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THE POLITICAL ECONOMY OF SCHOOL CHOICE: LINKING THEORY AND EVIDENCE*

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ABSTRACT

We derive an improved methodology for linking theoretical parameters of a political economy model of school choice to empirical values estimated by regressing local private enrolment shares on mean income, the median to mean ratio, religious and ethnic composition, and other variables. This leads us to reject the commonly maintained assumption that a coalition of "ends against the middle" determines local school funding, and to conclude instead that the median income voter is decisive. It also allows us to estimate the perceived relative efficiency advantage of private schooling, which we find to be about 30% at the margin.

Keywords: education demand, education finance, private education, public education, Director's Law, vouchers

JEL classification: H42, I22, I28

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1. INTRODUCTION

Continuing concern about the quality of public schooling in the United States, especially in low-income communities, is drawing increased attention to initiatives for change in the structure of education finance. State-level funding reforms aimed at reducing disparities in spending between school districts are an important example of such change; voucher programs that provide public financing for students to attend private schools are another example. The heated debates that surround many of the proposed reforms are partly rooted in differences in social values, but partly reflect differing assessments of their potential effectiveness in promoting broader access to better education—differences that stem from a lack of direct evidence. Consequently, substantial effort has been addressed to gauging the relevant parameters of household utility indirectly, from observed patterns of school spending and enrolment absent reform, by calibrating formal models of education choice. [1]

The present paper continues in this vein, but goes beyond previous efforts in explicitly identifying the link between theoretical elasticities and empirical coefficients. It specifies a political economy model of education choice that allows private tuition dollars to have a greater (or lesser) perceived purchasing power than tax dollars spent on public education, and uses a Stone-Geary utility function to accommodate a non-unitary income elasticity of demand. The parameters of the model, which we calibrate to observed empirical values, determine the nature of the political equilibrium that obtains.[2]

There is some direct evidence that private tuition dollars are perceived to have greater purchasing power in acquiring education than tax dollars (Evans and Schwab [13], Sander [43], Neal [36]), and a strong inference from revealed preferences implicit in spending and tuition data that this is the case. In the United States, opting out of public education does not reduce a household's school-tax liabilities and therefore only makes sense if parents perceive that the private school of their choice provides a better education than local public schools. As average tuition levels in private schools are substantially lower than spending per student in public schools, private tuition dollars must be perceived, by those who opt for cheaper private education, to be more effective than tax dollars in buying education quality. This implicit advantage presumably reflects not only a greater operating efficiency but also the charitable support that allows many private religious schools to offer subsidized tuition (the large majority of private schools in the United States are religious schools), as well as parents' innate preferences for the religious environment that parochial schools offer.[3] By explicitly incorporating this perceived advantage in our model we obtain a quantitative estimate of its magnitude, though we cannot apportion the contributions of its different sources, and gain better estimates of the other parameters of the model.

Non-unitary income elasticity of demand for education is implied by the frequently observed positive effect of local mean income on private enrolment.[4] Comparing it to the elasticity of substitution within a theoretically consistent framework enables us to identify the nature of the political equilibrium that obtains. A stronger income effect indicates a coalition of "ends against the middle" (Epple and Romano [12])—an alignment of rich and poor against the middle class—to which Stigler [47] referred as "Director's Law"; a stronger substitution effect implies an alignment of rich versus poor, in which the median income household is decisive.

Empirical estimation of the model draws on variation among local communities in the share of private enrolment in elementary and high school education,[5] which we regress on mean household income, the ratio of median to mean income, a set of ethnic, religious and demographic variables, and variables reflecting cost differentials such as teacher salaries and population density. This regression is estimated on three cross-sectional data sets:[6] the set of all 1,078 US cities with population over 25,000; a subset of 423 of these cities that approximately correspond to individual school districts;[7] and the set of corresponding school districts. The three regressions produce similar results; the coefficients are generally significant and their signs consistent with previous estimates; mean income has a significant positive effect on private enrolment; and the median-to-mean ratio has a significant negative effect.

The utility function is then calibrated by explicitly linking its parameters to the estimated derivatives of private enrolment with respect to mean income and the median-to-mean ratio, and to the observed private enrolment rate and tax rate. The values obtained from the three regressions vary within a range that is generally consistent with previous findings: between 0.70 and 0.90 for the income elasticity of education quality; between –1.02 and –1.33 for the elasticity of substitution between education quality and other goods; and between –0.09 and –0.10 for the tax-price elasticity of public spending per student. All three regressions indicate that the desired tax rate is a declining function of individual household income, and hence that the median income household is decisive. Thus our findings contradict the commonly held assumption that education finance is shaped by a coalition of "ends against the middle", indicating instead an alignment of poorer versus richer households and a political equilibrium in which the median income household is decisive. In addition, our calibrations attribute to private tuition dollars a perceived relative advantage of about 30% at the margin.

We test the robustness of these findings to changes in the specification of the utility function by replacing the Stone-Geary function with the commonly used CES function, which implies unitary income elasticity. This produces very similar results, and again indicates that the median income household is decisive. In addition, we calibrate the model to coefficient values within a 95% confidence range, and find that within this range, too, the median-income household is decisive. Finally, allowing for possible Tiebout sorting, we obtain alternative estimates of the relevant derivatives by simultaneously estimating a second equation that explains local income homogeneity as a function of private education, and calibrate the model to these estimates, albeit without integrating the sorting process in the theoretical model. The parameter values obtained in this way are similar to the first calibration, and again indicate an equilibrium in which the median-income household is decisive. Overall, we conclude that our finding of a medium-income-voter equilibrium is robust to the choice of data set, to the definition of the utility function, to statistical variation in the coefficient estimates, and to the type of estimation procedure.

Finally, we apply our findings to simulate the impact of a hypothetical school voucher on private enrolment, the tax rate, public spending per student, and welfare. Our basic calibration indicates that, holding the tax rate constant, a universal voucher—available to all households for use in all private schools—roughly equal to 20% of public spending per student ($1,000 in 1989 values), would increase private enrolment by about four percentage points (a 40% rise) and raise public spending per pupil by 1.5%, thus benefiting all households. If the tax rate is allowed to vary, the majority votes to reduce taxes slightly, resulting in a fall in public spending per pupil of 3.5% and a yet greater increase in private enrolment. This combined voucher and tax cut commands a ninety percent majority over the alternative of no voucher, and yields an increase in aggregate utility equal to a proportional increase in income of 0.25% (about $100 at the mean).[8] Of course, these are only indicative calculations;

they consider only the direct fiscal impact of a universal voucher under the assumptions of the model. Variation in the specific circumstances and design of the voucher program that do not enter in the model may have an overriding effect on costs and benefits (Levin and Driver [31]), as may broader social considerations, such as the importance of a shared educational experience for maintaining fundamental social and political institutions.

The structure of the paper is as follows. Section 2 describes the model and its political-economic equilibria. Section 3 sets out the comparative statics. Section 4 reports the empirical results. Section 5 recovers the parameters of the utility function, checks their robustness and compares our findings to previous studies. Section 6 demonstrates application of our results to school vouchers, and Section 7 concludes.

2. FORMAL ANALYSIS

2.1 Basic definition of the model

Consider an economy with a fixed, heterogeneous population of households of measure 1, indexed by i, with income levels y_i.[9] Denote the probability density function of household income by $f(y)$, its cumulative density function by $F(y)$, its mean by $\bar{y}$, and its median by y_m, and assume for simplicity that each household has one child.[10] All households have the same utility function U, deriving utility from a *numeraire* consumption good c, and from the quality of their children's education x:[11]

$$U(c, x) = a\,(c - c_0)^d/d + (1 - a)\,x^d/d \qquad (1)$$

where c_0, d and a are fixed, common parameters. The income elasticity of demand for school quality $h_y = y/(y - c_0)$ is unitary if $c_0 = 0$, greater than one if c_0 is positive, and less than one if c_0 is negative. The elasticity of substitution h_s is greater than one in absolute value if d is positive, and less than one if d is negative.[12]

Public education is available free of charge to all households at a uniform quality $\bar{x}$ funded by a proportional income tax rate t levied on all households and determined by majority vote.[13] Private education is available as an alternative to public schooling, and can be purchased from competitively priced private schools in any desired quality.[14] Thus households can choose to forgo public education and purchase private education instead, but this does not reduce their tax liability.

We equate educational quality with spending-per-pupil within each local school system,[15] while allowing that the private sector may provide more quality per tuition dollar than the public sector. Let q denote the proportion of households that use the public school system, and let p denote the cost per student of a unit of quality in the public school system. Then assuming that government spending is subject to a balanced budget constraint, the quality of public schooling is:

$$\bar{x} = t\ \bar{y} / (q\ p) \qquad (2)$$

Let 1 – g denote the degree of perceived advantage (or subsidization) of private education, so that the cost of a unit of quality in private schools is $g\,p$. As we noted in the introduction, a value of $g < 1$ is supported by direct evidence on school quality, and implied by expenditure per pupil in public schools being lower, on average, than tuition in private schools. Our assumption that g is uniform for all households ignores its subjective dimension, which implies some degree of heterogeneity. However, in the empirical estimation we control for variation across communities in religious and ethnic composition, which serves as an imperfect proxy for variation in g.

2.2 School choice

A household that sends its child to public school has indirect utility:

$$V(t, q^e, y_i) = a\ [(1-t)y_i - c_0]^d / d\ +\ (1-a)\ [t\,\bar{y} / (q^e p)]^d / d \qquad (3)$$

where it is assumed that c_0 and t are such that $(1 - t)\, y_i - c_0 > 0$ for all households, and q^e denotes the level of public enrolment that households anticipate when making their education decisions. A household that sends its child to private school solves:

$$\text{Max}_{\,c,x,}\ U(c, x) = a\ (c - c_0)^d / d + (1-a)\, x^d / d$$

$$\text{s.t.}\quad c + g\ p\ x = (1-t)\, y_i$$

and has indirect utility [16]

$$W(t, y_i) = g_0\,(g, p, d, a)\ [\,(1-t)\, y_i - c_0]^{\,d} / d \qquad (4)$$

In deciding whether to send its child to public or private school, the household compares $V(t, q, y_i)$ with $W(t, y_i)$. As opting out of public education does not reduce a household's tax obligations, and is thus aimed at obtaining a higher quality of education (and education quality is a normal good), other things being equal, households that opt out of public schooling will be those with higher incomes. Hence, for given tax level t and anticipated public enrolment q^e, either all households prefer public education, or there exists a threshold income level

$$\underline{y}(t, q^e) = c_0 / (1-t) + [t / (1-t)]\ [\bar{y} / q^e]\ [1/g\ (g, p, d, a)] \qquad (5)$$

such that all households with income below $\underline{y}$ send their children to public school and all those with income above $\underline{y}$ sends their children to private school. [17] Note that if the income elasticity of education quality is unitary ($c_0 = 0$) then $\underline{y}$ is proportionate to mean income. Hence, if all incomes increase by the same proportion, holding the tax rate fixed, q is unaffected. Moreover, as we show below, such a proportional change in all incomes also has no effect on the chosen tax rate. We derive g explicitly in Appendix B and show that it is decreasing in g : public enrolment declines when private efficiency increases, as one would expect.

