Published in
American Economic Review 90(1) (March 2000), 130-46

MOBILITY, TARGETING AND PRIVATE SCHOOL VOUCHERS

Thomas J. Nechyba*
Stanford University, Duke University, and NBER

*Department of Economics, Stanford University, Stanford, CA 94305-6072 (tnechyba@leland.stanford.edu). I am grateful to the Stanford Institute for Economic Policy Research (SIEPR) and the National Science Foundation (SBR-9809269 and SBR-9905706) for research support, and to an anonymous referee as well as seminar participants at Stanford, Duke, the University of Virginia, Vanderbilt, the University of Florida, Fundacao Getulio Vargas, Johns Hopkins, Texas A&M, the University of Washington, the New Zealand Ministry of Education, the First International Public Economic Theory conference and the 1999 Winter meetings of the American Economic Association for helpful comments. Part of this research was undertaken while I was visiting the Fundacao Getulio Vargas in Rio de Janeiro and part while I was on leave at the Hoover Institution at Stanford. The hospitality and financial support of both are greatly appreciated. All remaining errors remain mine.

Abstract

This paper uses general equilibrium simulations to explore the role of residential mobility in shaping the impact of different types of private school voucher policies. In particular, general vouchers available to all residents in the state are compared to vouchers specifically targeted to either underprivileged school districts or underprivileged households. The simulations are derived from a three-district model of low, middle and high income school districts (calibrated to New York data), where each school district is composed of multiple types of neighborhoods that may vary in house quality as well as the level of neighborhood amenities and externalities. 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 and 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.

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. But aside from a few limited experiments in some US cities, our experience with vouchers in the US remains virtually nonexistent. 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. 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 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 clarify the nature and magnitude of the general equilibrium forces that are likely to emerge under vouchers and 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 explore the impact of vouchers on the distribution of educational opportunities by tracing their likely impact on household choices within a general equilibrium multi-district economy. The approach 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 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,[1] little attention has 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. The resulting forces are quite basic and emerge in Nechyba (1999a): Private schools tend to form in low income districts in part 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 districts will private schools emerge elsewhere first.[2]

[1] See Nechyba and Strauss (1998) and Bayer (1999) as well as references therein for empirical evidence of the impact of public schools on residential location choices. Lankford and Wyckoff (1997) provide further compelling evidence on the importance of parental choices in changing segregation patterns.

[2] While the empirical evidence on private school formation is sparse, the observation that private schools are likely to appear in low quality districts conforms with the available empirical evidence from California which experienced a dramatic rise in the number of private schools in the late 1970's (Downes and Greenstein (1997)).

Given this insight, I focus here on the potential importance of residential mobility by employing a richer and more realistic model than that used in prior work and by embedding a state finance system that mirrors one that is in practice. I then study three voucher programs: (i) a general voucher applicable to any child in private school; (ii) a voucher targeted only to low income households; and (iii) a voucher targeted to poor districts. These voucher programs are demonstrated to have quite different impacts depending on the degree of mobility of households because proposals of type (i) and (ii) generate substantial migrations of moderate to high income households to good neighborhoods within poor communities while proposals of type (iii) do not. The results also provide evidence that these mobility effects improve the equity implications of vouchers.

2. A Brief Look at the Prior Literature

The central debate over vouchers has typically revolved around the tradeoff between an anticipated decline in public school peer quality (as better students and parents are attracted to private schools) and a hypothesized increase in public school efficiency from increased competition (Friedman (1962), Manski (1992), Levin (1992), Chubb and Moe (1990), McMillan (1999a)). However, we still lack conclusive empirical evidence on either of these effects. Hoxby (1994) and McMillan (1999b), for instance, report different empirical findings regarding the existence of a positive competitive effect in the absence of vouchers, while evidence from current voucher experiments is scarce (Rouse (1998)). Similarly, while at least some current private schools seem to outperform public schools (Neal (1997), Figlio and Stone (1997), Evans and Schwab (1995)), evidence on private school markets resulting from large scale voucher programs is available only in other contexts (as, for example, in Chile (Carnoy and McEwan (1998)). More recent theoretical work has therefore investigated such markets more closely and particularly in the presence of peer effects. Epple and Romano (1998) and Caucutt (1997) suggest that private schools can internalize peer externalities through tuition policies, which implies that low income/high ability children might benefit as private schools purchase their peer quality with scholarships. Epple, Newlon and Romano (1997) further demonstrate that public schools may use "tracking" to compete with private schools. Finally, Hoyt and Lee (1998) focus on issues surrounding voting on vouchers, and Glomm and Ravikumar (1995) concentrate on implications for future income distributions.

