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Maria Marta Ferreyra

*Carnegie Mellon University*, [mferrey@andrew.cmu.edu](mailto:mferrey@andrew.cmu.edu)

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# Estimating the Effects of Private School Vouchers in Multidistrict Economies

By MARIA MARTA FERREYRA\*

*This paper estimates a general equilibrium model of school quality and household residential and school choice for economies with multiple public school districts and private (religious and nonsectarian) schools. The estimates, obtained through full-solution methods, are used to simulate two large-scale private school voucher programs in the Chicago metropolitan area: universal vouchers and vouchers restricted to nonsectarian schools. In the simulations, both programs increase private school enrollment and affect household residential choice. Under nonsectarian vouchers, however, private school enrollment expands less than under universal vouchers, and religious school enrollment declines for large nonsectarian vouchers. Fewer households benefit from nonsectarian vouchers. (JEL H75, I21, I22)*

Private school vouchers play an important role in the education reform debate in the United States. Vouchers, it is argued, give households the opportunity to enroll their children in private schools and have access to their preferred type of education. Furthermore, because residence requirements for public schools frequently imply that households must purchase public schools and housing in a *bundle*, vouch-

ers may break this bundling by allowing households to choose private schools, which do not have residence requirements.

In this paper, I investigate the potential effects of large-scale voucher programs. Since the voucher programs enacted to date in the United States have included relatively few recipients and have often restricted school eligibility,<sup>1</sup> researchers have lacked the data to evaluate large-scale voucher programs and have turned to simulation to investigate them.<sup>2</sup> Because of vouchers' potential impact both on school and residential choices, large-scale programs can lead to substantial changes in property values, school funding, and student populations across school districts. The nature of these effects implies that an adequate study of large-scale voucher programs must rely on a general equilibrium analysis. Thus, I develop and estimate a new equilibrium model of school quality and household residential and school choices for an economy with multiple public

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<sup>1</sup> Publicly funded voucher programs for K-12 students currently exist in Cleveland, Milwaukee, and the District of Columbia, and in Utah and Florida for students with special needs. See <http://www.heritage.org>.

<sup>2</sup> See, for instance, Peter Bearse, Gerhard Glomm, and B. Ravikumar (2001), Elizabeth M. Caucutt (2002), Danny Cohen-Zada and Moshe Justman (2005), Dennis Epple and Richard Romano (1998, 2003a), Raquel Fernandez and Richard Rogerson (2003b), Charles F. Manski (1992), and Thomas J. Nechyba (1999, 2000, 2003).

school districts and private schools. I then use the parameter estimates to simulate different voucher programs.

Throughout, I make three contributions. First, I build upon Thomas J. Nechyba's (1999) theoretical work and develop a rich model for empirical implementation and counterfactual analysis. I model household idiosyncratic tastes for location and school choices, which gives rise to an equilibrium that mixes households with heterogeneous income and school choices even in districts with no housing quality variation. I also include household religious preferences and two types of private schools, Catholic and non-Catholic. Although not modeled thus far, religious preferences seem relevant for the understanding of private schools, as religious schools comprised 85 percent of the 1990 private high-school enrollment (US Department of Education, 1992).<sup>3</sup> Religious preferences also allow for the study of such important issues as what type of private schools would expand under vouchers and at what rate, and what the effects would be of prohibiting the use of publicly funded vouchers for religious schools. Even though the Supreme Court upheld such use in *Zelman v. Simmons-Harris* (122 S. Ct. 2002), states are not bound by this ruling when designing voucher programs.<sup>4</sup> In addition, I model nonresidential property for a better representation of the sources of public school funding, particularly in inner-city districts attended by low-income students, which are often endowed with large stocks of nonresidential property.

Second, in contrast with all other researchers who have examined the general equilibrium effects of vouchers by relying on calibrated numerical examples, I estimate my model.<sup>5</sup> This

<sup>3</sup> In simultaneous work, Cohen-Zada and Justman (2005) have considered religious preferences in their voucher simulations for a calibrated single-district economy. A number of their qualitative results agree with mine.

<sup>4</sup> Many states have constitutional provisions ("Blaine amendments") with more prohibitive criteria for the separation of church and state than those found in the First Amendment. See <http://www.ij.org>.

<sup>5</sup> The only other paper that simulates large-scale voucher experiments based on econometric estimates is Joseph Altonji, Ching-I Huang, and Christopher Taber (2004), which focuses on the impacts of vouchers on the peer group of students who remain in public schools, holding locational decisions and the political economy equilibrium constant.

allows me to investigate the empirical properties of the model, such as its ability to fit the relevant dimensions of the data and the effect of its various features on the parameter estimates and their accuracy. Although models of household sorting across jurisdictions originated with Charles M. Tiebout's (1956) work,<sup>6</sup> only recently have researchers estimated them. Since household residential choices interact with housing prices, community compositions, and the level of local public goods such as education, researchers have developed estimation approaches consistent with the structure of the equilibrium. As the complexity of these models often precludes closed-form solutions, the challenge arises of ensuring that, in the estimation, *all* the conditions that characterize an equilibrium hold. Whereas previous researchers have relied on two-step estimation procedures,<sup>7</sup> I apply a one-step, full-solution estimation method that solves for the general equilibrium of the model as part of the estimation procedure. This approach is particularly well suited to ensure that all equilibrium conditions hold, because the very computation of an equilibrium is the search for an allocation that fulfills all those conditions. While clearly desirable, full-solution estimation is computationally more costly than a two-step procedure. Therefore, I have developed fast algorithms for equilibrium computation that make my approach computationally feasible. Furthermore, this computation is the same one used for policy simulations, which yields internal consistency and makes policy outcomes completely transparent. Besides being the first attempt to estimate a multijurisdictional model by full-solution methods, this paper illustrates how a similar procedure might apply to estimate other types of equilibrium models. Thus, this research lies at the frontier of computational analysis and estimation.

Third, using the parameter estimates, I assess the effects of two hypothetical state-funded voucher programs for the Chicago metropolitan area: universal vouchers and vouchers restricted

<sup>6</sup> See Epple and Nechyba (2004) for a recent survey of the literature on Tiebout models.

<sup>7</sup> See, for instance, Epple and Holger Sieg (1999) and Patrick Bayer, Robert McMillan, and Kim Rueben (2005). A notable exception is the full-solution estimation developed by Stephen Calabrese et al. (2006) in work initiated after mine.

TABLE 1—SELECTED METROPOLITAN AREAS

Metropolitan area	1990 census population (in thousands)	Number of school districts	Largest district's relative size	Fraction of Catholic population	Share of local sources
Boston, MA	2,871	87	0.158	0.49	0.72
Chicago, IL	6,070	50	0.472	0.41	0.68
Detroit, MI	4,382	110	0.261	0.35	0.78
New York—Long Island, NY	11,156	167	0.644	0.43	0.76
Philadelphia, PA—NJ	4,857	106	0.315	0.34	0.57
Pittsburgh, PA	2,057	80	0.141	0.47	0.63
St. Louis, MO—IL	2,444	71	0.146	0.26	0.65

*Notes:* Secondary and unified school districts included. District relative size = number of housing units in district/number of housing units in metropolitan area. Share of local sources for public school funding is the district average share in each metropolitan area.

*Source:* 1990 Census and School District Data Book (SDDDB), and 1990 Churches and Church Membership in America.

to nonsectarian private schools (“nonsectarian vouchers”).<sup>8</sup> According to my simulations, both programs raise private school enrollment and lead to the formation of new private schools. While vouchers for low dollar amounts are used primarily by middle- and some high-income households, only moderate and high voucher amounts are taken up by low (and high) income households. Furthermore, the presence of vouchers affects household residential choice. For instance, some voucher users migrate toward neighborhoods with relatively low tax-inclusive housing prices and send their children to private schools, thus weakening the residential stratification of the current public school system. These relocations yield capital gains for homeowners in locations favored by voucher users, and capital losses elsewhere.

By affecting property values, property tax rates, and the size and composition of the public school student body, vouchers affect public school quality. Nonetheless, the effects differ across districts. While low vouchers benefit a majority of households, only high vouchers benefit the average low-income household. Furthermore, high vouchers accrue the largest proportional school quality gains to households below median wealth. From a welfare perspective, vouchers have sizable distributional effects. The average winner is poorer than the average loser, and low-income households real-

ize the largest welfare gains relative to their endowments.

When vouchers are restricted to nonsectarian schools, overall private school enrollment expands less than under universal vouchers, and Catholic school enrollment declines as the voucher rises. Further, fewer households benefit or gain school quality. In particular, fewer low-income households gain school quality. A theme of the simulations in this paper is that voucher effects greatly depend on the dollar amount of the voucher and aspects of the voucher program such as school or student eligibility.

The remainder of this paper is organized as follows: Section I presents some descriptive statistics for the data employed; Section II presents the model; Section III discusses the computational version of the model used for estimation; Section IV describes the estimation procedure and Section V discusses the estimation results; Section VI analyzes voucher effects in policy simulations and Section VII concludes.

## I. Descriptive Statistics

My analysis focuses on the metropolitan areas of New York, Chicago, Philadelphia, Detroit, Boston, St. Louis, and Pittsburgh, and the secondary and unified school districts therein. As of 1990, these were among the 20 largest metropolitan areas in the United States. They also depended highly on local sources for public school funding and had populations that were at least 25 percent Catholic (see Table 1).

<sup>8</sup> For simplicity, I consider only one type of religious school, namely Catholic schools. Thus, the nonsectarian voucher simulation restricts vouchers to non-Catholic private schools with the intent of capturing the effects of restricting vouchers to nonsectarian schools.

TABLE 2—SCHOOL DISTRICTS IN SELECTED METROPOLITAN AREAS: SUMMARY STATISTICS

	Mean	Standard deviation	1 <sup>st</sup> percentile	99 <sup>th</sup> percentile
Fall enrollment	1,988	10,741	115	10,698
Number of households	1,970	11,829	37	10,619
Fraction of households w/ children in private schools	0.112	0.082	0.000	0.357
In central district	0.194	0.051	0.097	0.268
Average household income (\$)—all households	63,589	27,985	24,066	169,457
Households w/children in public schools	60,496	25,363	23,690	154,423
Households w/children in private schools	84,736	54,219	19,664	297,177
Average housing rental value (\$)—all households	13,525	8,007	3,499	40,349
Households w/children in public schools	13,156	7,785	3,453	39,867
Households w/children in private schools	16,159	9,775	2,905	46,656
Average spending per student in public schools (\$)	7,674	3,987	3,221	22,500
District size relative to metro area	0.010	0.036	0.000	0.141
Share of local (district) revenues for public school	0.697	0.193	0.186	0.989
Share of state revenues	0.276	0.177	0.007	0.697
Nonresidential property value/resid. prop. value	0.457	0.518	0.000	2.651
In central district	1.181	0.535	0.678	2.146

Notes: Number of observations: 671 school districts. Household data and fall enrollment are for grades 9 through 12. District size = number of housing units in the district/number of housing units in the metropolitan area.

Source: 1990 SDDDB and 1989 Common Core of Data. For nonresidential property sources, see Section III.

As Table 2 shows, the school districts in these metropolitan areas vary widely along the dimensions of interest, such as private school enrollment, average household income and rental value, and public school spending per student. Moreover, households with children in private schools tend to have higher incomes while living in higher-rental-value houses than households with children in public schools. The central city district is the largest district in each of my sample's metropolitan areas and captures most of the private school enrollment and non-residential property.

In addition, the geographic variation in private school markets across metropolitan areas seems to be shaped, at least partly, by the geographic variation in the distribution of adherents to different religions. Among the 20 largest metropolitan areas in the United States, those with higher private school enrollment rates have higher Catholic school enrollment rates and proportionally more Catholics. Moreover, the correlation between the fraction of students enrolled in Catholic schools and the fraction of Catholics equals 0.79, which squares with the fact that in 1990 about 85 percent of Catholic high-school students in the United States were Catholic (Frederick Brigham Jr. 1990).

## II. The Model

In the model, an economy is a set of public school districts with fixed boundaries that contain neighborhoods of different qualities. There are three types of schools: public, private Catholic, and private non-Catholic. Households that differ in endowment, religious preferences, and idiosyncratic tastes for locations and school types maximize utility by choosing a location and a school for their children and by voting for property tax rates used to fund public schools. In equilibrium, no household wishes to move, switch to a different school, or vote differently.

### A. Households and Districts

The economy is populated by a continuum of households, each one endowed with one house. The set of houses in the economy is partitioned into school districts. Every district  $d$  is in turn partitioned into neighborhoods, and there are  $H$  neighborhoods in total in the economy. Houses may differ across neighborhoods, but within a given neighborhood are homogenous and have the same housing quality and rental price. The size of the housing stock equals the measure of endowed houses, and the housing stock cannot

be varied in quantity or quality. Furthermore, each household has one child, who must attend a school, either public or private. One public school exists in each district and the child may attend only the public school of the district where the household resides. If parents choose to send their child to a private school, Catholic or non-Catholic, they are not bound to any rule linking residence and school.

In addition to a house, households are endowed with a certain amount of income and there are  $I$  income levels. Besides endowment,<sup>9</sup> households differ in their religious orientation, which is given by their valuation of Catholic schools relative to non-Catholic schools. Thus, a household has one of  $K$  possible religious types, where types 1, ...,  $L$  are Catholic, and the remaining  $K-L$  are non-Catholic. Not all the  $L$  Catholic types are necessarily identical, for they may differ in their relative valuation of Catholic schools, and the same is true for the non-Catholic types. Finally, households also differ in their idiosyncratic preferences for locations and types of school.