Partial differentiation of (5) reveals that $\underline{y}$ is decreasing in q^e, and as $F(\underline{y}(t,\ 0))$ ≥ 0 and $F(\underline{y}(t,\ 1)) \leq 1$ there exists an equilibrium value of q^e that equates anticipated and actual enrolment,

$$F(\underline{y}\,(t, q^e)) = q^e \qquad (6)$$

Partial differentiation of (5) reveals also that $\underline{y}$ is increasing in t, and by total differentiation of (6) we have

$$dq/dt\ =\ [f(y)¶y/¶t]\ /\ [1 - f(y)\ ¶y/¶q] > 0 \qquad (7)$$

Thus (6) implicitly defines public enrolment as a monotonically increasing function of the tax rate. In Appendix C we show that its elasticity $h_{qt} = (dq/dt)\ /\ (q/t) < 1$.

2.3 Political equilibrium

Now consider households' political determination of the education tax rate by majo rity vote, each household voting so as to maximize its anticipated utility. High-income households derive greater utility from private schooling than from any level of public schooling and hence prefer as low a tax rate as possible.[18] A household with income y that anticipates sending its child to public education prefers a tax rate characterized by the first-order condition

$$dV/dt\ =\ -a\ y[(1-t)\,y - c_0]^{d-1}\ +\ (1-a)\,[\,\bar{y}\,/\,(q(t)\,p)]^{d}\ t^{d-1}[1 - h_{qt}]\ =\ 0 \qquad (8)$$

where voters anticipate the effect of the tax rate on enrolment—represented in (8) by $q(t)$ and h_{qt}—from equations (6) and (7). Note that if $c_0 = 0$ a proportionate change in all incomes that leaves unchanged the ratio of the decisive voter's income to mean income does not affect the preferred tax rate (given that such a change in incomes has no effect on q, as we saw above). Taking the partial derivative of dV / dt with respect to y, and denoting by $h_{t,y}$ the elasticity of the preferred tax rate with respect to household income holding average income fixed, we find after some manipulation (see Appendix D for details) that

$$h_{t,y} = \frac{c_0 - d(1-t)y}{(1-d)(y-c_0)} \tag{9}$$

When the preferred tax rate increases with income among all the households that prefer a positive tax rate, i.e., when $c_0 - d\,(1 - t)\,y > 0$, then an "ends against the middle" coalition is formed. The poor, who prefer less schooling for their children, join forces with the rich who would rather send their children to private schools and therefore prefer that as little as possible be spent on public schooling, in opposition to middle-income voters who prefer that more money be spent on public education—in accordance with Director's Law.[19] When this is the case the income of the decisive household, y_d, satisfies:[20]

$$F(y_d) = q - 0.5 \tag{10a}$$

which implies that the decisive household earns less than median income if there is some private enrolment. Conversely, when the preferred tax rate decreases with income among all the households that prefer a positive tax rate, i.e., when $c_0 - d\,(1 - t)\,y < 0$, then the decisive household is the median income household,[21] i.e.,

$$y_d = y_m \qquad (10b)$$

Thus in equilibrium three equations determine the three unknowns t, q, and y_d:

- equation (6) identifies the margin between public and private education,
- equation (10a) or (10b) identifies the decisive voter, and
- equation (8) characterizes the preferred tax rate of the decisive voter.

We will assume that these equations have a unique solution, and that the chosen values of t and q are strictly positive.[22] We allow the data to determine which type of equilibrium holds: ends against the middle (EATM) or median income (MI).

3. COMPARATIVE STATICS

We focus our analysis on the effect of two parameters, mean income $\bar{y}$ and the median-to-mean ratio r, on the equilibrium value of q.[23] To fix ideas we posit a lognormal distribution of income with parameters m and s^2. Denote the probability density function of the standardized normal distribution by f and its cumulative density function by Φ. Then median income is y_m = exp(m) and mean income is $\bar{y}$ = exp($m + s^2/2$). The ratio of median to mean income is therefore $r \equiv y_m / \bar{y}$ = exp($-s^2/2$), so that $s^2 = -2 \ln r$. Therefore ln y distributes normally with mean ln $r\bar{y}$ and standard deviation $(-2 \ln r)^{½}$. Incorporating this in the equilibrium equations (6) and (10)—equation (8) is unaffected—we have:

$$\Phi\{[\ln(\underline{y}(t, q; \bar{y}, p, g) - ln(r\bar{y})]/(-2 \ln r)^{½}\} = q \qquad (6')$$

And either

$$\Phi\{[\ln y_d - ln(r\bar{y})]/(-2 \ln r)^{½}\} = q - ½ \qquad (10a')$$

if an EATM equilibrium holds; or, if an MI equilibrium holds,

$$y_d = y_m = r\ \bar{y} \tag{10b'}$$

Substituting y_d into equation (8), we obtain that in either case, MI or EATM, the equilibrium values of q and t must satisfy the two equations:

$$G(q, t, r, \bar{y}) = \Phi\{ [1/ (2 \ln (1/ r))^{1/2}] \ln [\underline{y}(t, q ; \bar{y}, p, g) / (r\ \bar{y})] \} - q = 0 \tag{6?}$$

$$H(q,t,r,\bar{y}) = -a\ y_d (r, q, \bar{y})[(1-t)\ y_d (r, q, \bar{y}) - c_0]^{d-1}$$

$$+ (1-a) [\bar{y} / (qp)]^d\ t^{d-1} [1 - h_{qt}] = 0 \tag{8'}$$

where y_d in equation (8') is derived from (10a) if EATM holds, and from (10b) if MI holds. Equation (6") determines the margin between public and private schooling and (8') is the first-order condition for the decisive household. Total differentiation of (6'') and (8') with respect to a "generic" parameter z (either $\bar{y}$ or r) yields

$$G_q (dq/dz) + G_t(dt/dz) = -G_z \tag{11}$$

$$H_q (dq/dz) + H_t(dt/dz) = -H_z \tag{12}$$

from which

$$dq / dz = (H_z G_t - H_t G_z) / (H_t G_q - H_q G_t) \tag{13}$$

The partial derivatives of G and H can be explicitly derived as a function of the parameters of the model.[24] Hence dq / dz can also be expressed as an explicit function of the parameters of the model. We estimate $dq / d\bar{y}$ and dq / dr empirically in the next section, and use the results to find consistent values of c_0, d, a and g that conform to the observed values of q and t and to the estimated values of dq/dr and $dq/d\bar{y}$ evaluated at the mean.

Signing the partial derivatives (see Appendix E for details), we find that under either equilibrium, $H_t < 0 < G_t$, and for typical parameter values $G_r > 0$; under EATM, $G_y < 0 < H_y$ and $H_r > 0$; and under MI, $G_y > 0 > H_y$ and $H_r < 0$. Thus the direction of the net effects of mean income and of income homogeneity on public enrolment cannot be determined *a priori*. However, equation (13) does highlight the economic forces that shape them. As the denominator of (13) is positive from the second order condition, and $H_t < 0$,

$$sign\,(dq/dz) \quad = \quad sign\,\{G_z + [G_t/(-H_t)]\,H_z\} \tag{14}$$

Thus each parameter has both a direct effect on public enrolment, G_z, and an indirect effect through its effect on the preferred tax rate of the decisive voter, $[G_t/(-H_t)]\,H_z$. And because $-H_t > 0$ and $G_t > 0$, the sign of the indirect effect on public enrolment (through the tax level) is the same as the sign of the partial effect, H_z.

Consider the effect of an increase in mean income. When the income elasticity is greater than one, it has the direct effect of *decreasing* public enrolment $(G_{\bar{y}} < 0)$, but also causes an increase in the preferred tax rate $(H_{\bar{y}} > 0)$ that works to *increase* public enrolment. When income elasticity is less than one, but not too small, the direction of both partial effects is reversed: an increase in mean income directly increases public enrolment $(G_{\bar{y}} > 0)$, but also indirectly works to decrease public enrolment by decreasing the preferred tax rate $(H_{\bar{y}} < 0)$. In both cases the two forces work in opposite directions, and net effects will depend on actual parameter values.

Considering the effect of an increase in the median-to-mean ratio r, its direct effect is to increase public enrolment ($G_r > 0$), regardless of which type of equilibrium holds. However, the two equilibria differ in the sign of the indirect effect of r on public enrolment, through its effect on the tax rate. Under EATM, an increase in the median-to-mean ratio increases the tax rate ($H_r > 0$) and therefore increases public enrolment. Thus, under EATM the two forces work in the same direction and the overall effect on private enrolment is unequivocally negative. Under MI, $H_r < 0$, the two effects work in opposite directions, and the direction of the net effect will depend on actual parameter values.

4. EMPIRICAL ESTIMATION

Empirical estimation of the parameters of the model requires a choice of geographic units, which raises conflicting considerations. While the political decisions that determine spending on public education are taken at the school district level, the effective supply of private education facing a particular household is not restricted by school district boundaries and generally ranges over a wider area corresponding to the boundaries of urban agglomeration. In our theoretical analysis we ignore this distinction and assume that the school district coincides with the area that determines the supply of private education from which parents choose alternative schools for their children. However, this is rarely the case: most school districts are much smaller than the urban agglomerations in which they are located.[25] Estimating the model from data on urban agglomerations, such as cities or metropolitan areas, measures with relative accuracy the conditions of supply of private education, such as the share of Catholics in the local population, but may aggregate data from several smaller school districts, thus averaging income levels and possibly exaggerating income inequality (if incomes are more homogeneous within school districts). Conversely, estimating the model from data on individual school districts within a larger urban agglomeration measures mean income and income inequality more accurately but is less accurate in measuring the conditions of supply of private education.

