ON COMPETITION AND SCHOOL EFFICIENCY

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Abstract

A substantial literature indicates that the public school system in the United States is inefficient. Some have posited that this inefficiency arises from a lack of competition in the education market. On the other hand, the Tiebout hypothesis suggests that public schools already face significant competition. In this paper, the authors examine the extent to which competition for students influences the distribution of public school inefficiency in Texas. They use a Shephard input distance function to model educational production and use bootstrapping techniques to test for technical, allocative and scale inefficiencies. The authors find evidence of substantial inefficiency in the Texas school system but only weak and inconsistent evidence that competition for enrollment enhances school district efficiency (J.E.L. I21).

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I. Introduction

A substantial literature indicates that the public school system in the United States is inefficient. Hanushek's 1986 survey of the literature on educational production functions overwhelmingly concludes that expenditures are uncorrelated with student achievement gains. Cost function studies and data envelopment analyses support similar conclusions (see, for example, Bessent et al. 1982, Färe, et al. 1989 or Callan and Santerre 1990).

Some have posited that this inefficiency arises from a lack of competition in the education market. Chubb and Moe (1990 and 1991) find evidence that administrative autonomy fosters school efficiency and argue that increased competition among schools would promote such autonomy. Other researchers attribute school inefficiency to the monopoly powers of the public school system (for examples, see Boaz 1991 or Gwartney 1991).

On the other hand, public schools in the U.S. may already face significant competition in the sense of Tiebout (1956). As the Tiebout model would predict, a number of researchers have demonstrated that a greater variety of public schools in a metropolitan area leads, ceteris paribus, to increased homogeneity within local jurisdictions, (Hamilton et al. 1975, Eberts and Gronberg 1981, Gramlich and Rubinfeld 1982, Munley 1982 and Grubb 1982). Jud (1983) demonstrates that residents express their preferences for public schools by voting with their feet. Martinez-Vazquez and Seaman (1985) find that private schools are less prevalent in communities with a variety of public school choices. Hoxby (1994) and Borland and Housen (1993) find evidence that Herfindahl indices of competition for student enrollment can explain some of the variation in educational production.

To evaluate directly the connection between school efficiency and competition for students, we model the multiple output, multiple input school production technology using a Shephard (1953) input distance function. By bootstrapping the distance function, we can test for technical, allocative and scale inefficiencies in educational production. We find only weak evidence that competition for students influences the distribution of public school inefficiency in Texas. Thus, our analysis implies that reforms aimed solely at increasing competition among schools may not achieve the desired results.

II. The Literature

Over the years, economists have used a variety of techniques to evaluate school performance. Most researchers have focused on estimating single-output, average production functions for schooling. Although a few recent studies have examined monetary returns to schooling (Betts 1995 and Card and Krueger 1992a, 1992b), the most common measures of educational outputs have been test scores (for examples, see Berger and Toma 1994, Eberts and Stone 1987, Wahlberg and Fowler 1987 and the literature surveyed in Hanushek 1986). Generally, researchers assume that schools produce these educational outputs using inputs related to school personnel, per-pupil expenditures, and family background.[1]

The production functions yield estimates of the marginal products of the inputs, and allow researchers to infer which inputs would have the greatest marginal impact on achievement.[2] Most researchers using this approach have found that inputs within school district control (such as expenditures or class sizes) have little or no marginal impact on test scores (Hanushek 1986).

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[1] See Cohn and Geske (1990) for a thorough review of the output and input measures employed in these types of studies,

[2] See Levin (1974) and Hanushek (1979) for critical reviews of the production function approach.

Card and Krueger (1992a, 1992b) find evidence that school inputs have a positive effect on the monetary returns to schooling, but their analysis is based on state-level data about school characteristics and may be subject to aggregation-induced biases (see Hanushek, Rivkin and Taylor 1995). Using less aggregate data, Betts (1995) finds no evidence of marginal effects.

Recently, some researchers have modified production function analysis to incorporate scale, technical and allocative inefficiencies, and multiple measures of educational output. Most of the researchers using this generalized approach have relied on nonstochastic techniques like data envelopment analysis (e.g., Bessent and Bessent 1980; Bessent et al. 1982, 1984; Färe et al. 1989; and Grosskopf et al. 1994). However, a few researchers have used stochastic techniques. Deller and Rudnicki (1993) assume that school inefficiency has a half-normal distribution and use maximum likelihood techniques to estimate a single-output frontier production function. McCarty and Yaisawarng (1993) and Ray (1991) combine DEA and regression analysis in a partially stochastic two-step procedure that incorporates multiple outputs.[3] Grosskopf et al. (forthcoming) use an indirect output distance function to examine the consequences of budgetary reforms when school districts are inefficient. Like the production-function analyses, these studies generally find evidence of substantial school inefficiency.