Household preferences for a combination of location and school type are described by the following Cobb-Douglas utility function:

$$(1) \quad U(\kappa, s, c, \varepsilon) = s^\alpha c^\beta \kappa^{1-\beta-\alpha} e^\varepsilon,$$

$$\kappa = k_{dh},$$

where  $\alpha, \beta \in (0, 1)$ ,  $k_{dh}$  is an exogenous parameter representing the inherent quality of neighborhood  $h$  in district  $d$  (i.e., housing size and age, geographic amenities, etc.),  $c$  is household consumption,  $s$  is the parental valuation of the quality of the child's school, which depends on the household's religious preferences, and  $\varepsilon$  is the household's idiosyncratic preference for the combination of location and school type.<sup>10</sup> For a given household,  $\varepsilon$  varies across combinations of location and school type. Furthermore,  $\varepsilon$  is distributed according to a continuous distribution  $G(\varepsilon)$  and is independently and identically distributed across combinations of loca-

tion and school type for a given household and across households.

Household  $i$  seeks to maximize utility (1) subject to the following budget constraint:

$$(2) \quad c + (1 + t_d)p_{dh} + T = (1 - t_y)y_n + p_n,$$

where  $y_n$  is the household's income,  $t_y$  is a state tax rate, and  $p_n$  is the rental price of the household's endowment house. Given its per-period total income, represented by the right-hand side of (2), the household chooses to live in location  $(d, h)$  with housing price  $p_{dh}$  and property tax rate  $t_d$ , and chooses a school with tuition  $T$  for its child ( $T = 0$  for public schools). Remaining income is used for consumption  $c$ .

### B. Production of School Quality

All schools in the economy produce school quality  $\bar{s}$  according to the following production function:

$$(3) \quad \bar{s} = q^\rho x^{1-\rho},$$

where  $\rho \in [0, 1]$ ,  $q$  stands for the school's average peer quality and  $x$  is spending per student at the school. Denote by  $S$  the set of households whose children attend the school and by  $\bar{y}(S)$  the average income of these households. Then the school's average peer quality is defined as  $q = \bar{y}(S)$ .<sup>11</sup> If the school is private, the spending per student  $x$  equals tuition  $T$  and may be supplemented with nontuition revenue,

<sup>11</sup> In this specification, peer quality captures all parental influences not mediated through school budgets that are positively correlated with parental income, such as parental involvement and monitoring, which have been found to be positively associated with education and income (McMillan 2000). For simplicity I have assumed perfect correlation between peer quality and household income, although Nechyba (2000, 2003) has explored imperfect correlation by adding student's ability to the peer quality measure and found his fundamental results unchanged. Epple and Romano (2003b) model achievement as a function of own ability and school quality, which in turn depends on the student body's average ability. They point out that any household variable, such as parental involvement, that positively affects both the child's performance and her school conforms to their model. Through similar reasoning, one concludes that if income measures ability, and ability affects achievement, none of this paper's findings is affected by the peer quality measure. See Epple and Romano (2003b) for references to the theoretical literature that considers peer effects in the production of education.

<sup>9</sup> Here and elsewhere, "endowment" refers to house and income endowment as opposed to income endowment only. "Wealth" is also used to denote "endowment."

<sup>10</sup> A referee suggested the investigation of interesting alternative specifications of idiosyncratic preferences. A discussion of those alternatives and further estimation results for one of them are available on request.

whereas it equals the spending per student in district  $d$ ,  $x_d$ , if the school is public and run by the local government.

The parental valuation of school quality (see  $s$  in equation (1)), depends on each household's religious preferences. A household of religious type  $k = 1, \dots, K$ , whose child attends a school with religious orientation  $j = 1, 2$  (Catholic or non-Catholic respectively, with public schools being nonsectarian and therefore non-Catholic) and quality  $\tilde{s}_j$ , perceives the school's quality as follows:

$$(4) \quad s_{kj} = R_{kj}\tilde{s}_j,$$

where  $R_{kj} > 0$  is a preference parameter further discussed below.

### C. Public Schools

The quality of the public school in district  $d$  is  $\tilde{s}_d = q_d^p x_d^{1-\rho}$ , where  $q_d$  is the average income of households in district  $d$  with children attending this school. The public spending in education is funded by local property taxes, possibly aided by the state. Thus, the spending per student in district  $d$  is given by  $x_d = t_d(P_d + Q_d)/n_d + AID_d$ , where  $n_d$  is the measure of households choosing public school in district  $d$ ,  $AID_d$  is the amount of state aid per student for district  $d$ , funded through state income tax, and  $P_d$  and  $Q_d$  are the values of residential and nonresidential district property, respectively.<sup>12</sup>

### D. Private Schools

Private schools are modeled as clubs formed by parents under an equal cost-sharing rule. Since the school production function in (3) creates incentives for a household to join a school with households of equal or higher endowment, and the production of school quality features constant returns to scale, households of a given

endowment may optimally segregate into a private school and reject lower endowment households. Therefore, a private school formed by households of income level  $y_n$  has peer quality  $q = y_n$ .

Households share costs equally at a private school. Thus, the tuition equals the households' optimal spending on education, holding their residential locations fixed. That is, after choosing a location  $(d, h)$  with quality  $k_{dh}$ , household  $n$  of religious type  $k$  with income  $y_n$  may choose to send its child to a private school with tuition  $T$  and religious orientation  $j = 1, 2$  (Catholic or non-Catholic), which maximizes utility (1) subject to the budget constraint (2) and the perception of school quality  $s = R_{kj}q^p x_j^{1-\rho}$ , where  $q = y_n$ , and  $x_j = T$ . Notice that the optimal tuition  $T$  determined by solving this optimal choice problem does not depend upon  $R_{kj}$ . Furthermore, private schools may supplement their tuition revenue with other sources. In particular, a private school of religious orientation  $j$  may match its tuition at the rate  $z_j$ , so that  $x_j = (1 + z_j)T$ . Parents who decide to open a private school choose the school religious orientation (Catholic or non-Catholic) that yields the higher utility.

### E. Household Decision Problem

Households are utility-maximizing agents that choose locations  $(d, h)$  and schools simultaneously, while taking tax rates  $t_d$ , district public school qualities  $s_d$ , prices  $p_{dh}$ , and the composition of the communities as given. Household  $n$  chooses among all locations  $(d, h)$  in the budget set determined by the constraint  $(1 + t_d)p_{dh} \leq (1 - t_y)y_n + p_n$ . For each location, the household compares its utility under public, Catholic, and non-Catholic private schools. Migrating among locations is costless in the model and the household may (and often will) choose to live in a house other than its endowed house.

### F. Absolute Majority Rule Voting

Households also vote on local property tax rates. At the polls, they take their location, their choice of public or private school, property values, and the choices of others as given. Households that choose private schools vote for a tax rate of zero, whereas households that choose public schools vote for a nonnegative tax rate.

<sup>12</sup> For simplicity, I model nonresidential property as owned by an absentee landlord who does not participate in the elections to set property tax rates, and I assume that its supply is inelastic. Hence, there is full capitalization of property taxes for nonresidential property, so that the gross-of-tax rental price of nonresidential property is fixed. Since the tax base includes the net-of-tax value of this property, my treatment captures the incentive faced by voters when taxing nonresidential property.

Because voters choose the tax rate conditional on their school choice taking everything else as given, their preferences over property tax rates are single peaked. Property tax rates are determined by majority voting as long as they at least support an exogenously specified spending floor  $\bar{x}_d$ ; if they do not, the property tax rate is set to cover the spending floor, which reflects adequacy clauses in state constitutions that seek to guarantee the minimum spending required to provide adequate public school quality. The state cooperates in funding public education in district  $d$  by providing an exogenous aid amount per student  $AID_d$ . This aid, which operates as a flat grant, is in turn funded by a state income tax whose rate  $t_y$  is set to balance the state's budget constraint.

### G. Equilibrium

An *equilibrium* in this model specifies a partition of the population into districts and neighborhoods, local property tax rates  $t_d$ , a state income tax  $t_y$ , house prices  $p_{dh}$ , and a partition of the population into subsets of households whose children attend each type of school, such that: (a) every house is occupied; (b) property tax rates  $t_d$  are consistent with majority voting by residents who choose public versus private school, taking their location, property values, and the choices of others as given when voting on local tax rates; (c) the budget balances for each district; (d) the state budget balances; and (e) at prices  $p_{dh}$ , households cannot gain utility by moving and/or changing schools.

Though the equilibrium is proved to exist with a finite number of household types (Nechyba 1999), no proof has been developed for the case of an infinite number of household types. Nonetheless, I have established conditions sufficient to determine whether an allocation is an equilibrium, and have developed an algorithm to compute the equilibrium.<sup>13</sup>

<sup>13</sup> With a finite number of household types, the allocation of households to locations and schools is unique if the variation in district average housing quality is sufficiently large (Nechyba 1999). Without this variation, it may not be possible to determine uniquely where the wealthy live and form high-quality public schools. Hence, for the empirical model, I constructed neighborhoods to maximize such variation. Simulations have shown that the equilibrium is robust

### III. The Computational Version of the Model

In the computational version of the model, the concept of an “economy” corresponds to a metropolitan area, and households do not migrate across metropolitan areas. The estimation strategy involves computing the equilibrium for each metropolitan area at alternative parameter points to search for the point that minimizes a well-defined distance between the predicted equilibrium and the observed data. Since the equilibrium does not have an analytical solution, I solve for it through an iterative algorithm for a tractable representation of each metropolitan area. Thus, this section describes the setup of districts and neighborhoods in this representation, the construction of household types, the state financial regime applied in computing the equilibrium, and the algorithm employed.

#### A. Community Structure

I measure the actual size of neighborhoods, districts, and metropolitan areas by the number of housing units. For computational tractability, I aggregate the actual districts of each metropolitan area into *pseudo-districts* in order to compute the equilibrium, such that the largest district is a pseudo-district in itself, while smaller, contiguous districts are pooled into larger units. The actual 671 districts thereby yield 58 pseudo-districts. Figure 1 depicts census tracts, and school districts and pseudo-districts for the Chicago metropolitan area. Once the pseudo-districts (henceforth called districts) are constructed, I split them into neighborhoods of approximately the same size, such that some districts have only one neighborhood while others

to the selection of different initial prices and assignments of households to locations. Although for a given variation in housing quality multiple equilibria are more likely when households place a sufficiently high value on school quality (high  $\alpha$ ) or when peer quality is very important relative to spending (high  $\rho$ ), estimates for this model do not satisfy these conditions. Finally, notice that the type of equilibrium that I compute, with higher-income households living in higher-quality districts, seems to have been an empirical regularity in US metropolitan areas for a number of years, thus becoming a reasonable focal point for estimation and policy simulations.



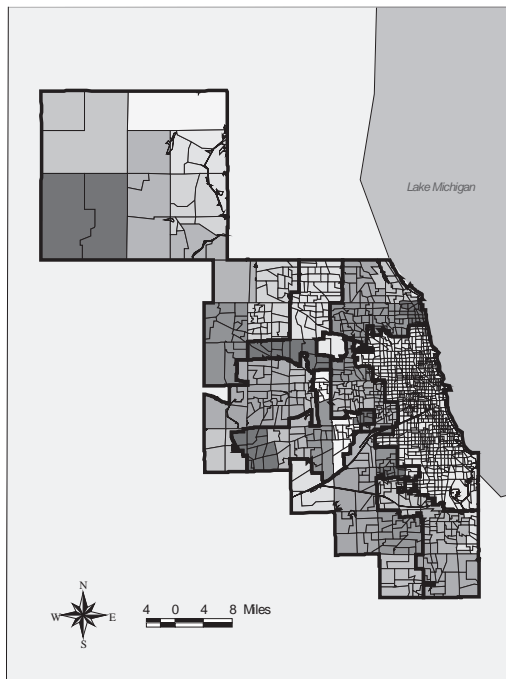


FIGURE 1. CHICAGO: CENSUS TRACTS, SCHOOL DISTRICTS, AND SCHOOL PSEUDO-DISTRICTS

*Notes:* The fine lines are the boundaries of census tracts, and different shades identify census tracts located in different school districts. The thick lines are the boundaries of the pseudo-districts.

have several. Larger metropolitan areas have larger neighborhoods.

### B. Neighborhood Quality Parameters

In the theoretical model, each neighborhood is composed of a set of homogeneous houses, such that neighborhood  $h$  in district  $d$  has a neighborhood quality index equal to  $k_{dh}$ . Since standard datasets do not measure neighborhood quality, I construct an index that captures housing quality and neighborhood amenities, *excluding* public school quality. The census geographical concept that best approximates a neighborhood is the census tract. Hence, I first compute the neighborhood quality index for each census tract by regressing the logarithm of tract average rental price on a set of neighborhood characteristics and school district fixed effects for each metropolitan area, then making each

tract's neighborhood quality index equal to the tract's fitted rental value net of school district fixed effects.<sup>14</sup> The motivation for this regression is that, broadly speaking, rental prices reflect housing characteristics, neighborhood amenities, and public school quality. Thus, the district fixed effect nets out the school quality component from the measure of neighborhood quality. After obtaining the neighborhood quality index for each census tract, I construct neighborhoods of the desired size by pooling contiguous tracts whose value for the neighborhood quality index lies in the same range. Lastly, I assign each neighborhood the median quality index from the neighborhood's tracts.<sup>15</sup>

For an example of the final representation of a metropolitan area through pseudo-districts and neighborhoods, see Figure 2 for the Chicago metropolitan area. The central city of Chicago overlaps entirely with the central district. Unlike the suburban districts, which have one neighborhood each, the central district has seven neighborhoods, which differ in housing quality. On average, the central district has the lowest housing quality in the metropolitan area, although some neighborhoods in the central district are of higher housing quality than others in the suburbs.