To address this issue, we estimate the derivatives of the private enrolment share with respect to mean income and the median to mean ratio from three cross-sectional data sets: all 1,078 US cities with population over 25,000 in 1990 (dataset A); 423 of these cities that appear in the postal address of a single unified school district (dataset B); and the 423 corresponding school districts (dataset C).[26] Tables 1, 2 and 3 present descriptive statistics, which are generally similar for the three datasets.[27] The full city dataset is very similar to the restricted city dataset, with the exception of average population, which is smaller in the restricted dataset reflecting the exclusion of a small number of very large cities (there is very little difference in median population size). Comparing the matched datasets of cities and school districts, we find that the cities have a higher average density than school districts, a smaller number of school-age children per household, and a smaller average population. The most significant difference is in the dependent variable, *private enrolment share*, which has an average almost four percentage points higher in the school district dataset. We attribute this partly to differences in the definition of the variable (see the Data Appendix), and partly to differences in their characteristics, some of which are captured in the data,[28] and note that *private enrolment share* is highly correlated across matching cities and school districts in datasets B and C, as are the other variables represented in the two datasets (Table 4).

4.1 The variables

We group the right-hand variables that explain the *private enrolment share* under five headings: household income level, median-to-mean income ratio, cost of education quality per household relative to other spending categories, cost factors differentially affecting private education, and ethnic and religious composition.

Household income level measured by *mean household income.* Previous studies generally found a significant positive effect (Sonstelie [45], [46], James [27], West and Palsson [47], McCormick et al. [33], among others), but Hamilton and Macauley [22] found a negative effect. As noted above, in theory there is no a priori prediction of the sign we should expect. *Mean household income squared* is included to allow a nonlinear effect.

T*he *ratio of median to mean household income (rho). Under EATM we expect a negative effect on private enrolment, while under MI the sign is not determined. Hamilton and Macauley [22] found negative effects on private enrolment, as did Buddin et al. [6] in their analysis of school choice from micro-data. Schmidt [44] found a negative effect for secular private schools and a positive effect for religious schools.

Cost of education quality per household relative to other spending categories is measured by *salary*, average teachers' salaries, by state, controlled for experience and cost of living; and *school-age children per household.* The direction of the effect of these variables on private enrolment is ambiguous a priori, but we expect them to have the same sign.

Cost factors that differentially affect private education include *density, population size, the state grant impact factor, and % Catholic.* While *density* and *population* affect the cost of education in general, we expect a stronger effect on private education, where scale effects and transportation costs are generally larger. We expect them both to have a positive effect on private enrolment, while allowing for non-linearity. State subsidies to local communities raise the relative cost of private schooling in lower income communities. We measure it by multiplying the state government's share in education spending (in the state) by the ratio of the difference between mean state income and mean local income to mean local income; we refer to this as the *state grant impact factor*. It assumes that state aid to local schools varies directly with the general level of state participation in education expenses and with the relative poverty of the local community. We expect it to have a negative effect on *private enrolment*. A high percentage of Catholics may also affect costs, as Catholic schools are subsidized to a greater degree than other private schools (Hoxby [24]). Studies that have found these variables to have significant effects (with the expected sign) include, among many others, Clotfelter [8] and Long and Toma [32] on Catholic share; James [27] on density and Catholic share; Hamilton and Macauley [22] on Catholic share and population; McCormick et al., [33] on population; Buddin et al. [6] on Catholic share and density; and Romer et al. [40] on state grants.

Ethnic and religious composition is measured by *% Catholic, % African-Americans, and % Hispanic, each with a squared term.* In addition to the effect of a large Catholic population on the effective cost of private education, discussed above, a desire for religious homogeneity in the school suggests that the Catholic share effect should be concave: where Catholics comprise a majority of the population they should have less of a desire for private education. Previous empirical findings associate a similar positive impact on private enrolment with a high proportion of African-Americans, e.g., Clotfelter [8], James [27], Hamilton and Macauley [22], McCormick et al. [33], and Schmidt [44]. As micro-data studies indicate that African-Americans themselves are less likely to attend private schools, this must be interpreted as reflecting an external influence of African-Americans on other population groups, suggesting a similar negative non-linear effect there, too. Sonstelie [45] found that the proportion of Hispanics, after controlling for Catholic share, had a negative effect on private enrolment.

In addition, we included *percentage of homeowners* in the regression because of the role of property values both in funding school spending, and in capturing external benefits from schooling—and the imperfect correlation between property values and income. If homeowners have a higher ratio of housing value to income than do renters, or if they are more keenly aware of the tax cost of education, and hence support lower tax rates, more private enrolment is indicated. Conversely, if large external benefits lead homeowners to have a greater interest in schooling quality than renters then less private schooling is indicated. If home ownership is a proxy for permanent income, or wealth, not reflected in current income then the effect of home ownership should have the same sign as mean income.

4.2 Regression results

The results of three OLS regressions of the share of private enrolment on the right-hand variables listed above, one for each of the three datasets, are presented in Table 5.[29] As the observations in each of our datasets greatly vary in size we report *t*-statistics corrected for heteroscedasticity according to White [50].[30] The three regressions produce generally similar results and in each case the regression explains more than half the variance in the dependent variable.

In all three equations, mean household income has an increasing concave effect on the share of private enrolment, and the median-to-mean ratio has a negative effect. The Catholic share variables are the most significant in the equation, with a concave effect on private enrolment that peaks (in all three regressions) when the share of Catholics in the population is just under 50%: when Catholics form a local majority their demand for private schooling diminishes. The share of Hispanics has a negative effect on private enrolment, after controlling for Catholic share, with a trough at just under 50%, indicating either that Hispanics have less interest in private schooling than other Catholics, or that Catholic schools in Hispanic areas are less attractive to non-Hispanics. The share of African-Americans has a similar positive concave effect that peaks when the African-American share is 45%, consistent with the hypothesis that a large African-American minority increases the proportion of whites that choose private schooling. Density, which offers a greater advantage for private than for public schooling, has an increasing, concave effect on private enrolment, as expected, as does population size, though to a lesser extent.[31] The significant negative effects of school-age children per household and of teachers' salaries on private enrolment are consistent with the positive effect of income on private enrolment: a higher ratio of education costs to income favors public schooling. The positive coefficient of the share of homeowners can be interpreted as representing components of permanent income not captured by current income that are reflected in property values. The state-grant impact factor has the expected negative sign: state aid reduces private enrolment.

Table 6 presents the impact on private enrolment of a change of one standard deviation at the mean in each of the right-hand variables.[32] The largest values are associated with the share of Catholics, ethnic composition, density, the share of homeowners, and the number of school-age children per household.

5. CALIBRATION AND SENSITIVITY ANALYSIS

We next use the estimation results to calibrate the parameters of the model to each of the three regression results, finding values of c_0, d, a and g that conform to the observed values of private enrolment, the tax rate, the derivative of public enrolment with respect to mean income $dq/d\,\bar{y}$, and its derivative with respect to the mean-to-median ratio dq/dr, both evaluated at the mean of dataset A. We then compute confidence intervals for the coefficient estimates from dataset A, check the sensitivity of our estimates to a change in the specification of the utility function, introduce an ad hoc correction for Tiebout sorting and compare our results to earlier studies.

5.1 Calibration

In all three calibrations we used the same values of q and t, which we set equal to their values in dataset A (the full set of cities with population over 25,000), while varying the derivative values in accordance with the regression results. We set q equal to 89.5%, the average share of public enrolment. Public expenditure per student in the United States in the same year (1989-90) was $4,972. Letting m denote the ratio of school-age children to households, this value corresponds to $(t \cdot \bar{y})/(q \cdot m)$ in the model. Taking the mean value of m = 0.46, and substituting mean income and public enrolment for $\bar{y}$ and q, we obtain a tax level of 5.17%. These values are retained in all three calibrations.

First calibrating the model to the derivatives estimated from dataset A, we find the derivative of public enrolment with respect to mean income evaluated at the mean equal to –0.056, and its derivative with respect to the median-to-mean ratio equal to 0.073.[33] We then numerically solve four equations in the four unknowns c_0, d , a and g, under the two alternative equilibrium assumptions, EATM and MI. The four equations are: the private enrolment equation (6''), the first order condition (8'), and two equations that set the derivatives of public enrolment with respect to mean income and the median-to-mean ratio, specified by (13), equal to their estimated values.

Solving under EATM, i.e., assuming that the decisive household satisfies $F(y_d) = q - ½$, we obtain values of c_0 and d that do not satisfy the condition $c_0 - d(1-t)\,y > 0$ for any income level y, and hence are not consistent with an EATM equilibrium. Solving under MI, i.e., under the assumption that the median income household is decisive, we obtain parameter values that satisfy $c_0 - d\,(1 - t)\,y < 0$ for all income levels y, and thus are consistent with MI. These values are: $c_0 = -7{,}807$, $d = 0.23$, $a = 0.90$ and $\gamma = 0.69$. They imply that the income elasticity of demand for education quality at the mean, $\bar{y}/(\bar{y} - c_0)$, is equal to 0.84, the elasticity of substitution is equal to –1.31 and the price elasticity of the Marshallian demand curve is –1.29 (Appendix F). The implicit tax-price elasticity of public spending per student equals –0.09.[34]

Similarly calibrating the model to the derivatives estimated from dataset B finds the model consistent with an MI equilibrium, but not an EATM equilibrium, yielding an income elasticity equal to 0.90, an elasticity of substitution of –1.33, and a value of 0.70 for ?.[35] The implicit tax-price elasticity of public spending per student equals –0.10. Calibrating the model to the derivatives estimated from dataset C again finds the model consistent with an MI equilibrium, but not an EATM equilibrium, while indicating elasticities of slightly smaller magnitudes—an income elasticity of 0.70 and an elasticity of substitution equal to –1.02. The tax-price elasticity of public spending per student is –0.10. The value of ? is 0.66, implying a slightly larger perceived efficiency advantage.[36] Thus in calibrating the model to the results of the three regressions, income elasticity varies between 0.70 and 0.90; the elasticity of substitution varies between –1.02 and –1.33; the tax-price elasticity of public spending per student varies between –0.09 and –0.10; the perceived advantage of private tuition dollars varies between 30% and 34%; and an MI equilibrium is indicated throughout. [37]

5.2 Confidence intervals

To further check the sensitivity of our results to variation in the coefficient estimates we calculated an elliptical 95% joint confidence range around the estimated coefficients of mean income and the median to mean ratio from dataset A, and calibrated the model on its perimeter (see Appendix H for details). The efficiency parameter, g, varies between 0.64 and 0.72; income elasticity at the mean varies between 0.64 and 1.03; and the elasticity of substitution between –0.92 and –1.76. We then checked the sign of the key expression $c_0 - d\,(1 - t)\,y$ and found that throughout this range MI holds for any level of income above $3,600 annually, which can be taken to include all households.[38] This further supports our conclusion that our findings are consistent with an MI equilibrium and not an EATM equilibrium.