Analyses of educational cost functions yield similar results. Barrow (1991) estimated a cost function frontier for schools in England and found

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[3] In the first step, they construct efficiency measures for schools by applying DEA to data on multiple educational outcomes and discretionary inputs (such as teachers and administrators). In the second step, they regress the efficiency measures on a set of non-discretionary inputs (such as student body characteristics).

that actual costs were 4 percent to 16 percent above the minimum estimated cost for the schools in his sample. Callan and Santerre (1990) found evidence that school districts in Connecticut produce primary and secondary education using inefficiently large quantities of capital and transportation services. Jimenez (1986) concluded that schools in Bolivia and Paraguay used excessive amounts of capital and that many of the schools in Bolivia exhibited diseconomies of scale. Eberts and Stone (1986) found that rent extraction in the form of higher teacher salaries adds between 7 percent and 15 percent to educational costs in unionized school districts in the United States.

III. The Distance Function

We use a Shephard (1953) input distance function to model school production and generate measures of technical, allocative and scale inefficiency. The input distance function is a convenient tool for analyzing potentially inefficient public enterprises for a number of reasons. Because the distance function is dual to the cost function, it lends itself to fully stochastic frontier estimation without sacrificing the ability to evaluate multiple outputs. However, unlike the cost function, the input distance function requires data on input quantities rather than input prices. Thus, the distance function is preferable in cross-section settings where prices do not vary, such as when making comparisons across schools within a single labor market. The distance function also has the advantage for our purposes of being "agnostic" with respect to the economic motivation of the decision maker, unlike the cost function which presumes cost minimizing behavior.[4]

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[4] While the cost function assumes cost minimizing behavior, inefficiency can be allowed for in the cost function using techniques outlined by Schmidt and Sickles (1984).

Formally, the input distance function is a mapping from the set of all nonnegative input vectors $x = (x_1, x_2, \ldots, x_N)$ and nonnegative output vectors $y = (y_1, y_2, \ldots, y_M)$ into the real line, i.e.,

$$D(y,x) = \max \{\lambda : (x/(\lambda)) \text{ is an element in } L(y)\} \qquad (1)$$

where

$$L(y) = \{(x) : \text{ x can produce y}\}. \qquad (2)$$

The distance function satisfies fairly general regularity properties (see Färe and Grosskopf (1990) for details), including being homogeneous of degree one in inputs, concave in inputs, convex in outputs, and nondecreasing in inputs.

The distance function is perhaps most easily understood with the aid of a diagram. Consider Figure 1. Observation K employs the input bundle (x_i, x_j) to produce output level y. The distance function seeks the largest proportional contraction of that input bundle which allows production of the original output level y (which may be a vector). In this example, the value of the distance function for observation K is OK/OK'. This illustrates the following characteristic of the distance function, namely

$$D(y,x) \geq 1 \quad <=> \quad x \in L(y). \qquad (3)$$

Furthermore, $D(y,x) = 1$ if and only if the input bundle is an element of the isoquant of L(y). The reciprocal of the value of the input distance function is the Farrell (1957) input-saving measure of technical efficiency. We use it to measure variations in technical efficiency among school districts.

As discussed in Blackorby and Russell (1989) the first derivatives of the input distance function with respect to input quantities yield (cost-deflated) shadow or support prices of those inputs.[5] We can use these shadow prices to test for allocative efficiency. Let $w = (w_1, w_2, \ldots, w_N)$, where w is positive, be the vector of observed input prices. If a municipality is allocatively efficient then the following holds:

$$D_i(y,x)/D_j(y,x) = w_i/w_j, \text{ for all } i,j = 1,2,\ldots N. \tag{4}$$

D_i is the first derivative of $D(y,x)$ and is interpreted as the virtual or shadow price of the ith input. Alternatively, we can define a measure κ_{ij} as the degree to which the shadow price ratio agrees with the actual price ratio, where the formulation in (5) follows the nonminimal cost literature,[6]

$$\kappa_{ij} = \frac{D_i(\cdot)/D_j(\cdot)}{w_i/w_j} \tag{5}$$

see for example Toda (1976) or Atkinson and Halvorsen (1986).

If $\kappa_{ij} = 1$ for all i,j then the observation is said to be allocatively efficient. When $\kappa_{ij} \neq 1$ we can have the following non-optimal situations. If

$$\kappa_{ij} > 1, \tag{6}$$

factor i is underutilized relative to j at observed relative prices, and if

$$\kappa_{ij} < 1, \tag{7}$$

factor i is overutilized relative to j at observed relative prices. In figure 2, the school district is observed to employ input bundle $\bar{x}$. The observed

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[5] This result follows from Shephard's (dual) lemma because the input distance function is dual to the cost function (see Färe and Grosskopf (1990)).