Few attempts, however, have been made to extend the analysis to multi-district settings. De Bartolome (1990) uses a two community model with peer effects to point out inefficiencies from voting when voters ignore the impact of migration, and Fernandez and Rogerson (1996) find in a two community model (without peer effects) that policies which raise the fraction of wealthy residents in poor districts tend to be welfare enhancing. This conclusion is mirrored in Nechyba (1996). Epple and Romano (1995) introduce multiple districts into their framework but do not focus on vouchers. Finally, Goldstein and Gronberg (1986) develop a simple theoretic model in which they illustrate the nature of the mobility effect that arises when school choice and local public finance models are merged, and Nechyba (1999a) demonstrates its potential importance in some stylized settings while putting forth the technical background for the methodology employed here.

While these migration forces are thus easily illustrated, simple models help 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, existing housing varies substantially across districts, 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 than that of Nechyba (1999a), calibrate it more carefully with better data, and investigate the likely magnitude of migration and general equilibrium effects of vouchers.

3. The Model

The theoretical model I employ builds on Nechyba (1999a)) where I introduced 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 (Epple and Sieg (forthcoming)), but households within a district are assumed to send their children to the same district public school regardless of which neighborhood within the district they reside in. 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. 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 and is provided in more extensive detail in Nechyba (1999a). The current model differs, however, in that (i) it contains five rather than three neighborhoods within each district; (ii) it does not assume perfect correlation between child ability and family income and incorporates a richer specification of peer quality; (iii) it builds a richer type space (750 rather than 81 types); (iv) it improves considerably on the calibration of the model to the data (such as incorporating a more realistic income distribution and a better match of house prices); and (v) it employs a hybrid local/state financing system that is less stylized.

3.1. District Structure

The set of houses is represented by the unit interval N=[0,1] which is partitioned into 3 equally sized school districts, with each district further partitioned into 5 equally sized neighborhoods. C_{dh} denotes the set of houses in neighborhood h of district d, and C_d is the union of all neighborhoods in that district. Furthermore, $\mu(C_{dh})$ and $\mu(C_d)$ represent the measures of houses in each of these partitions. It should be noted at the outset, however, that each district is assumed to contain only a single public school, or alternatively that public schools within a district are of the "open enrollment" type and thus provide identical quality levels in equilibrium.[3]

The three districts 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

[3] The assumption of a single public school per district is admittedly restrictive but can be defended along several dimensions. First, New York has over 700 school districts, and many school districts in the suburbs of New York (that are employed in my calibration) are therefore relatively small and contain a limited number of schools per district. Second, to the extent to which there exist separate public schools for subsets of neighborhoods within districts, the present model would predict similar within-district migrations across neighborhoods resulting from vouchers. The important difference is that spending within districts would be the same while peer quality would differ, which would generate a model similar to the stylized equal state funding model in Nechyba (1999a) where the economy could be interpreted as a district with an equal spending constraint across within-district schools. That model demonstrates that even with spending held equal across "districts" (or schools within districts in this reinterpretation of the model), the migration forces remain large and important so long as there remains heterogeneity of housing stocks. Such heterogeneity is likely to exist within areas in districts that are served by one school, although the degree of heterogeneity within these areas is likely to be lower. As I mention in Section 3.7, however, the heterogeneity of housing within the districts in the model used here is lower than that observed generally in school districts. Thus, the model's results are likely to be applicable to environments in which there exist areas within districts defining sub-districts, as well as to voucher programs at the district level for large districts.