<sup>14</sup> As neighborhood characteristics in the regression, I use tract average housing characteristics from the Census, and linear and quadratic terms in tract distance to the metropolitan area center. Ideally, I would include these characteristics as arguments in the utility function, and estimate their coefficients along with the remaining parameters of the model. Since computational constraints prevent me from estimating a large number of parameters, I estimate the coefficients as described above. See Ferreyra (2002) for more details on the computation of the neighborhood quality parameter and the data used to compute rental values and neighborhood characteristics.

<sup>15</sup> The process of constructing pseudo-districts and neighborhoods involves the following steps: (a) based on the total size of the metropolitan area, determine the number of equal-sized neighborhoods that yield tractable computations; (b) find the neighborhood quality parameter for each census tract; and (c) pool contiguous tracts with similar values for their neighborhood quality parameters into one neighborhood, such that no actual district is split between neighborhoods, each neighborhood comes as close to the size determined in (a) as possible, and the central district remains a pseudo-district in itself. For estimation-related reasons, I organize the neighborhoods thus constructed into as many pseudo-districts as possible, rather than having fewer pseudo-districts with many neighborhoods each.

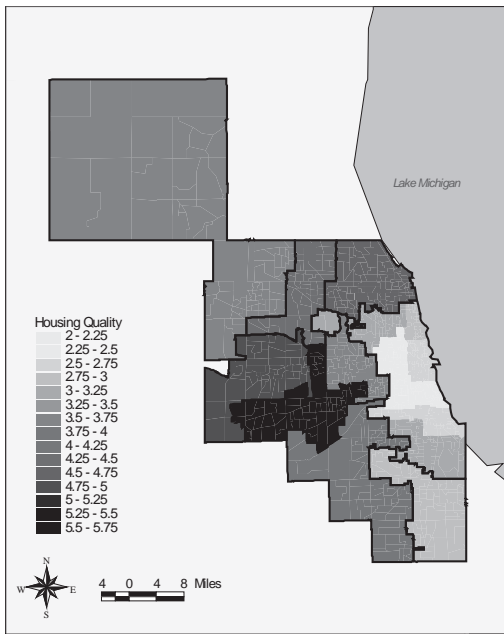


FIGURE 2. CHICAGO: HOUSING QUALITY BY NEIGHBORHOOD

### C. Households

I consider income levels equal to the tenth, thirtieth, fiftieth, seventieth, and ninetieth percentiles of the income distribution of households with children in public or private schools in grades 9 through 12 in each metropolitan area. For computational purposes, the joint distribution of housing and income endowment is as follows. At the beginning of the equilibrium computation, the distribution of income in each neighborhood is initially the same and equal to the metropolitan area's. Hence, income and housing endowments are independently distributed, as are religious preferences and endowments.<sup>16</sup>

Recall that each household is characterized

<sup>16</sup> For computational convenience I place a measure of households equal to ten in each (house endowment, income) combination. For instance, if the proportions of Catholics and non-Catholics in the metropolitan area are 28 and 72 percent, respectively, then Catholic and non-Catholic households have initial measures equal to three and seven, respectively, in each (house endowment, income) combination, given the lack of empirical evidence against income and religion being independently distributed (Ferreira 2002). Data on the fraction of Catholics in a metropolitan area come from the 1990 Church and Church Membership in America survey.

by two religious matches, one with respect to Catholic schools and another with respect to non-Catholic schools. If household  $n$  is Catholic, its religious preferences are described by its matches with respect to Catholic and non-Catholic schools,  $R_{C,C}^n$  and  $R_{C,NC}^n$ , respectively; if household  $n$  is non-Catholic, its religious preferences are given by its matches with respect to Catholic and non-Catholic schools,  $R_{NC,C}^n$  and  $R_{NC,NC}^n$ , respectively. Since there are two types of schools, I make  $R_{C,NC}^n = R_{NC,NC}^n = 1$  and focus on the relative valuation of Catholic schools. Unlike income, whose distribution comes straight from the data, the distribution of religious matches  $R_{C,C}^n$  and  $R_{NC,C}^n$  needs to be estimated. Therefore, I construct a discrete distribution of religious matches by assuming an underlying continuous distribution: I assume that  $R_{C,C}^n$  and  $R_{NC,C}^n$  are distributed uniformly over the intervals  $[(1+r)(1-\delta), (1+r)(1+\delta)]$  and  $[(1-r)(1-\delta), (1-r)(1+\delta)]$ , respectively, where  $0 < r < 1$  and  $0 < \delta < 1$ . The parameter  $r$  is both the premium enjoyed by the average Catholic in a Catholic school, and the negative of the discount suffered by the average non-Catholic in a Catholic school, whereas the parameter  $\delta$  is proportional to the coefficient of variation of these distributions.<sup>17</sup> Finally, since households in the model also differ in their idiosyncratic preferences for combinations of location and school type, I assume that  $\varepsilon$  follows a type I extreme value distribution with scale parameter  $1/b$ , where  $b > 0$ . Thus,  $F(\varepsilon) = \exp(-\exp(-\varepsilon/b))$ , and the variance of  $\varepsilon$  equals  $(1/6)\pi^2 b^2$ .

### D. State Aid and Nonresidential Property

Since the metropolitan areas included in my analysis on average fund more than two thirds of public school spending through local sources, it is clear that the efforts from those states to equalize spending across districts are quite limited. Furthermore, these metropolitan areas differ in the actual (and extremely complex) state formulas for the allocation of funds among districts

<sup>17</sup> To exemplify the determination of household religious matches, assume that 28 percent of all households are Catholic,  $r = 0.2$  and  $\delta = 0.1$ , which implies that  $R_{C,C}^n$  and  $R_{NC,C}^n$  are uniformly distributed between 1.08 and 1.32, and between 0.71 and 0.88, respectively. Hence, the first, second, and third Catholic household types have matches equal to 1.08, 1.20, and 1.32, and the first through seventh non-Catholic household types have matches equal to 0.72, 0.75, 0.77, 0.80, 0.83, 0.85, and 0.88, respectively.

(Caroline M. Hoxby 2001), and the allocation process involves subtleties often unobservable to the researcher (Nechyba 2003). Hence, I simplify by using the same mechanism across metropolitan areas—a local funding system with a state flat grant per student which may differ across districts and is equal in value to the state aid reported by the 1990 School District Data Book.<sup>18</sup> As for the nonresidential property, its gross-of-tax value for a district is such that in the absence of property taxes, the ratio between this value and the observed value of the residential property tax base equals the district observed ratio of assessed nonresidential to residential property.<sup>19</sup>

### E. The Algorithm

In the model, the parameter vector is  $\theta = (\alpha, \beta, \rho, r, \delta, b)$ . Computing the equilibrium for each parameter point and metropolitan area is an iterative process in which households choose locations and schools and vote for property taxes until no household gains utility by choosing differently. The input for the algorithm consists of the community structure, initial distribution of household types, initial housing prices, state aid, nonresidential property and spending floor for each district, and the Catholic school tuition subsidy rate. The output is the computed equilibrium from which I extract the variables whose predicted and observed values I match in the estimation (see the Appendix, [http://www.e-aer.org/data/june07/20030801\\_app.pdf](http://www.e-aer.org/data/june07/20030801_app.pdf), for further details).

## IV. Estimation

I estimate the model using a minimum distance estimator. I match the observed and sim-

ulated values of the following district-level variables, which I construct based on the 1990 School District Data Book:  $y_1$  = average household income,  $y_2$  = average housing rental value,  $y_3$  = average spending per student in public schools, and  $y_4$  = fraction of households with children in public schools. In addition, I match  $y_5$ , the fraction of households with children in Catholic schools at the metropolitan area level, calculated from the 1989 Private School Survey.<sup>20</sup> These variables, which are scaled to have unit variance in the sample, are of interest because they provide the basic characterization of household sorting across districts and schools, and the resulting spending in public schools.

Let  $D$  denote the total number of districts in the sample ( $D = 58$ ),  $M$  the number of metropolitan areas ( $M = 7$ ), and  $N_j$  the number of observations available for variable  $y_j$ ,  $j = 1, \dots, 5$ , so that  $N_1 = N_2 = N_3 = N_4 = D$ , and  $N_5 = M$ . Assume that district  $i$  is located in metropolitan area  $m$ . Then, denote by  $X_i$  the set of exogenous variables for district  $i$ , such that  $X_i = x_i \cup x_m \cup x_{-i}$ . Here,  $x_i$  is district  $i$ 's own exogenous data (state aid, nonresidential property and spending floor, number of neighborhoods, neighborhood quality in each neighborhood),  $x_m$  is exogenous data pertaining to metropolitan area  $m$  (tenth, thirtieth, fiftieth, seventieth, and ninetieth income percentiles, and the fraction of Catholic households in the metropolitan area), and  $x_{-i}$  is the "own" data from the other districts in metropolitan area  $m$ . In addition, the set of independent variables for  $y_{5m}$  is  $X_m$ , which is the union of all the  $X_i$  sets corresponding to the districts that belong to metropolitan area  $m$ . Finally, let  $n_i$  denote the number of housing units sampled in district  $i$ , and let  $n_m$  denote the number of housing units sampled in metropolitan area  $m$ .

I assume the following:

$$(5) \quad E(y_{ji}|X_i) = h_j(X_i, \theta)$$

$$j = 1, \dots, 4; i = 1, \dots, N_j,$$

<sup>18</sup> Whereas the actual matching grant mechanisms in these metropolitan areas create incentives for higher property tax rates, the assumed flat grants have the opposite effect. By creating an incentive for higher property tax rates, however, nonresidential property mimics the effect of matching grants. Furthermore, districts that receive large matching grants tend to have large stocks of nonresidential property as well.

<sup>19</sup> I constructed the observed ratio of assessed nonresidential to residential property using data from the departments of revenue of Illinois, Pennsylvania, and New York, the Massachusetts Taxpayers Foundation, the Citizens Research Council of Michigan, and the 1987 US Census of Governments.

<sup>20</sup> The fraction of households that reside in a district and send their children to Catholic schools is not available, since no data source links households' residences with different types of private schools. It seems reasonable to assume, however, that households with children enrolled in Catholic schools located in a given metropolitan area reside there, which allows me to match Catholic school enrollment at the metropolitan area level.

$$(6) \quad E(y_{5m} | \mathbf{X}_m) = h_5(\mathbf{X}_m, \boldsymbol{\theta}) \quad m = 1, \dots, M,$$

where the  $h$ 's are implicit nonlinear functions that express the equilibrium value of each endogenous variable I match as a function of the exogenous data and the parameter vector  $\boldsymbol{\theta}$ . Since the  $y_{ji}$ 's are (district-level) sample means,  $C(y_{ji}, y_{ki} | \mathbf{X}_i, \mathbf{X}_{i'}) = \sigma_{jk}/n_i$  if  $i = i'$  and 0 otherwise, with  $V(y_{ji} | \mathbf{X}_i) = \sigma_{jj}/n_i = \sigma_j^2/n_i = \sigma_{ji}^2$ , where  $\sigma_{jk}$  and  $\sigma_j^2$  denote population covariances and variances, respectively. Similarly, given that the  $y_{5m}$ 's are also sample means,  $C(y_{ji}, y_{5m} | \mathbf{X}_i, \mathbf{X}_m) = \sigma_{j5}/n_i$  if district  $i$  is located in metropolitan area  $m$ , and  $C(y_{ji}, y_{5m} | \mathbf{X}_i, \mathbf{X}_m) = 0$  otherwise. Also,  $V(y_{5m} | \mathbf{X}_m) = \sigma_{55}/n_m = \sigma_5^2/n_m = \sigma_{5m}^2$ .

### A. Estimation Strategy

Because the number of observations is rather small, I estimate the model using Feasible Weighted Least Squares to account for heteroskedasticity across observations and then use the cross-equation covariances to obtain correct standard errors. The first stage of Feasible Weighted Least Squares determines the value for  $\boldsymbol{\theta}$  that minimizes the following loss function:

$$(7) \quad L(\boldsymbol{\theta}) = \sum_{j=1}^4 \sum_{i=1}^{N_j} (y_{ij} - \hat{y}_{ij}(\boldsymbol{\theta}))^2 + \sum_{m=1}^M (y_{5m} - \hat{y}_{5m}(\boldsymbol{\theta}))^2,$$

and the residuals from this regression are used to compute  $\hat{\sigma}_j^2$  and  $\hat{\sigma}_5^2$ . The second stage runs Nonlinear Least Squares on variables transformed to account for heteroskedasticity, and seeks to minimize the following loss function in the transformed variables:

$$(8) \quad \tilde{L}(\boldsymbol{\theta}) = \sum_{j=1}^4 \sum_{i=1}^{N_j} (y_{ji}^* - \hat{y}_{ji}^*(\boldsymbol{\theta}))^2 + \sum_{m=1}^M (y_{5m}^* - \hat{y}_{5m}^*(\boldsymbol{\theta}))^2,$$

where  $*$  denotes division by  $\hat{\sigma}_{ji}$  or  $\hat{\sigma}_{5m}$ . The value of  $\boldsymbol{\theta}$  that minimizes this function,  $\hat{\boldsymbol{\theta}}$ , is my estimate for the parameter vector. In addition to the model in Section II, I estimate three simplified models to highlight the empirical richness of my theoretical framework. In particular, model 1 excludes household idiosyncratic preferences (i.e.,  $b = 0$ ) while the others include them.