[6] In this literature, firms are assumed to minimize (unobservable) shadow costs given (unobservable) shadow prices. This is achieved by introducing additional parameters into the cost function that essentially allow input prices to "pivot". These parameters are used to construct the κ_{ij} in equation 5. Unlike the distance function methodology, this technique cannot identify firm-specific relative shadow prices.

relative price of the two inputs is given by the absolute value of the slope of the line w. The relative shadow prices (ratio of marginal products) that supports the input vector $\bar{x}$ is given by the absolute value of the slope w*w*. In this case the ratio of shadow prices is less than the ratio of observed prices implying that input i is overutilized relative to input j. That is, $k_{ij} < 1$. Based on observed relative prices, allocative efficiency occurs at x', where the isoquant is tangent to the line w'w' which is parallel to the line w. Another way of interpreting the value of $k_{ij} < 1$ is that the marginal product per dollar paid the input j exceeds the marginal product per dollar paid for input i at the observed input mix and prices.

While the partial derivatives of the distance function with respect to *inputs* can be used to indicate allocative inefficiency, the partial derivatives of the distance function with respect to *outputs* can be used to indicate economies of scale (see Färe and Grosskopf 1994). If the input distance function scale elasticity

$$\epsilon = -1/(\sum_m \frac{\partial D}{\partial y_m}\frac{y_m}{D}) \tag{8}$$

is greater than 1, then the observation is exhibiting increasing returns to scale. If ϵ is less than 1, then the observation is exhibiting decreasing returns to scale. Constant returns to scale imply that $\epsilon = 1$.

IV. <u>The Data</u>

The Texas Research League provides data for the 1988-89 school year on Texas' 1055 public school districts. The data include information on enrollment, the effective number of teachers, administrators, staff and teacher aides employed in each district (per pupil),, the average salaries paid to each type of employee and other school characteristics. The Texas Education Agency (TEA) provides information by school district on average student achievement in reading, writing and mathematics in odd numbered grades, the number of students taking the test battery by grade level, student ethnicity and other student body characteristics. Together, the combined sources provide complete information on 303 public school districts with at least 100 students in both the 5th and 11th grades.[7] From these data, we construct measures of school outputs, student and family inputs and school inputs for each school district. We use data on total enrollments in all public and accredited private schools in Texas to construct measures of the degree of competition among school districts.

Output Measures

The literature on measuring school effects has reached a broad consensus that the most appropriate measure of school output is the marginal effect of the school on educational outcomes (see, for example, Hanushek 1986, Hanushek and Taylor 1990, Aitkin and Longford 1986 or Boardman and Murnane 1979). We use student achievement on a battery of test scores as the relevant educational outcome and extract the marginal effect of schools by following the value-added residuals techniques described in Hanushek and Taylor and Aitkin and Longford.

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[7] We restrict our attention to school districts with at least 100 students in each of the relevant grades to avoid sampling problems that might be introduced by a small number of students. Furthermore, we exclude the Dallas independent school district from the analysis because it had more than twice the enrollment of the next-largest school district for which we had data. Data were not available for many of the large school districts in the state.

Thus, we estimate school district output per pupil using Texas Educational Assessment of Minimum Skills (TEAMS) scores in mathematics, reading and writing, data on changes in cohort size, and demographic data on the racial and socioeconomic composition of the student body (Texas Education Agency 1987, 1989). At the primary (5th grade) and secondary (11th grade) levels, we estimate the per-pupil value added by the school district according to equation (9).

$$\begin{aligned} \ln(\mathrm{TEAMS89}_{sg}) &= \alpha_g + \sum_{j=1}^{2} \delta_{jg} \ln(\mathrm{ETHNICITY}_{sj}) + \delta_{3g} \ln(\mathrm{SES}_s) \\ &\quad + \delta_{4g} \ln(\mathrm{XCOHORT}_{sg}) + \sum_{j=5}^{7} \delta_{jg} \ln(\mathrm{TEAMS87}_{sj(g-2)}) + \epsilon_{sg} \end{aligned} \tag{9}$$

where the ln(•) operator denotes the natural log of the variable, $\mathrm{TEAMS89}_{sg}$ is the average total TEAMS scores for school district s for grade level g in 1989, $\mathrm{TEAMS87}_{sj(g-2)}$ is the average TEAMS score in subject j (reading, writing and mathematics) for the same cohort two years previously, $\mathrm{ETHNICITY}_{sj}$ is the fraction of the student body of school district s that is non-hispanic WHITE or HISPANIC (respectively), SES_s is the fraction of the student body of school district s that is not receiving free or reduced-price lunches (the best available proxy for socio-economic status), $\mathrm{XCOHORT}_{sg}$ is the ratio of the grade g cohort size in 1989 divided by the grade g-2 cohort size in 1987 (a control to prevent schools from improving their average score by shedding students), and the estimated residual, ϵ_{sg}, represents the average value added per pupil in school district s, plus an error term.[8]