households. Table 1 gives summary statistics for each class of districts. Furthermore, 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 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. In the simulations below I will assume migrations of households do not change these neighborhood qualities, but, as I argue in the conclusion, this only biases the main results of the paper downward. Furthermore, while the calibration is using data from New York suburbs, it should be noted that I have run similar simulations calibrated to data from New York City which yield similar results.[4]

3.2. Endowments and Preferences

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, where household n is endowed with house n. An income function $z: N \rightarrow \mathbb{R}_+$ replicates a discretized version of the actual household income distribution observed in our sample by dividing households into 10 "income types." Income levels range from 1 (corresponding to $10,000) to 10 (corresponding to $100,000), which eliminates extremely poor and extremely wealthy households. 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.

Each income type is initially spread uniformly across all neighborhoods (in all school

---

[4] For some samples of such results and a non-technical treatment, see Nechyba and Heise (forthcoming). The forces described in this papers are relevant to inner cities because of the heterogeneity of housing within those areas.

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. Note that this does not imply that low income households are assumed to *live* in high priced houses. Rather, on the way to determining the benchmark equilibrium from which the simulations start, households buy and sell houses at market prices. In practice, the value of these house endowments falls between 0.3 and 2.5 and thus simply smooths out the discretized income distribution. The initial 10 income types are thus transformed into 150 endowment types with the resulting endowment distribution more smoothly replicating the income distribution observed in the New York districts.

Each household n is also assumed to have one child, and one of 5 possible ability levels corresponding in magnitude to parental income levels is assigned by an ability function $a{:}N\rightarrow\mathbb{R}_+$ to each household.[5] Solon (1992) and Zimmerman (1992) provide a point estimate for the empirical correlation of parental and child income of 0.4, and evidence from behavioral genetic studies place the genetic correlation between parental and child cognitive ability at between 0.4 and 0.5 (McEwan, Nechyba and Older-Aguilar (1999)). The ability function a is therefore chosen to yield a correlation of parental income and child ability of 0.4. Given 150 endowment types specified above, this addition of ability levels generates a total of 750 types.

Finally, each household acts as one utility maximizing agent endowed with preferences represented by the utility function $u(d,h,s,c) = k_{dh}\, s^{\alpha} c^{\beta}$ that takes as its arguments the district and neighborhood the household lives in, its private good consumption $c\in\mathbb{R}_+$, and the perceived school quality level $s\in\mathbb{R}_+$ enjoyed by the household's child. The determination of s (which represents either

[5] 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.

public school quality in the district of residence or private school quality if the household chooses private schools) is explored next, and the calibration of k_{dh}, 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 $q(n) = (z(n)^{\theta}\ a(n)^{(1-\theta)})/7.5$.[6] Thus, as θ increases, the importance of parental income 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 (McMillan (1999b)) as opposed to the child's inherent ability. Letting x be equal to per pupil spending and q to average peer quality, household choices are then 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 (Hanushek (1986)), 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

[6] 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 it is eases the interpretation of the parameter ρ in the next equation. Also, note that $z(n)$ - parental income rather than the full value of the endowment - enters q. Sensitivity analysis suggests that results are almost invariant to changing this assumption to include the house endowment in q as well.

therefore reflects 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.[7] The calibration of the parameter ρ is left to Section 3.6.

