. Due to the discreteness of housing, however, house prices can vary within small intervals. The size of these intervals is decreasing in the number of housing types, and experiments with the current CGE model suggest that, with 15 house qualities across five districts, these intervals are quite small.

equilibrium must be expanded to allow for the emergence of private schools. As noted in Nechyba (1999), this raises two theoretical problems: First, Stiglitz (1974) points out that single peakedness of preferences over tax rates is lost in the presence of private alternatives, which implies that, in the absence of additional assumptions on voter behavior, a voting equilibrium does not exist.[27] For present purposes, however, this problem is solved by simply extending the definition of voter myopia to include the choice of private or public schooling (in addition to community composition and property values) as a factor voters take as given when voting. Thus, preferences over taxes for those voters who choose public schools remain single peaked as before, and preferences for voters who chose private schools are single peaked with peak at $t=0$ (in the absence of state aid) or $t<0$ (under state aid).[28] However, the assumption of a constitutionally set minimum level of spending prevents majorities to impose negative property tax rates.

The second problem is that a model for private school markets must be introduced into the already complicated Tiebout framework. I make two simplifying assumption: (1) there is free entry into the private school market, and (2) private schools are prohibited from differentiating between students in their *tuition* policies but are not prohibited from differentiating between them in their *admissions* policies. Each private school that opens therefore announces two characteristics: the tuition rate that is charged per child, and the minimum peer quality accepted into the school. [29]

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[27] Recent contributions to the public choice literature on voting in the presence of private alternatives include Epple and Romano (1996) and Glomm and Ravikumar (1998). The problem is generally studied in single community settings, and proposed solutions are difficult to import into the current multi-community framework.

[28] As pointed out in Nechyba (1999), this leads to the existence of trivial equilibria in which there are no public schools (and, given everyone attends private schools, no public schools arise). In the simulations, however, these trivial equilibria are reported only if there does not exist an equilibrium with public schools.

[29] Note that, for technical reasons in part exposited in Nechyba (1999), this differs from the model of Epple and Romano (1998) in which schools discriminate in their tuition but not their admissions policies.

Given that there are no set-up costs or increasing returns in the production technology *f* faced by private schools, it is then immediate that all parents whose children attend a particular private school must be of the same endowment and peer type in equilibrium and that they pay tuition that is exactly equal to their most preferred level of per pupil spending. Suppose, for a moment, that this were not the case. In particular, suppose that a private school provided education to children of two different income types. Then a new school that offered admission only to the higher income type (at the same tuition) would improve the utility of the higher income parents (because of the higher overall peer quality achieved through selective admissions). Under free entry, such a school would in fact arise. Similarly, free entry eliminates all tuition levels other than those most preferred by parents.[30]

This definition of a private school market then allows for an expansion of the definition of a public school equilibrium in which η is artificially set to N to one in which η is arises endogenously.

Definition: An *actual equilibrium* $\{J,t,s,p,\eta\}$ is the same as a public school equilibrium except that conditions (4) and (5) are replaced by (4') and (5'):

(4') At prices p, households cannot gain utility by moving *and/or changing schools*;

(5') The private school market is perfectly competitive, and private schools are able to discriminate in their admission policy but not in their tuition policy.

The existence of such an equilibrium is guaranteed. (See Nechyba (1999) for a more extensive discussion on both existence and uniqueness issues).

[30] For a formal proof of this, see Nechyba (1999).This is similar to the familiar logic that underlies the Hamilton (1975) local public finance result that zoning results in homogeneous communities. In that model, communities (rather than private schools) fix a local tax/spending package (analogous to tuition levels) and set a minimum zoning (rather than peer quality) level. Nechyba (1999) also pointed out that the assumptions made here are formally equivalent to treating private schools as excludable clubs under an equal cost sharing rule.

3.6. Calibration of Remaining Parameters

Having specified the calibration of incomes and endowments, I now turn to the remaining preference and production function parameters. On the preference side, house quality parameters $\{k_{dh}| d \in D, h \in H\}$ as well as the Cobb-Douglas exponents α and β remain to be specified, while on the production side values for ρ (the parameter specifying the relative weight of spending over peer quality in school output production) and θ (the parameter indicating the relative importance of parental income versus child ability in determining peer quality) are still uncalibrated.

The general strategy for a large part of this calibration is similar to that laid out in Nechyba (1997b). I assume an underlying utility function $u(h,s,c) = h^{\delta}s^{\alpha}c^{\beta}$ where h jointly captures housing and neighborhood quality and is interpreted as the annualized flow of housing/neighborhood services. Given that s is determined in a Cobb Douglas production process that places weight (1-ρ) on per pupil spending x, we can re-write this utility function as $u(h,x,c;q) = h^{\delta}(x^{(1-\rho)}q^{\rho})^{\alpha}c^{\beta} = \gamma h^{\delta}x^{(1-\rho)\alpha}c^{\beta}$ where q is equal to peer quality and $\gamma = q^{\rho\alpha}$. When treating h, x and c as choice variables in an ordinary maximization problem, the exponents δ, $(1-\rho)\alpha$, and β can then, without loss of generality, be normalized to sum to 1 and interpreted as budget shares. Thus, I calculate the budget shares for h, x and c for a hypothetical "median household" that consumes the imputed median annualized flow of housing/neighborhood services (in the data), earns the median income and "chooses" the mean school spending level observed in New York, and I interpret these as δ, $(1-\rho)\alpha$, and β (equal to 0.22, 0.13 and 0.65 respectively). Given data on house prices rather than flows of housing services, the median annualized flow of housing/neighborhood services is calculated for the median house value in the data assuming a 5% interest rate.