5.3 CES specification

To check whether the results are sensitive to the specific form of the utility function we tested the alternative specification of a “pure” CES function with $c_0 = 0$, again focusing on dataset A. This specification leaves three parameters to be determined—a, g and d—and three equations with which to determine them, as $c_0 = 0$ implies $dq/d\bar{y} = 0$. Solving the three equations yields $a = 0.84$, $g = 0.72$ and $d = 0.36$. Again, an MI equilibrium is indicated by the point estimates, as $d > 0$ implies that $c_0 - d\,(1 - t)\,y < 0$ for all y (as $c_0 = 0$ by assumption). To test sensitivity of these estimates to statistical variation in the estimate of the coefficient of r we took a 95% confidence interval around its point estimate and calibrated the three parameters of the model at each of twelve equally distanced points in the interval. The efficiency parameter g varies between 0.71 and 0.73, and d varies between 0.27 and 0.44 indicating an elasticity of substitution between -1.37 and -1.78, and an MI equilibrium throughout.

5.4 Control for Tiebout sorting

OLS estimation of the effect of income homogeneity on the share of private enrolment may be biased if there is also a reciprocal effect of local schooling opportunities on income homogeneity (Goldstein and Pauley [21]). Such an effect arises from mobility between communities: households choosing where to live take into account the quality of local schools and the level of local taxes. Hence communities with a large selection of private schools are more likely to attract a heterogeneous population.[39] Integrating this effect in the theoretical model is beyond the scope of the present paper, but we control empirically for the effect of a possible bias by simultaneously estimating an income distribution equation in which the dependent variable is the median-to-mean ratio.[40]

The results of the three-stage least squares estimation (on dataset A) are presented in Table 7. Setting the derivatives of private enrolment with respect to mean income and the median-to-mean ratio in the model equal to their estimated values, and solving equations (6") and (8') under MI, we obtain parameter values that are, again, consistent with MI.[41] They imply an elasticity of income at the mean equal to 0.98, and an elasticity of substitution equal to -1.20, an implicit tax-price elasticity of public spending per student of -0.14, and a perceived efficiency advantage of 26%. In a 95% confidence range, the income elasticity varies between 0.83 and 1.13; the elasticity of substitution varies between -0.84 and -1.65; and the efficiency advantage varies between 21% and 30%. Again, an MI equilibrium is indicated in all cases.

5.5 Comparison to previous findings

Our range of values for the income elasticity of demand for school quality from the three basic OLS regressions, between 0.70 and 0.90, is just under Romer et al.'s [40] estimates derived from a detailed study of spending and voting in New York school districts, and Fernandez and Rogerson's [15] estimates based on a pooled cross-section of state-level data over four decades, on the order of 0.90; it accords with Poterba's [38] estimate of 0.75, from state-level data; and is at the higher end of the range of estimates cited Bergstrom et al. [1], which they summarize as indicating that the income elasticity of demand for public education "is on the order of 2/3". [42]

Our range of values for the elasticity of substitution between education quality and other goods, between –1.02 and –1.33, is greater in magnitude than Fernandez and Rogerson's [14] calibration based on variation in spending levels across school districts in California, which indicated a range of values between –0.80 and –0.95.[43] Our corresponding estimate of the tax-price elasticity of spending per student, of about –0.10, accords with Sonstelie [46] and Romer et al. [40], and is well within the range of earlier studies summarized by Black et al., [3] and Bergstrom et al. [1]. It indicates very moderate variation in the desired level of tax rates within communities, which may be attributed to Tiebout sorting.[44]

Finally, we note that our range of values for g, the relative cost of education quality in private schooling, between 0.66 and 0.70, implying a perceived advantage for private education of between 30% and 34%, confirms direct observations, discussed in Section 1, that private schools provide greater perceived value per tuition dollar than public schools, and approximates the actual difference in teachers' salaries between private and public schools.[45]

Taken together, our findings strongly indicate an MI equilibrium, contradicting the assumption common to most quantitative analyses of school funding in the United States, that EATM equilibria are prevalent. We attribute this difference to the explicit link we forge between our empirical estimates and the underlying parameters of a theoretical model that allows private tuition dollars to be more effective in purchasing education quality than tax dollars. As we show in the following section, in which we use our results to simulate the fiscal effect of a voucher program, this can have a substantial effect on policy analysis.

6. APPLICATION TO EDUCATION VOUCHERS

We conclude with an application of our results to simulate the effect of a hypothetical school voucher of $1,000 (roughly equal to 20% of public spending per student in 1989/90), available to all households without restrictions on its use, on public enrolment, taxes, public spending per student and welfare in a "typical" community with a mean income of $39,600, and a median-to-mean ratio of 0.801, the average values in dataset A.[46]

Letting s denote the sum of the voucher, and assuming it is funded from the same tax base as public education, public expenditure per pupil is $[t\bar{y}-(1-q)s]/(qm)$, and the utility of a household that chooses private schooling is $W[(1-t)y + sm]$. The model is the same otherwise, and we solve it for t and q using the parameter estimates from the preceding section. Table 8 presents the results of our calculations for the OLS calibration from dataset A and the 3SLS calibration.[47]

Holding the tax rate fixed, a voucher program increases public spending per student if the cost of paying the vouchers is less than the savings to the public system as a result of the reduced student load. For a 20% voucher and initial value of private enrolment equal to 10.5%, the voucher program must increase private enrolment by at least 2.7 percentage points for this condition to hold.[48] We find an increase in private enrolment of 4.3 percentage points for the OLS calibration (3.6 for the 3SLS estimates), which is well beyond this threshold, implying an increase in public spending per student of 1.5% (0.9%) holding the tax rate fixed.[49] Note that both the OLS and 3SLS calibrations indicate a stronger response of private enrolment than Epple and Romano's [12] results.[50] Calculating the elasticity of private enrolment with respect to the size of the voucher at a voucher level of $1,000, we find a value of 0.37 under our OLS estimates and 0.32 under 3SLS, compared to 0.14 for Epple and Romano's final choice of parameters. Their calibration implies that the threshold increase in private enrolment would not be reached.

If the tax rate is allowed to change, the impact of the voucher program on taxes and public spending per student can be decomposed into income and substitution effects. The large increase in private enrolment holding the tax rate fixed implies a positive income effect on the decisive voter that works to increase both consumption and school quality, under the usual assumption that both are normal goods; this has the effect of lowering taxes. At the same time, by lowering the threshold income level $\underline{y}$, the voucher program increases the implicit price of education quality in terms of forgone consumption for the median income household,[51] generating a substitution effect that works to increase the ratio of consumption to school quality, which also works to lower taxes. The net result is a lower tax rate and a generally indeterminate direction of change in the level of public spending per student. Our calculations for the OLS calibration show a decline of 0.35 percentage points in the tax rate (a relative decline of 7%) and a decline of 3.5% in public spending per pupil. This increases the welfare of households with income over $13,500,[52] and yields an increase in aggregate utility equivalent to a $109 increase in mean income. The 3SLS calibration indicates a decline of 0.06 percentage points in the tax rate (a relative decline of 1.2%) and a relative increase of 0.1% in school spending, implying a very small Pareto-improvement.

7. CONCLUDING REMARKS

There is growing recognition of the need to examine alternative modes of education finance as a means of improving the quality of education, especially in low-income communities. Reliable estimates of the underlying parameters of household utility that determine collective political decisions on public spending and individual decisions on school choice offer valuable insights, at the design stage, on the likely impact of proposed reforms on private enrolment, tax rates and public spending per student. The present paper offers an improved methodology for deriving such estimates. It extends previous political economy models of education finance and school choice by allowing a difference between tax dollars and private tuition dollars in their impact on perceived education quality, and by accommodating a non-unitary income elasticity. These extensions enable us to calibrate the parameters of household utility from a regression of private enrolment on mean income and income homogeneity—controlling for religious, racial and demographic composition, and various cost factors—estimated from United States city and school district data.

Our findings indicate an income elasticity of education quality between 0.70 and 0.90; an elasticity of substitution between education quality and other goods between –1.02 and –1.33; and a tax-price elasticity of public spending per student on the order of –0.10. These results imply a political equilibrium in which the median income household is decisive rather than one in which there is a coalition of "ends against the middle"; Director's Law does not apply to local public funding of education. Moreover, this finding is robust to variation of the coefficient estimates within a 95% confidence range, to a CES specification of the utility function, and to an ad hoc correction for Tiebout sorting. Our findings also indicate that the marginal household choosing between private and public schooling views a dollar spent on private tuition as between 30% and 34% more effective than a tax dollar spent on public education. Applying our findings to evaluate the impact of a school voucher roughly equal to 20% of public spending per student, we find that it substantially increases private enrollment, lowers the tax rate, and benefits nearly all households, though it may slightly lower public spending per student.

Several avenues for further work are indicated. Possible theoretical extensions include explicit modeling of the distinction between religious and non-religious private schools, variation in religious sentiment among households, and variation in family size; allowing peer-group effects to influence student achievement; and incorporating a richer institutional framework to address the specifics of state funding and the political decision-making process. More ambitiously, integrating these elements of education finance and school choice decisions within a broader network of interaction between state governments and multiple local jurisdictions operating at different levels with overlapping boundaries, while recognizing that households are "imperfectly" mobile, is necessary for understanding the long-term relation between urban development and local education policies.