Estimating school outputs as equation residuals generates output measures that represent deviations from the state average. School districts that add less value than the state average have negative output measures. Since the distance function methodology cannot handle negative outputs, we transform the value-added residuals into tractable per-pupil output measures by adding the mean of the log-transformed post-test scores to the corresponding value-added residuals. To further transform the per-pupil output measures into total output measures, we add the log of grade-level enrollment ($ENROLL_{sg}$). Therefore,

$$\ln(OUTPUT_{sg}) = \overline{\ln(TEAMS89_g)} + \epsilon_{sg} + \ln(ENROLL_{sg}) \tag{10}$$

is our proxy for the output of school district s. It represents the total achievement level we would expect school district s to produce if it had the same student-body composition as the sample average. Alternatively, one can think of $OUTPUT_{sg}$ as the level of total student achievement purged of the effect of home production and earlier achievement.[9] Since we are examining value added on achievement test scores in grades 5, and 11, there are two outputs for each school district.

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[8] Because the two value-added equations share common regressors ($ETHNICITY_{i,j}$ and SES_i) we suspected a cross-equations correlation between the error terms, and therefore among our output measures. We found that the correlations between error terms were surprisingly low (in the neighborhood of 0.22), but significant and therefore estimate the output measures simultaneously using the standard SAS package for seemingly unrelated regression (SUR).

[9] We note that this general technique was also employed by Callan and Santerre (1990) to arrive at a measure of educational quality. However, Callan and Santerre did not have access to pretest information and therefore were unable to derive a value-added quality measure.

Input Measures

We focus on two variable inputs within school district control -- instructional and administrative personnel. We define the quantity of instructional inputs per pupil as the weighted average of the number of teachers and teacher aides per pupil.[10] The quantity of administrative inputs per pupil is the weighted average of the number of administrators and support personnel per pupil.[11] In both cases, we derive weights from the average wages paid for the personnel categories. To generate measures of total instructional (INST) and administrative (NINST) inputs, we multiply these per-pupil measures of variable input by the sum of the enrollments in grades 5 and 11 ($ENROLL_s = ENROLL_{s5} + ENROLL_{s11}$).

Other important school inputs are beyond school district control, at least in the near term. We have identified two: the quantities of non-labor school inputs and family inputs. Unfortunately, there are no direct measures for either of these inputs. Because expenditures on maintenance and operations should be a positive function of the size of the capital stock, we use data on school district expenditures on maintenance and operations per pupil, multiplied by $ENROLL_s$, as our proxy for the quantity of non-labor inputs (M&OINPUT).[12] We use the exponent of the predicted values from equation (9) multiplied by the corresponding grade-level enrollments ($ENROLL_{sg}$) to measure

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[10] Ideally, we would like to adjust the quantity numbers for variations in teacher quality. However, Hanushek (1986) has demonstrated that observable teacher characteristics like salary, experience and educational background do not indicate classroom effectiveness. Lacking a reliable indicator of teacher quality, we treat teachers as homogeneous.

[11] Support personnel include supervisors, counselors, librarians, nurses, physicians and special service personnel.

[12] Callan and Santerre (1990) use a similar proxy for capital stock.

the contribution of home production at each grade level (STUINPUT_{sg}).[13] In essence, STUINPUT_{sg} is an index that depends on the ethnic and socio-economic composition of the school district, the percentage change in enrollment for each grade, and past achievement test scores. For each school district there are two measures of fixed student inputs corresponding to the primary and secondary grade levels.

Competition Measures

Finally, we construct six measures of the degree of competition for students. First, following Hoxby (1994) and Borland and Housen (1993), we construct Herfindahl indices of student enrollment for each metropolitan statistical area (MSA).[14] Second, we construct concentration ratios for each MSA.[15] Third, we determined each school district's share of the enrollment market in its MSA. Finally, we recalculate all three measures (Herfindahl indices, concentration ratios and market shares) using counties rather than metropolitan areas to define the relevant markets. The 58 rural school districts in our sample can be included in the competition measures whenever the relevant market is defined as a county. For all of the competition measures, we use data on total enrollments in both public and accredited private schools (Texas Education Agency 1990, 1989). Table 1 presents

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[13] We take the exponent of the predicted values from (9) in order to undo the logarithmic transformation.