Of course, housing in the model is not a continuous variable h but rather consists of a discrete number of house/ neighborhood quality levels $\{k_{dh}| d \in D, h \in H\}$. I therefore combine the housing value distribution data from the School District Data Book with my estimate for δ to calibrate the fifteen values for k_{dh} across the three representative school districts. In particular, I take the housing distribution for all houses in districts of a particular type (i.e. low, middle or high income as defined above), find house values at the 10^{th}, 30^{th}, 50^{th}, 70^{th} and 90^{th} percentile (corresponding to neighborhoods 1 through 5 in district 1) and convert these to annualized housing flows (using a 5% interest rate). I then combine these annualized flow values with the exponent δ to arrive at the five housing (or neighborhood) quality parameters for this representative district. More precisely, suppose that for houses in districts falling into district category 3 (i.e. "high income districts"), the annualized flow of housing services for a house at the 50^{th} percentile of the distribution is 1.5 (corresponding to \$15,000). The housing quality parameter for neighborhood 3 (the "median neighborhood") in district 3 is then just equal to $(1.5)^{\delta}$, i.e. $k_{23} = (1.5)^{\delta} = (1.5)^{0.22} = 1.093$. This procedure is then similarly applied to other district types to arrive at housing quality parameters for all neighborhoods in all representative districts. These parameters are reported in Table 2.

While housing quality parameters as well as the exponent β have thus been determined, the values for α, ρ and θ remain ambiguous. With respect to θ, I know of no consistent and reliable estimates from past work that can be helpful in determining the impact of parental socioeconomic status relative to child ability in determining peer externalities. I therefore make no attempt to arrive at a single value for θ and rather report simulations for different values ranging from 0 to 1. This leaves only α and ρ, and the calibration procedure above has placed a restriction on these values given that $(1-\rho)\alpha$ is interpreted as the budget share of school spending for the median in the data. Again, there is little in the data or in prior empirical work that can be used to assign precise values to ρ and

α. However, if ρ is set close to 0 (i.e. if school quality is determined primarily by spending levels rather than peer quality), private schools do not emerge in the model unless voucher levels are unreasonably high. Similarly, if ρ is set too close to 1 (i.e. if school quality is determined primarily by peer quality and not by spending), public schools cannot exist in equilibrium even without vouchers. Therefore, if the benchmark equilibrium without vouchers is meant to reflect an equilibrium in which public schools dominate but in which some households are on the margin of choosing private schools, the value of ρ is limited to a range significantly narrower than the interval [0,1]. More precisely, Table 3a gives the fraction of households choosing public schools in the absence of vouchers under different assumptions regarding ρ and θ (assuming the previously derived joint restriction on α and ρ holds). These numbers indicate that reasonable values for ρ must lie below 0.5. Similarly, Table 3b gives the fraction of households choosing public schools in the presence of vouchers of 0.5 (equivalent to $5,000). If the model is to reflect that at least some households are on the margin of choosing private schools, these numbers indicate that ρ must lie above 0.3. For the remainder of the simulations reported in this paper, I therefore set ρ within the interval [0.3,0.5]. To arrive at a precise value for ρ, I choose that value which (given θ) yields a distribution of mean incomes across school districts that most closely reflects that of Table 1. While ρ therefore differs depending on θ, it always falls close to the midpoint of the interval [0.3,0.5]; i.e. $\rho \approx 0.4$. Sensitivity analysis using values in the neighborhood of 0.4 indicates that the main results of the paper are unaffected by the precise choice of ρ from this plausible interval.

It should be noted at this point that I have not attempted to use ρ to replicate the private school attendance rates for New York, and that the benchmark equilibria all have 100 percent public school attendance. While the alternative of using ρ in this fashion is tempting, I believe that this would be misleading. In the absence of vouchers, households choose private schools for a variety of reasons, many of which have little to do with the factors modeled in this paper. In particular, religion, race and differences in pedagogical philosophies are likely to be quite important, as is the presence of high income households that are currently not modeled. I therefore make to attempt here to mimic private school attendance rates in the benchmark equilibrium. I note in passing, however, that such rates have been replicated in this model by adding either an additional preference parameter for private schools or by including higher income agents and additional house types. Results from such a model are not markedly different from those reported here, but they quite unnecessarily complicate an already involved model.[31] For the remainder of the paper, I will therefore interpret the agents in the model as limited to those who are in the public school system prior to the introduction of vouchers, and, unless otherwise stated, assure the reader that an introduction of private school attendees into the model (as described above) leaves the results emphasized in this paper virtually unchanged.