### B. Computational Considerations

Since model 1 has a finite number of household types, it exhibits a coarseness that poses challenges for the equilibrium computation, the estimation, and the fit of the data. To estimate this model, I use a refined grid search, which allows the objective function to be evaluated at each parameter point independently of others and lends itself to the type of parallel computing that I exploit in the estimation. The disadvantage of a grid search, however, is that the grid size grows exponentially with the number of parameters. Using Condor to estimate this model,<sup>21</sup> I evaluate the objective function at about 250 parameter points simultaneously using a separate processor for each point. A function evaluation takes approximately ten minutes on a 1 Ghz Intel processor, and the full estimation takes about a week.

In contrast, the presence of an infinite number of household types in models 2, 3, and 4 facilitates the computation of the equilibrium and the estimation of the model, for which I employ a cyclical coordinate descent algorithm (Dimitri P. Bertsekas 1995). A function evaluation takes about 40 seconds. Furthermore, the full estimation takes between one and two days in a 3 Ghz Intel processor and can be run on a desktop, which is a clear simplification over model 1.<sup>22</sup>

<sup>21</sup> A project of the Computer Science Department at the University of Wisconsin-Madison, Condor is a software system harnessing the power of a cluster of UNIX workstations on a network (<http://www.cs.wisc.edu/condor>).

<sup>22</sup> In model 1, the loss function is discontinuous because of the discreteness of household types and the presence of a median voter in each district. However, a sufficiently large number of household types and school districts would yield a smooth objective function. Although majority voting still generates some minor discontinuity in the objective function for models 2, 3, and 4, a sufficiently large number of districts would yield a completely smooth function. For the sake of computing standard errors, I proceed as if I had good

### C. Identification

The model is identified if no two distinct parameter points generate the same equilibrium for each metropolitan area. A sufficient condition for local identification is that the matrix of first derivatives of the predicted variables with respect to the parameter vector has full column rank when evaluated at the true parameter points, a condition which requires sufficient variation in the exogenous variables across districts and metropolitan areas. Evaluated at my parameter estimates, the matrices of first derivatives of the estimated models have full column rank in my sample.

Although changing one parameter changes several endogenous variables given the nature of the model, one can still identify the first-order effects by varying each parameter computationally. A higher school quality coefficient in the utility function ( $\alpha$ ) implies higher educational spending and lower housing prices, and a higher coefficient on consumption ( $\beta$ ) implies higher household consumption and lower housing prices. A higher elasticity of school quality with respect to peer quality ( $\rho$ ) lowers the importance of spending in the production of school quality, hence lowering spending. Furthermore, a higher  $\rho$  makes households more willing to segregate into private schools.

An increase in the Catholic school premium ( $r$ ) raises the relative valuation of Catholic schools among Catholics yet lowers it among non-Catholics. If  $r = 0$ , then Catholics have the same preferences as non-Catholics and households sort themselves across private school types randomly. The greater the value of  $r$ , the higher is the fraction of Catholic school enrollment accounted for by Catholics. An increase in  $\delta$  raises the variation around the mean religious match among Catholics and non-Catholics. As  $\delta$  rises, more Catholics come to prefer non-Catholic over Catholic schools and the reverse happens to non-Catholics. In particular, the identification of  $r$  and  $\delta$  is largely driven by the variation in religious affiliation and Catholic school enrollment across metropolitan areas. Finally, an increase in the value of the variance of idiosyncratic preferences ( $b$ ) strengthens the

role of idiosyncratic preferences in household location and school choice. When  $b = 0$ , households' choices are determined only by their wealth and their religious preferences; when  $b$  is sufficiently large, household choices are determined only by their idiosyncratic preferences, which results in a random sorting of households across locations and schools.

### D. Relationship to Other Estimated Multijurisdictional Models

The inclusion of household idiosyncratic preferences in my model resembles the use of random utility in demand models for differentiated products used in industrial organization (Steven Berry 1994; Berry, James Levinsohn, and Ariel Pakes 1995). Applying this framework, Bayer et al. (2005) have estimated an equilibrium model of household sorting using restricted-access census micro data for the San Francisco Bay Area. Although this model features a rich and flexible demand side for housing and location-specific characteristics, it does not endogenize the provision of local public goods. Hence, this model does not account for the variation in spending, and possibly quality, across public schools in a given metropolitan area, which in turn relates to which households would be more likely to take up vouchers, and how vouchers would affect local public school quality. In addition, this model does not explore the role of privately provided alternatives to local public goods.<sup>23</sup>

The first papers to estimate an equilibrium model of household sorting among local juris-

<sup>23</sup> In this framework, the demand for each jurisdiction is the aggregation of individual demands emerging from the random utility model and is a function of the mean utility level across households. This, in turn, is found by equating the predicted demand for each jurisdiction with the observed population—namely, by “inverting” the jurisdiction’s population share. Since mean utility is assumed to be a linear function of the jurisdiction’s observed and unobserved characteristics for a given set of parameters, and the observed characteristics—such as housing prices—are presumably correlated with the unobserved ones, the parameters of the model are estimated through an instrumental variable regression of the mean utility level on the observed characteristics. Hence, estimation relies on a two-step procedure that first solves for the partial equilibrium of the housing market given other endogenous variables, and then addresses this endogeneity through instrumental variables techniques.

approximations to the continuous functions and rely on numerical derivatives.

TABLE 3—PARAMETER ESTIMATES

Parameter	Model 1 estimates	Model 2 estimates	Model 3 estimates	Model 4 estimates
$\alpha$	0.12 (0.001)	0.086 (0.002)	0.068 (0.001)	0.077 (0.003)
$\beta$	0.72 (0.001)	0.661 (0.006)	0.680 (0.009)	0.678 (0.007)
$\rho$	0.24 (0.001)	0.010 (0.070)	0.121 (0.029)	0.221 (0.008)
$r$	0.11 (0.009)	0.010 (0.063)	0.010 (0.049)	0.451
$\delta$	0.25 (0.001)	0.270 (0.723)	0.713 (0.278)	0.275 (0.037)
$b$		0.031 (0.001)	0.030 (0.001)	0.029 (0.0003)
Sum of squared residuals	871.564	451.572	298.463	316.187
Unweighted sum of squared residuals	714.460	255.581	225.953	244.215

Notes: Standard errors in parentheses. For number of observations, see Section IV. Sum of squared residuals uses second-stage weights from model 3. Unweighted sum of squared residuals uses no weights. Ranking of models by sum of squared residuals is robust to the use of weights from any model.

dictions while accounting for the endogeneity of local tax and expenditure policies were Epple and Sieg (1999) and Epple, Thomas Romer, and Sieg (2001), whose estimator exploits equilibrium necessary conditions. This model does not include private schools, and its local public good index aggregates elements with potentially dissimilar roles in a voucher environment.<sup>24</sup> While household preference heterogeneity plays a key role in household sorting in this model, housing quality variation within and across districts is essential to sorting in my framework. Moreover, policy simulations carried out with a model related to Epple and Sieg's have focused on exogenous public good changes (Sieg et al. 2004). In contrast, I recognize that the provision of local public goods would adjust endogenously under vouchers through both household individual choices and voters' collective decisions.

## V. Estimation Results

Table 3 presents the parameter estimates for the estimated models, each of which is dis-

cussed in turn below. I present three simplified models before turning to the most general formulation, which corresponds to the model in Section II. Model 1 excludes household idiosyncratic preferences for locations and schools, nonresidential property, and spending floor in public schools, and assumes a zero subsidy rate for Catholic schools. Catholic school enrollment in this model is driven mostly by the heterogeneity of preferences for Catholic schools parameterized through  $r$  and  $\delta$ . In this model, when faced with the choice between schools that are identical in everything except religious orientation, at least some Catholics would choose non-Catholic schools if  $\delta > r/(1 + r)$ , whereas at least some non-Catholics would choose Catholic schools if  $\delta > r/(1 - r)$ . Indeed, the parameter estimates for this model generate sufficient overlap that Catholics may enroll in non-Catholic schools and vice versa. These estimates also lead to the rejection of the hypothesis that Catholics' and non-Catholics' preferences for Catholic schools follow the same distribution,<sup>25</sup> hence predicting that most of the equilibrium Catholic school enrollment

<sup>24</sup> For instance, even if all households have the same preferences for housing and school quality, some of them might be willing to live in districts with low public school quality yet relatively good housing and low property-tax inclusive housing prices, for the sake of sending their children to private schools.

<sup>25</sup> Interestingly, when model 1 is estimated without including household religious preferences or religious schools, the point estimate for  $\rho$  is higher, as it captures all factors different from spending which lead to the formation of private schools, including preferences for religious education (see Ferreyra 2002).

proceeds from Catholic households. For example, in the nonvoucher equilibrium for Chicago, 84 percent of the Catholic school enrollment is accounted for by Catholic households, a prediction that squares very well with the observed religious composition of Catholic schools (see Section I).

Although the parameter estimates are highly significant, largely as a result of fitting sample means from census data based on thousands of observations, the fit of the data displays some shortcomings. First, only districts with variation in housing quality (i.e., with more than one neighborhood) exhibit any variation in predicted household income and school choices. Hence, this model is not capable of replicating the observed private school enrollment in suburban districts, which have only one neighborhood in my representation. Second, model 1 faces problems in matching the observed public school spending. In particular, in the central districts the predicted average household income and property values are sufficiently low that it is optimal for residents to vote for a property tax rate of zero and have public schools funded exclusively through state aid.

In order to explore the role of idiosyncratic preferences, model 2 builds on model 1 by adding these preferences for location and school type. Thus, in model 2, households sort themselves across locations and schools based not only on their income and religious preferences, but also on their idiosyncratic tastes. Hence, in equilibrium all districts attract households of varying incomes that make heterogeneous school choices. This, in turn, facilitates the fit of private school enrollment in suburban districts and of other variables as well. Perhaps not surprisingly, however, the addition of a second type of household preference heterogeneity results in reduced precision for the estimates of parameters characterizing private school enrollment,  $\rho$ ,  $r$ , and  $\delta$ . While model 2 fits private school and Catholic school enrollment better than model 1, it does so almost solely on the basis of idiosyncratic preferences. Furthermore, a consequence of  $r$  not being significantly different from zero is that Catholics attend Catholic schools at the same rate as non-Catholics. This result counters the empirical evidence that 85 percent of Catholic school students come from Catholic households (see Section II) and reveals model 2's failure to capture an essential

feature of private school markets—namely, who chooses which type of private school. Hence, in model 4, I exploit additional information that permits more precise estimation of the parameters associated with private school enrollment.

Model 3 generalizes model 2 to better reflect the environment in which educational expenditures are determined. First, it incorporates the nonresidential property tax base, which is particularly important in central cities. Second, it reflects that state constitutional requirements for provision of education place an effective minimum on expenditure per student. Since constitutions do not specify a minimum in explicit dollar terms, I use the empirical approach of finding a minimum expenditure level (60 percent of a district's observed spending) based on fit to the data. Third, it incorporates tuition subsidies received by Catholic school students. In the central district, the best-fitting subsidy rate is 100 percent, though the results are not substantially affected by the choice of a lower subsidy rate.<sup>26</sup> The resulting model 3 fits the data better than model 2, particularly with respect to spending.

Turning to model 4, I improve the precision of one parameter characterizing preferences for Catholic schools by requiring that the weighted average proportion of Catholics in Catholic schools be equal to the observed national average of 0.85, as data on the religious composition of Catholic schools are not available at the metropolitan area level. I do this through the following iterative procedure: (a) fixing  $r$ , find the remaining parameters that minimize the objective function; (b) fixing the remaining parameters, update  $r$  to replicate the observed national average of 0.85; (c) repeat steps (a) and (b) until all the parameter values converge. Since model 4 contains the most general formulation of the theoretical model, I use its parameter estimates hereafter.

<sup>26</sup> I explored a number of generalizations to address the misfit of spending besides the one featured here, such as district variation in the number of public school children per household based on census data, and different levels for the spending floor. For the chosen floor, the predicted spending in the city of Chicago is approximately 80 percent of the observed one. Although the national average subsidy rate in Catholic high schools is about 40 percent (Michael Guerra and Michael Donahue 1990), subsidies are heavily based on need, leading to the expectation that a substantially higher one prevails in the city.

### A. Analyzing the Fit of the Individual Variables

Figures 3A through 3E depict the predicted and observed values for each variable. Overall, the model fits the data reasonably well, particularly for the central districts and the largest metropolitan areas. Furthermore, rank-order correlation analyses reveal the model's ability to replicate the observed district rankings within metropolitan areas. This relatively good fit is an encouraging result, given the parsimonious parameterization of the model, the aggregation into pseudo-districts and the coarse discretization of the distributions of income and religious preferences.