[14] The Herfindahl index for a given market is the sum of the squared enrollment shares for all of the public and private school districts in that market.

[15] The concentration ratio for a given market is the sum of enrollment shares for the four largest school districts (public or private) in that market.

descriptive statistics for our measures of enrollment competition.

V. Estimation

The translog cost function has a long history of use in estimating cost functions because of its flexibility and ability to nest various hypotheses within its structure. In this analysis we use a translog form for the distance function. Suppressing the observational subscript,

$$\begin{aligned} \ln D = \alpha &+ \sum_{j} \beta_j \ln x_j + ½ \sum_{j}\sum_{k} \beta_{jk} \ln x_j \ln x_k + \sum_{j}\sum_{m} \rho_{jm} \ln x_j \ln y_m \\ &+ \sum_{j}\sum_{r} \gamma_{jr} \ln x_j \ln z_r + \sum_{r} \delta_r \ln z_r + ½ \sum_{r}\sum_{j} \delta_{rj} \ln z_r \ln z_j \\ &+ \sum_{m} \lambda_m \ln y_m + ½ \sum_{m}\sum_{n} \lambda_{mn} \ln y_m \ln y_n + \epsilon . \end{aligned} \tag{11a}$$

where x_j is the quantity for discretionary inputs (INST and NINST), z_n is the quantity for non-discretionary inputs (STUINPUT_5, STUINPUT_{11}, and M&OINPUT) and y_m are the output quantities (OUTPUT_5 and OUTPUT_{11}). We impose homogeneity in the discretionary inputs ($\Sigma\beta_n = 1$, $\Sigma\beta_{mn} = 0$, $\Sigma\rho_{mn} = 0$, $\Sigma\gamma_{mn} = 0$) as required by the definition of the input distance function.

One advantage of the translog specification is that by Shepherd's lemma the first derivative of (11a) with respect to x_1 equals the expenditure share for input 1 ($S_1 = w_1x_1/(w_1x_1 + w_2x_2)$). Because estimating the distance function and the share equation together in a system of simultaneous equations would improve the efficiency of the estimated parameters, we use the observed input quantities and the ratio of the state-level average prices for teachers and administrators ($P=w_2/w_1$) to define instructional expenditure shares (S_1) for each observation. We use the ratio of average prices to derive expenditure shares rather than the observed relative prices because the observed prices may include rents.[16]

Thus, we estimate the following system of equations

$$\begin{aligned} \ln D = \alpha &+ \sum_j \beta_j \ln x_j + \tfrac{1}{2} \sum_j \sum_k \beta_{jk} \ln x_j \ln x_k + \sum_j \sum_m \rho_{jm} \ln x_j \ln y_m \\ &+ \sum_j \sum_r \gamma_{jr} \ln x_j \ln z_r + \sum_r \delta_r \ln z_r + \tfrac{1}{2} \sum_r \sum_j \delta_{rj} \ln z_r \ln z_j \\ &+ \sum_m \lambda_m \ln y_m + \tfrac{1}{2} \sum_m \sum_n \lambda_{mn} \ln y_m \ln y_n + \epsilon, \\ S_1 = \beta_1 &+ \beta_{11} \ln x_1 + \beta_{12} \ln x_2 + \sum_m \rho_{1m} \ln y_m + \sum_r \gamma_{1r} \ln z_r + \mu \end{aligned} \tag{11b}$$

using restricted least squares to accommodate the nonvariance of the left hand side of the first equation.

By definition, the input distance function is bounded from below by 1. However, the predicted values of the first equation in (11b) (the log of the distance function) are distributed around zero. Therefore, we follow Greene (1980) in adjusting the intercept term by adding the absolute value of largest OLS residual ($\max(\epsilon)$). The scaling yields values of the first equation in (11b) that are greater than 0, which when transformed yield values for the estimated distance function that are greater than 1. As mentioned above, inverting the value of the input distance function for each observation yields our measure of Farrell technical inefficiency (τ_s). Values of τ_s range from 0 to 1, with a value of 1 indicating that the school district is technically efficient (in the sense that output could not be increased without reallocating variable inputs).

Because expenditure shares by definition sum to one, the predicted values from the instructional share equation (together with the variable input quantities and the ratio of average prices $P=w_2/w_1$) provide sufficient

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[16] Implicitly, this approach assumes that although wage levels may vary among communities in the sample, teachers and administrators receive the same compensating differential or cost-of-living differential (in percentage terms).

information to generate a point estimate of κ for each school district (κ_s).[17] If $\kappa_s > 1$ (<1) then the wage-deflated marginal product of instructors is greater than (less than) the wage-deflated marginal product of administrative staff. We use the value of κ_s as our measure of allocative inefficiency: the farther κ_s is from 1, the greater is the difference between the market price and the observed price and the more allocatively inefficient is the school district.

