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FOREWORD

The issue of school choice has spurred heated debate in the policy arena over the last few years. While there has been a wide variety of literature discussing particular choice plans and the implications of such plans, less literature has been devoted to the development of a full model of school choice. In this paper, we derive an integrated model of the demand for and supply of public, private, and home school education. An empirical model of the simultaneous determination of the demand for types of education and supply of those types of education is also developed. Finally, a unique data set on school choice in Tennessee is used to estimate own and cross price elasticities of demand for types of schooling. These results are used to simulate the effects of a school voucher program. The simulation results show that a hypothetical $500 voucher program would led to a decrease in public school enrollment by 6 percent and decrease public school expenditures by 4.8 percent.
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THEORETICAL AND EMPIRICAL DIMENSIONS OF SCHOOL CHOICE

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I. INTRODUCTION

As voters, individuals participate in the decision of how much of a government-provided good should be produced, but as private citizens they may choose to supplement or replace it with privately-provided goods. The individual’s decision to supplement or substitute for the government-provided good is influenced by his/her demand relative to that of the decisive voter (who determines public sector output), the perceived quality of public sector output, and the prices of relevant substitutes and complements. Examples of such behavior include the demand for safety (public police versus private security systems), trash collection (public versus private collection), health care (public clinics versus private hospitals), welfare (public support versus voluntary contributions) and education. The substitution between private and public education is the subject of this paper.

The demand for education is not so simple a matter as choosing whether to send a child to public school or to the local private school. First, individuals and families are empowered to set some standards for their public schools through the voting process. At the same time, families face the choice of where to send their children: public schools inside or outside their district, religious or non-religious private schools, or home schools. These decisions -- voting and choosing the type of education -- are integrally linked.

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To date, however, we have yet to formulate and estimate a model of school choice that includes the collective determination of public school output and the individual choice over key education substitutes: public schools in the district, public schools outside of the district, home schools, and religious and non-religious private schools. Without such a model we cannot measure the effects of such policies as school vouchers on the demand for types of education, nor the effect of the quality of public and private schools on the demand for those types of education.

In this paper, we derive an integrated theoretical model of the demand for the supply of public, private, and home school education. We begin with a theoretical model of a household that maximizes its utility over the consumption of types of education, other government-provided goods and privately-provided goods. An empirical model is then developed that captures the simultaneous determination of the demand for types of education and the supply of those forms of education. Finally, the model is tested with unique data on the demand for the five schooling alternatives controlling for the endogeneity of school prices. The results of our theoretical and empirical models show that school choice is a complicated web involving simultaneous community and individual optimization. The own and cross price elasticities of school substitutes are important determinants of both school choice and public school expenditures. Applying our results to the hypothetical introduction of a $500 voucher for private schooling, we find that public school enrollment would decline by 6 percent and expenditures on public schooling would decline by 4.8 percent. Our results also suggest that programs targeted at increasing private school quality will significantly reduce public school expenditures and enrollment.
The paper proceeds as follows. In the next section, we summarize relevant literature on school choice. In the second section, we develop a complete model of the demand for and supply of education, given the full set of schooling choices. The third section of the paper develops an empirical model of school choice and discusses the data used in the estimation. The empirical results and their implications for future education policy are discussed in the final section.

II. BACKGROUND

The current literature on education choice has not modelled the full set of school choice options, with or without the important simultaneous determination of public school output and schooling prices. On the public school side of the education market, the literature has drawn on the pathbreaking work of Thomas Bordcherding and Robert Deacon (1972) and Theodore Bergstrom and Robert Goodman (1973) who sought to test the applicability of the median voter model to the demand for government-provided goods. Subsequent literature on public schooling has concentrated on the empirical determinants of public school expenditures and public school enrollment. Alan Gustman and George Pidot (G-P, 1973) and Donald Baum (1986) took some of the early steps in estimating simultaneous models of the determinants of public school expenditures and the demand for public schools (measured by enrollment or test scores). In both cases, the price of public schooling (the tax price) was found to be a positive and significant determinant of public school expenditures. G-P also found that expenditures were a significant
determinant of public school enrollment. In both cases, schooling substitutes were largely ignored.\(^1\)

While substitution among the wide variety of school choice options has not received much attention in the literature, some have recognized the substitution effects between public and private schools. Robert Inman (1978b) presented a comprehensive conceptual framework of public and private schooling, but did not consider all education alternatives, nor estimate the demand for private education directly. Helen Ladd (1975) used the percent of private school children as a control in her estimation of public school expenditures and Jon Sonstelie (1979) used the percent Catholic as a taste control for private schooling in his estimation of public school enrollment. Ladd found that the percent of children in private school had no significant effect on public school expenditures and Sonstelie found that the percent Catholic had a negative effect on public school enrollment. On the flip side of the coin, Jorge Martinez-Vasquez and Bruce Seaman (1985) examined the effect of public school choice options (measured as the number of public schools in an SMSA), public school expenditures and prices of private schools on private school enrollment. They found that the number of public schools had a significant negative effect on private school enrollment, that public school expenditures did not significantly affect private school enrollment, and that the own-price elasticity of private schools was significant only for elementary enrollment. Finally, Homer Erekson (1982) examined linkages

\(^1\)Donald Baum's (1986) conceptual approach included a specific model of the demand for education (measured as test scores) and the supply of public education (measured in terms of labor costs). His model showed the importance of the simultaneity of the supply and demand for public education and his empirical results showed that previous reduced form models of the demand for public schools produced biased parameter estimates.
between private school enrollments and public school spending and found nonparochial school enrollments to be sensitive to public school expenditures.

Yet another strand of the literature has concentrated solely on the determinants of private school enrollment. Donald Jud (1983), Edwin West and Halldor Palsson (1988), Donald Frey (1983), Youn Kim (1988), and James Long and Eugenia Toma (L-T, 1988) all estimate the demand for private schooling as a function of tuition prices. These papers found own-price elasticities ranging from greater than zero (L-T) to -3.0, but were not able to determine the effect of the price of substitutes on the demand for private schools.