3.7. Benchmark Equilibrium

Table 4 gives a representative benchmark equilibrium for the case of $\theta=0.5$. (Benchmark equilibria for values other than $\theta=0.5$ are not sufficiently different to warrant separate tables.) Note that per pupil spending levels as well as mean incomes closely mimic those found in the representative districts reported in Table 1. Similarly, interjurisdictional differences and overlaps in housing prices are similar to those found in the data, both for representative districts and for actual sample districts in New York. Finally, one might be concerned that the aggregation of the data into representative districts might lead to too much intra-jurisdictional variance in incomes (and house prices) in the

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[31] These results are available from the author upon request.

districts used in the model. However, a comparison of the model's interjurisdictional variance in incomes to the intrajursidictional variances (see Table 6) actually understate the within district heterogeneity commonly found in school district data (see, for example, Bogart (1990)). Thus, given that many of the results below are dependent on the presence of within school district variation in housing and income, these results will tend to be under rather than overstated.

4. Simulation Results

In this section, I report simulation results of three types of private school voucher plans, and I focus on reporting levels and variances of variables in the model without conducting detailed welfare analysis using changes in household utility levels. While utility measures can easily be calculated, these tend to be relatively uninformative as they contain changes in utility from a variety of sources and thus do not focus on the important goals of education policy that emphasize the levels and distribution of educational opportunities. A detailed welfare analysis therefore adds little beyond what the numbers in the tables below suggest, and I therefore restrict such analysis to a final footnote to this section.

In each of the simulations below, a voucher of level y is simply a piece of paper that gives any eligible household the option of redeeming y dollars from the state government if the household sends its child to a private school that charges tuition of at least y. If the private school charges tuition less than y, the voucher entitles the eligible household only to the full amount of the tuition.[32] The state government then sets a proportional state income tax sufficient to finance the voucher program.

[32] Note that this implies that, in equilibrium, everyone who uses a voucher will send his child to a private school that charges tuition greater than or equal to the level of the voucher. Note further that I focus here on private school vouchers, not vouchers that would also extend to public schools in other districts. This is done primarily because of evidence that public school district choice often is limited by legal provisions that allow good school districts to claim capacity constraints as an exclusionary device for interested outside students. (See Nechyba and Heise (1998) for a discussion of this.)

Voucher plans differ only in the definition of eligibility. In particular, a *full voucher* plan is defined as any voucher plan under which every household regardless of place of residence and income is eligible for the voucher. A *community targeted voucher* plan, on the other hand, limits eligibility to the subset of households that resides in the targeted school district(s), while an *income targeted voucher* plan is one that limits eligibility to households whose income falls below a targeted income level regardless of place of residence.

4.1. Tiebout Equilibrium Changes under Full Vouchers

Table 5 begins with a full voucher program and reports the fraction of households attending private schools as well as mean income and mean property values by school district for different levels of the voucher and for different assumptions for the value of θ. (Note again that dollar values are expressed in tens of thousands, and property values are expressed as annualized house rents.) As expected, regardless of the level of θ, private school attendance in all communities is monotonic in the level of the voucher, but private school attendance arises first in district 1, the low income district. The income and property value columns provide the explanation: as private schools begin to form, community income rises due to the immigration of relatively high income households who bid up the price of some of the houses in the better neighborhoods within the community. These immigrants come from the middle and high income communities where house values capitalize the value of the good public schools. Once the decision is made to send a child to private school, households choose to migrate to comparable houses/neighborhoods (or at least to houses/neighborhoods of sufficient quality) in communities that are cheaper due to their poor public school system.

Table 5 also demonstrates that the qualitative nature of the changes in the Tiebout equilibrium is quite independent of assumptions regarding the value of θ. As θ increases, peer quality is determined more by parental income rather than child ability. This implies that those who have most to gain from separating from the public school system are the very households that can most afford to do so. It seems that for this reason the speed of privatization rises as θ increases.

The major implication ofTable 5 is that, in the presence of full mobility, modest levels of private school attendance cause a substantial decrease in residential stratification of both community income and property values. This becomes even more evident in Table 6 which reports the variance of both incomes and property values within and across school districts. The variances across districts decline substantially and monotonicaly (with the exception of the extreme voucher level that causes a complete collapse of the public school system) as voucher levels rise. Homeowners in wealthy communities with good school districts clearly suffer as their house values decline while homeowners in the poor community benefit from capital gains due to increases in their house values. However, these benefits are not uniformly shared as the intra-community variance in property values rises somewhat in the poor community and falls in the wealthy community.

4.2. Targeting and Mobility

Tables 5 and 6 focused on the case of full vouchers under complete mobility; i.e. vouchers that are accessible to all households where each household is assumed to be costlessly mobile. I now investigate precisely how much of the results are due to the mobility assumption and what implications this has for different kinds of targeting. Table 7 begins by comparing the percentage of students attending private schools from Table 5 to cases where households are immobile and cases where vouchers are targeted either to communities or to individuals.

First, the columns labeled A replicate the percentages previously reported in Table 5 for full voucher programs under full mobility. Columns labeled B differ from those labeled A in that mobility is made prohibitively expensive. Note that in general, if mobility is assumed away, private school attendance increases more slowly as voucher levels rise, and private schools now never arise in the wealthy district. Thus, when forced to remain in their original communities, residents of the high income community are sufficiently satisfied with their local public schools so as not to utilize vouchers, as are residents of the middle income community when $\theta=1$. Residents of the low income community, on the other hand, take up vouchers when their level becomes sufficiently high.