We use coefficient estimates from the first equation in (11b) to generate estimates of scale elasticity (ϵ_s) as defined by equation (8). Because equation (8) indicates scale elasticity with respect to variable inputs and our analysis incorporates fixed inputs (M&OINPUT and STUINPUT_g), ϵ_s should be interpreted as a short-run measure of scale inefficiency.

We would also like to be able to indicate whether or not our measures of technical (τ_s), allocative (κ_s) and scale (ϵ_s) inefficiency are statistically meaningful. To conduct the significance tests we perform a nested bootstrap. Specifically, we create 250 data sets of 303 observations each based on random draws with replacement from the original sample. Equation (9) is then re-estimated for each of these data sets. The resulting OUTPUT_{sg} and STUINPUT_{sg} measures are used to re-estimate (11b). Finally, we use the 250 estimates of the coefficients from (9) and (11b) in conjunction with the original data set

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[17] With some rearrangement, the definition of κ_{12} given in equation 5 becomes

$$\kappa_s = \left(\frac{\partial D/\partial x_1}{\partial D/\partial x_2}\right) / \frac{w_1}{w_2} = \left(\frac{\partial D/\partial x_1}{\partial D/\partial x_2}\right) \cdot P.$$

where x_1 in INSTR and x_2 is NINST. Because there are only two variable inputs under consideration, we have dropped the subscripts on κ indicating input type.

to create 250 measures of τ_s, κ_s and ϵ_s for each observation. Tables 3 and 4 compare the coefficient estimates from the bootstrapping procedure to those generated by the original estimation.

We use the distribution of the bootstrapped efficiency measures to indicate statistical significance. For technical inefficiency, we consider the observation to be statistically inefficient when τ_s is less than 1 at least 95 percent of the time. For allocative inefficiency, we consider the observation to be statistically inefficient when κ_s is either greater than 1 at least 95 percent of the time, or less than 1 at least 95 percent of the time. The observation is exhibiting increasing returns to scale when ϵ_s is greater than 1 at least 95 percent of the time, and exhibiting decreasing returns to scale when ϵ_s is less than 1 at least 95 percent of the time.

VI. Results

Table 5 presents descriptive statistics on our three measures of school district inefficiency. From the underlying information, we draw several broad conclusions.

First, most of the school districts in our sample are inefficient. Of the 303 school districts in our sample, only 2 can be considered efficient in all three dimensions. In contrast, 39 are inefficient in all three dimensions. Technical inefficiency is more common than scale or allocative inefficiency.

Second, the inefficiencies are substantial. On average, the school districts in our sample could reduce costs by at least 27 percent by becoming technically efficient. Because it is possible that even the best practice technology observed in our data incorporates some inefficiency, this estimate can be thought of as a lower bound on district inefficiency.

Third, there is a distinct pattern to the allocative inefficiency in the sample. For every observation where we could detect allocative inefficiency, $\kappa > 1$ indicating that the marginal productivity of teachers per dollar paid is significantly greater than the marginal productivity of administrators per dollar paid. The analysis strongly suggests that Texas school districts tend to misallocate their resources in favor of administrative personnel, ceteris paribus.

Fourth, most Texas school districts exhibit constant returns to scale. The remainder exhibit decreasing returns to scale. There is no evidence that school districts of at least moderate size can exploit increasing returns.

Finally, as the data in Tables 6 and 7 indicate, we find only weak and inconsistent evidence that increases in the degree of competition for students enhance school district efficiency. When we use metropolitan areas to define the relevant markets, we find no significant correlation between our measures of inefficiency and any measure of competition. When we use counties to define the relevant markets, we find a weak correlation between the degree of technical inefficiency and the extent of market competition. School districts tend to be less efficient in counties with concentrated markets (as measured by Herfindahl indices or concentration ratios), but the effect is modest and not evident in all of the relevant correlation coefficients. The evidence also suggests that school districts with larger shares of county enrollment tend to be less technically efficient than school districts with smaller market shares. Since there is no significant correlation between a school district's size and its measured technical efficiency, this effect may also indicate the influence of competitive pressures.

One possible explanation for this muted response to competitive pressures is excessive regulation. In 1989, the Texas legislature regulated class sizes, administrative and support staffing and teacher salaries. Research by Grosskopf et al. (1994) suggests that such regulations constrain the personnel allocations of most Texas school districts. In this case, regulatory constraints leave school districts unable to respond to market incentives and measures of efficiency would have no relation with measures of competition.