While we have come a long way in understanding the determinants of public school enrollment and expenditures, and private school enrollment, we have yet to examine the effects of the full set of school choices on public school expenditures and on enrollment in each type of schooling in the simultaneous framework. As a result, the income and price effects found in other studies may be misleading, as they suffer from omitted variables bias (prices of substitutes) and specification bias (endogeneity of prices and demands for various schooling types). We seek to fill these gaps in the literature by specifying and testing a complete model of education choice.

III. CONCEPTUAL FRAMEWORK

Our formulation of the demand side of the education market is intended to be sufficiently general to capture the collective (or median voter) demand for public schooling and individual demands for schooling alternatives. We begin with households that must choose how to allocate family resources across private good consumption, public good consumption and the consumption of education. The family utility function is of the form

\[ U = u(X, G, E_1, \ldots, E_k), \quad k = 1, \ldots, K, \]  

(1)
where $X$ is a composite private commodity, $G$ is a composite commodity representing the output of government provided noneducation services (per capita) and $E_k$ are units of education output (per child) provided through public schooling ($E_i$) and private schooling ($E_{k}, k \neq 1$). Using the terminology of Bradford, Malts and Oates (1969), the $G$ and $E_k$ are "C-outputs," or measures of service outcomes that directly enter the utility function; intermediate services (or "D-outputs"), such as an hour of classroom instruction, must be combined with environmental factors to determine actual service outcomes. This specification of $U$ allows the $E$ to be either substitutes or complements for one another.\(^2\)

The consumer/taxpayer allocates fixed income $Y$ and lump sum aid from higher levels of government $L$ (expressed in per capita terms) across consumption consistent with the budget constraint:

$$Y + L = X + \tau_c G + \tau_E E_i + \sum_{k \neq 1} P_k E_k.$$  \hspace{2cm} (2)

It is assumed for convenience that $P_1 = 1$. Implicit in this specification is a public sector balanced budget requirement. The tax prices $\tau_c$ and $\tau_E$ will in practice reflect different tax mechanisms. The term $\tau_E$ can be written as:

$$\tau_E = (1 - t_f) (1 - t_m) (V_i / V) C_1(E_i) \cdot n_i,$$  \hspace{2cm} (3)

where $t_f$ is the federal personal income tax rate included to accommodate deductibility; $t_m$ is the government matching rate for education expenditure; $(V_i / V)$ is individual $i$’s share of the tax

\(^2\)We assume that the households are single-child units. Additional children could be accommodated through sub-arguments of $E_k$. In this specification, we do not allow for mobility across jurisdictional lines.
used to finance education\(^3\); \(C_i(E_j)\) is the marginal resource cost of producing an incremental unit of educational output per student, which is not constant; and \(n_i\) is the number of public school students. Note that \(\tau_e\) includes two components, each individual’s share of financing costs or 

\[
(1 - t_p)(1 - t_m) \left( \frac{V_i}{V} \right) + \text{total resource costs per unit of } E_j, \text{ or } (C_i(E_i) \cdot n_i), \text{ and reflects the price of final output (or } E_j) \text{ not simply intermediate instructional services. The term } \tau_e \text{ is a composite price encompassing the set of other local revenue sources used to finance non-education services and can be written as:}
\]

\[
\tau_G = C(G) \cdot n \left[ (1 - t_p) \left( \frac{D_i}{D} \right) \left( \frac{S_i}{S} \right) \right],
\]

(4)

where all variables are as explained above and \((D_i/D)\) and \((S_i/S)\) are individual \(i\)'s share of deductible and non-deductible taxes, \(C(G)\) is the marginal resource cost of producing an additional unit of \(G\) per person, and \(n\) is the total number of people.

Optimization of (1) subject to (2) is assumed to yield constant elasticity demand functions for all arguments of the utility function for each individual.\(^4\) From these individual demands we generate the community demand for public school output \(E_i^m\) (reflecting the behavior of the median voter), and five market demands for alternative educational outputs \(E_k\) (reflecting the behavior of all consumers).

The voting process at the level of the public school district captures the collective demand for public school output. This demand can be shown, under certain conditions, to correspond to

\(^3\)In the case of the property tax, \(V_i/V\) would be the individual’s share of total assessed property in the jurisdiction; in the case of the sales tax, it would represent the individual’s share of taxable consumption, and in the case of the income tax, it would represent the individual’s share of taxable income (controlling for progressivity).

\(^4\)The constant elasticity formation is consistent with others, including Borcherding and Deacon (1972) and Robert Inman (1978b).
the preferences of the median voter. But simultaneous with this political decision is the individual household decision of which type of schooling to consume. If we assume for convenience that the public school district represents the market area for education alternatives, we can aggregate individual demands to the level of the market. Therefore, there is one median voter demand equation, which determines the level of public education output, and \( k \) household demand equations corresponding to individual market demands for all education alternatives. These equations can be written as:

\[
E_1^m = A Y^e L^\gamma t_{E}^{a_0} t_{E}^{n_1} (E_1, n_1) \prod_{k \neq 1} P_{E_k}^{a_0} (E_k, n_k) \prod_{i} T_i^{a_i}, \quad (5)
\]

\[
E_1^m = A Y^e L^\gamma t_{E}^{a_0} t_{E}^{n_1} (E_1, n_1) \prod_{k \neq 1} P_{E_k}^{a_0} (E_k, n_k) \prod_{i} T_i^{a_i}, \quad k = 1, \ldots, K. \quad (6)
\]

Equation (5) refers to the median voter demand for public school output so that the right-hand side variables correspond to the median voter, and in equation (6), the same variables correspond to individual households. The median voter sets the level of public school output and the individual households' school choice decisions are derived simultaneously with the median voter's decision. The terms \( t_{E} (E_1, n_1) \) and \( P_{E_k} (E_k, n_k) \) reflect the endogeneity of the public school output price and private school prices (or marginal costs) with respect to the level of output and the number of students. The \( T_i \) capture tastes for education output.

\[\text{---}
\]

\(^5\text{See Robert Inman (1978b).}\)

\(^6\text{While the median voter sets the level of public school output, individual households may consume public school, or some other type of school. If the level of public school output is less than that demanded by a particular household at the given price, they will consume another type of schooling. Robert Inman (1978b) discusses this concept in reference to the public/private decision.}\)
Note that the demand for education is influenced by the own price $τ_E$, as well as by the cross prices of other public services $τ_C$ and the prices of education alternatives $P_K$. An important implication of this specification is that it provides two routes to influencing education output and consumption: changes in tax structure and changes in the price of alternative schooling types.