The presence of idiosyncratic preferences, non-residential property, spending floor, and Catholic school subsidies leads to reasonably good predictions for private school enrollment (Figure 3A), although the truncation of my five-point income distribution at the ninetieth percentile of income prevents greater predicted enrollment rates in the wealthiest districts. The model fits district average household income and rental value well (Figures 3B and 3C, respectively), thus replicating residential sorting patterns. Nonetheless, the model tends to underpredict rental value. While this might be due partly to limitations of the neighborhood quality parameters, constructed without including a number of actual physical neighborhood amenities, it also points to the possibility that housing prices may reflect neighborhood demographic composition above and beyond public school peer quality. The generalizations made on the spending side have helped fit public school spending reasonably well (Figure 3D). However, the fact that the observed spending in the central cities of Pittsburgh, Boston, and St. Louis ranks almost at the top of their respective spending distributions is not replicated by the model. This suggests that additional factors, such as details of the state aid allocation and interjurisdictional productivity differences in public schools, may be important. Finally, Catholic school enrollment is particularly well fitted for New York, Chicago, and Detroit, as indicated by their close fit to the 45-degree line (Figure 3E).<sup>27</sup>

<sup>27</sup> The correlation between observed and fitted Catholic school enrollment is particularly sensitive to the fit for Philadelphia. As it turns out, Philadelphia is one of the

Table 4 shows the correlations between the matched variables for the observed and fitted values. The correlations for fitted values resemble the actual correlations reasonably well. While acknowledging the limitations in the fit of the data and considering them informative for future extensions, I view the evidence presented here as indicative that the model successfully captures the patterns in the data.

### B. Benchmark Equilibrium for Chicago

To provide a context for the upcoming discussion of the simulation outcomes, I now discuss the benchmark equilibrium for the Chicago metropolitan area, which is the nonvoucher equilibrium simulated with the parameter estimates. Figure 4 depicts the geographic distribution of income, rental value, private school enrollment, and public school spending in the benchmark equilibrium, which reasonably mirror the data. In particular, the simulated benchmark equilibrium correctly predicts that urban public schools have the lowest spending and peer quality in the metropolitan area. Furthermore, the benchmark equilibrium captures the fact that private school enrollment rates are higher in the city than in the suburbs. It also predicts that urban private school attendees reside in the central district's best neighborhoods, whose low tax-inclusive housing prices reflect the district's low public school quality. On average, private school households are wealthier and have a stronger preference for Catholic schools than public school households. Most private school attendees are enrolled in Catholic schools, whose students are primarily Catholic, whereas public and private non-Catholic school students are mainly non-Catholic.

## VI. Simulating Private School Vouchers

I simulate two types of voucher programs for the Chicago metropolitan area. The first type is a universal voucher program in which every

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dioceses that have made it a priority to retain a historically large presence in K-12 education and have been especially successful at attracting philanthropists to their mission, thus being able to offer greater subsidy rates than the national average I consider. Nonetheless, the good fit for Chicago is reassuring from the perspective of using Chicago for my voucher simulations.



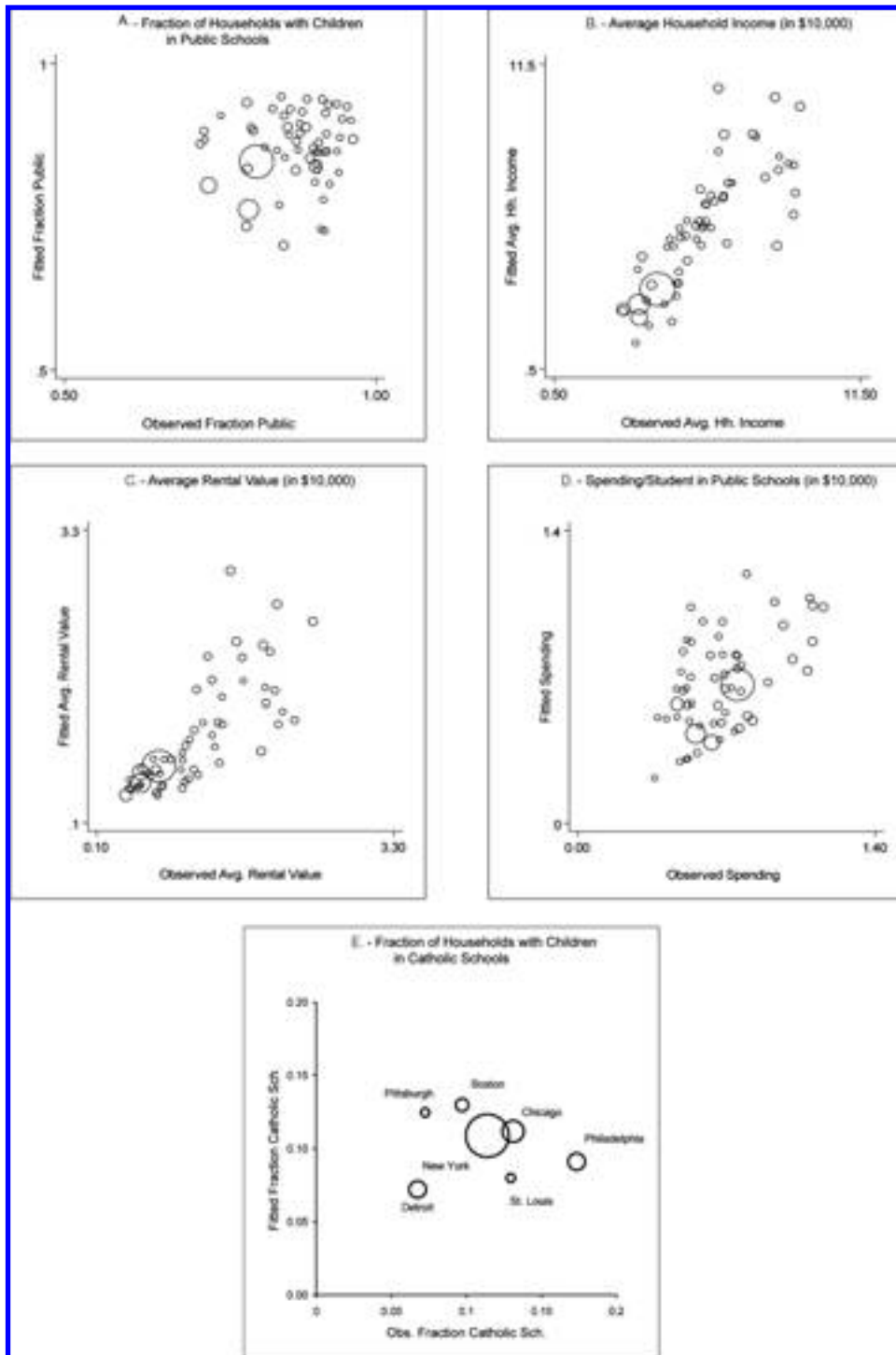


FIGURE 3. FITTED VERSUS OBSERVED VALUES

*Notes:* Observed values are on the horizontal axis; fitted values are on the vertical axis. Circle size is proportional to the observation's total measure of households. Correlations between fitted and observed values are weighted by each observation's measure of households and are as follows: 0.30, 0.85, 0.80, 0.56, -0.02 for Figures 3A through 3E, respectively.

TABLE 4—GOODNESS OF FIT: SOME CORRELATIONS

	Average household income	Average rental value	Spending per student	Fraction public
A. Observed Data				
Average household income	1			
Average rental value	0.98	1		
Spending per student	0.52	0.61	1	
Fraction public	0.25	0.21	-0.13	1
B. Fitted Data				
Average household income	1			
Average rental value	0.88	1		
Spending per student	0.74	0.57	1	
Fraction public	0.46	0.31	0.73	1

Note: Number of observations: 58 districts. Weighted correlations—weight: district measure of households.

household is eligible for a voucher that may be used for any type of private school. The second program (“nonsectarian vouchers”) differs in that the voucher may be used only for non-Catholic schools. In either program, households may supplement the voucher with additional payments toward tuition but cannot retain the difference when the tuition is lower than the voucher level. Consequently, the tuition is never set below the voucher level.

Furthermore, the state exogenously determines the voucher level,  $\nu$ , in these simulations. Since vouchers are funded through a state income tax, the state income tax has to fund both the flat grants for public school students and the vouchers for private school students. Moreover, during the policy simulations, household  $n$ 's budget constraint differs from the one given in (2) as follows:

$$(9) \quad c + (1 + t_d)p_{dh} + \max(T - \nu, 0) \\ = (1 - t_y)y_n + p_n.$$

Notice that when forming private schools, households choose their optimal tuition taking into consideration voucher availability and dollar amount. Other things equal, vouchers lead to a higher tuition and school quality level while reducing the share of tuition paid by parents. Since it is not clear how donors to Catholic schools might respond to vouchers, I assume that the *total* tuition subsidy for urban Catholic schools provided in the nonvoucher equilibrium remains constant throughout the simulations,

which means that the subsidy per child may rise or decline depending on enrollment.<sup>28</sup>

#### A. Universal Vouchers

Below I analyze the effects of universal vouchers on school choices, residential decisions, and school quality in both public and private schools. In addition, I discuss the welfare implications of universal voucher policies and provide some perspective on my findings.

*Household Sorting across Schools and Jurisdictions under Universal Vouchers.*—Table 5A presents some results from the simulation of universal vouchers for \$1,000, \$3,000, \$5,000, and \$7,000.<sup>29</sup> Private school enrollment grows with the voucher amount, and reaches a maximum of 0.74 of the entire population for a \$7,000 voucher. Voucher availability gives rise

<sup>28</sup> In the benchmark equilibrium, households make choices based partly on their idiosyncratic preferences, and these choices affect their reaction to vouchers. For instance, a household with a high idiosyncratic preference for Catholic urban schools which chooses to live in the city and send their children to Catholic schools may respond differently to vouchers than an otherwise identical household with different idiosyncratic preferences which chooses suburban public schools. The Appendix provides details on the treatment of self-selection in the voucher simulations.

<sup>29</sup> Voucher amounts are up to \$4,300, \$2,700, \$5,900, and \$7,500 for the Florida, Cleveland, Milwaukee, and DC programs, respectively, while per pupil spending in those places is approximately equal to \$7,500, \$11,000, \$11,000, and \$12,000, respectively (see <http://www.ij.org> and <http://www.heritage.org>).

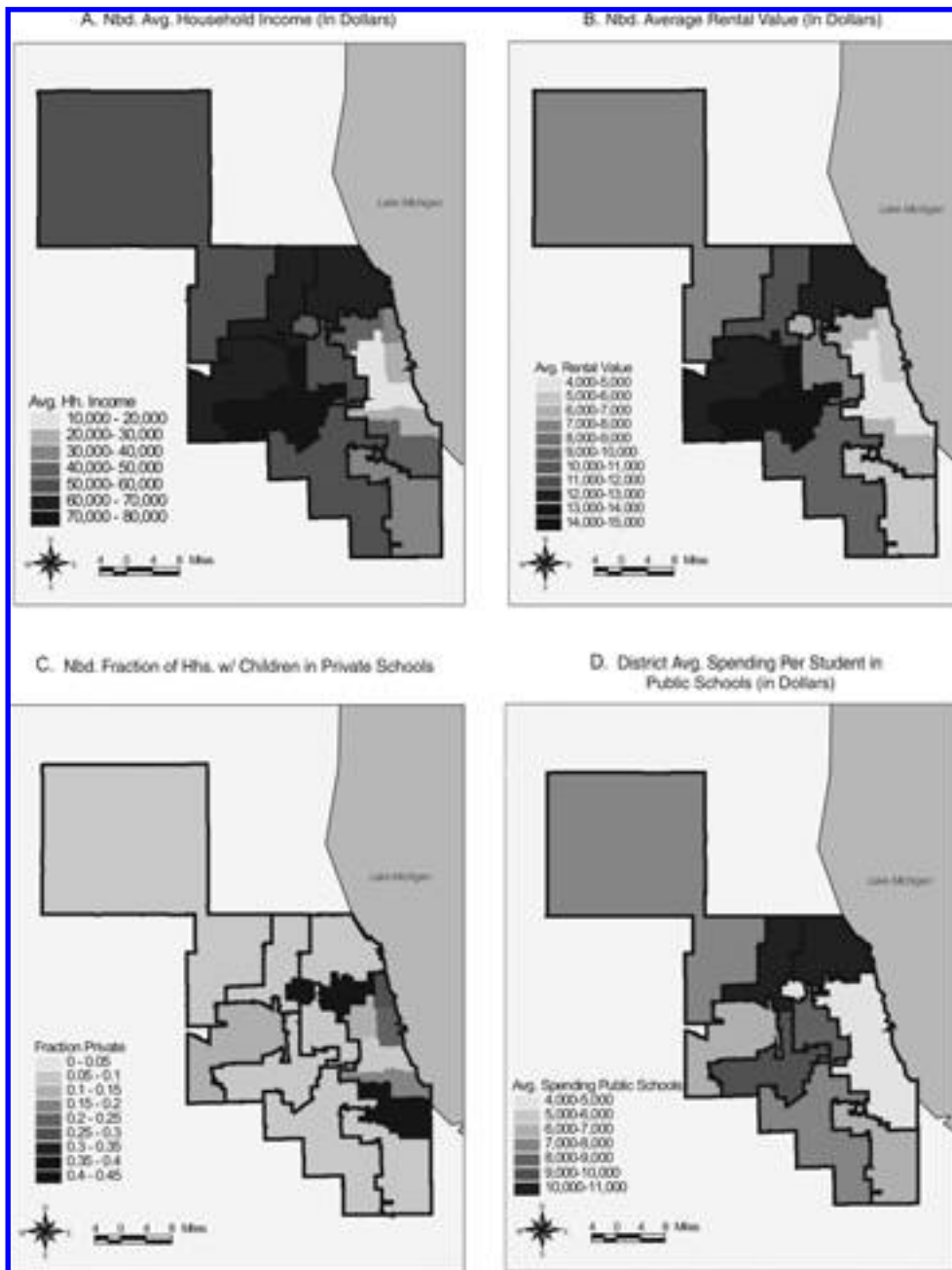


FIGURE 4. CHICAGO: NONVOUCHER EQUILIBRIUM

to both new Catholic and private non-Catholic schools, yet the private school market share for Catholic schools decreases with the voucher level. Furthermore, universal vouchers enable more households to attend the type of school

that best suits their preferences. Thus, Catholic schools attract an increasing number of non-Catholics with a preference for Catholic schools, while non-Catholic schools capture fewer Catholics.