3.4. The Public Choice Process and Private School Markets

Next, the public choice process that determines average public school spending in district d (x_d) and the nature of private school markets are 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, J_d is the population residing in district d, AID_d is the total state aid received by district d, and $P(C_d) = \Sigma_{h \in H}\, \mu(C_{dh})\, p(C_{dh})$ is the local property tax base which varies with the endogenously determined house price function $p{:}N \rightarrow \mathbb{R}_+$ that gives rise to an equilibrium house price vector p. This vector assigns a unique price to each of the 15 house/neighborhood types. The district specific AID_d corresponds to state aid levels in the representative districts in New York in 1990 (reported in Table 1) and is treated as exogenous (on a per pupil basis) but is funded through a state income tax. 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

---

[7] For a more detailed discussion of ways to resolve this puzzle, see Lazear (1999) and Nechyba (1999a,b), and for a discussion of the empirical evidence for peer effects, see McEwan, Nechyba and Older-Aguilar (1999).

exist. While voters take state aid into account, they are otherwise assumed to be quite *myopic* in that they take community composition, property values and school choice as given when going to the polls. Nechyba (1999a) describes this in detail and shows how it insures existence of a voting equilibrium.

Finally, 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. Given that there are no returns to scale in the production technology f, it is 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. The assumptions underlying this private school market are formally equivalent to treating private schools as excludable clubs under an equal cost sharing rule (Nechyba (1999a)). Finally note that while the mechanism is different, the advantage given to private schools over public schools - allowing them to select peer quality - is similar to that of Epple and Romano (1998) even though it does not allow for the same efficiency gains.[8] One implication of this peer advantage of private schools is that the demand for private schooling rises with ability while the demand for public school quality is independent of ability.

---

[8] Epple and Romano (1998) allow private schools to discriminate in their tuition policies which allows them to price externalities. I use a simpler mechanism here because of technical issues (Nechyba (1999a,b)).

3.5. *Equilibrium*

An equilibrium in this model must specify a list {J,t,T,s,p,η} that includes a partition J of households into districts and neighborhoods, local property tax rates $t \in \mathbb{R}_+^3$, a state income tax T, local public school qualities $s \in \mathbb{R}_+^3$, house prices $p \in \mathbb{R}_+^{15}$ and the sub-set of the population that attends public rather than private schools $\eta \subseteq N$. This list must satisfies the following conditions:

(1) $\mu(J_{dh})=\mu(C_{dh})\ \forall\ (d,h)$ (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, where $x_d = (t_d P(C_d)+AID_d)/\mu(\eta \cap J_d)$ (budgets balance) and $q_d = ((Z(\eta \cap J_d))^{\theta}\ (A(\eta \cap J_d))^{(1-\theta)})/7.5$;[9]
(4) $T=[\Sigma_d(\mu(\eta \cap J_d)(AID_d))+(y\ \mu(N \backslash \eta))]/z(N)$ (the state budget balances)[10];
(5) At prices p, households cannot gain utility by moving and/or changing schools;
(6) The private school market is perfectly competitive, and private schools are able to discriminate in their admission policy but not in their tuition policy.

Existence and uniqueness properties for this equilibrium are established in Nechyba (1999a)).

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, the house quality parameters k_{dh} as well as the Cobb-Douglas exponents α and β remain to be specified, while on the production side values for ρ and θ are still uncalibrated. The general strategy for a large part of this calibration is similar to that laid out in Nechyba (1997b) for a different type of model.

I assume an underlying utility function $u(h,s,c) = h^{\delta}s^{\alpha}c^{\beta}$ where h jointly captures housing and

---

[9] $Z(J_d) = \int_{Jd} z(n)$ 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.

[10] $N \backslash \eta$ represents the set of households choosing private schools, and y is the voucher level. Note that this assumes that all private school attendees are eligible for vouchers. Under restricted eligibility, (5) is adjusted accordingly.

neighborhood quality and is interpreted as the annualized flow of housing/neighborhood services. Since $s=f(x,q)= x^{(1-\rho)}q^{\rho}$, $u(h,x,c;q) = h^{\delta}(x^{(1-\rho)}q^{\rho})^{\alpha}c^{\beta} = \gamma h^{\delta}x^{(1-\rho)\alpha}c^{\beta}$ 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, 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).[11]

Next, I combine the housing value distribution data 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 10th, 30th, 50th, 70th and 90th percentile, 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/neighborhood quality parameters for this representative district. More precisely, suppose that for houses in districts falling into district