Next, columns C and D report private school attendance rates under voucher plans that are targeted to community 1, with columns C allowing costless mobility while columns D assume mobility to be prohibitively expensive. First, note that private schools now arise exclusively in community 1 where the voucher is usable. Second, note that columns C and A are identical for voucher levels less than or equal to 0.2 (and for 0.3 when $\theta=0$). This is because private schools do not arise for these voucher levels in communities other than community 1 even when the program is not targeted. *For low levels of vouchers, targeting to the low income community is thus equivalent to not targeting at all when households are assumed to be mobile*. For higher levels of vouchers, take up rates in community 1 are at least as high under targeting (and higher in some cases). Furthermore, eliminating the possibility of migrating causes reductions in take up rates similar to those previously found for full voucher programs.

Finally, columns E and F consider cases (for costless mobility and no mobility respectively) of voucher plans targeted at households whose income is less than 2 (i.e. less than \$20,000). For both $\theta=1$ and $\theta=0.5$, E and F are omitted from the table because no private schools arise, and for $\theta=0$, private schools arise only for vouchers of 0.6 or higher. *Personally targeted vouchers are therefore relatively ineffective in the model unless most of the peer effect is through the channel of child ability* (i.e. θ close to 0). In that case, low income parents of high ability children choose to use vouchers, but only in communities where public schools are quite poor. Income targeting of vouchers therefore isolates public schools in wealthy and middle income districts from competitive pressures they would face under community targeting or no targeting. Again, as for the two previously considered voucher programs, mobility increases the take up rate substantially.

4.3. Impacts on Educational Opportunities

Tables 8 through 10 present the public school related variables for scenarios A through D assuming θ=0.5. (Results for voucher plans targeted at individuals under the two mobility assumptions are left out given that no private schools arise under such plans when θ=0.5 and when results for other values of θ are sufficiently similar.) In Nechyba (1999) I had demonstrated that the direction of the change in per pupil spending on public schools in low income communities is ambiguous under many local financing schemes because, while political pressures against public school spending increase with private school use, the increased presence of middle to high income residents who pay taxes (on a larger property tax base) without using the public schools provides a counteracting force that acts like a local matching grant. However, I also demonstrated that the larger a portion of the local budget in the poor district is made up by exogenous state funds, the smaller will be the latter effect. In New York, over half of public school funding in poor districts comes from the state, which is enough to cause the simulations to yield decreases in per pupil spending with increased use of private schools. (Spending levels off at 0.6 because of the assumed constitutionally required floor on spending.) Under our full mobility assumptions, however, vouchers also cause an unambiguous decline in per pupil spending in wealthy districts as the political constituency for high spending in those districts decreases (due to high income families leaving to set up private schools elsewhere) and as the tax base shrinks (i.e. as property values fall). Furthermore, ability levels in public schools in middle and wealthy districts decline as parents of high ability children are the first to be drawn into the private sector. Only in the poor community do ability levels in public schools initially rise as high income/low ability households are pushed out of the community by middle and upper income immigrant households who are choosing the low income district in order to send their children to public schools. On balance, however, *peer* quality declines in all public schools. This, combined with declining per pupil spending, causes declines in parental perceptions of public school quality, declines which are generally more pronounced for wealthy communities than for poor communities whenever households are assumed to be mobile. Without mobility, of course, ability and peer levels change only when private schools form in the community, which happens primarily in the poor community. Thus, wealthy districts are largely unaffected by voucher policies, whether targeted or not, whenever it is assumed that households are not mobile.

Most interesting and perhaps most surprising, however, are the impacts on the variances in these school variables across students. Table 12 presents these for the case of no targeting (with the case of community targeting yielding similar though somewhat more muted outcomes). The first set of columns in the table provide variances across public school students (who are declining in number), while the latter columns provide variances across all students, public and private. First, note that, as voucher levels increase, variances of per pupil spending, ability, peer quality and parentally perceived quality all decline among public school students under full mobility while they increase under prohibitively expensive mobility. Under full mobility, wealthy communities suffer from out-migrations of high ability, high income households who are not willing to pay for high house prices due to good public schools when they have chosen to send their children to private schools. This causes quality variables to decline in wealthy communities, and to decline proportionately more than in poor communities. Under no mobility, on the other hand, quality variables remain constant for communities that do not experience private school enrollments - i.e. wealthy communities. Thus, the lack of out-migrations resulting from the mobility restrictions causes quality to remain constant in communities with good public schools while public school quality falls in communities with initially poor schools.

What we care about most, however, might not be the variance of quality across students who remain in the public system but rather the variance in quality across all students who were initially in the public system. Surprisingly, when households are fully mobile, the variance in per pupil spending across these students actually falls for moderate levels of vouchers, and this decline is sufficiently high to outweigh the increase in variances across abilities and peer quality to cause variances in parental perceptions of school quality to remain roughly stable. This is true because, under mobility, the greatest segment of initial private school attendees are composed of high ability households from relatively modest neighborhoods in wealthy communities, households that can most easily find substitute housing in lower wealth communities . With the implicit subsidy from wealthy homeowners gone, however, they now choose private school spending levels below those they enjoyed in their previous public school even if they previously voted for high spending given the price subsidy from the wealthy. Thus, in addition to the decrease in the variance in spending across public school students, the variance drops further when private school students are also considered. At the same time, the exit of students into the private system unambiguously increases the variance in abilities and peer quality even as the variance in peer quality across public school students falls. Under no mobility, however, the variance in all quality variables unambiguously rises because the migration effects giving rise to the narrowing in the variance under full mobility is now absent. Private school attendees thus exit the public system primarily in the low spending district, thus raising the variance in spending.