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Table 1. Descriptive Statistics, Dataset A:
All 1,078 Cities with Population Over 25,000

Variable	Mean	Standard deviation	Median	Min	Max
Private enrolment share, %	10.5	5.8	9.1	0.5	51.6
Mean income ($000s)	39.6	12.9	36.3	17.8	122.1
Median to mean income (rho), %	80.1	7.9	80.7	44.5	97.1
% Catholics	22.7	15.7	18.8	0.2	81.0
% Hispanics	10.6	15.5	4.1	0.2	93.9
% African-Americans	11.7	15.6	4.5	0.04	98.1
Density (000s per square mile)	3.8	3.4	2.9	0.01	44.6
Salary ($000s)	33.1	2.63	33.2	23.9	38.3
State grant impact factor	3.1	13.0	2.6	–40.6	56.0
% homeowners	58.3		59	22	92
Population (000s)	97.5	288.2	47.2	25.0	7,323
School-age children per household	0.46		0.44	0.07	1.31
Unemployment, %	6.53	3.00	6.10	0	17.9
% females in labor force	46.6	2.5	46.6	36.4	57.1
Female participation rate, %	58.0	7.0	57.9	27.3	81.9
% of population age 65+	12.5	5.2	12.2	2.0	48.5
% employed in manufacturing	17.2	7.6	16.4	2.4	43.5
% employed in public administration	4.8	3.4	3.8	1.0	31.8
% of over 25 with bachelor degree	22.8	11.7	19.8	1.6	71.2
% of over 25 with high school or more	77.5	10.6	78.1	26.3	97.2

Table 2. Descriptive Statistics, Dataset B:
423 Cities in Dataset A Matching One Unified School District

Variable	Mean	Standard deviation	Median	Min	Max
Private enrolment share, %	10.4	5.6	8.9	1.0	32.5
Mean income ($000s)	39.1	11.2	36.1	22.5	112.4
Median to mean income ratio, %	80.5	7.6	81.3	49.8	95.7
% Catholics	23.9	17.4	20.3	0.2	81.0
% Hispanics	9.7	14.4	3.6	0.2	90.1
% African-Americans	11.4	15.0	4.4	0.1	75.7
Density (000s per square mile)	3.6	3.6	2.6	0.1	44.6
Salary ($000s)	32.8	2.6	32.9	27.0	38.3
State grant impact factor	3.2	12.1	3.1	-38.4	56.0
% homeowners	57.3	12.5	58.0	22.0	92.0
Population (000s)	76.8	115.3	47.7	25.0	1,586
School-age children per household	0.45	0.14	0.44	0.16	1.29

Table 3. Descriptive Statistics, Dataset C:
423 Unified School Districts Corresponding to the Cities in Dataset B

Variable	Mean	Standard deviation	Median	Min	Max
Private enrolment share, %	14.0	5.9	13.2	1.9	38.6
Mean income ($000s)	40.1	11.6	36.9	21.8	125.8
Median to mean income ratio, %	80.9	6.7	81.3	49.8	101.1
% Hispanics	9.1	13.4	3.3	0.1	89.6
% African-Americans	9.9	13.5	4.3	0.04	75.5
Density (000s per square mile)	1.01	1.32	0.54	0.00	11.13
State grant impact factor	1.9	11.7	1.7	-41.4	71.1
% homeowners	60.4	11.6	62.0	21.6	90.7
Population (000s)	110.0	167.6	62.8	16.1	1,937
School-age children per household	0.59	0.16	0.57	0.02	1.37

Table 4. Correlation between Corresponding City and School District Variables in Datasets B and C

Private enrolment share	0.91
Mean income ($000s)	0.93
Median to mean income ratio	0.86
% Hispanics	0.95
% African-Americans	0.96
Density (000s per square mile)	0.77
State grant impact factor	0.83
% homeowners	0.85
Population (000s)	0.77
School-age children per household	0.87

Table 5. Share of Private Enrolment, Three OLS Regressions
(t-statistics in parentheses, corrected for heteroscedasticity, White [51])

Variable	Cities with population over 25,000 (Dataset A)	Cities in dataset A matching one school district (Dataset B)	School districts corresponding to dataset B cities (Dataset C)
Constant	10.58 (4.11)	10.06 (2.84)	13.21 (3.63)
Mean income	0.144 (2.47)	0.106 (1.16)	0.206 (2.30)
Mean income squared	-0.0011 (-2.39)	-0.00090 (-1.24)	-0.0013 (-1.98)
Median to mean income ratio	-0.073 (-2.85)	-0.093 (-2.58)	-0.099 (-2.26)
Salary	-0.268 (-3.85)	-0.223 (-2.41)	-0.119 (-1.13)
Density	0.732 (8.87)	0.796 (6.30)	1.45 (3.62)
Density squared	-0.010 (-4.18)	-0.0096 (-3.42	-0.046 (-1.04)
% Catholics	0.380 (12.80)	0.426 (9.82)	0.422 (8.29)
% Catholics squared	-0.0039 (-8.92)	-0.0043 (-6.78)	-0.0044 (-5.95)
% Hispanics	-0.116 (-3.78)	-0.171 (-4.16)	-0.194 (-4.50)
% Hispanics squared	0.0012 (3.90)	0.0017 (2.75)	0.0019 (2.90)
% African-Americans	0.153 (7.65)	0.160 (4.11)	0.168 (3.41)
% African-Americans squared	-0.0017 (-5.26)	-0.0017 (-2.44)	-0.0020 (-2.32)
% homeowners	0.118 (6.33)	0.107 (4.06)	0.044 (1.32)
State grant impact factor	-0.032 (-1.62)	-0.027 (-0.91)	-0.079 (-2.16)
Population	0.0033 (3.40)	0.0045 (1.37)	0.0032 (1.40)
Population squared	-4.74e-7 (-3.51)	-1.06e-6 (-0.42)	4.79e-8 (0.04)
School-age children per household	-10.43 (-6.55)	-6.72 (-3.37)	-6.13 (-3.17)
Number of observations	1,078	423	423
Adjusted R-square	0.51	0.55	0.52

Table 6. Impact on the Share of Private Enrolment (in percentage points) **of a Change in the Right-Hand Variables of One Standard Deviation at the Mean**

	Dataset A	Dataset B	Dataset C
Mean income	0.73	0.40	1.19
Ratio of median to mean income (rho)	-0.58	-0.70	-0.66
Salary	-0.70	-0.58	-0.31
Density	2.22	2.60	1.46
% Catholics	3.22	3.98	3.89
% African-Americans	1.77	1.81	1.65
% Hispanics	-1.42	-1.95	-2.07
% homeowners	1.52	1.34	0.51
State grant impact factor	-0.41	-0.33	-0.92
Population	0.93	0.49	0.53
School-age children per household	-1.56	-0.94	-0.98

Table 7. Simultaneous equations estimates (3SLS)

t-statistics in parentheses; all variables except *rho* and private enrolment treated as exogenous

Variable	% Private enrolment		Median to mean ratio	
	coefficient	t-statistic	coefficient	t-statistic
Constant	11.89	(5.05)	39.77	(9.77)
% Private enrolment			-0.963	(-4.36)
Mean income	0.1053	(1.86)	0.26	(2.62)
Mean income squared	-0.00123	(-2.62)	-0.00318	(-4.45)
Median to mean ratio (rho)	-0.163	(-4.75)		
State grant impact factor	-0.086	(-5.24)		
% Catholics	0.403	(12.89)	0.462	(5.46)
% Catholics squared	-0.004	(-8.62)	-0.00448	(-4.78)
% Hispanics	-0.108	(-4.38)	-0.124	(-2.69)
% Hispanics squared	0.00084	(2.45)	0.00066	(1.31)
Population	0.0027	(2.75)	-0.00044	(-0.27)
Population squared	-4.3e-7	(-2.65)	-7.37e-8	(-0.29)
% African-Americans	0.135	(6.03)	0.099	(2.57)
% African-Americans squared	-0.00165	(-4.74)	-0.00181	(-3.24)
Density	0.768	(8.97)	1.186	(7.52)
Density squared	-0.00952	(-3.43)	-0.014	(-3.87)
Salary	-0.081	(-1.94)		
School-age children per household	-7.83	(-5.70)	-4.177	(-1.74)
% homeowners	0.121	(7.31)	0.317	(12.41)
Unemployment rate			0.052	(0.92)
% female in labor force			-0.492	(-5.83)
Female participation rate			0.516	(13.44)
% of population age 65+			0.04	(0.89)
% employed in manufacturing			0.144	(7.03)
% employed in public administration			0.23	(6.35)
% over 25 with bachelor's degree			-0.214	(-9.45)
% over 25 with high school or more			0.154	(3.87)

Table 8. Impact of a $1,000 voucher program

	Tax rate is fixed		Tax rate is allowed to vary		
	Private enrolment	Public spending per student	Tax rate	Private enrolment	Public spending per student
No voucher	10.5%	$4,972	5.17%	10.5%	$4,972
OLS	14.8%	$5,049	4.81%	17.3%	$4,805
3SLS	14.1%	$5,016	5.11%	14.4%	$4,977

DATA APPENDIX

Datasets A and B are drawn from the 1994 County and City Data Book on CDROM (U.S. Bureau of the Census), except: *% Catholic*, from Bradley et al. (1992); *salary*, from American Federation of Teachers 50-State Teacher Salary Survey, 1990-91, available at http://www.aft.org/research/salary/stgrave/50state.xls ; and state government share in education spending, from the Digest of Education Statistics (1995, table 157).

All data refer to 1990, except *mean income* (1989); expenditure per student (1989-1990); and *salary* and state government share in education spending (1990-1).

Employment shares refer to the civilian labor force.

All shares are in percentage points (*private enrolment, the median to mean ratio, % Catholics, % employed in manufacturing,* etc.).

Population is in thousands.

Density is measured as thousands of people per square mile.

Private enrolment is measured as a percentage of persons enrolled in elementary or high school, three years old and over.

Mean income is per capita money income multiplied by persons per household, in thousands of dollars.

The median to mean ratio is the ratio of median household income to *mean income*.

$$\textit{State grant impact factor} = \left[\begin{matrix}\text{state govt share in} \\ \text{education spending}\end{matrix}\right] \times \left[\frac{\text{state income per household}}{\text{city income per household}} - 1\right]$$

School-age children per household is the ratio of persons age 5-17 to the number of households

Salary is the average teacher's salary, by state, adjusted for teaching experience and cost of living.

In **Dataset C**, *private enrolment, mean income, the median to mean ratio, % Hispanic, % Black* and *population* are taken from the School District Data Book on CD-ROM for 1989-90 (National Center for Education Statistics). Remaining data are from the corresponding cities in Dataset B.

Private enrolment is measured as a percentage of total enrolment among "total relevant children", i.e., resident children 3 to 19 years of age who are not high school graduates and are of an appropriate grade for the school district.