[11] Note that the budget share of 0.13 for education ($(1-\rho)\alpha$) is quite high - about twice the value it takes in other studies such as Epple and Romano (1998). The reason for this here is that I have assumed that each household has one child when actually each household at any given time on average has half a child. The one child assumption implies that, with correctly calibrated *per pupil* public school funds, *total* funds raised for public education in the no voucher scenario are about twice what they should be. One possibility would be to pursue the opposite strategy of endowing each household with half a child, which implies a budget share that is about half what it is here. Given the static nature of the model, it is unclear what the "right" strategy is: A sizeably fraction of the elderly, for instance, tend to vote in favor of increased public school funding despite the fact that they have no school-aged children themselves. One interpretation of having "too many" children in the model could therefore be that each child actually "counts" for more than one household. This would imply that it may be appropriate to assign preference values higher than the actual budget share paid for education by the average household and closer to the budget share that would exist if each household had to pay for one child. While this causes *total* spending to be overstated in the model, it may also capture the underlying behavioral parameters relevant for mobility more closely. Finally, it should be noted that, in other simulation contexts using this model, a modification to the assumption of one child per household did not change the main results dramatically once the model is re-calibrated in other dimensions.

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. $k_{23} = (1.5)^{\delta} = (1.5)^{0.22} = 1.093$.[12]

This leaves only α, ρ and θ uncalibrated. With respect to θ, I know of no estimates from past work that can be helpful. I therefore make no attempt to arrive at a single value for θ but 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, I find no guidance from the empirical literature. 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, 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 restricted to a narrower interval. Simulations reported in Nechyba (1999b) suggest this to lie within [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 generally falls close to 0.4. Sensitivity analysis using values for ρ 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.

---

[12] The resulting parameters go unreported here but are available in Table 3 of Nechyba (1999b).

3.7. Benchmark Equilibrium

Table 2 gives a representative benchmark equilibrium for the case of θ=0.5. (Benchmark equilibria for values other than θ=0.5 are not sufficiently different to warrant separate tables.) Note that per pupil spending levels closely mimic those found in the representative districts reported in Table 1, and mean incomes are close to the medians in Table 1. Similarly, inter-jurisdictional 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). However, a comparison of the model's interjurisdictional variance in incomes to the intrajursidictional variances actually understate the within district heterogeneity commonly found in school district data (Bogart (1990), Epple and Sieg (forthcoming)). Given that many of the results below depend on the presence of within school district heterogeneity, these results will tend to be under rather than overstated.

4. Simulation Results

In this section, I report simulation results for three types of vouchers. A voucher y simply 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.[13] The state government then sets a proportional state income tax sufficient to finance the voucher program. Voucher plans differ only in their definition of eligibility. A *full voucher* plan entitles every household to a voucher. A *district*

---

[13] Note 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 is often limited by the use of claimed capacity constraints as an exclusionary device. (Nechyba and Heise (forthcoming)).

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 3 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. Regardless of the level of θ, private school attendance in all districts 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, district 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 district. These immigrants come from the middle and high income districts 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 ones of sufficient quality) in districts that are cheaper due to their poor public school system. 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 of Table 3 is that, in the presence of full mobility, modest levels of private school attendance cause a substantial decrease in residential stratification of both district income and property values. Table 4 reports the variance of both incomes and property values within and across school districts. The variances in mean incomes 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 good school districts clearly suffer as their house values decline while homeowners in the poor district tend to benefit from capital gains due to increases in their house values. However, these benefits are not uniformly shared as the intra-district variance in property values rises somewhat in the poor district and falls in the wealthy district.[14]

A detailed welfare analysis using utility measures is also possible, although I have argued elsewhere that this may be less meaningful than one might hope for.[15] Nevertheless, 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 district who leave the district as a result of the immigration of private school attendees tend to be better off due to realized capital gains, 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 tend to be better off (because they are benefitting from a better peer group) 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

[14] Home owners in the worst neighborhood in district 1 suffer capital losses for most voucher levels because public schools in the district decline in quality but no private school attendees desire to live in that neighborhood.