On the supply side of the education market producers are assumed to behave as competitive firms, choosing that level of output where price equals marginal cost. For the public sector, where there is monopoly in the provision of $E_j$, this assumption rules out supply-side rent seeking and agenda setting, and (combined with a balanced budget requirement) implies that producers seek to maximize consumer surplus of the median voter. Suppliers of education are assumed to use a common technology to produce instructional services, but may provide different levels of final education output due to the influences of crowding, environmental factors and product demand.\(^7\) The technology of service provision is captured by the well-behaved firm-level cost function:

$$C = h \left( S, r, w \right).$$

(7)

where $C$ are total costs, $S$ are instructional services (or intermediate $D$-outputs, such as an hour of classroom instruction), and $r$ and $w$ are exogenous factor prices (for labor and all other inputs). Instructional services per student $s$ are in turn captured by the traditional congestion function

$$s = Sn^\theta \left( 0 \leq \theta \leq 1 \right),$$

(8)

with $\theta$ reflecting the degree of publicness. Environmental factors, such as community and school characteristics, may add to or detract from the learning process. The output function that maps

\(^7\)For a similar application, see Donald Baum (1987). For a more general review of schooling production, see Eric Hanushek (1986). Note also that the public sector may face union pressures that influence the production technology, but that is not treated here.
per student instructional services \( s \) and environmental factors \( m \) into units per student education output \( E \) is:

\[
E = e(s, m). \tag{9}
\]

While the functional form of (8) is assumed to be the same for all producers, differences in \( m \) and \( s \) yield different levels of \( E \).

Substituting the congestion function (7) into the output function (8), solving for

\[
S = e^{-1}(E, n^0, m),
\]

and substituting this result into the cost function (6) produces the following marginal costs schedule for output \( E \), expressed in per student terms as \( c/n = h(*)/n \):

\[
C' = g(E, n^0, m, r, w). \tag{10}
\]

Market supply relationships for the \( k \)th form of education output are derived by aggregating firm (school)-level marginal cost functions for all firms producing \( E_k \). We denote these aggregate or market supply expressions as:

\[
C_k = f(E_k, n^0, m, r, w) \quad k = 1, \ldots, K, \tag{11}
\]

where \( C_k \) is the supply side counterpart to \( P_k \), with one supply equation for each type of education. Equation (11), the median voter equation (5) and the market demand equation (6) constitute a complete model of the supply of a demand for education, and allow for simultaneous determination of public and private school outputs, costs and enrollments.

IV. EMPIRICAL FRAMEWORK

In this section we develop the empirical counterpart to the conceptual model presented above. We estimate a system of eight equations: a median voter demand for public school output \( E_I \) based on equation (5); five market demands for education substitutes \( E_k \) -- public, public transfer, private religious, private secular and home schooling based on equation (6); and
market supply schedules for religious and nonreligious schooling, based on equation (11).\footnote{The supply schedule for home schooling would require demographic and socio-economic information on individuals that is not available here. We instead use the prevailing wage as the price of home schools and assume that it is exogenous. As noted in the text, the transfer price is treated as exogenous.}

Public school output (determined by the median voter), schooling prices (as discussed below) and individual household demands for various types of schools (based on individual characteristics, prices, and school characteristics) are all treated as endogenous. The empirical model is based on the theoretical model above, with school districts in Tennessee as the unit of analysis.

The demand equations (in log form) are:

$$\ln \text{PUBOUT} = \beta_0 + \beta_1 \ln \text{TAXPRI} + \beta_2 \ln P_T + \beta_3 \ln \hat{P}_R + \beta_4 \ln \hat{P}_N$$
$$+ \beta_5 \ln MEDINC + \beta_6 \ln STAID + \beta_7 \ln FED AID$$
$$+ \beta_8 \ln PCTMA + \beta_9 \ln PROBKIDS + \beta_{10} \ln RELOUT$$
$$+ \beta_{11} \ln NRELOUT + \beta_{12} \ln NONWHT + \beta_{13} SSD + \beta_{14} RENT$$
$$+ \beta_{15} \ln POPKIDS + \beta_{16} \ln \hat{P}^{\text{PUBKIDS}} + \epsilon$$

(12)

$$\ln \text{ENROLL}_j = \Gamma_{j0} + \Gamma_{j1} \ln \hat{P}_R + \Gamma_{j2} \ln \hat{P}_N + \Gamma_{j3} \ln P_T + \Gamma_{j4} \ln \text{INCOME}$$
$$+ \Gamma_{j5} \ln \hat{P}^{\text{PUBOUT}} + \Gamma_{j6} \ln RELOUT + \Gamma_{j7} \ln NRELOUT$$
$$+ \Gamma_{j8} \ln PROBKIDS + \Gamma_{j9} \ln EDADULT + \Gamma_{j10} \text{CITY}$$
$$+ \Gamma_{j11} \ln NONWMT + \Gamma_{j12} \ln POPKIDS + \mu_j$$

(13-17)

where $\text{ENROLL}_j = \text{PUBKIDS, TRANSKIDS, RELKIDS, NRELKIDS, and HOMEKIDS.}$

Equation (12) represents the median voter’s demand for public education, while equations (13-17) refer to choices of individual households over public (PUBKIDS), public transfer (TRANSKIDS), private religious (RELKIDS), private secular (NRELKIDS) and home (HOMEKIDS) schooling.
The dependent variables in equations (13) are aggregate enrollments in each type of schooling by school district. All right-hand side variables in these equations are specified as the averages for the school district.