The median to mean ration is the ratio of per capita income to mean household income multiplied by the number of persons per housing unit.

School-age children per household is the ratio of "total relevant children" to the number of housing units

The *state grant impact factor* is calculated as above from school district income.

Appendix A

The elasticity of substitution is defined as

$$h_s = \frac{d\ln(x/c)}{d\ln p} = \frac{d\ln(x/c)}{d(x/c)} \cdot \frac{d(x/c)}{dp} \cdot \frac{dp}{d\ln p} = \frac{c}{x} \cdot \frac{d(x/c)}{dp} \cdot p \qquad (15)$$

where *x*, *c* are the Marshallian demand curves.

The Marshallian demand are obtained by solving

$$Max \quad U(c,x) = a \cdot (c - c_0)^d / d + (1-a) \cdot x^d / d$$

$$s.t \quad c + xp = y$$

which gives the first-order condition

$$\left(\frac{y - xp - c_0}{x}\right)^{d-1} = \frac{1-a}{a \cdot p}$$

Rearranging terms to extract *x* gives

$$\frac{y - c_0}{x} - p = \left(\frac{1-a}{a \cdot p}\right)^{\frac{1}{d-1}} = \left(\frac{a \cdot p}{1-a}\right)^{\frac{1}{1-d}}$$

Therefore, the Marshallian demand functions for *x* and *c* are given by

$$x = \frac{y - c_0}{p + \left(\frac{a \cdot p}{1-a}\right)^{\frac{1}{1-d}}} \qquad (16)$$

$$c = y - xp = y - \frac{(y - c_0) \cdot p}{p + \left(\frac{a \cdot p}{1-a}\right)^{\frac{1}{1-d}}} = \frac{y \cdot \left(\frac{a}{1-a}\right)^{\frac{1}{1-d}} \cdot p^{\frac{d}{1-d}} + c_0}{\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}} \cdot p^{\frac{d}{1-d}} + 1} \qquad (17)$$

and $x/c = \dfrac{y - c_0}{y \cdot \left(\frac{a}{1-a}\right)^{\frac{1}{1-d}} \cdot p^{\frac{1}{1-d}} + c_0 \cdot p}$.

Hence

$$\frac{d(x/c)}{dp} = -\frac{(y-c_0)\cdot\left[y\cdot\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}\cdot\left(\frac{1}{1-d}\right)\cdot p^{\frac{d}{1-d}}+c_0\right]}{\left[y\cdot\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}\cdot p^{\frac{1}{1-d}}+c_0\cdot p\right]^2}$$

Then

$$h_s = \frac{d(x/c)}{dp}\cdot\frac{cp}{x} = -\frac{y\cdot\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}\cdot\left(\frac{1}{1-d}\right)\cdot p^{\frac{d}{1-d}}+c_0}{y\cdot\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}\cdot p^{\frac{d}{1-d}}+c_0} \tag{18}$$

It follows directly that $|h_s| > 1$ when $d > 0$ and $|h_s| < 1$ when $d < 0$.

Appendix B

The indirect utility of a household that sends its children to private school is:

$$W = [(1-t)y-c_0]^d \; /d \;\cdot(1-a)\cdot\left[\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}\cdot(pg)^{\frac{d}{1-d}}+1\right]^{1-d}(pg)^{-d}$$

Combining this with (3), the function g in threshold income level, $\underline{y}$, specified in (5)

$$\underline{y}(t, q) = c_0 / (1-t) + [t/(1-t)]\,[\bar{y}/q]\,[1/g\,(g, p, d)]$$

is then given by the following expression:

$$g(a, d, p, g) = p\cdot\left\{\left[g^{\frac{-d}{1-d}}+\left(\frac{a}{1-a}\right)^{\frac{1}{1-d}}p^{\frac{d}{1-d}}\right]^{1-d}-\frac{a}{1-a}\cdot p^d\right\}^{\frac{1}{d}}$$

Clearly $g'(g) < 0$.

Appendix C

Net income decreases in the tax rate, so voters will choose a higher tax rate only if the quality of the public school increases in the tax rate, i.e., $\partial\, [t\,\bar{y}\,/\,(q\;p)]\,/\partial\; t > 0$. Then

$$\partial\, [t\,\bar{y}\,/\,(q\;p)]\,/\partial\; t = (\,\bar{y}\,/\,p)\,\partial(t\,/\,q)\,/\,\partial\; t \;=\; (\,\bar{y}\,/\,p)\,(\,q - t\,\partial\, q/\partial t\,)\; q^2$$

$$=\; \bar{y}\,/\,(pq)\,(1 - h_{qt}\,) > 0$$

Hence $0 < h_{qt} < 1$.

Appendix D

For a household with income y that anticipates using public education, the preferred tax rate is characterized by the first-order condition

$$H = dV/dt \;=\; -a\; y\,[(1-t)y - c_0]^{d-1} \;+\; (1 - a)\,[\,\bar{y}\,/(q(t)p)]^{d}\, t^{d-1}[1 - h_{qt}] = 0$$

Total differentiation of dV/dt with respect to y yields

$$\frac{\partial t}{dy} = \frac{-H_y}{H_t} = \frac{a\cdot\left[(1-t)\,y - c_0\right]^{d-2}\left[d\,(1-t)\,y - c_0\right]}{a\cdot y^2\,(d-1)\left[(1-t)\,y - c_0\right]^{d-2} + (d-1)(1-a)(\bar{y}\,/\,qp)^d\; t^{d-2}\,(1-h_{qt})} \qquad (*)$$

According to the first order condition, it is derived that:

$$(d-1)(1-a)(\bar{y}\,/\,qp)^d\; t^{d-2}\,(1-h_{qt}) = (d-1)\cdot a\cdot\left[(1-t)\,y - c_0\right]^{d-1}/\,t \qquad (**)$$

Substituting (**) into (*) and performing some simple manipulations we obtain:

$$\frac{\partial t}{dy} = \frac{-H_y}{H_t} = \frac{d\,(1-t)\,y - c_0}{(d-1)\,y(\,y - c_0)\,/\,t}$$

The elasticity of the desired tax level with respect to household income is therefore:

$$h_{t,y} = \partial t\,/\,\partial y\cdot y\,/\,t = \frac{c_0 - d\,(1-t)\,y}{(1-d)(\,y - c_0)}$$

Appendix E

Both types of equilibria are defined by the two equations:

$$H(q, t, z) = -a\, y_d(r, q, \bar{y})[(1-t)\, y_d(r, q, \bar{y}) - c_0]^{d-1} + (1-a)[\bar{y}/(qp)]^d t^{d-1}[1-h_{qt}] = 0 \quad (*)$$

$$G(q, t, z) = \Phi\{ [1/(2 \ln(1/r))^{1/2}] \ln [\underline{y}(t, q; \bar{y}, p, g)/(r\bar{y})] \} - q = \Phi(x) - q = 0 \quad (**)$$

where , $\underline{y}(t, q) = c_0/(1-t) + [t/(1-t)][\bar{y}/q][1/g(g, p, d)]$ (***)

Taking partial derivatives of equations (*), (**) with respect to $(t, q, \bar{y}, r)$ we obtain:

- $$G_t = f(x) \cdot \frac{1}{(2\ln(1/r))^{0.5} \cdot \underline{y} \cdot (1-t)^2} \cdot \left(c_0 + \frac{\bar{y}}{qg} \right)$$

$c_0 + t\bar{y}/(qg) > 0$ according to equation (***) implying that $G_t > 0$.

- $$G_{\bar{y}} = -f(x) \cdot \frac{c_0}{(2\ln(1/r))^{0.5} \cdot \underline{y} \cdot (1-t) \cdot \bar{y}}$$

That is, $G_{\bar{y}}$ is negative when the elasticity of income is greater than unity ($c_0 > 0$), and is positive when the elasticity of income is smaller than unity ($c_0 < 0$)

- $$G_r = \frac{f(x)}{(2\ln(1/r))^{1.5} \cdot r} \cdot \left(\ln(\underline{y} r / \bar{y}) \right)$$

$G_r = 0$ when $r = \bar{y}/\underline{y}$, and is increasing for higher values of r. Of 1,078 cities this condition held in all but 1. Heuristically, typical values of r are in the vicinity of 0.8 (local communities are more homogenous in income than the national population). The share of public education is typically over 85%. In a lognormal distribution with r = 0.8, the ratio of average income to income on the 85th percentile is 0.62, considerably less than 0.8.

- $$G_q = -f(x) \cdot \frac{t \cdot \bar{y}}{(2\ln(1/r))^{0.5} \cdot \underline{y} \cdot (1-t) \cdot q^2 \cdot g} - 1 < 0$$

- $$H_t = a\, y_d^{\,2} (d-1)[(1-t)\, y_d(r, q, \bar{y}) - c_0]^{d-2} + (d-1)(1-a)[\bar{y}/(qp)]^d t^{d-2}[1-h_{qt}]$$

In a CES utility function $d - 1 < 0$ is implied by decreasing marginal utility. Therefore, $H_t < 0$.

- $H_q = -a\ (dy_d/dq)[(1-t)\,y_d - c_0]^{\delta-2}\ (d\ (1-t)y_d - c_0) - d\ (1-a)(\bar{y}/p)^{\delta}\, t^{d-1} / q^{\delta+1}[1-h_{qt}]$
- $H_\rho = -a\ (dy_d/dr)[(1-t)\,y_d - c_0]^{d-2}\ (d\ (1-t)y_d - c_0)$

That is, H_r is positive when an EATM equilibrium holds ($d\ (1-t)y_d - c_0<0$), and is negative when an MI equilibrium holds ($d\ (1-t)y_d - c_0>0$).

- $H_{\bar{y}} = -a\ (dy_d/d\bar{y})[(1-t)\,y_d - c_0]^{d-2}\ (d\ (1-t)y_d - c_0) + d\ (1-a)(qp)^{-\delta}(t\,\bar{y})^{d-1}\ [1-h_{qt}]$

Lemma 1: $H_{\bar{y}}(c_0 = 0) = 0$

Proof: $H\ (c_0=0) = -a\ y_d\,[(1-t)\ y_d]^{d-1} + (1-a)\ \ [\bar{y}/(qp)]^{d}\ t^{d-1}\,[1-h_{qt}]$

$$= -a\ (1-t)^{\delta-1}\ y_d^{\,d} + \bar{y}^{\,\delta}/(qp)^{-d}\,t^{d-1}\,[1-h_{qt}] = 0$$

Rearranging terms, we obtain $a\ (1-t)^{\delta-1}\,y_d^{\,d} = (1-a)\ \bar{y}^{\,\delta}/(qp)^{-d}\,t^{d-1}\,[1-h_{qt}]$. Dividing both sides by $\bar{y}$ we obtain $a\ (1-t)^{\delta-1}\,(y_d/\bar{y})^{\delta} = (1-a)\,(qp)^{-d}\,t^{d-1}\,[1-h_{qt}]$.