Alternatively, one could interpret our results as evidence that the Texas education market is contestable. The contestable markets literature holds that it is potential competition from potential entrants rather than competition from active suppliers that induces efficient firm behavior (Willig 1987). If Texas' education markets are sufficiently contestable then our measures of competition need not reflect the actual competitive pressures facing Texas school districts, and one need not expect a strong correlation between our measures of competition and school district efficiency.[18] To the extent that the markets for primary and secondary education are already contestable, there may be little reason to believe that policies (like vouchers) designed to foster additional active competition would also foster additional school district efficiency.

Finally, one could interpret our results as evidence against the Tiebout hypothesis. The hypothesis' prediction that competition among jurisdictions creates market-like incentives for efficient government leads us to expect a correlation between the degree of competition and governmental efficiency. Because we find such a correlation only occasionally and weakly, our evidence offers little support for this hypothesis.

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[18] Without a measure of potential competition (or what Morrison and Winston (1987) call a "hit-and-run" variable) we cannot test this hypothesis.

VII. Conclusions

Using an input distance function to model the relationship among the multiple inputs and multiple outputs of Texas school districts, we find evidence of widespread inefficiency. Most school districts in our sample are technically inefficient and more than two-thirds of the districts misallocate resources to favor administrative staff at the expense of classroom instructors.

Policies that foster competition among school districts have been proposed as a partial solution to the problem of school inefficiency. However, school districts already face competition for enrollments from private schools and other area public schools. If inefficiency in the school system could be reduced by increasing the degree of competition among schools, then we would expect to find evidence that school districts that currently face a lot of competition are more efficient than school districts that currently face less competition.

We can find only weak and inconsistent evidence in favor of such a proposal. If one uses metropolitan areas to define the relevant markets, there is no systematic variation in Herfindahl indices, concentration ratios or market shares that would suggest that competition for enrollment enhances school district efficiency. If one uses counties to define markets, there is weak evidence that competition enhances school district efficiency. One could interpret these findings as evidence that the Texas education market is so heavily regulated that public school districts are not able to respond to market incentives. Alternatively one could conclude that the Texas education market is contestable. In either case, our analysis suggests that reforms aimed solely at increasing competition among schools could be ineffectual.

Table 1

Descriptive Statistics

	Mean	Std.Dev.	Minimum	Maximum
ENROLL_{5}	554.12	696.76	100.00	4108.00
$\mathrm{TEAMS89}_{5}$	2415.97	84.33	2153.00	2670.00
$\mathrm{TEAMS87}_{math,5}$	834.65	31.00	747.00	917.25
$\mathrm{TEAMS87}_{reading,5}$	799.73	36.07	689.41	914.00
$\mathrm{TEAMS87}_{writing,5}$	757.22	32.04	660.51	850.00
$\mathrm{XCOHORT}_{5}$	98.41	8.21	72.34	127.06
ENROLL_{11}	458.71	593.44	100.00	3446.00
$\mathrm{TEAMS89}_{11}$	1568.51	41.44	1421.00	1709.00
$\mathrm{TEAMS87}_{math,11}$	787.16	28.23	708.00	875.00
$\mathrm{TEAMS87}_{reading,11}$	787.81	26.04	679.00	869.00
$\mathrm{TEAMS87}_{writing,11}$	743.62	33.56	629.00	861.00
$\mathrm{XCOHORT}_{11}$	81.40	9.69	50.00	112.61
WHITE	61.77	27.59	1.10	99.00
HISPANIC	27.01	29.65	0.70	98.80
SES	66.50	22.86	2.41	100.00
NINST	9.30	11.46	1.48	60.51
INST	61.32	75.45	11.92	456.01
M&OINPUT	381301.12	495202.90	47726.15	3306520.33

Table 2

Measures of Enrollment Competition
Descriptive Statistics

	Mean	Std.Dev.	Minimum	Maximum
County				
Herfindahl Index	37.2	23.6	11.9	100
Concentration Ratio	84.4	14.2	56.1	100
Market Share	34.9	31.3	0.4	100
Metropolitan Area				
Herfindahl Index	20.1	13.5	10.9	86.6
Concentration Ratio	65.6	15.5	47.4	100
Market Share	11.4	17.4	0.3	92.9