[15] The argument against such welfare analysis rests on the fact that it pays no attention to where welfare gains and losses are coming from and thus is not very informative. Particularly, household welfare may change because of house price changes, because of better matches of housing demand due to the de-coupling of housing and schooling choices, or because of changes in school quality. Current research is focused on disentangling these effects more clearly.

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).

4.2. Targeting and Mobility

Next I investigate how much of these results are due to the mobility assumption and what implications this has for different kinds of targeting. Table 5 begins by comparing the percentage of students attending private schools from Table 3 to cases where households are immobile and cases where vouchers are targeted either to districts or to individuals.

First, the columns labeled A replicate the percentages previously reported in Table 3 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 districts, residents of the high income district are sufficiently satisfied with their local public school so as not to utilize vouchers, as are residents of the middle income district when $\theta=1$. Residents of the low income district, 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 district 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 district 1. 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 districts other than district 1 even when the program is not targeted. *For low levels of vouchers, targeting to the* *low income district is thus equivalent to not targeting at all when households are assumed to be mobile*. For higher levels of vouchers, take up rates in district 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 \$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 districts where public schools are poor. Income targeting thus isolates public schools in wealthy and middle income districts from competitive pressures they would face under district targeting or no targeting.

4.3. Impacts on Educational Opportunities

Two interesting questions can now be asked regarding the impact of vouchers on educational opportunities. First, does overall quality rise, and second, does the distribution of quality become more inequitable. Given the importance of peer effects in the model, and given the assumed absence of competition-induced increases in productive efficiency, it is clear that public school quality almost certainly must decline as high ability children are selecting into private schools. Table 6 which presents public school variables for full voucher programs assuming $\theta=0.5$ confirms this. Not only do peer quality variables in public schools decline due to cream skimming by private schools, but per pupil spending falls as voters turn against public schools.[16] While this result is in line with the prior literature, it should probably not be overemphasized as the model explicitly prohibits counteracting forces that might cause public schools to improve.[17]

Most interesting and perhaps most surprising are the impacts on the variances in these school variables across students. Table 7 presents these for the case of no targeting (with the case of district 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 districts suffer from out-migrations of high ability, high income households. This causes quality variables to decline in wealthy districts, and to decline proportionately more than in poor districts. Under no mobility, on the other hand, quality variables remain constant for districts that do not experience private school enrollments - i.e. wealthy districts. Thus, the lack of out-migrations resulting from the mobility restrictions causes quality to remain constant in districts with good public schools while it falls in districts with initially poor schools.

What we care about most, however, might not be the variance of quality across students who

---

[16] In Nechyba (1999a)) I had demonstrated that the direction of the change in per pupil spending on public schools in low income districts 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 decreases in spending with increased use of private schools.

[17] Tables similar to Table 6 for other voucher and other mobility assumptions are available in Nechyba (1997b).

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. This is true because, under mobility, the greatest segment of initial private school attendees is composed of high ability households from relatively modest neighborhoods in wealthy districts, households that can most easily find substitute housing in lower wealth districts. 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 in some sense be viewed as roughly equivalent to outcomes without vouchers, far from most a priori predictions of vast increases in inequities in education.[18] This is true despite the assumption of rather

[18] An important caveat to this is that, in the absence of competition induced improvements in public schools, those students that are left in public schools are worse off. Rawlsian welfare analysis applied to these results would, therefore, view the simulated voucher outcomes less favorably than might be implied by the variance measures of Table 7.

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 (Nechyba and Heise (forthcoming)). Regardless of which other assumptions are incorporated, it therefore seems essential to explicitly incorporate public school district choice.

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. On the normative side, even with assumptions that are quite stacked against vouchers, variances in overall quality may not be adversely affected by full or district 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 districts, the benchmark neighborhood 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, 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 districts 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 districts 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. This 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. Furthermore, the model as presented here is one of homeowners and does not include renters. While other simulations (not reported here) with renters 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, additional effects, such as returns from specialization, reductions in bureaucratic and political inefficiencies and a more explicit 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 (Nechyba and Heise (forthcoming)), 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 better overall evaluation of vouchers, and no simulation model can ultimately take the place of empirical analysis of real voucher experiments.