Data considerations strongly influence the specification of the demand equations. For equation (12), we test a number of measures of schooling output, including level performance indicators (i.e., standardized test scores), gain performance indicators (intended to measure the average increment in student learning, by grade, from one year to the next) and expenditures per student.\textsuperscript{9} Implications of using alternative output measures are discussed below. The remaining right hand side variables for equation (12) are discussed below.

The specification of the own price of public school output $t_e$ is based on equation (3). The first component of the public school price, the median voter's cost share TAXPRI, is defined as an index of median home value to total assessed property in the jurisdiction.\textsuperscript{10} The second component of the price includes marginal resource costs and the number of students in public schools. We include a proxy variable for marginal resource costs -- the percent of instructional staff with a masters degree (PCTMA) -- to reflect variation in input costs. Environmental effects are measured by the number of public school students suspended or expelled, PROBKIDS. Finally, to complete the public school price, we include the (endogenous) number of public

\footnotesize
\textsuperscript{9}Gain indicators are preferred to level indicators (such as standardized test scores) since the latter reflect all prior learning. Value-added or total school performance indicators would be superior measures for our application but are not available. For background on educational performance indicators, see Robert Meyer (1993).

\textsuperscript{10}This component is typically referred to as the tax share. The denominator of the index includes commercial and industrial property, which reflects the lower tax price associated with exporting opportunities. Matching aid is inconsequential and is ignored. We could not obtain data to estimate the effects of federal deductibility.
school students PUBKIDS. These various components of the price of public schooling are entered as separate regressors in order to identify their independent effects.

The prices of non-religious, religious and transfer schooling are included in equation (12).\textsuperscript{11} Since we do not have data on per unit prices of these alternatives, we use the tuition prices of these schools and control for amount of education through a quality control as explained in the following paragraph. The tuition prices of private religious schools $P_R$ and private secular schools $P_N$ in the public school district are the average prices of the schools and are treated as endogenous.\textsuperscript{12} The last price term is the average tuition charged by adjacent public school districts that accept out-of-district transfer students $P_T$. We treat $P_T$ as exogenous since it is set independent of enrollment and varies little over time. In general we expected higher prices for substitutes to public schooling to increase public school output since the likelihood of the median voter consuming public schooling increased.

We obtained data on the college accreditation level of private secular schools and private religious schools in an effort to control for quality. By school district, we calculated the average accreditation level of private schools in the district, so that an average accreditation level of .5

\textsuperscript{11}We omit the cross price of other public services $t_C$ for two reasons. First, the tax share component of $t_C$ is roughly proportional to the inverse of the number of households (taxpayers), and is therefore highly collinear with other variables in the model. Second, there is simply no good mechanism for capturing and empirically identifying the marginal cost of output provision across the set of noneducation public services. We also omit the price of home schooling since there is no direct measure of cost, and proxies (such as the average wage in the community) are highly collinear with the income variables on our empirical model.

\textsuperscript{12}The private school pricing equations explain variations in average tuition and fees as a function of enrollments; the schools’ accredited by the Southern Association of Colleges and Schools; the number of specialized and extracurricular activities offered by private schools; and religious affiliation, educational attainment and poverty status of the population. These estimation results are available from the authors on request.
versus .2 means that on average the private schools in the first district are more highly accredited than those in the second district. In our model, this accreditation measure reflects school quality for nonreligious (NRELOUT) and religious (RELOUT) private schools.

Median voter income is measured by median family income MEDINC in each public school district. Per capita measures of state aid STAID and federal aid FEDAID are included as separate regressors. Higher incomes (and levels of intergovernmental aid) are expected to lead to higher levels of school output. The population of school-aged children POPKIDS is intended to control for scale effects. Finally, we include three taste controls, or "shift parameters," in the model: the percent of the population that is nonwhite NONWHT, the percent of the population that rents a home RENT and a dummy variable to reflect the presence of "special school districts" SSD.13

Equations (13-17) are the empirical market demand equation for each public school district in Tennessee.14 Since we do not observe individual demands directly for the various

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13Tennessee’s special school districts (SSDs) represent a unique political structure vis a vis the more numerous city and county systems. The SSDs, of which there are currently 14, were created by the state legislature at the request of residents concerned with school funding and school quality. (The creation of new SSDs is no longer allowed.) Popularly elected school boards, analogous to those for city and county systems, establish school budgets and propose school-related property tax rates. Final approval of tax rates rests with the state legislature, although this has always been a mere formality.

14While our data allow identification of the location of schooling consumption, it is impossible to identify the community of residence for private school students and public school transfer students. One implication is that we cannot specify the dependent variable as a share since the denominator is ill defined. A second implication is that one might expect the range of choice set characteristics, including both in-district and out-of-district schools, to influence choice. We follow the typical treatment of this problem as it arises elsewhere in the literature (for example, migration and business location) by including only in-district characteristics in each demand equation. (An exception is the tuition charged by adjacent public school systems.) As we note below, we have experimented with extended specifications of the model and find that
schooling choices, we rely on revealed preferences for schooling services, as reflected by enrollments in each type of schooling, to specify the dependent variables. All (except dichotomous) variables are entered in log form. In equations (13-17), we include the (endogenous) religious and non-religious school prices and the (exogenous) transfer price $P_T$.\textsuperscript{15}

Equations (13-17) contain the endogenous public school output variable PUBOUT, as determined within the system by the median voter.\textsuperscript{16} We also include the number of problem children PROBKIDS to reflect the quality of the school environment, and the output measures RELOUT and NRELOUT\textsuperscript{17} Additional controls include per capita personal income INCOME, a dummy variable for city school districts CITY, the percent of the population that is nonwhite NONWHT and the percent of the population with less than a ninth grade education EDADULT.\textsuperscript{18} The population of school-aged children POPKIDS is included as a scale control.