From an equity perspective, then, the mobility assumption yields outcomes that can be viewed as roughly equivalent to outcomes without vouchers, far from most a priori predictions of vast increases in inequities in education. This is true despite the assumption of rather extreme cream skimming behavior on the part of private schools, despite the assumption that competition per se will yield no increases in efficiency and despite a model of peer effects that does not allow for gains from specialization of schools. A relaxation of any of these assumptions would, of course, make vouchers more attractive on both efficiency and equity grounds, but simulations reported elsewhere indicate that migration effects of magnitudes similar to those described above would persist.[33] Regardless of which other assumptions are incorporated into policy analysis, it therefore seems essential to incorporate public school district choice into policy analysis of private school vouchers.[34]

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[33] See Nechyba and Heise (1998) for examples of such simulations.

[34] As suggested at the beginning of this section, a detailed welfare analysis using utility measures from the simulations is possible. While I have argued that such analysis may not be as meaningful as one might wish, I have calculated utility levels for all 750 types as voucher levels change. The results of this analysis are intuitive given the discussion above: Residents of the low income community who leave the district as a result of the immigration of private school attendees are made better off due to capital gains from selling their property, as are some residents of the middle and high income community whose rental payments fall. Furthermore, for low levels of vouchers, those that take up the voucher are made better off while those remaining in the public school system (especially those in the middle and high income communities) are made worse off. As voucher levels increase, however, high income households (even those choosing to take up the voucher) may be made worse off due to high state income tax payments to finance vouchers, while low income households are made better off from the implicit state subsidy of the voucher. This is true for both low income households who take up the voucher (and pay relatively little for it) and those that remain in the public system (who now receive matching aid from local residents who are paying local taxes but attending private schools).

5. Conclusions and Open Questions

This paper builds on previous research indicating that mobility of households may play an important part in school finance debates. In the results presented here, mobility is demonstrated to be important for both the positive analysis attempting to predict the impact of vouchers on the distribution of educational opportunities and the normative analysis evaluating its equity properties. On the positive side, it is shown that, in a model roughly calibrated to reflect the state of school finance in New York, the general equilibrium impact of assuming mobility of households may outweigh most other effects in the analysis. This has deep implications for policy makers considering various options of targeting vouchers to those in most need. In particular, the impacts of targeted voucher policies are vastly more pronounced under targeting schemes aimed at low public school quality districts rather than poor individual households, especially if households are relatively mobile. On the normative side, even with assumptions that are quite stacked against vouchers, variances in overall quality may not be adversely affected by the introduction of either full vouchers or community targeted vouchers, and variances in per pupil spending may actually decline.

While the use of house prices to calibrate neighborhood quality levels is intended to capture both neighborhood and house characteristics within and across communities, it has been emphasized throughout that the benchmark quality levels are assumed to remain constant in the face of rather large voucher induced migrations. There are at least three reasons to be suspicious of this assumption: First, households that relocate are likely to change housing qualities at least marginally; second, they are likely to effect changes in neighborhood amenities; and third, neighborhood externalities may change by the mere fact that different individuals now reside in these neighborhoods. However, it is important to note that all three of these restrictions are likely to *understate* the main results presented in this paper. Since migrations lead to less stratification of income across jurisdictions, immigrants to lower income communities are likely to expand housing quality, increase neighborhood amenities and contribute to positive neighborhood externalities (if these are correlated with income), while immigrants to higher income communities are likely to cause the opposite. This implies that the attractiveness of neighborhoods in lower income jurisdictions is understated while that of neighborhoods in higher income jurisdictions is overstated in the current framework which causes the model to underestimate rather than overestimate migration effects.

A few cautionary notes are, of course, appropriate. As is emphasized throughout this paper, the mobility assumption changes crucially the impact of voucher initiatives. Given that mobility is costly in the short run, it is unlikely that the types of effects implied by the model under full mobility would arise immediately in any real voucher experiment, and a more careful multi-period analysis might therefore be more appropriate. Furthermore, the model as presented here is one of homeowners and does not include renters. While other simulations (not reported here) in which residents are renters rather than owners confirm the robustness of the migration trends, welfare analysis with the model would differ as income effects from capital gains and losses would be absent. Finally, while we have indicated that the private school formations predicted in this model are roughly consistent with private school formations observed after the *Serrano* school reforms in California, it remains unclear precisely what types of private schools might emerge under large scale voucher initiatives. Additional effects, such as returns from specialization, reductions in bureaucratic and political inefficiencies and the role of parental involvement in public schools are all left out of the current analysis. While other work with this model indicates that the migration effects I point to in this paper remain equally strong when these other factors are added, the contribution of this paper is primarily to point to the importance of mobility and its implications for targeting of voucher policies. Clearly, more research is called for to come to a clearer overall evaluation of vouchers in comparison to other school reform proposals, and no simulation model can ultimately take the place of empirical work with real world voucher experiments.