TABLE 5A—UNIVERSAL AND NONSECTARIAN VOUCHERS IN CHICAGO: SCHOOL CHOICE AND DEMOGRAPHIC AND FISCAL EFFECTS

	B.E.	Universal voucher amount				Nonsectarian voucher amount			
		\$1,000	\$3,000	\$5,000	\$7,000	\$1,000	\$3,000	\$5,000	\$7,000
<i>Private school enrollment</i>									
Fraction households in private schools	0.16	0.22	0.43	0.60	0.74	0.19	0.29	0.48	0.62
Fraction households in Catholic schools with respect to private schools	0.72	0.69	0.61	0.55	0.50	0.60	0.34	0.17	0.11
Fraction private schools households in central district	0.72	0.72	0.75	0.64	0.55	0.71	0.71	0.68	0.60
Fraction low-income households that use vouchers		0.13	0.53	0.71	0.78	0.03	0.20	0.53	0.68
<i>School choice before and after vouchers</i>									
Fraction households choosing public-public		0.78	0.57	0.41	0.26	0.81	0.71	0.52	0.37
Fraction households choosing public-private		0.06	0.27	0.43	0.58	0.03	0.13	0.33	0.47
Fraction households choosing private-public		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fraction households choosing private-private		0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15
Fraction households choosing Catholic-Catholic		0.11	0.11	0.11	0.11	0.11	0.09	0.08	0.06
Fraction households choosing Catholic-non-Catholic		0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05
Fraction households in optimal school type	0.68	0.70	0.75	0.76	0.77	0.68	0.67	0.66	0.65
<i>Religious composition of public and private schools</i>									
Catholic schools: fraction of Catholic students	0.86	0.83	0.85	0.75	0.73	0.84	0.85	0.87	0.87
Private non-Catholic schools: fraction non-Catholic students	0.67	0.69	0.74	0.78	0.80	0.66	0.65	0.64	0.63
Public schools: fraction of Catholic students	0.34	0.32	0.35	0.23	0.20	0.35	0.35	0.36	0.36
<i>Demographics</i>									
Average household income ratio	2.71	2.67	2.72	2.62	2.48	2.68	2.68	2.63	2.60
Average housing rental value ratio	2.64	2.56	2.54	2.53	2.73	2.61	2.54	2.62	2.57
Fraction of households that move		0.07	0.27	0.43	0.56	0.04	0.15	0.35	0.50
<i>Fiscal effects</i>									
Income tax rate	0.03	0.03	0.04	0.08	0.12	0.03	0.04	0.06	0.10
Avg. property tax rate	0.24	0.23	0.20	0.15	0.08	0.23	0.23	0.17	0.13
Avg. tax burden (property tax + income tax)	\$3,500	\$3,500	\$3,900	\$4,800	\$6,200	\$3,400	\$3,700	\$4,300	\$5,500
Avg. nonresidential property tax revenue per household	\$2,200	\$2,100	\$1,800	\$1,500	\$1,000	\$2,100	\$2,100	\$1,600	\$1,400

Notes: "B.E." denotes "benchmark equilibrium." "Public-public" is short for "public schools before vouchers, and public schools after vouchers." "Optimal school type" is the type of school for which the household has the highest religious match. Average household income ratio = avg. hh. income in highest housing quality district/average household income in lowest housing quality district. Average housing rental value ratio = id. average household income ratio, but for housing rental value.

Figure 5 depicts household sorting across public, Catholic, and private non-Catholic schools for selected universal and nonsectarian voucher levels. Since the majority of households enjoy a spending per student above \$1,000 in the absence of vouchers, only households that can supplement a low voucher take it, and most of them already attend private schools in the benchmark equilibrium. Higher voucher levels, however, appeal both to low-income households in urban public schools and to middle- and high-income households in suburban public schools.

The majority of voucher users are urban residents before vouchers, yet between 10 and 15 percent are suburbanites who move into the city. These migrants are middle- and high-income households with children in suburban public schools who move to the central district because of its relatively low tax-inclusive property values. Hence, vouchers attenuate the residential stratification generated by the residence-based

public school system as they break the bundling of residence and public schools. Since tax-inclusive property values continue to be relatively high in the suburbs given the tax rates required to meet their spending floors, the effect persists as the voucher grows. Interestingly, voucher availability reduces the housing premium in the best school districts, but raises it in the locations favored by voucher users, thus causing capital losses or gains, respectively, to those homeowners.<sup>30</sup>

Vouchers also induce migration from the city to the suburbs on the part of households that seek private schools and better housing after reaping capital gains in the city. Although a quarter of voucher users remain in the suburbs, an increasing fraction relocates across them.

<sup>30</sup> See Eric Brunner, Jon Sonstelie, and Mark Thayer (2001) for empirical evidence that homeowners in good public school districts are less likely to vote in favor of universal vouchers.

TABLE 5B—UNIVERSAL AND NONSECTARIAN VOUCHERS IN CHICAGO: EFFECTS ON SCHOOL QUALITY AND HOUSEHOLD WELFARE

	B.E.	Universal voucher amount				Nonsectarian voucher amount			
		\$1,000	\$3,000	\$5,000	\$7,000	\$1,000	\$3,000	\$5,000	\$7,000
<i>All schools</i>									
Average quality	\$10,200	\$10,100	\$10,000	\$10,400	\$11,300	\$10,100	\$11,000	\$10,000	\$10,200
Average spending	\$ 6,800	\$ 6,700	\$ 6,600	\$ 7,100	\$ 8,100	\$ 6,700	\$ 6,700	\$ 6,700	\$ 7,530
Average peer quality	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Fraction of households w/higher school quality		0.50	0.51	0.57	0.65	0.44	0.53	0.53	0.63
Fraction low-income households w/higher school quality		0.05	0.06	0.41	0.79	0.06	0.06	0.05	0.69
<i>Public schools</i>									
Average quality	\$10,200	\$10,400	\$11,600	\$12,300	\$11,700	\$10,100	\$10,700	\$11,400	\$11,900
Central district	\$ 6,100	\$ 6,000	\$ 5,000	\$ 5,100	\$ 5,700	\$ 5,900	\$ 6,100	\$ 4,900	\$ 5,000
Suburbs (average)	\$13,000	\$13,200	\$13,800	\$13,000	\$10,800	\$13,100	\$13,400	\$13,300	\$12,300
Avg. spending	\$ 6,800	\$ 7,000	\$ 7,700	\$ 8,300	\$ 7,900	\$ 6,700	\$ 7,200	\$ 7,600	\$ 8,000
Central district	\$ 4,300	\$ 4,200	\$ 3,300	\$ 3,500	\$ 4,000	\$ 4,100	\$ 4,300	\$ 3,300	\$ 3,400
Suburbs (average)	\$ 8,500	\$ 8,700	\$ 9,200	\$ 8,600	\$ 7,000	\$ 8,600	\$ 8,900	\$ 8,800	\$ 8,100
Average peer quality	\$43,000	\$43,800	\$48,800	\$50,900	\$49,100	\$43,100	\$44,500	\$48,900	\$49,500
Central district	\$21,400	\$21,200	\$20,400	\$20,400	\$19,900	\$21,000	\$21,000	\$20,100	\$19,200
Suburbs (average)	\$58,500	\$58,300	\$58,300	\$57,100	\$55,400	\$58,400	\$58,300	\$57,500	\$56,400
<i>Private schools</i>									
Average quality	\$10,700	\$ 9,200	\$ 7,800	\$ 9,100	\$11,200	\$ 9,900	\$ 8,700	\$ 8,600	\$10,300
Average spending	\$ 6,800	\$ 5,800	\$ 5,100	\$ 6,400	\$ 8,200	\$ 6,290	\$ 5,500	\$ 5,800	\$ 7,300
Average peer quality	\$55,800	\$49,500	\$40,100	\$41,000	\$43,700	\$53,600	\$46,600	\$40,900	\$42,300
<i>Welfare implications</i>									
Fraction of households that win with vouchers		0.71	0.47	0.46	0.42	0.69	0.60	0.35	0.33
Fraction of low-income households that win w/vouchers		1.00	0.81	0.69	0.65	0.97	1.00	0.59	0.56
Average welfare change		\$170	\$237	-\$106	-\$1,040	\$97	\$215	-\$135	-\$978
Average welfare change/average household wealth		0.00	0.00	0.00	-0.02	0.00	0.00	0.00	-0.02
<i>Winners</i>									
Average wealth		\$47,700	\$42,700	\$43,900	\$42,700	\$49,100	\$44,900	\$41,900	\$42,400
Average taste for Catholic schools		0.95	1.05	1.05	1.06	0.93	0.94	0.88	0.88
<i>Losers</i>									
Average wealth		\$65,700	\$61,900	\$60,500	\$60,300	\$61,500	\$65,000	\$58,700	\$58,000
Average taste for Catholic schools		0.82	0.79	0.79	0.80	0.86	0.87	0.93	0.93

Furthermore, private schools progressively spread to the suburbs, although the presence of nonresidential property and high spending floors keep property tax rates relatively high and maintain high-quality public schools. Not surprisingly, private schools appear last in the best school districts.

While vouchers bring higher income households to the city, suburban districts with good housing yet low public school quality also attract wealthier voucher users. In addition, the greater affordability of districts with the best public schools appeals to wealthy households that strongly prefer public schools. Furthermore, the largest capital gains accrue to homeowners in the best urban neighborhoods and in the suburban districts chosen by voucher users. Although suburban locations lose property value with low vouchers, some of them gain for sufficiently high vouchers, as majorities choose private schools and vote for zero property tax

rates, which further raises housing demand and rental values.

Whether vouchers can improve school quality for low-income households is an important policy issue that first requires understanding voucher use among such households, whose income is less than or equal to \$20,000. As it turns out, most such households need a relatively high voucher amount to compensate for the good public school peers they would lose in a private school and the spending per student they might forego. Yet half of the low-income segment takes up a \$3,000-voucher, and vouchers above \$1,000 are used at a higher rate among these households than in the rest of the population. Encouraged by tuition subsidies, they also attend Catholic schools at higher rates.