\textsuperscript{15}We treat the price of public school output $t_e$ as a pure income effect in the demands for schooling alternatives, since taxes are paid regardless of one's consumption choice.

\textsuperscript{16}Recall equation (5) for public schools, which shows that the median voter’s demand for public school output is a function of the number of children in public schools, while the individual household demand for public school is also a function of the amount of $E_i$.

\textsuperscript{17}The average number of extracurricular and special activities for religious and nonreligious schools was also included to control for quality but had no appreciable influence on the results.

\textsuperscript{18}Caution must be exercised in interpreting the results for various taste variables as responses may reflect person or place characteristics. For example, a higher share of the population with less than a ninth grade education might be positively correlated with private schools enrollment. Interpreted as a person characteristic, this relationship would suggest that those with less education have a greater propensity to consume private school output. Interpreted as a place characteristic, this same relationship implies that consumers may seek to avoid contact with children in the public schools who have parents with low levels of educational attainment.
The estimation relies on school-district level data for the state of Tennessee for academic year 1990/91. Data on public schools and their enrollments were drawn from the *Annual Statistical Report of the Department of Education* and through direct correspondence with the State Department of Education and State Board of Education. Home schooling enrollments by school district were also provided by the State. Data on public school transfer students and the tuition charged by receiving school districts were obtained through a telephone survey of all school systems in the state.

A master listing of nearly 500 private schools (including enrollments and accreditation status of all schools) was obtained from the Department of Education. We surveyed, by mail, all 500 private schools.\(^{19}\) The survey requested information on tuition and fee charges, staffing and salaries, activities and special programs offered, and so on. A total of 175 complete surveys were received, and were complemented by extensive telephone follow-ups and the use of third-party information (including private school directories). In all, we obtained complete information on over 60 percent of the schools.

Finally, we use Census data and data acquired from miscellaneous sources to specify our remaining variables. Variable names, definitions and descriptive statistics for all data are reported in Table 1. Note that our database includes 116 school districts.\(^{20}\)

\(^{19}\)The survey instrument and a brief discussion of findings are available from the authors on request.

\(^{20}\)There are a total of 138 schools districts in the state, including 93 county systems, 31 city systems and 14 special school districts. Several SSDs were omitted from the analysis due to overlapping boundaries that preclude proper variable specification.
V. ESTIMATION RESULTS

Our goal in this paper is to fully specify the education choice decision and determine the importance of substitutes for public education. In the case of education, we hypothesized that the characteristics of private alternatives -- both prices and measures of quality -- influence the median voter's demand for public school output and individuals' demands for types of education. We used 3SLS in the estimation of the system of equations, due to endogeneity and the correlation of error terms across equations. The estimation results, reported in Tables 2 and 3, provide very strong support for these hypothesized relationships. We find that both prices and measures of output for different schooling types are in fact important determinants of public school output, and public, private and home school enrollments.

The median voter results are reported in Table 2. The output measure is expenditures per student. In addition to a negative own-price effect (TAXPRI) in each of the equations, we find that higher private school prices \( P_R \) and \( P_N \) lead the median voter to demand higher levels of public school output. This result is consistent with the fundamental notion that as the price of a private substitute increases (quality held constant), the demand for the public output increases. At the same time, the cross-price elasticities of religious and non-religious schools are

---

21 We have tested versions of the empirical model for both collinearity and heteroskedasticity and find no evidence of problems.

22 Specifications of the output equation using test scores and gain indicators produced highly unstable results; these results are available on request. We attribute the weak results to the inherently multidimensional nature of schooling output and our inability to isolate all factors influencing levels of attainment.

23 We have estimated a traditional median voter equation that omits cross prices of private alternatives and private school quality controls. The estimated price (income) elasticity is higher (lower) than that reported in Table 2.
smaller than the own-price elasticity, .087 and .088 respectively, showing that these forms of schooling are substitutes for public schooling in the eyes of the median voter. Transfer prices do not affect demand, perhaps because of underlying transportation costs or weak linages between transfer tuition charges and school output, or because the median voter perceives adjacent public school systems to be too similar to the resident district to justify additional out-of-pocket expenditures.\textsuperscript{24}

The effect of the private school output variables RELOUT and NRELOUT on the median voter’s choice of public school output demonstrates the critical role of both prices and quality. Holding prices constant, the results show that higher private school output leads the median voter to demand less public school output. Note that this result is counter to the claims of many that greater competition between the public and private sectors will increase public sector output. Because of the importance of this result and its implications, we return to this point in the discussion below.

Prices and outputs for educational alternatives also play a pivotal role in the choice of schooling mode, as demonstrated by the enrollment equation results of Table 3. In a simultaneous system such as that developed here, the own and cross prices of education influence education demand in two ways. First, if education is a normal good, the demand for a particular type of schooling will be negatively affected by its own price, as is the case for public school output and TAXPRI. But through the system there is a second effect attributable to the

\textsuperscript{24}We have tested numerous alternative specifications of the transfer prices, including the highest (adjacent) district price, the lowest price, price differentials between districts and prices adjusted for distance. We have also incorporated additional adjacent district characteristics including sociodemographic factors and measures of public school output. In general none of these alternatives provided substantive explanatory power.
dependence and public school output on prices. As prices change, the output of the public schools is altered, and since enrollments depend on output, enrollments may change as well. Combining these two effects:

\[
\frac{\partial \text{PUBKIDS}}{\partial P_i} = \frac{\partial \text{PUBKIDS}}{\partial P_i} + \frac{\partial \text{PUBKIDS}}{\partial \text{PUBOUT}} \cdot \frac{\partial \text{PUBOUT}}{\partial P_i}
\]

The first term on the right hand side is the direct price effect (i.e., the coefficient of \(P_i\) in the enrollment equation) and the second term is the indirect effect through the median voter equation. It turns out that the indirect effect through the reaction of enrollments to the level of public school output is very important. As seen in the first column of results in Table 3, individual demand for public schooling is not directly affected by the prices of private substitutes (i.e., the \(\Gamma_{P_i}\) are insignificant) but is indirectly influenced due to the effect of private school prices on public school output. Hence, higher private school prices (both religious and nonreligious) encourage more public school spending, which at the same time leads to higher public school enrollment. Higher religious private school prices also discourage religious school enrollment (with an own-price elasticity of -.90) and encourage non-religious private school enrollment (with a cross-price elasticity of 1.31).