6. References

Bayer, Patrick. "An Empirical Analysis of the Equilibrium in the Education Market." Unpublished PhD dissertation, Stanford University, 1999.

Bogart, William T. *Essays on Intergovernmental Grants, Property Taxation and Housing Markets*. Unpublished Ph.D. dissertation, Princeton University, 1990.

Bureau of the Census. *1990 Census of Population and Housing*. Washington, DC: The Bureau of the Census, 1992.

Carnoy, Martin and Patrick McEwan. "The Effects of Competition from Private Schools on Achievement: A Longitudinal Analysis of Chilean Schools." Working paper, Stanford University, 1998.

Caucutt, Elizabeth. "Peer Group Effects in Applied General Equilibrium." Working paper, University of Rochester, 1997.

Chubb, John and Terry Moe. *Politics, Markets and America's Schools*. Washington, DC: Brookings Institution, 1990.

De Bartolome, Charles. "Equilibrium and Inefficiency in a Community Model with Peer Group Effects." *Journal of Political Economy*, February 1990, 98(1), pp. 110-33.

Downes, Thomas and Shane Greenstein. "Entry into the Schooling Market: How is the Behavior of Private Suppliers Influenced by Public Sector Decisions?" Working paper, Tufts University, 1997.

Epple, Dennis, Elizabeth Newlon and Richard Romano. "Ability Tracking, School Competition and the Distribution of Educational Benefits." Working paper, Carnegie Mellon University, 1997.

Epple, Dennis and Richard Romano. "Competition Between Private and Public Schools, Vouchers, and Peer-Group Effects." *American Economic Review*, March 1998, 88(1), pp. 33-62.

Epple, Dennis and Richard Romano. "Public School Choice and Finance Policies, Neighborhood Formation, and the Distribution of Educational Benefits." Working paper, University of Florida, 1995.

Epple, Dennis and Holger Sieg. "Estimating Equilibrium Models of Local Jurisdictions," *Journal of Political Economy*, forthcoming.

Evans, William and Robert Schwab. "Finishing High School and Starting College: Do Catholic Schools Make a Difference?" *Quarterly Journal of Economics*, November 1995, 110(4), pp. 941-74.

Figlio, David and Joe Stone. "School Choice and Student Performance: Are Private Schools Really Better?" Working paper, University of Oregon, 1997.

Friedman, Milton. *Capitalism and Freedom*, Chicago: The University of Chicago Press, 1962.

Glomm, Gerhard and B. Ravikumar. "Vouchers, Public and Private Education, and Income Distribution." Econometrics and Economic Theory Paper No. 9508, Michigan State University, 1995.

Goldstein, Gerald and Timothy Gronberg. " Local Public Goods and Private Suppliers: Musical Suburbs Replayed." *Journal of Urban Economics*, May 1986, 19(3), pp. 338-55.

Hanushek, Eric. "The Economics of Schooling: Production and Efficiency in Public Schools," *Journal of Economic Literature*, September 1986, 24(3), pp. 1147-217.

Hoyt, William and Kangoh Lee. "Educational Vouchers, Welfare Effects and Voting." *Journal of Public Economics*, August 1998, 69(2), pp. 211-28.

Hoxby, Caroline M. "Do Private Schools Provide Competition for Public Schools?" NBER working paper 4978, Cambridge, 1994.

Lankford, Hamilton and James Wyckoff. "The Effect of School Choice and Residential Location on the Racial Segregation of K-12 Students." Working paper, SUNY-Albany, 1997.

Lazear, Edward P. "Education Production." Hoover Institution working paper, Stanford University, 1999.

Levin, Henry. “Market Approaches to Education: Vouchers and School Choice.” *Economics of Education Review*, December 1992, 11(4), pp. 279-85.