With the expansion in the use of vouchers, funded by the state, fiscal burdens progressively shift from district property taxes onto the state income tax. While the average property tax rate

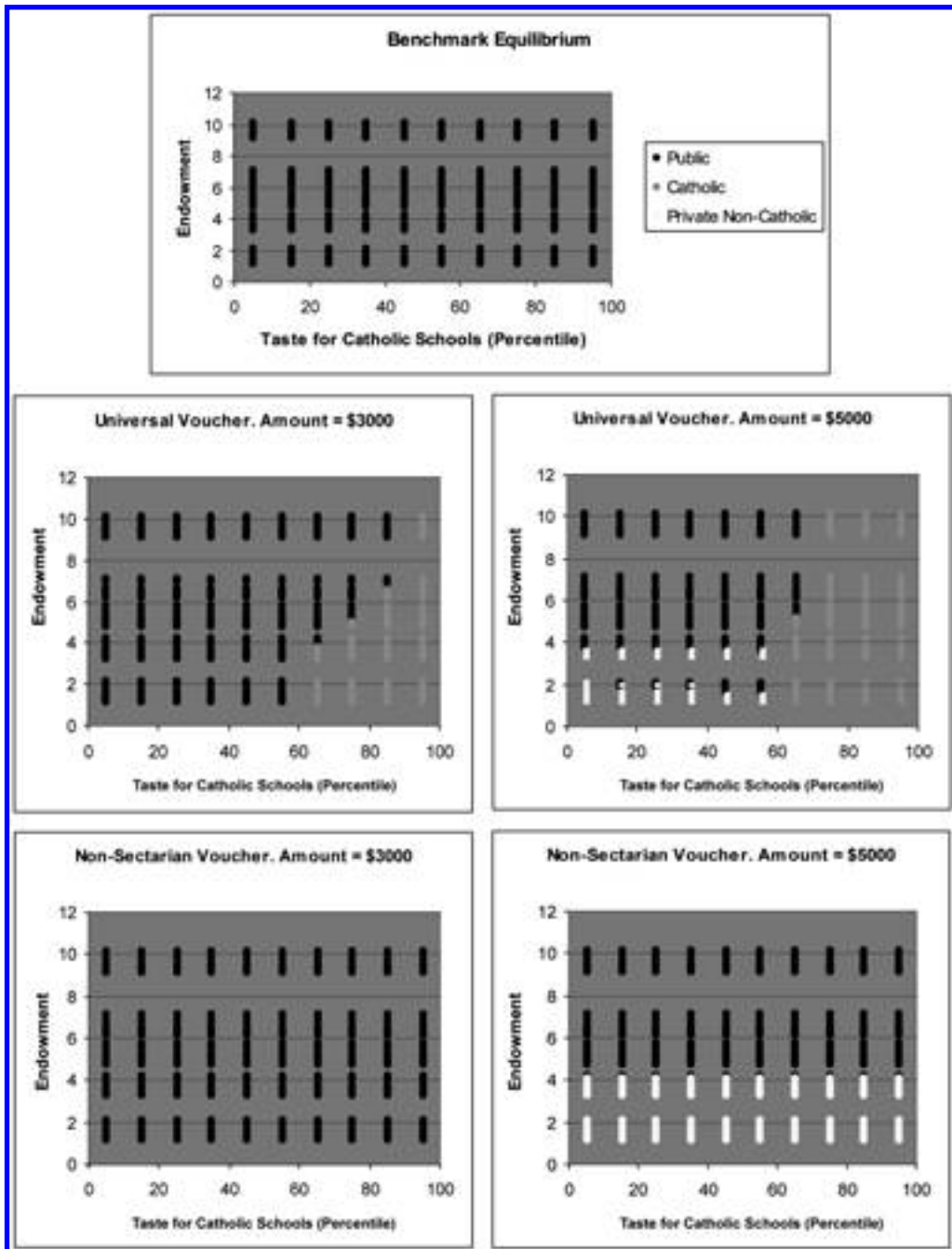


FIGURE 5. CHICAGO: PREDICTED HOUSEHOLD SORTING ACROSS SCHOOLS FOR BENCHMARK EQUILIBRIUM, AND UNIVERSAL AND NONSECTARIAN VOUCHERS

Notes: Endowment expressed in \$10,000. Each graph depicts the most popular choice made by each group of households with a given endowment and taste for Catholic schools.

falls with the increasing number of voters who favor zero property taxes, the income tax rate rises as the net outcome of lower state aid expense for public schools and higher voucher expense for private schools.

*Universal Voucher Effects on School Quality.*—By affecting household residential and school choices, vouchers affect the quality of public and private schools as the evolution of school quality indicators shows in Table 5B. Most households gain school quality for vouchers of at least \$3,000. Average school quality declines slightly for low voucher amounts but rises for larger ones; under a \$7,000 voucher, the average school quality is 11 percent higher than in the benchmark equilibrium, a gain of 2.1 percent relative to average household endowment. At the same time, the variation in spending and school quality rises for vouchers up to \$5,000 and then falls for larger vouchers as private schools converge to a tuition equal to the voucher. The variation in peer quality experienced by students, however, grows as the educational system becomes increasingly private.

Behind these aggregate patterns lie remarkable differences across public and private schools. The public schools that remain open are the best ones, which accounts for the rising public school indicators. Average private school indicators, on the other hand, first drop, as households with an income lower than the original private school population take up the voucher and then rise as wealthier households do so.

Furthermore, vouchers affect public schools by affecting property tax rates, the value of the property tax base, the size of public school enrollment, and the composition of the public school student body. Property tax rates fall as a greater number of voters choose a zero-property tax rate, and the value of the residential property tax base falls or rises depending on whether the location is favored by voucher users. Other things equal, the reduction in public school enrollment increases spending per student in public schools, since fewer children need support in public schools. As households alter their residential and school choices, peer quality in public schools is affected as well.

The net effect of these forces, in turn, differs by district and voucher amount. For urban public schools, spending initially falls with the sub-

stantially lower property tax rate induced by vouchers, but then rises when the effect of the lower public school enrollment prevails and leads to a higher per-student property tax revenue, particularly from nonresidential sources. In suburban schools, the declining public school enrollment raises per-student property tax revenue until private schools comprise the majority of district voters, at which point the effect of the lower tax rate prevails. Moreover, voucher impact on public school peer quality also varies widely across districts. For instance, districts with the lowest benchmark equilibrium peer quality lose some of their best peers, whereas the reverse takes place in districts with the highest peer quality, whose declining housing prices entice some wealthy households.

To evaluate how school quality gains and losses are distributed in the population, Figure 6 depicts the average school quality for the tenth, thirtieth, fiftieth, seventieth, and ninetieth percentile endowments in the benchmark and universal voucher equilibria. Not surprisingly, school quality is increasing in endowment in all scenarios, yet converges across endowments as the voucher grows to cover most of the tuition payment. Vouchers below \$5,000 mainly favor—albeit modestly—middle- and high-income households with the ability to supplement the voucher. In contrast, higher vouchers favor households below the seventy-fifth percentile endowment, though they slightly damage those above, who are affected by the growing income tax burden and often attend declining public schools. Yet the greatest gains for sufficiently large vouchers accrue to households with an approximate endowment of \$35,000. These households attend urban public schools in the benchmark equilibrium and mix with lower-wealth peers but then access higher-quality schools, either by moving to suburban districts with better public schools or by switching to private schools.

Low-income voucher users gain spending with sufficiently high vouchers but always lose peer quality. In this segment, school quality losses peak for the \$3,000 voucher, which causes the loss of a significant number of good peers to those who remain in public schools, yet is not high enough to match the prevoucher quality for those who switch to private schools. However, almost all low-income Catholic school students gain school quality for vouchers of at least \$5,000, and a \$7,000 voucher yields

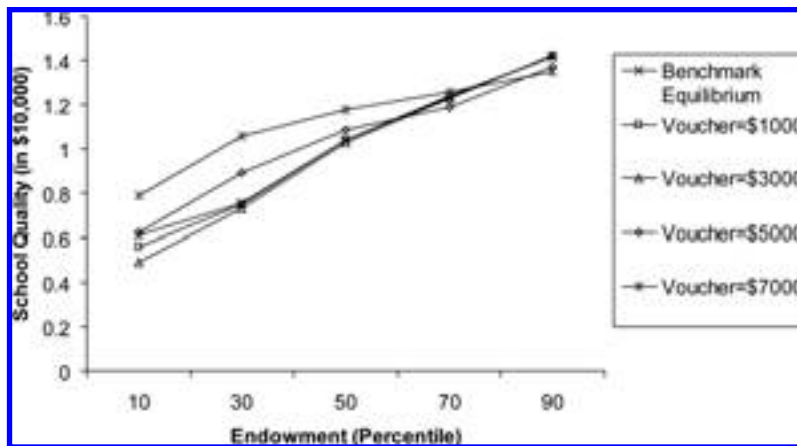


FIGURE 6. CHICAGO: PREDICTED EFFECTS OF UNIVERSAL VOUCHERS ON SCHOOL QUALITY (Average school quality for the 10<sup>th</sup>, 30<sup>th</sup>, 50<sup>th</sup>, 70<sup>th</sup>, and 90<sup>th</sup> percentile endowment)

school quality gains for *all* low-income voucher users. Although students who remain in urban public schools lose school quality at all voucher levels, less than a quarter remain for vouchers above \$3,000.

*Welfare Implications of Universal Vouchers.*—Among the most relevant issues concerning vouchers is who wins or loses when they are introduced. To measure welfare gains, I compute individual compensating variations for each voucher amount. As Table 5B shows, the majority of the population benefits, albeit slightly, from \$1,000 vouchers, whereas just below half gains from larger voucher amounts. Furthermore, the average welfare gain reaches a maximum at \$237 for \$3,000 vouchers and a minimum at  $-\$1,040$  for \$7,000 vouchers. These outcomes, in absolute value equal to 0.5 and 2 percent of the average household endowment, respectively, show that the average welfare gains are relatively small,<sup>31</sup> although the distributional effects are large. For instance,

<sup>31</sup> The estimated average welfare gains are comparable to those of Epple and Romano (1998) and Fernandez and Rogerson (2003b). As Fernandez and Rogerson (2003a) point out, vouchers operate on a small sector of the economy, as education accounts for about 5 percent of aggregate household income. When rescaled by sector size, average welfare effects are clearly larger, between 10 and 40 percent of the sector size in my simulations. Furthermore, my static model underestimates long-run welfare outcomes by not accounting for the impact of changes in current school

while the average winner may reap gains of up to 3 percent of his endowment, the average loser may suffer losses of up to 5 percent. The average winner is less wealthy yet more strongly prefers Catholic education than does the average loser. Wealthy households, which already enjoy high-school quality before vouchers, tend to lose under high vouchers *regardless of their school choices*, due to their high income tax burden and capital losses. Moreover, households remaining in public schools make up the largest fraction of welfare-losing households for vouchers below \$7,000, despite the school quality gains attained by many of them.

While more households reap school quality gains as the voucher grows, fewer experience welfare gains. Furthermore, winners at low voucher levels are *less* likely to gain school quality than losers, a fact that is reversed at high voucher levels. Although seemingly counterintuitive, these findings simply highlight the multiplicity of channels that give rise to welfare changes: low vouchers mostly lead to savings in school or tax-inclusive housing spending that allow for greater consumption, whereas high vouchers yield school quality gains as well.

The top row of Figure 7 gives further insight into the distributional effects of universal vouchers. On average, welfare gains are decreasing in

quality on future generations' earnings (see Fernandez and Rogerson 2003a, b).



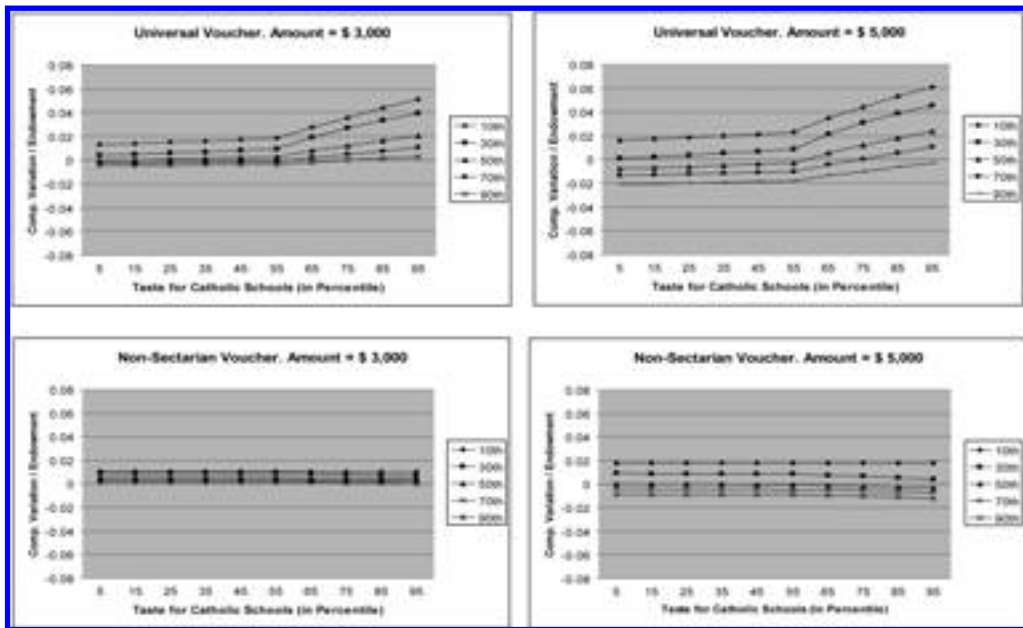


FIGURE 7. CHICAGO: PREDICTED WELFARE GAINS BY HOUSEHOLD ENDOWMENT AND RELIGIOUS PREFERENCES

Notes: Each line represents a household endowment; households in the 10<sup>th</sup>, 30<sup>th</sup>, 50<sup>th</sup>, 70<sup>th</sup>, and 90<sup>th</sup> percentile of endowment are plotted.

endowment, yet households with the strongest preference for Catholic schools at each wealth level experience the largest gains. In addition, the large fiscal cost of the \$7,000 voucher is evidenced by the fact that all households gain less for \$7,000 than for \$5,000 vouchers. A salient outcome is that the greatest relative welfare gains accrue to low-income households, which reap average gains between 2 and 3 percent of their wealth. Furthermore, low-income households benefit from vouchers at a higher rate than the rest of the population, and virtually all voucher users in this segment improve their welfare. With small vouchers, low-income households gain consumption through lower property taxes in the central district although they lose school quality in urban public schools; with large vouchers they gain consumption, and, if switching into private schools, school quality as well.

*The Role of Voucher Targeting.*—Although proposed a number of times, universal vouchers have not been implemented to date; rather, current programs have restricted eligibility by household income and/or residence. To investi-

gate the impact of these restrictions, I simulated vouchers restricted to households in the central district (district-targeted vouchers), or with incomes below \$30,000. About 50 or 40 percent of the population, respectively, is eligible for each program in these simulations.