But, $y_d = y_m = r\,\bar{y}$ under MI, and $y_d = r \cdot \bar{y} \cdot e^{\left[\Phi^{-1}(q-0.5)\cdot(2\cdot\ln(1/r)^{0.5}\right]}$ under EATM. That is, in both cases $y_d/\bar{y}$ is not a function of mean income. Therefore, the first order condition is not a function of mean income, and $H_{\bar{y}}(c_0 = 0) = 0$.

Lemma 2: $\partial H_{\bar{y}}/\partial c_0 > 0$

Proof:

$$H_{\bar{y}} = a\ (y_d/\bar{y})[(1-t)y_d - c_0]^{d-2}\ [c_0 - d\ (1-t)\,y_d] + (1-a)\,d\ [1/(qp)]^{d}\,t^{d-1}\,\bar{y}^{\,d-1}\ [1-h_{qt}]$$

Therefore, as $(1-t)\,y_d(1-d) + c_0 > 0$ under the condition specified in the text

$$\partial H_{\bar{y}}/\partial c_0 = a \cdot (y_d/\bar{y}) \cdot \left[(1-t)\,y_d - c_0\right]^{d-3}(1-d)\left[(1-t)\,y_d(1-d) + c_0\right] > 0$$

From lemma 1 and lemma 2 $H_{\bar{y}}(c_0 > 0) > 0$ and $H_{\bar{y}}(c_0 < 0) < 0$.

Under EATM:

- $dy_d/d\bar{y} = y_d/\bar{y}$
- $dy_d/dr = y_d/r\ [1 - \Phi^{-1}(q-0.5)/(2\ln(1/r))^{1/2}] > 0$
- $dy_d/dq = y_d(2\ln(1/r))^{1/2}/f(q-0.5) > 0$

Under MI: $dy_d/d\bar{y} = r$, $dy_d/dr = \bar{y}$, $dy_d/dq = 0$

Appendix F

The Marshallian demand curve is obtained in Appendix A and is given by $x = \dfrac{y - c_0}{p + \left(\dfrac{a \cdot p}{1-a}\right)^{\frac{1}{1-d}}}$. Differentiating it with respect to p we obtain:

$$\frac{dx}{dp} = -\frac{(y-c_0)\cdot\left[1 + \left(\dfrac{a\cdot}{1-a}\right)^{\frac{1}{1-d}}\cdot\left(\dfrac{1}{1-d}\right)\cdot p^{\frac{d}{1-d}}\right]}{\left[p + \left(\dfrac{a\cdot p}{1-a}\right)^{\frac{1}{1-d}}\right]^2}$$

The elasticity of demand is then

$$h_{x,p} = \frac{dx}{dp}\cdot\frac{p}{x} = -\frac{1 + \left(\dfrac{a\cdot}{1-a}\right)^{\frac{1}{1-d}}\cdot\left(\dfrac{1}{1-d}\right)\cdot p^{\frac{d}{1-d}}}{1 + \left(\dfrac{a\cdot}{1-a}\right)^{\frac{1}{1-d}}\cdot p^{\frac{d}{1-d}}} = -\frac{1 + 22.3p^{0.3}}{1 + 17.1\cdot p^{0.3}}$$

which for p = 1 equals -1.29.

Appendix G

The elasticity of public school expenditure with respect to the tax price is:

$$h_{t \cdot \bar{y}/q, rq} = h_{t,rq} - h_{q,rq} = 1/h_{rq,t} - 1/h_{rq,q}$$

$$= 1/(h_{r,t} + h_{q,t}) - 1/(h_{r,q} + 1) = 1/(1/h_{t,r} + h_{q,t}) - 1/(1/h_{q,r} + 1)$$

Then $\partial q/¶ r$ is available directly from the estimation, from which we calculate $h_{q,r}$ = 0.065; we obtain $\partial t/¶ r$ from the comparative statics on (6'') and (8'), as specified in (11) and (12), and convert it to an elasticity, which equals –0.029; and from equation (6''), $h_{q,t} = (-G_t / G_q) / (q/t)$ equals 0.265. Substitution in the above expression yields the value –0.09.

Appendix H

In order to find a 5% confidence range for the four parameters $(a, g, c_{0,} d)$ we first find a joint confidence range for the homogeneity effect b_r and the income effect $b_{mean} = b_{\bar{y}} + 2 \cdot 39.6 \cdot b_{\bar{y}^2}$ at the mean value of mean income $\bar{y} = 39.6$. In matrix notation this confidence range satisfies:

$$(\hat{b}_r - b_r, \hat{b}_{mean} - b_{mean}) \begin{bmatrix} \mathrm{var}(\hat{b}_r) & \mathrm{cov}(\hat{b}_r, \hat{b}_{mean}) \\ \mathrm{cov}(\hat{b}_r, \hat{b}_{mean}) & \mathrm{var}(\hat{b}_{mean}) \end{bmatrix}^{-1} \begin{pmatrix} \hat{b}_r - b_r \\ \hat{b}_{mean} - b_{mean} \end{pmatrix} \leq 2 \cdot F^{0.05}_{1078-18}$$

which implies

$$(\hat{b}_r - b_r, \hat{b}_{mean} - b_{mean})\begin{bmatrix} \mathrm{var}(\hat{b}_{mean}) & -\mathrm{cov}(\hat{b}_r, \hat{b}_{mean}) \\ -\mathrm{cov}(\hat{b}_r, \hat{b}_{mean}) & \mathrm{var}(\hat{b}_r) \end{bmatrix}\begin{pmatrix} \hat{b}_r - b_r \\ \hat{b}_{mean} - b_{mean} \end{pmatrix} \leq 6 \cdot D$$

where D is the determinant of the variance-covariance matrix.

For the OLS estimates we have:

$$\hat{b}_r = -0.072945, \qquad \hat{b}_{mean} = \hat{b}_{\bar{y}} + 79.2 \cdot \hat{b}_{\bar{y}^2} = 0.0563034, \qquad \mathrm{var}(\hat{b}_r) = 0.000657,$$

$$\mathrm{var}(\hat{b}_{mean}) = \mathrm{var}(\hat{b}_{\bar{y}}) + 158.4 \cdot \mathrm{cov}(\hat{b}_{\bar{y}}, \hat{b}_{\bar{y}^2}) + 6272.64 \cdot \mathrm{var}(\hat{b}_{\bar{y}^2}) = 0.0008085285$$

$$\mathrm{cov}(\hat{b}_r, \hat{b}_{mean}) = \mathrm{cov}(\hat{b}_{\bar{y}}, \hat{b}_r) + 79.2 \cdot \mathrm{cov}(\hat{b}_{\bar{y}^2}, \hat{b}_r) = -0.000156384$$

The confidence range for b_r and b_{mean} is then given by the ellipse:

$$266 \cdot (0.0729 + b_r)^2 - 102.9 \cdot (0.0563 - b_{mean})(0.0729 + b_r) + 216.1 \cdot (0.0563 - b_{mean})^2 = 1$$

We then calibrated the four parameters of the model at each of thirty equally distanced points on the perimeter of the ellipse. The range of values for each parameter obtained in this procedure is the range reported in the text.

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[1] Direct evidence on school vouchers is limited as prohibitive costs limit the scope for private experimentation while public experimentation has been politically controversial. See, e.g., Howell and Peterson [25] for a recent summary of experimental programs in the United States, West [49] on the limited international experience with vouchers, and Fiske and Ladd [16] for a detailed case study of the radical market-based reform of education in New Zealand. Rangazas [39] and Epple and Romano [12], among many others, evaluate school vouchers by reconstructing the utility function, as we do in this paper. Experience with state finance reform is more extensive, but despite the wide attention it has received, direct conclusions have been largely qualitative in nature (Murray et al. [34], Downes and Figlio [9]). Fernandez and Rogerson's [14] quantitative analysis of school funding reform in California, an exception, also calibrates the parameters of a utility function.

[2] Rangazas [39], Epple and Romano [12] and Glomm and Ravikumar [20] explicitly model individual utility in a political economy model of public and private education, but impose unitary income elasticity, and assume equal efficiency in private and public schools. Sonstelie [46] allows a non-unitary income elasticity and greater efficiency in private education, but without explicitly specifying a utility function.

[3] In 1993-4, expenditure per pupil in public elementary and secondary schools was $5,767, almost twice the average tuition in all private schools, $3,116, and more than twice the average in Catholic schools, $2,178, which account for half of private enrolment. The average base salary for public school teachers was $34,153 compared with $21,968 for private school teachers (National Center for Education Statistics [35]). Hoxby [24] found that, on average, 50% of costs in Catholic elementary schools are covered by donations from local households and dioceses, and implicitly by teachers who are members of a religious order and accept less than the going wage. However, this may be offset to some extent if parents are expected to supplement tuition by donating their time and money.

[4] See James [27], McCormick et al. [33], and West and Palsson [48], among others, for empirical evidence of the positive effect of local mean income on private enrolment. In Section 2 we show formally that unitary income elasticity implies that the private enrolment rate is income-neutral, and hence is not consistent with the evidence.

[5] Roughly 10% of elementary and high school children in the United States attend fee-paying private schools, with private enrolment rates ranging between 0.5% and 51.6% across cities.

[6] While school districts are the relevant geographic unit for analyzing communal decisions on public schooling, individual choice between private and public schooling reflects also the supply of private schooling in an urban area that generally transcends local school district boundaries. We use both types of data to test the robustness of our findings.

[7] These are all the cities that appear in the address of exactly one unified (i.e., elementary and high school) school district.

[8] Calculations based on the 3SLS calibration yield similar results to the basic calibration if the tax rate is held fixed. If the tax rate is allowed to vary, a smaller reduction in taxes is indicated, and a smaller increase in private enrolment, resulting in a very small rise in public spending, which implies a correspondingly small Pareto improvement.

[9] We assume the structure of the local community is fixed in the short run, but check the sensitivity of our results to Tiebout sorting in the empirical analysis. Integrating migration effects in the formal analysis, in the spirit of Epple and Sieg [10], is beyond the scope of this paper.