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TABLE 1

	Representative School Districts		
	Low Income (d=1)	Middle Income (d=2)	High Income (d=3)
Median House Value	$65,927	$83,078	169,113
Median Household Income	$32,183	$43,824	$69,125
Per Pupil Spending	$6,352	$7,515	$10,479
Fraction Raised Locally	41%	54%	72%
Per Pupil State Aid	$3,720	$3,480	$2,930

TABLE 2

Selected Parameters

Population	District Size	Utility and Production Function Exponents			
N	$\mu(C_{dh})$	α	β	ρ	θ
[0,1]	0.0667	0.217	0.650	≈0.400	varies

District	State Aid	Min.Spend.	Size
1	0.372	0.600	0.333
2	0.348	0.600	0.333
3	0.293	0.600	0.333

d \ h	Housing Quality Parameters (k_{dh})				
	1	2	3	4	5
1	0.791	0.830	0.905	0.955	1.005
2	0.845	0.890	0.950	1.000	1.075
3	0.885	0.920	1.030	1.105	1.250

TABLE 3

Public School Attendance

θ \ ρ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
					a. Voucher = 0.0				
0.0	100%	100%	100%	100%	88%	24%	0%	0%	0%
0.5	100%	100%	100%	100%	89%	25%	0%	0%	0%
1.0	100%	100%	100%	100%	92%	29%	0%	0%	0%
					b. Voucher = 0.5				
0.0	100%	100%	73%	31%	0%	0%	0%	0%	0%
0.5	100%	100%	78%	31%	0%	0%	0%	0%	0%
1.0	100%	100%	85%	46%	0%	0%	0%	0%	0%

TABLE 4

Benchmark Equilibrium
θ=0.5

	Average Income	Avg Property Values	Per Pupil Spending	Average Ability	School Quality
District 1	3.2973	0.5859	0.6674	5.1643	0.6076
District 2	4.5527	0.9032	0.7856	6.0388	0.7336
District 3	7.1500	1.6950	1.0499	7.3125	1.0057

	House Prices by Neighborhoods				
	1	2	3	4	5
District 1	0.3213	0.4225	0.5501	0.6953	0.9403
District 2	0.4731	0.6482	0.8812	1.0815	1.4321
District 3	1.0111	1.3411	1.6962	1.9673	2.4593

TABLE 5
Migration and Private School Attendance

Community 1

	Fraction Private			Mean Income			Mean Property Values		
Vouch	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0
0.0	0.0000	0.0000	0.0000	3.3719	3.2973	3.3100	0.5613	0.5859	0.6592
0.1	0.2000	0.1000	0.0000	3.9000	3.5000	3.3100	0.5746	0.6042	0.6592
0.2	0.4000	0.2333	0.1333	4.5000	3.9000	3.7000	0.6213	0.6042	0.6617
0.3	0.6667	0.5667	0.3333	5.0000	4.7000	4.1500	0.6763	0.7292	0.6726
0.4	0.6667	0.6667	1.0000	4.9000	4.6000	3.9889	0.6413	0.7659	0.6859
0.5	0.6667	1.0000	1.0000	4.6000	4.5333	4.5250	0.6692	0.6309	0.6901
0.6	1.0000	1.0000	1.0000	3.7083	3.5301	3.6500	0.6530	0.6459	0.5017

Community 2

	Fraction Private			Mean Income			Mean Property Values		
Vouch	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0
0.0	0.0000	0.0000	0.0000	4.5281	4.5527	4.4900	0.8966	0.9032	0.9232
0.1	0.0000	0.0000	0.0000	4.4500	4.5071	4.4900	0.8882	0.9157	0.9232
0.2	0.0000	0.0000	0.0000	4.3457	4.4500	4.4000	0.8841	0.9149	0.9249
0.3	0.2000	0.1333	0.0000	4.1000	4.0000	4.3000	0.8241	0.8532	0.9216
0.4	0.5333	0.2667	0.7333	5.3000	4.2000	5.3000	0.8716	0.8778	0.8882
0.5	0.8667	0.7667	0.7667	5.7000	5.2167	5.1750	0.9316	0.8174	0.9241
0.6	1.0000	1.0000	1.0000	5.0917	5.1199	5.2000	0.8495	0.8557	0.7541

Community 3

	Fraction Private			Mean Income			Mean Property Values		
Vouch	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0	θ=1	θ=0.5	θ=0
0.0	0.0000	0.0000	0.0000	7.1000	7.1500	7.2000	1.6950	1.6950	1.6058
0.1	0.0000	0.0000	0.0000	6.6500	6.9929	7.2000	1.6783	1.6733	1.6058
0.2	0.0000	0.0000	0.0000	6.1543	6.6500	6.9000	1.5533	1.6558	1.6008
0.3	0.0000	0.0000	0.0000	5.9000	6.3000	6.5500	1.4850	1.4538	1.5892
0.4	0.0667	0.0000	0.6037	4.8000	6.2000	5.7111	1.3217	1.3725	1.4050
0.5	0.0667	0.0667	0.0667	4.7000	5.2500	5.3000	1.2688	1.1525	1.2633
0.6	1.0000	1.0000	1.0000	6.2000	6.3500	6.1500	1.3233	1.3717	1.3133