Table 6 compares outcomes across universal, district-targeted, and income-targeted vouchers. While most district-targeted voucher users already live in the city before vouchers, 15 or 20 percent move from the suburbs to the city. As these middle- and high-income movers bid up urban housing prices, the city's lowest-income residents are priced out of the city and are thus rendered unable to access the voucher. With average income rising in the city and falling elsewhere, income segregation across districts falls. In fact, district-targeted vouchers accomplish more desegregation than universal vouchers because, by tying voucher eligibility to residence, they lead to greater increases in urban housing values, which only wealthier households can pay for. Across all three programs, district-targeted vouchers yield the greatest capital gains and losses to urban and suburban homeowners, respectively. Yet be-

TABLE 6—COMPARING UNIVERSAL, DISTRICT, AND INCOME-TARGETED VOUCHERS IN CHICAGO

	B.E.	Universal voucher		District-targeted voucher		Income-targeted voucher	
		\$3,000	\$5,000	\$3,000	\$5,000	\$3,000	\$5,000
<i>Private school enrollment and voucher use</i>							
Fraction of households in private schools	0.16	0.43	0.60	0.36	0.42	0.33	0.40
Fraction of eligible households who use voucher		0.43	0.60	0.69	0.83	0.55	0.73
<i>Residential choice before and after vouchers</i>							
Fraction of voucher users choosing city-city		0.62	0.50	0.83	0.78	0.82	0.81
Fraction of voucher users choosing suburb-city		0.13	0.14	0.17	0.22	0.14	0.15
Fraction of voucher users choosing city-suburb		0.05	0.10	0.00	0.00	0.02	0.02
Fraction of voucher users choosing suburb-suburb		0.20	0.26	0.00	0.00	0.02	0.02
<i>Average household income</i>							
Households choosing city-city		\$26,400	\$25,900	\$27,500	\$28,600	\$26,700	\$26,000
Households choosing suburb-city		\$41,400	\$43,000	\$43,400	\$45,500	\$26,000	\$26,200
Households choosing city-suburb		\$42,200	\$39,000	\$34,300	\$26,900	\$49,700	\$50,200
Households choosing suburb-suburb		\$61,900	\$63,000	\$61,700	\$62,600	\$62,100	\$62,900
Households in the city	\$28,300	\$28,200	\$29,000	\$29,400	\$31,800	\$26,600	\$26,000
Households in the suburbs	\$59,800	\$59,800	\$59,100	\$58,900	\$56,800	\$61,300	\$61,800
<i>Average housing rental value</i>							
Houses in the city	\$ 5,300	\$ 5,500	\$ 5,500	\$ 5,500	\$ 5,700	\$ 5,400	\$ 5,400
Houses in the suburbs	\$10,000	\$ 9,700	\$ 9,600	\$ 9,100	\$ 8,300	\$10,000	\$ 9,600
<i>Welfare implications</i>							
Fraction of households that win with vouchers		0.47	0.46	0.42	0.40	0.33	0.33
Fraction of low-income households that win w/vouchers		0.81	0.69	0.65	0.88	0.93	0.95
<i>Winners and losers</i>							
Average wealth—winners		\$42,700	\$43,900	\$42,700	\$35,200	\$27,100	\$24,600
Average wealth—losers		\$61,900	\$60,500	\$60,300	\$60,500	\$65,900	\$66,600

Note: "City-city" is short for "city before vouchers, and city after vouchers."

cause this program clearly benefits urban while hurting suburban residents, fewer households benefit from district-targeted than universal vouchers.

In contrast, income-targeted vouchers bring into the city the least poor of the voucher recipients, who no longer need to live in the suburbs to access some public schools. Under universal vouchers, these households would be priced out of the city by wealthier suburbanites in the competition for urban housing. Now, however, they can access the city, although by doing so they slightly resegment the metropolitan area. Since the targeted population has limited purchasing power, housing prices and public school quality change significantly less than with district-targeted vouchers. In spite of being the fiscally least costly of all three programs, income-targeted vouchers have the lowest rate of winning households because virtually no household outside the target benefits from this program.

*Further Issues.*—While an important aspect of vouchers is their ability to expand household residential and school choices, thus unleashing a variety of equilibrium effects, one might worry that the absence of moving costs in the model overpredicts relocations and their associ-

ated effects. To provide some perspective on this issue, I simulated universal and nonsectarian voucher programs without household relocation.<sup>32</sup> Since most voucher users relocate under full mobility, private school formation is slower now and heavily concentrated in the central district regardless of the voucher amount. Due to the lower voucher user rate, urban public schools keep their good peers yet lose spending at higher rates by foregoing the increase in property values that immigrants would induce under full mobility. Moreover, the reduction in property tax rates leads to lower public school spending, yet is not large enough to yield welfare gains through greater consumption. Overall, lack of mobility, which may be viewed as a short-run constraint, leads to fewer households experiencing school quality and welfare gains.

One might also wonder how much of the voucher effects described for the full mobility case are associated with the greater residential and school choice set afforded by vouchers, and how much with the mere increase in public spending for education. To investigate the normative

<sup>32</sup> Detailed results for these simulations are available from the author upon request.

effects of vouchers per se, I simulated an increase in per pupil state aid of equal dollar amount for each district, whose equilibrium total state expense equals that under vouchers. The greater state aid crowds out property tax effort on the part of suburban districts, which end up with almost the same levels of spending and quality as in the benchmark equilibrium. It significantly increases spending in the central district, however, where property taxes grow in response to a wealthier electorate and a greater public school enrollment associated with the improved public schools. Nonetheless, the higher property tax burden overwhelms the school quality gains for urban households, in contrast with the welfare enhancing reduction in property tax burden under vouchers. The increase in state aid, which effectively reduces the variation in spending across districts by benefiting the central district proportionally the most, motivates less relocation than the voucher as it eliminates much of the property tax incentive to migrate across locations. By favoring public schools, this policy also leads to fewer households attending their optimal type of school and to current and former private school attendees losing the most welfare of all households. The combination of higher property tax burden for urban households and more limited school choice leads to only 12 percent of the population benefiting from this policy, as opposed to 43 percent who gain from the \$5,000 voucher.

Finally, I investigated the robustness of the Chicago findings by simulating both voucher programs for the New York metropolitan area. While the qualitative results are similar, the main differences are centered on the fact that New York City accounts for 70 percent of the metropolitan area whereas Chicago comprises about 50 percent. Since the central district is larger in New York, public school attendees come from more varied income levels. Hence, proportionally more households benefit from the opportunity to segregate into private schools, and the largest school quality gains accrue to households at the median rather than the thirtieth percentile of the endowment distribution. The larger central district also creates more opportunities for the establishment of private schools in the city's best neighborhoods and generates property tax savings to more households. The combination of greater opportunities for school quality improvement and

property tax savings yields welfare gains to the majority of the population at every voucher amount in New York. This contrasts with Chicago and warns against generalized conclusions regarding the political support for vouchers.

### B. *Nonsectarian Vouchers*

Nonsectarian vouchers raise the price of Catholic schools relative to non-Catholic private schools, thus inducing some households, depending on their religious preferences and budget constraints, to substitute non-Catholic private schools for Catholic schools. Tables 5A and 5B compare the results of universal and nonsectarian vouchers. Nonsectarian vouchers induce *less* private school enrollment than universal vouchers, precisely because many households that would use a universal voucher would choose Catholic schools. Furthermore, under nonsectarian vouchers, fewer households *than in the benchmark equilibrium* choose their optimal school type. Whereas enrollment grows in all private schools under universal vouchers, it now rises at private non-Catholic schools but falls at Catholic schools, since only households with a high taste for Catholic schools and the ability to pay for them remain (row 3, Figure 5). Nonetheless, the enrollment losses in Catholic schools are tempered by tuition subsidies in urban Catholic schools, and Catholic schools' share falls from 11 percent of the total enrollment in the benchmark equilibrium to 6 percent under the \$7,000 voucher, with most of this decline occurring for high vouchers.

Since both universal and nonsectarian vouchers subsidize private school attendance, they produce some qualitatively similar effects. They induce residential changes and generate comparable effects on property values. In addition, they have a similar impact on school quality and public schools. Both programs progressively shift the fiscal burden toward the state income tax, thus redistributing income from the wealthy to the poor. The combination of a higher fiscal burden, capital losses, and relatively small gains in school quality makes the average loser wealthier than the average winner in both programs, and households that remain in public schools after vouchers comprise the largest fraction of losing households. Moreover, households at the thirtieth wealth percentile reap the largest school quality gains in the two programs

while low-income households enjoy the largest welfare gains.

Despite these similarities, universal and nonsectarian vouchers differ in other important ways. Fewer households attain school quality gains under nonsectarian vouchers, and urban schools experience greater losses because public school enrollment does not fall enough to offset the declining property tax rate, while property values do not grow enough to raise spending. More low-income households use a universal than a nonsectarian voucher, given the financial incentive to attend Catholic schools. Furthermore, a greater number of low-income households gain school quality through universal vouchers—this is true for both voucher users and nonusers. Hence, to match universal vouchers' school quality outcomes for the poor, a nonsectarian program needs to provide a more generous voucher.

The two voucher programs also differ in private school location patterns. Since fewer households compete for urban housing under nonsectarian vouchers, a greater fraction of nonsectarian private schools locate in the city, and no new Catholic schools open in the suburbs. At low voucher levels, fewer users originally come from the city, given that urban Catholic school attendees cannot use the voucher, and low-income households cannot supplement it.

Moreover, universal and nonsectarian vouchers have different welfare implications. For instance, the average welfare gain is higher for universal vouchers below \$7,000, and households benefit from \$1,000 and \$5,000 universal vouchers at a higher rate.<sup>33</sup> While at each endowment level Catholic households gain the most, they lose the most under nonsectarian vouchers of at least \$5,000 (bottom row, Figure 7). Although most households either gain or lose in both programs, about 15 percent of all households gain from high universal yet lose from nonsectarian vouchers. These households,

<sup>33</sup> The average welfare gain and the fraction of winners from a nonsectarian \$7,000 voucher are higher than for a \$7,000 universal voucher because the lower adoption rate of the nonsectarian voucher imposes a lower fiscal burden. Although more households gain from a nonsectarian than from a universal \$3,000 voucher, the difference in welfare gains is negligible for the households that win with nonsectarian yet lose with universal vouchers.

whose children either attend Catholic schools in the benchmark equilibrium or would choose them through universal vouchers, now turn to public or private non-Catholic schools for sufficiently high vouchers. With welfare outcomes that differ by 5 percent of their wealth across voucher regimes, it is not surprising that these households are those whose welfare is most affected by the choice of voucher program.<sup>34</sup>

## VII. Concluding Remarks

Private school vouchers remain a controversial policy in the United States. In the absence of actual large-scale voucher programs, policy simulation can provide us with insights on their potential effects. Thus, in this paper I estimate a multidistrict equilibrium model with private schools and use the parameter estimates to simulate voucher programs. An important contribution is the inclusion of religious schools and household religious and idiosyncratic preferences, which has enabled me to compare the effects of universal vouchers with vouchers restricted to nonsectarian schools in the Chicago metropolitan area. Whereas the two programs give rise to some similar effects, the reaction of the private school market differs in each case. In addition, fewer people, particularly from the lower-income segment of the population, benefit from nonsectarian vouchers. While those with the strongest preference for Catholic education gain the most under universal vouchers, they lose the most under nonsectarian vouchers.

The fact that households that care the most about religious education are the ones that lose the most in a nonsectarian program may seem an obvious result, and a skeptical reader may question its usefulness. It is important to bear in mind, however, the tradition in the United States federal jurisprudence that upholds parents' right to choose the type of education they want for their children—including, of course, religious education (see Joseph P. Viteritti 1999). Moreover, the US Supreme Court upheld the Cleveland voucher program as "entirely

<sup>34</sup> The Catholic Church has publicly stated its full support for unrestricted parental choice programs and specifically advocates against the exclusion of religious schools from voucher programs (see, for instance, <http://www.usccb.org/bishops>, <http://www.ncea.org/publicpolicy/policystatements>, and <http://www.flacathconf.org>).

neutral with respect to religion” and as a “program of true private choice” (*Zelman v. Simmons-Harris*, 122 S. Ct. 2002, 2473). An outcome of this decision was the enactment of the first federally funded voucher program in the District of Columbia, which started in the 2004/05 academic year. At the state level, however, the role of Blaine amendments in court battles continues to raise questions on the consequences of excluding religious schools from voucher programs. Besides providing tools for answering these questions, this paper’s framework is appropriate to analyze other relevant issues, such as child-centered funding, the expansion of current voucher programs, and the potential effect of recent voucher proposals not yet implemented.<sup>35</sup>

While powerful, this framework certainly leaves room for important extensions, such as the refinement of neighborhood quality measures, the inclusion of preferences for neighborhood demographic composition, and the modeling of neighborhood schools. Although no simulation exercise will be able to replace the actual enactment of a large-scale voucher program, developing and estimating general equilibrium models of local jurisdictions that incorporate private school markets can still shed much light on the potential outcomes of school choice programs.

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<sup>35</sup> Between 1999 and 2006, 42 states, including California, New York, and Texas, have considered enacting voucher programs. Recently the Wisconsin legislature expanded the Milwaukee choice program, and the Ohio legislature is considering the expansion of the Cleveland program. While this paper analyzes vouchers for K–12 education, vouchers are also being used for pre-kindergarten in Louisiana and Florida (see <http://www.heritage.org>).

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