[10] We control for variation across communities in average family size in the empirical estimation. An extension of the present model could allow for variation in the number of children across households within a community, thus highlighting the effect on private school enrolment of the correlation between income and family size.

[11] The quantity of schooling is constant; private education replaces rather than supplements public

education.

[12] This is shown in Appendix A.

[13] Public schooling in the United States is largely financed by a combination of property taxes and state grants, with local taxes determined by referendum on proposals set by a school board (Romer et al., [40]). These factors are ignored in our analysis, which implicitly assumes that incomes are perfectly correlated with property values and education is entirely funded from local sources. We discuss these issues further with regard to the empirical estimation.

[14] This neglects the fixed costs of education, which especially limit quality choice in smaller communities. However, we do control for community size in the empirical estimation.

[15] There is an extensive empirical literature, and no little disagreement, on the effect of material resources—such as class size—on scholastic achievement and classroom behavior (Krueger [28], Card and Krueger [7], Hanushek [23], among many others). Clearly other factors are also at work, such as the incentive structure in the education system. However, for our purpose it is sufficient that parents perceive added resources to have a beneficial effect on school quality.

[16] $g_0 = (1-a)\cdot[(a/(1-a))^{\frac{1}{1-d}} \cdot (pg)^{\frac{d}{1-d}} + 1]^{1-d}(pg)^{-d}$

[17] This feature, common to all such models, does not agree with the empirical fact that there is some income heterogeneity among families that send their children to private schools within the same school district; it stems from our assumption that income fully determines school choice. Extending the model to accommodate variation in γ as well as in income, rectifies this.

[18] This is an extreme formulation that abstracts from the indirect effect of public schooling on crime rates, property values, etc. that provides higher income households with an incentive to support public education. For our purpose it is sufficient that households that would never send their own children to public education prefer education tax rates that are lower than the tax rate that is actually chosen.

[19] This is the equilibrium posited by Sonstelie [46], Rangazas [39], Epple and Romano [12], etc.

[20] See Epple and Romano [12] for details of the derivation. As they observe, this necessary condition is only sufficient for a local equilibrium, and a global equilibrium may not exist. However, institutional restrictions that set a minimal threshold for public spending per student may rule out rival equilibria.

[21] In this case existence is assured from the single-crossing property (Gans and Smart [18]). A third possibility is that $c_0 - d\,(1-t)\,y < 0$ is satisfied in one range of incomes and $c_0 - d\,(1-t)\,y > 0$ in another, in which case the political equilibrium may take other forms. Our empirical findings indicate that $c_0 - d\,(1-t)\,y > 0$ holds at all levels of income, and so we do not elaborate on this here. Details are available from the authors on request.

[22] If g is small enough then the equilibrium values of q and t are zero; we assume that this is not the case and the decisive voter always chooses a positive level of public education.

[23] Detailed derivations of the comparative statics described in this section are provided in Appendix E.

[24] This is done in Appendix E; H_q and H_z take into account the variation in y_d when q changes.

[25] There are over 15,000 school districts in the United States of which more than half have fewer than 1,000 students, and over 80% have fewer than 3,000, the average number of public school students in a town of 25,000 residents (School District Data Book on CD-ROM, National Center for Education Statistics).

[26] Detailed data definitions and sources are provided in the Data Appendix.

[27] The variables *% Catholic* and *salary* are identical for datasets B and C, and so do not appear in Table 3. We did not have an independent source of data for catholic affiliation by school districts.

[28] This may also be partly attributed to Tiebout effects that are more pronounced at the school district than at the municipal level. The slightly higher incomes, lower densities, smaller fraction of minorities and larger percentage of homeowners in the school districts in dataset C may attract a disproportionate share of households that opt for private schools. Modeling this effect explicitly is beyond the scope of the present analysis.

[29] As public enrolment only takes on values between zero and one, a limited-dependent-variable

specification is indicated, in principle. However, when we checked the fitted values of the dataset A regression we found they fell outside this range in only three of the 1,078 observations.

[30] Goldfeld and Quandt's heteroscedasticity test returned a significance level of 0.052 for dataset A.

[31] The elasticity of the private enrolment share with respect to density at the mean (dataset A) is 0.24; its elasticity with respect to population size is 0.03.

[32] To maintain comparability, all valuations are taken at the mean of dataset A.

[33] The signs are reversed because the model is defined in terms of public enrollment, q, while the empirical estimation explains private enrolment, $1 - q$. Income is measured in thousands of dollars; enrollment and the median to mean ratio in percentage points.

[34] For the decisive median income household, a private cost of $t\, y_m$ "buys" public school quality equal to $(t\,\bar{y}) / (q\ p\ m)$. The tax price of public school quality is then the ratio of cost to quality $r\ p\ q\ m$. Holding m and p fixed, we focus on variation in $r\ q$. The elasticity of public spending per student with respect to the tax price holding mean income fixed is then $h_{t,rq} - h_{q,rq} = -0.09$ (Appendix G). Intuitively, as the elasticity of substitution measures the elasticity of the ratio c/x with respect to their price ratio, and education accounts for only a small fraction of income, it closely approximates the price elasticity of demand. And the difference between the tax-price elasticity of public spending and the price elasticity of demand for quality is approximately one because spending is the product of quality and price.

[35] The other individual parameter values are: $a = 0.89$, $d = 0.25$ and $c_0 = -4{,}445$.

[36] The individual parameter values are: $a = 0.95$, $d = 0.02$ and $c_0 = -16{,}785$.

[37] There is wide variation in patterns of state funding and control across states, for which our variable *state-grant impact factor* is only a very imperfect proxy. At the suggestion of one of the referees, we also estimated the regression on dataset A omitting all observations from California, where public spending per pupil is largely determined by the state. This had little impact on the effect of mean income or the median-to-mean ratio, though other coefficients were affected.

[38] MI held for all positive income levels at twenty-six of thirty points on the perimeter of the 95% confidence ellipse, and at the remaining four points held for incomes above $3,600.

[39] Nechyba [37] computes calibrated, general-equilibrium simulations of school choice and mobility between school districts, which indicate that "Private schools tend to form in low-income districts in part to serve middle- to high-income immigrants…"

[40] Schmidt [44] simultaneously estimated private schooling and income distribution equations, but did not control for private education in the income distribution equation. We expect private enrolment to have a negative effect on the median-to-mean ratio. The variables included in its equation are based on the previous studies of Levernier et al. [30], Bishop et al. [2] and Braun [5].

[41] The values obtained were $c_0 = -824$, $d = 0.17$, $a = 0.90$ and $\gamma = 0.74$, consistent with an MI equilibrium. Solving under EATM produced values of c_0 and d that were not consistent with EATM.

[42] Lower estimates of the income elasticity that they cite are in the vicinity of one half.

[43] Attempts to estimate directly the price elasticity of demand for private education from micro-data, by regressing individual schooling decisions on private tuition levels, are difficult to interpret because they implicitly assume that education quality is independent of tuition. Long and Toma [32] and Buddin et al. [6] failed to identify a significant price effect (e.g.,), while Lankford and Wyckoff [29] found large, significant elasticities: –0.92 for elementary education and –3.67 for secondary education.

[44] A series of careful studies by Bergstrom, et al. [1], Rubinfeld, et al. [39] and Rubinfeld and Shapiro [40] used qualitative survey responses directly to determine the effect of individual income on the desired level of public spending. The net effects they found were small in magnitude and statistically insignificant, while varying in sign. Bergstrom et al. [1,"model 4"] found an elasticity of –0.05; Rubinfeld et al. [41], controlling for Tiebout sorting, found an elasticity of –0.01; and Rubinfeld and Shapiro [42, "model B"] found an elasticity of 0.011. In all cases, the size of the net effect was less than one standard deviation of both the income and price coefficients.

[45] Private school teachers' average base salary was 64% that of public school teachers in 1993/4 (see

note 3, above). The perceived advantage our analysis attributes to private schools is considerably smaller than Sonstelie's [46] corresponding value of 0.37. (However, Sonstelie notes the extreme sensitivity of the value he derives to small changes in the coefficient estimates.)

[46] These simulations are only indicative; the institutional detail they omit may have a large effect on costs, savings and enrolment; and the added costs of the program are likely to materialize more quickly than the savings. Moreover, if ? reflects the charitable support of parishes and the reduced salaries of teachers in religious orders, and these cannot keep pace with a large expansion of private enrolment, then the relevant cost differential between private and public schooling will be smaller than its calibrated value. Finally, we ignore constitutional constraints on using taxes to support religious schools, and while these have been loosened by the Supreme Court's recent decision in *Zelman et al. v. Simmons-Harris et al.* [51] it remains to be seen how much they have been loosened.

[47] This illustrative calculation clearly ignores other important aspects of education vouchers, such as the effect of increased competition on education efficiency; restrictions on the use of vouchers in parochial schools, the differential effect of changes in public school peer-group quality on students of different abilities (Epple and Romano [12]); and the effect a broad-based voucher scheme would have on household location choice (Nechyba [37]).

[48] The threshold value, $1 - q^*$, is calculated from $t\bar{y}/q_0 < [t\bar{y} - (1-q^*)s]/q^*$, where q_0 = 89.5% and $s/[t\bar{y}/q_0] = 20\%$. Hoyt and Lee [25, p. 224] calculate a related threshold, concluding that, "in the U.S. a decrease in public enrolments exceeding only 2.3% would reduce taxes," holding school quality fixed.

[49] Rangazas' [39] conclusion of larger increases in public spending per student is based on the assumption of an EATM political equilibrium and on previous estimates of the tuition price elasticity of private education discussed above.

[50] They assume unitary income elasticity, an elasticity of substitution of –0.65, and no difference in efficiency between public and private schooling (in our notation, $c_0 = 0$, $d = -0.54$, $g = 1$ and $a = 0.98$) and examine the impact of a 24% voucher.

[51] This assumes that the threshold income $\underline{y}$ between public and private schooling is in the range in which the income density function f is decreasing (this is always satisfied empirically). Then introduction of vouchers, by lowering q, increases the density of the distribution at the threshold income, $f(\underline{y})$, so that the direct impact on public school quality of a change in the tax rate is offset by the stronger countervailing change in public enrolment.

[52] This accounts for 90% of the population. For households with very low incomes the fall in spending per student outweighs the benefit of the tax cut.