As seen in Table 3, the results for private religious and private nonreligious schools suggest rather strong substitution responses across these types of education. In addition to a significant own-price effect on religious school enrollments, there is an elastic cross-price effect with respect to nonreligious private school prices \(P_N\) and an elastic "cross-output" effect with respect to nonreligious private school output NRELOUT. Somewhat surprisingly, these results are not symmetric in terms of the nonreligious school equation. One plausible explanation is that
those seeking more elitist nonreligious private school alternatives are more likely to choose out-of-district (including out-of-state) alternatives not captured by our data.

Prices and outputs play a much smaller role for transfer and home school students.\textsuperscript{25} There is evidence, however, that transfers are sensitive to both public school environment (PROBKIDS) and the community environment (EDADULT), with more problem children and a less educated populace leading to increased transfers out of the resident public school district.\textsuperscript{26} The importance of public school and community environment, and the lack of importance of private school alternatives, provides indirect evidence that transfers come directly from the public schools rather than private schools. The weak results for the home school equation likely reflect the many diverse motivations that underlay this mode of substitution. In

\textsuperscript{25}An additional substitution response might be to simply drop out of school. While we would not expect this alternative to be as sensitive to prices and outputs as other alternatives, we have nonetheless estimated a dropout "enrollment" equation as part of our complete system. This specification suffers from numerous limitations but is still insightful. First, we find that dropouts are higher where there is a larger number of problem children in the public schools. This is consistent with Russell Rumberger (1987) who finds that nationally more than one-half of male dropouts exit school because of a dislike of school or because of a suspension/expulsion. Second, factors reflecting market opportunities (such as per capita income and community unemployment rates) have no impact on the number of dropouts. Finally, we find that dropouts are systematically higher where public and private school outputs are higher. This is a provocative result suggesting that students may be alienated or driven from schools by higher standards and stiffer competition.

\textsuperscript{26}Concerns over the absence of price and output effects for the transfer equation lead us to alternative specifications of the model. Our data allowed us to specify transfers in a number of ways, including transfers into the system, transfers out the system (the measure used in the estimation presented in the text) and net transfers. These alternatives were combined with the various explanatory variables discussed in footnote 24 above, but never produced reasonable estimation results. It is possible that student transfers simply depend on the environmental factors identified in the text, commuting patterns and previous place of residence for those who moved from one district to another.
general, parents choose home schooling to provide their children with unique educational outputs, and our ability to control for these factors empirically is limited. Our results do suggest, at least for Tennessee, that home schoolers substitute primarily with nonreligious private schools, as evidence by the positive cross-price effect on $P_N$.

A final and somewhat surprising result, particularly for the higher priced nonreligious private schools, is the absence of income effects in the enrollment equations. Taken literally, these results indicate that, holding prices and output constant, there is no greater propensity for communities with higher average income to make greater or lesser use of private school substitutes. (This does not mean, however, that individuals with high income fail to choose private school alternatives.) The absence of income effects is not uncommon in the literature on education and school choice.\textsuperscript{28}

VI. SIMULATIONS AND DISCUSSION

What do these results have to say regarding the choice between publicly and privately provided goods? First, and most generally, public-private choice is a complicated web involving simultaneous community and individual optimization. Failure to explicitly recognize each of these dimensions of the problem will produce an incomplete picture of how choices are made and the implication of these choices. Second, and more specifically, we find that prices and measures of output quality are instrumental to public-private choice, and to choices within the set of private alternatives. Parents of children who attend more traditional schooling alternatives -- the resident

\textsuperscript{27}See Maralee Mayberry (1989).

\textsuperscript{28}Examples include Gustman and Pidot (1973), Baum (1986) and Martinez-Vazquez and Seaman (1985).
district public school or formal private schools -- are drawn to schools of better quality and are repelled by higher prices (all else constant). On the other hand, those making use of less traditional alternatives, home and transfer schooling, do not seem to be as influenced by market forces, and are not as likely to be influenced by typical public policies.

One of the most extensively discussed policy initiatives on public-private choice would increased the effective demand for schooling alternatives through provision of vouchers (or tuition tax credits) for private schooling.29 Families could use the voucher (or tax credit) to defray a portion of the costs of sending a child to the school of their choice. The often stated goal of such programs is to improve school quality through parental empowerment and additional competition.

We have used our estimation results to simulate the public school output and enrollment responses to a $500 tuition voucher, assumed to be financed exogenously by the federal government. The $500 voucher has a significant impact on the relative prices of schooling alternatives, reducing the (average) price of religious schools by 38 percent and the (average) price of nonreligious schools by 17 percent. The simulation results reveal that public school output (i.e., public schools expenditures per pupil) would decline by 4.8 percent as the median voter responded to lower relative prices. The combined effect of lower prices and lower public school quality leads to the outmigration of 6 percent of public school enrollments. Based on our analysis, parental empowerment and competition have the undesirable effect of lowering the quality of public schooling.

29See The Carnegie Foundation (1992) for a discussion of actual choice programs and their effects.
Given the growing interest in private alternatives and the public's perception of their quality, we have also used our framework to examine the implications of exogenous improvements in private school output (RELOUT and NRELOUT). A 10 percent increase in private school quality would reduce public school output by over 7 percent, as determined by the median voter. The reduction in public school output, combined with the exogenous increase in private school quality, leads to a decline in public school enrollment of 8.9 percent.