Table 6
Variances within and across Communities
Theta = 0.5

	Variance in Income Values			
Vouch	Comm. 1	Comm 2	Comm 3	Across Comm.
0.00	1.7048	3.0709	1.0025	2.5739
0.10	3.4500	2.2214	1.3639	2.1549
0.20	5.0900	2.1725	2.0025	1.4117
0.30	5.4600	3.3500	1.9100	0.9267
0.40	4.3400	4.7600	2.1600	0.7467
0.50	4.6822	5.3281	3.1625	0.1091
0.60	2.3539	3.6461	3.5025	1.3325

	Variance in Property Values			
Vouch	Comm. 1	Comm 2	Comm 3	Across Comm.
0.00	0.0652	0.1469	0.2331	0.2175
0.10	0.0600	0.1309	0.2195	0.2016
0.20	0.0612	0.1270	0.2081	0.1946
0.30	0.1556	0.1262	0.1824	0.1001
0.40	0.1690	0.1210	0.1768	0.0695
0.50	0.2223	0.3148	0.1393	0.0466
0.60	0.1787	0.2809	0.3739	0.0930

Table 7
Private School Attendance

Community 1

	θ=1				θ=0.5				θ=0					
Vouch	A	B	C	D	A	B	C	D	A	B	C	D	E	F
0.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.10	20%	0%	20%	0%	10%	0%	10%	0%	0%	0%	0%	0%	0%	0%
0.20	40%	3%	40%	3%	23%	0%	23%	0%	13%	0%	13%	0%	0%	0%
0.30	67%	7%	67%	7%	57%	20%	63%	20%	33%	0%	33%	0%	0%	0%
0.40	67%	7%	67%	7%	67%	37%	67%	37%	100%	67%	100%	67%	0%	0%
0.50	67%	27%	77%	27%	100%	80%	100%	80%	100%	80%	100%	80%	0%	0%
0.60	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	63%	20%

Community 2

	θ=1				θ=0.5				θ=0					
Vouch	A	B	C	D	A	B	C	D	A	B	C	D	E	F
0.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.30	20%	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.40	53%	0%	0%	0%	27%	17%	0%	0%	73%	37%	0%	0%	0%	0%
0.50	87%	0%	0%	0%	77%	70%	0%	0%	77%	77%	0%	0%	0%	0%
0.60	100%	0%	0%	0%	100%	87%	0%	0%	100%	100%	0%	0%	0%	0%

Community 3

	θ=1				θ=0.5				θ=0					
Vouch	A	B	C	D	A	B	C	D	A	B	C	D	E	F
0.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.30	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.40	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.50	7%	0%	0%	0%	7%	0%	0%	0%	7%	0%	0%	0%	0%	0%
0.60	100%	0%	0%	0%	100%	0%	0%	0%	100%	0%	0%	0%	0%	0%

A = full mobility and no targeting
B = no mobility and no targeting
C = full mobility and targeting to community 1
D = no mobility and targeting to community 1
E = full mobility and targeting to low incomes
F = no mobility and targeting to low incomes

* Note: E and F are not reported for θ=1 and θ=0.5 because no private schools arise.

Table 8
Public School Variables
θ=0.5, full mobility, no targeting

Community 1					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.6674	5.1643	0.5199	0.6076
0.10	90%	0.6688	5.4861	0.5147	0.6047
0.20	77%	0.6688	5.4484	0.4934	0.6047
0.30	43%	0.6000	5.1442	0.4274	0.5239
0.40	33%	0.6000	4.2969	0.3609	0.4896
0.50	0%	****	****	****	****
0.60	0%	****	****	****	****

Community 2					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.7856	6.0388	0.6699	0.7336
0.10	100%	0.7864	5.4575	0.6319	0.7376
0.20	100%	0.7864	5.2187	0.6135	0.7376
0.30	87%	0.7585	4.9279	0.5156	0.6500
0.40	73%	0.7973	4.8935	0.4770	0.6570
0.50	23%	0.6000	1.2500	0.2108	0.3949
0.60	0%	****	****	****	****

Community 3					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	1.0499	7.3125	0.9427	1.0057
0.10	100%	1.0531	7.0112	0.9119	1.0075
0.20	100%	1.0531	6.5937	0.8592	1.0075
0.30	100%	0.9723	4.7500	0.7142	0.8594
0.40	100%	0.9278	4.0781	0.6652	0.8070
0.50	93%	0.8819	3.3761	0.5452	0.7276
0.60	0%	****	****	****	****

Table 9
Public School Variables
θ=0.5, no mobility, no targeting

Community 1					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.6674	5.1643	0.5199	0.6076
0.10	100%	0.6674	5.1643	0.5199	0.6076
0.20	100%	0.6674	5.1643	0.5199	0.6076
0.30	80%	0.6000	4.0820	0.4217	0.5269
0.40	63%	0.6000	3.6184	0.3805	0.5069
0.50	20%	0.6000	1.2500	0.2108	0.4113
0.60	0%	****	****	****	****

Community 2					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.7856	6.0388	0.6699	0.7336
0.10	100%	0.7856	6.0388	0.6699	0.7336
0.20	100%	0.7856	6.0388	0.6699	0.7336
0.30	100%	0.7856	6.0388	0.6699	0.7336
0.40	73%	0.6000	4.4531	0.4789	0.5864
0.50	30%	0.6000	3.0208	0.3478	0.5110
0.60	13%	0.6000	2.6800	0.2950	0.4507