Manski, Charles. “Educational Choice (Vouchers) and Social Mobility.” *Economics of Education Review*, December 1992, 11(4), pp. 351-69.

McEwan, Patrick, Nechyba, Thomas and Dina Older-Aguilar. “The Impact of Parental and Community Characteristics on Student Outcomes.” Working paper, Stanford University, 1999.

McMillan, Robert. “Heterogeneity, Competition, and Public School Productivity.” Working paper, Stanford University, 1999a.

McMillan, Robert. “Parental Involvement and Competition: an Empirical Analysis of Public School Quality.” Working paper, Stanford University, 1999b.

National Center for Education Statistics. *School District Data Book v. 1.0*. Washington, DC: US Department of Education, 1995.

Neal, Derek. “The Effect of Catholic Secondary Schooling on Educational Achievement.” *Journal of Labor Economics*, January 1997, 15(1), pp. 98-123.

Nechyba, Thomas. “School Finance Induced Migration Patters: The Case of Private School Vouchers.” *Journal of Public Economic Theory*, January 1999a, 1(1), pp. 5-50.

Nechyba, Thomas. “A Model of Multiple Districts and Private Schools: The Role of Mobility, Targeting and Private School Vouchers.” NBER working paper, Cambridge, 1999b.

Nechyba, Thomas. “Existence of Equilibrium and Stratification in Local and Hierarchical Public Good Economies with Property Taxes and Voting.” *Economic Theory*, August 1997a, 10(2), pp. 277-304.

Nechyba, Thomas. “Local Property and State Income Taxes: The Role of Interjurisdictional Competition and Collusion.” *Journal of Political Economy*, April 1997b, 105(2), pp. 351-84.

Nechyba, Thomas. “A Computable General Equilibrium Model of Intergovernmental Aid.” *Journal of Public Economics*, November 1996, 62(3), pp. 363-97.

Nechyba, Thomas and Michael Heise. “School Finance Reform: Introducing the Choice Factor.” In *City Schools: Lessons from New York* (Ravitch, D. and J. Viteritti, eds), Baltimore: Johns Hopkins University Press, forthcoming.

Nechyba, Thomas and Robert Strauss. “Community Choice and Local Public Services: A Discrete Choice Approach.” *Regional Science and Urban Economics*, January 1998, 28(1), pp. 51-74.

Rouse, Cecilia. “Private School Vouchers and Student Achievement: An Evaluation of the Milwaukee Parental Choice Program.” *Quarterly Journal of Economics*, May 1998, 113(2), pp. 553-602.

Solon, Gary. “Intergenerational Income Mobility in the United States.” *American Economic Review*, June 1992, 82(3), 393-409.

Witte, J. “Private School versus Public School Achievement: Are There Findings That Should Affect the Educational Choice Debate?” *Economics of Education Review*, December 1992, 11(4), pp. 371-94.

Zimmerman, David. “Regression Toward Mediocrity in Economic Stature.” *American Economic Review*, June 1992, 82(3), 409-29.

Table 1
Summary Statistics for Representative Districts

	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
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 3
Migration and Private School Attendance

District 1

Vouch	Fraction Private			Mean Income			Mean Property Values		
	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

District 2

Vouch	Fraction Private			Mean Income			Mean Property Values		
	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

District 3

Vouch	Fraction Private			Mean Income			Mean Property Values		
	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	0.0667	4.8000	6.2000	5.7111	1.3217	1.3725	1.4050
0.5	0.0667	0.0667	0.6037	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 4
Variances within and across Districts
Theta = 0.5

	Variance in Income Values			
Vouch	District 1	District 2	District 3	Across Districts*
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	District 1	District 2	District 3	Across Districts*
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

*Across-district variances are variances in means across districts.

Table 5
Private School Attendance

	District 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%

	District 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%

	District 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 district 1
D = no mobility and targeting to district 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 6
Public School Variables
θ=0.5, full mobility, no targeting

	District 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%	****	****	****	****

	District 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%	****	****	****	****

	District 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 7
Distribution of School Characteristics

	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