These results are generally consistent with the views of critics who argue that expanded school choice will do more harm to the nation's public schools than good. Yet it is important to understand why we get these results. While our framework captures both supply and demand sides of the education market, there are limited direct mechanisms in this model for public sector suppliers to increase public school quality (teacher quality for example). Hence, our results provide strong evidence that purely demand side initiatives -- whether for private education or other privately provided services -- will not be effective in improving public sector output and supply. For demand side initiatives to be successful, they must be met by initiatives on the supply side of the market as well. In the context of education, this might include changes in governance, charges in policies and policy coordination, or some combination of both. It is, perhaps, a hybrid of "systemic" reform (including changes in school governance and policies) and changes in the structure of education demand that holds the promise of improved schools and student performance.30

REFERENCES


<table>
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<tr>
<th>Variable</th>
<th>Description</th>
<th>Non-logged Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBOUT</td>
<td>Log public education expenditures per student</td>
<td>3373.3</td>
</tr>
<tr>
<td>PUBMATH6</td>
<td>Log sixth grade math gain score</td>
<td>18.08</td>
</tr>
<tr>
<td>PUBMATH6P</td>
<td>Log sixth grade math gain as percent of national norm</td>
<td>95.16</td>
</tr>
<tr>
<td>PUBSCI6</td>
<td>Log sixth grade science gain score</td>
<td>13.35</td>
</tr>
<tr>
<td>PUBSCI6P</td>
<td>Log sixth grade science gain as percent of national norm</td>
<td>102.68</td>
</tr>
<tr>
<td>PUBMATH8</td>
<td>Log eighth grade math gain score</td>
<td>18.32</td>
</tr>
<tr>
<td>PUBMATH8P</td>
<td>Log eighth grade math gain as percent of national norm</td>
<td>101.76</td>
</tr>
<tr>
<td>PUBSCI8</td>
<td>Log eighth grade science gain score</td>
<td>7.13</td>
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<tr>
<td>PUBSCI8P</td>
<td>Log eighth grade science gain as percent of national norm</td>
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<td>PUBTCAPM6</td>
<td>Log sixth grade standardized math test score</td>
<td>5.54</td>
</tr>
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<td>PUBTCAPS6</td>
<td>Log sixth grade standardized science test score</td>
<td>4.91</td>
</tr>
<tr>
<td>PUBTCAPM8</td>
<td>Log eighth grade standardized math test score</td>
<td>5.35</td>
</tr>
<tr>
<td>PUBTCAPS8</td>
<td>Log eighth grade standardized science test score</td>
<td>5.33</td>
</tr>
<tr>
<td>PUBKIDS</td>
<td>Log number of public school students</td>
<td>5333.3</td>
</tr>
<tr>
<td>HOMEKIDS</td>
<td>Log number of home school students</td>
<td>8.56</td>
</tr>
<tr>
<td>TRANKIDS</td>
<td>Log number of students transferring out of the district</td>
<td>178.3</td>
</tr>
<tr>
<td>RELKIDS</td>
<td>Log number of religious private school students</td>
<td>154.3</td>
</tr>
<tr>
<td>NRELKIDS</td>
<td>Log number of non-religious private school students</td>
<td>361.9</td>
</tr>
<tr>
<td>( P_r )</td>
<td>Log transfer tuition price</td>
<td>156.7</td>
</tr>
<tr>
<td>( P_n )</td>
<td>Log tuition price for non-religious private schools</td>
<td>2920.2</td>
</tr>
<tr>
<td>( P_s )</td>
<td>Log tuition price for religious private schools</td>
<td>1308.9</td>
</tr>
<tr>
<td>TAXPRI</td>
<td>Log tax price for median voter</td>
<td>0.0021</td>
</tr>
<tr>
<td>MEDINC</td>
<td>Log median family income</td>
<td>25991.1</td>
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<td>NONWHT</td>
<td>Log percent of families non-white</td>
<td>0.0825</td>
</tr>
<tr>
<td>RENT</td>
<td>Log percent of families that are renters</td>
<td>0.268</td>
</tr>
<tr>
<td>STAID</td>
<td>Log state aid per capita</td>
<td>279.8</td>
</tr>
<tr>
<td>FEDAID</td>
<td>Log federal aid per capita</td>
<td>2.3</td>
</tr>
<tr>
<td>PCTMA</td>
<td>Log percent of public school teachers with masters degree or better</td>
<td>0.4823</td>
</tr>
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<td>Variable</td>
<td>Description</td>
<td>Non-logged Mean</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>SSD</td>
<td>Special school district dummy (=1 for special school districts)</td>
<td>0.0929</td>
</tr>
<tr>
<td>PROBKIDS</td>
<td>Log percent of problem children in public schools</td>
<td>0.0702</td>
</tr>
<tr>
<td>CITY</td>
<td>City school system dummy variable (=1 for city)</td>
<td>0.2286</td>
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<tr>
<td>POPKIDS</td>
<td>Log of the population of children</td>
<td>7569.5</td>
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<tr>
<td>EDADULT</td>
<td>Log of percent of adults with less than 9th grade education</td>
<td>0.2008</td>
</tr>
<tr>
<td>INCOME</td>
<td>Log of per capita income</td>
<td>10638.3</td>
</tr>
<tr>
<td>RELOUT</td>
<td>Religious school output (=1 for accreditation)</td>
<td>.021</td>
</tr>
<tr>
<td>NRELOUT</td>
<td>Non-religious school output (=1 for accreditation)</td>
<td>.200</td>
</tr>
</tbody>
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### TABLE 2
Estimation Results: Public School Output Determination