Community 3					
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	1.0499	7.3125	0.9427	1.0057
0.10	100%	1.0499	7.3125	0.9427	1.0057
0.20	100%	1.0499	7.3125	0.9427	1.0057
0.30	100%	1.0499	7.3125	0.9427	1.0057
0.40	100%	1.0499	7.3125	0.9427	1.0057
0.50	100%	1.0499	7.3125	0.9427	1.0057
0.60	100%	1.0499	7.3125	0.9427	1.0057

Table 10
Public School Variables
θ=0.5, full mobility, targeting to community 1

			Community 1		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.6674	5.1643	0.5199	0.6076
0.10	90%	0.6688	5.4861	0.5147	0.6047
0.20	77%	0.6688	5.4484	0.4934	0.6047
0.30	37%	0.6000	4.1051	0.3616	0.4900
0.40	33%	0.6000	4.2969	0.3609	0.4896
0.50	0%	****	****	****	****
0.60	0%	****	****	****	****

			Community 2		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.7856	6.0388	0.6699	0.7336
0.10	100%	0.7864	5.4575	0.6319	0.7376
0.20	100%	0.7864	5.2187	0.6135	0.7376
0.30	100%	0.6985	5.3281	0.5556	0.6381
0.40	100%	0.6970	4.9479	0.5446	0.6315
0.50	100%	0.6671	3.7656	0.4754	0.5825
0.60	100%	0.6596	3.7266	0.4796	0.5807

			Community 3		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	1.0499	7.3125	0.9427	1.0057
0.10	100%	1.0531	7.0112	0.9119	1.0075
0.20	100%	1.0531	6.5937	0.8592	1.0075
0.30	100%	0.9420	5.1562	0.7417	0.8553
0.40	100%	0.9246	5.3021	0.7348	0.8434
0.50	100%	0.8782	5.2500	0.7085	0.8059
0.60	100%	0.8649	5.2891	0.7043	0.7967

Table 11
Public School Variables
θ=0.5, no mobility, targeting to community 1

			Community 1		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.6674	5.1643	0.5199	0.6076
0.10	100%	0.6674	5.1643	0.5199	0.6076
0.20	100%	0.6674	5.1643	0.5199	0.6076
0.30	80%	0.6000	4.0820	0.4217	0.5269
0.40	63%	0.6000	3.6184	0.3805	0.5069
0.50	20%	0.6000	1.2500	0.2108	0.4113
0.60	0%	****	****	****	****

			Community 2		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	0.7856	6.0388	0.6699	0.7336
0.10	100%	0.7856	6.0388	0.6699	0.7336
0.20	100%	0.7856	6.0388	0.6699	0.7336
0.30	100%	0.7856	6.0388	0.6699	0.7336
0.40	100%	0.7856	6.0388	0.6699	0.7336
0.50	100%	0.7856	6.0388	0.6699	0.7336
0.60	100%	0.7856	6.0388	0.6699	0.7336

			Community 3		
Vouch	Attend.	Spending	Ability	Peers	Quality
0.00	100%	1.0499	7.3125	0.9427	1.0057
0.10	100%	1.0499	7.3125	0.9427	1.0057
0.20	100%	1.0499	7.3125	0.9427	1.0057
0.30	100%	1.0499	7.3125	0.9427	1.0057
0.40	100%	1.0499	7.3125	0.9427	1.0057
0.50	100%	1.0499	7.3125	0.9427	1.0057
0.60	100%	1.0499	7.3125	0.9427	1.0057

Table 12

Full Mobility, No Targeting

	Variance Across Public School Students				Variance Across All Students			
Vouch	Spending	Ability	Peers	Quality	Spending	Ability	Peers	Quality
0.00	0.0256	0.7780	0.0306	0.0276	0.0256	0.7780	0.0306	0.0276
0.10	0.0257	0.5360	0.0277	0.0279	0.0250	1.3535	0.0370	0.0288
0.20	0.0255	0.3837	0.0227	0.0275	0.0236	2.1945	0.0422	0.0280
0.30	0.0206	0.0212	0.0138	0.0175	0.0185	5.5197	0.0664	0.0236
0.40	0.0135	0.1382	0.0141	0.0133	0.0136	7.2392	0.0750	0.0210
0.50	0.0127	0.7233	0.0179	0.0177	0.0314	10.4334	0.0835	0.0345
0.60	****	****	****	****	0.0344	11.0413	0.0933	0.0476

No Mobility, No Targeting

	Variance Across Public School Student				Variance Across All Students			
Vouch	Spending	Ability	Peers	Quality	Spending	Ability	Peers	Quality
0.00	0.0256	0.7780	0.0306	0.0276	0.0256	0.7780	0.0306	0.0276
0.10	0.0259	0.8120	0.0308	0.0281	0.0259	0.8120	0.0308	0.0281
0.20	0.0259	0.8120	0.0308	0.0281	0.0259	0.8120	0.0308	0.0281
0.30	0.0339	1.6673	0.0434	0.0375	0.0324	2.2388	0.0439	0.0352
0.40	0.0501	2.7694	0.0668	0.0532	0.0419	4.7148	0.0651	0.0429
0.50	0.0417	5.8064	0.0953	0.0620	0.0495	7.1608	0.0731	0.0512
0.60	0.0208	2.2043	0.2076	0.0316	0.0497	8.3204	0.0620	0.0480