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Parameter Estimates (Standard Errors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAXPRI</td>
<td>-0.106* (.051)</td>
</tr>
<tr>
<td>$P_r$</td>
<td>-0.003 (.005)</td>
</tr>
<tr>
<td>$P_s$</td>
<td>0.087* (.044)</td>
</tr>
<tr>
<td>$P_n$</td>
<td>0.088* (.033)</td>
</tr>
<tr>
<td>MEDINC</td>
<td>0.122* (.066)</td>
</tr>
<tr>
<td>STAIID</td>
<td>0.424* (.191)</td>
</tr>
<tr>
<td>FEDAIID</td>
<td>0.097* (.042)</td>
</tr>
<tr>
<td>PCTMA</td>
<td>0.059 (.068)</td>
</tr>
<tr>
<td>PROBKIDS</td>
<td>-0.022 (.015)</td>
</tr>
<tr>
<td>RELOUT</td>
<td>-0.510* (.207)</td>
</tr>
<tr>
<td>NRELOUT</td>
<td>-0.197* (.074)</td>
</tr>
<tr>
<td>NONWHT</td>
<td>-0.008 (.017)</td>
</tr>
<tr>
<td>SSD</td>
<td>-0.024 (.050)</td>
</tr>
<tr>
<td>RENT</td>
<td>0.128* (.051)</td>
</tr>
<tr>
<td>POPKIDS</td>
<td>0.338 (.220)</td>
</tr>
<tr>
<td>PUBKIDS</td>
<td>-0.354 (.222)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.582 (.1733)</td>
</tr>
</tbody>
</table>

The dependent variable is expenditures per student in average daily attendance. All (except dichotomous) variables are entered in log form. An asterisk (*) indicates significant at the 90 percent level or better. The system weighted $R^2$ is .76. The estimation technique is three-stage least squares.
### TABLE 3
Estimation Results: Enrollment Determination

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>PUBKIDS</th>
<th>RELKIDS</th>
<th>NRELKIDS</th>
<th>TRANKIDS</th>
<th>HOMEKIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_x$</td>
<td>-0.145</td>
<td>-0.897*</td>
<td>-0.508</td>
<td>0.387</td>
<td>-0.060</td>
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<tr>
<td></td>
<td>(.109)</td>
<td>(.453)</td>
<td>(.345)</td>
<td>(.425)</td>
<td>(.112)</td>
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<tr>
<td>$P_s$</td>
<td>0.003</td>
<td>1.318*</td>
<td>0.225</td>
<td>-0.148</td>
<td>0.176*</td>
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<tr>
<td></td>
<td>(.072)</td>
<td>(.370)</td>
<td>(.278)</td>
<td>(.338)</td>
<td>(.090)</td>
</tr>
<tr>
<td>$P_f$</td>
<td>0.006</td>
<td>-0.056</td>
<td>-0.035</td>
<td>0.01</td>
<td>0.014</td>
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<tr>
<td></td>
<td>(.010)</td>
<td>(.050)</td>
<td>(.038)</td>
<td>(.048)</td>
<td>(.013)</td>
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<td>INCOME</td>
<td>0.197</td>
<td>0.460</td>
<td>-0.332</td>
<td>2.013</td>
<td>0.199</td>
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<tr>
<td></td>
<td>(.283)</td>
<td>(1.397)</td>
<td>(1.072)</td>
<td>(1.340)</td>
<td>(0.348)</td>
</tr>
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<td>PUBOUT</td>
<td>1.251*</td>
<td>-1.663</td>
<td>0.873</td>
<td>-0.873</td>
<td>0.162</td>
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<tr>
<td></td>
<td>(.414)</td>
<td>(2.032)</td>
<td>(1.563)</td>
<td>(1.960)</td>
<td>(0.511)</td>
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<td>RELOUT</td>
<td>0.854*</td>
<td>3.607*</td>
<td>5.685*</td>
<td>-3.281</td>
<td>1.457*</td>
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<tr>
<td></td>
<td>(.440)</td>
<td>(2.190)</td>
<td>(1.656)</td>
<td>(2.023)</td>
<td>(0.527)</td>
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<tr>
<td>NRELOUT</td>
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<td>-1.449*</td>
<td>0.839</td>
<td>-0.608</td>
<td>-0.217</td>
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<tr>
<td></td>
<td>(.151)</td>
<td>(.758)</td>
<td>(.573)</td>
<td>(.703)</td>
<td>(.188)</td>
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<td>PROBKIDS</td>
<td>0.078*</td>
<td>0.007</td>
<td>0.137</td>
<td>0.268*</td>
<td>0.010</td>
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<tr>
<td></td>
<td>(.030)</td>
<td>(.141)</td>
<td>(.109)</td>
<td>(.139)</td>
<td>(.036)</td>
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<td>EDADULT</td>
<td>0.055</td>
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<td>-0.220</td>
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<tr>
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<td>(.773)</td>
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<td>0.593</td>
<td>0.057</td>
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<td>-0.098</td>
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<td>(.095)</td>
<td>(.466)</td>
<td>(.360)</td>
<td>(.454)</td>
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<td>0.001</td>
<td>0.284*</td>
<td>-0.238</td>
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<tr>
<td></td>
<td>(.032)</td>
<td>(.156)</td>
<td>(.120)</td>
<td>(.149)</td>
<td>(.039)</td>
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<tr>
<td>POPKIDS</td>
<td>0.821*</td>
<td>0.760*</td>
<td>0.647*</td>
<td>0.704*</td>
<td>0.241*</td>
</tr>
<tr>
<td></td>
<td>(.042)</td>
<td>(.208)</td>
<td>(.159)</td>
<td>(1.97)</td>
<td>(.052)</td>
</tr>
<tr>
<td>Constant</td>
<td>-9.244*</td>
<td>-0.105</td>
<td>-3.871</td>
<td>-12.069</td>
<td>-3.888</td>
</tr>
<tr>
<td></td>
<td>(2.794)</td>
<td>(13.951)</td>
<td>(10.753)</td>
<td>(13.420)</td>
<td>(3.514)</td>
</tr>
</tbody>
</table>

The dependent variables are the log of the number of students in each mode of education. All (except dichotomous) variables are entered in log form. An asterisk (*) indicates significant at the 90 percent level or better. The system weighted $R^2$ is .76. The estimation technique is three-stage least squares.
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