Table 3

Predicted Outcomes on the TEAMS_{89} by Grade

	Base Case		Average of Bootstrap	
	5th Grade	11th Grade	5th Grade	11th Grade
Intercept	4.55*	3.83*	4.49	3.81
	(0.29)	(0.26)	(0.37)	(0.29)
$\text{TEAMS87}_{math,j}$	-0.01	0.27*	0.002	0.27
	(0.07)	(0.04)	(0.07)	(0.05)
$\text{TEAMS87}_{reading,j}$	0.15*	0.22*	0.16	0.23
	(0.07)	(0.06)	(0.10)	(0.06)
$\text{TEAMS87}_{writing,j}$	0.33*	0.03	0.33	0.03
	(0.06)	(0.03)	(0.07)	(0.02)
WHITE	0.002	0.01*	0.001	0.01
	(0.004)	(0.003)	(0.01)	(0.004)
HISPANIC	-0.001	-0.0003	-0.01	0.000
	(0.001)	(0.001)	(0.01)	0.001)
XCOHORT_j	-0.06*	-0.04*	-0.06	-0.04
	(0.02)	(0.01)	(0.02)	(0.01)
SES	0.01	0.004	0.01	0.004
	(0.01)	(0.004)	(0.01)	(0.006)

System weighted R-square for the Base Case is .6963

Standard errors in parentheses.

*Indicates statistical significance at the 5% confidence level.

Table 4

Translog Input Distance Function

	Base Case	Average of Bootstrap	
INTERCEPT	6.70	7.11	(0.07)
ℓX1	0.50	0.50	(0.0005)
ℓX2	0.50	0.50	(0.0005)
ℓY1	-0.11	-0.37	(0.25)
ℓY2	-1.13	-1.23	(0.22)
ℓR1	0.12	0.54	(0.24)
ℓR2	1.39	1.34	(0.24)
ℓR3	-0.86	-0.87	(0.02)
ℓX1ℓX1	0.16	0.16	(0.0002)
ℓX1ℓX2	-0.16	-0.16	(0.0002)
ℓX2ℓX2	0.16	0.16	(0.0002)
ℓX1ℓY1	-0.03	-0.02	(0.002)
ℓX1ℓY2	0.03	0.02	(0.002)
ℓX1ℓR1	0.04	0.03	(0.002)
ℓX1ℓR2	-0.04	-0.03	(0.002)
ℓX1ℓR3	-0.0004	-0.001	(0.0002)
ℓX2ℓY1	0.03	0.02	(0.002)
ℓX2ℓY2	-0.03	-0.02	(0.002)
ℓX2ℓR1	-0.04	-0.03	(0.002)
ℓX2ℓR2	0.04	0.03	(0.002)
ℓX2ℓR3	0.0004	0.001	(0.0002)
ℓY1ℓY1	4.32	3.09	(0.54)
ℓY1ℓY2	-3.56	-3.98	(0.57)
ℓY1ℓR1	-7.89	-5.63	(1.06)
ℓY1ℓR2	1.82	2.49	(0.57)
ℓY1ℓR3	1.10	1.03	(0.06)
ℓY2ℓY2	-2.75	-2.67	(0.23)
ℓY2ℓR1	5.20	5.59	(0.57)
ℓY2ℓR2	4.37	4.15	(0.47)
ℓY2ℓR3	-0.44	-0.34	(0.05)
ℓR1ℓR1	3.53	2.47	(0.52)
ℓR1ℓR2	-3.56	-4.22	(0.58)
ℓR1ℓR3	-0.94	-0.81	(0.06)
ℓR2ℓR2	-1.62	-1.45	(0.24)
ℓR2ℓR3	0.48	0.34	(0.05)
ℓR3ℓR3	-0.08	-0.08	(0.003)

Standard errors in parentheses.

Table 5
Descriptive Statistics for Inefficiency Measures

	Technical τ	Allocative κ	Scale ϵ
Total School Districts			
Mean	0.73	1.02	0.89
Std. Deviation	0.06	0.03	0.21
Minimum	0.58	1.00	0.35
Maximum	1.00	1.18	1.00
N	303	303	303
Inefficient School Districts			
	$\tau<1$	$\kappa>1$	$\epsilon<1$
Mean	0.72	1.03	0.50
Std. Deviation	0.05	0.02	0.07
Minimum	0.58	1.01	0.35
Maximum	0.89	1.18	0.65
N	300	207	66

Table 6
The Pearson Correlation Between School Efficiency and Competition

	Inefficiency Measures		
	Technical τ	Allocative κ	Scale ϵ
Competition Measures			
Market = Metropolitan Area			
Herfindahl Index	-0.047	0.014	-0.039
Concentration Ratio	-0.009	-0.005	-0.105
Market Share	-0.133	-0.095	-0.105
Number of observations	201	201	201
Market = County			
Herfindahl Index	-0.116*	0.069	-0.059
Concentration Ratio	-0.107	0.129*	-0.028
Market Share	-0.173*	0.047	-0.029
Number of observations	303	303	303

*Indicates statistical significance at the 5% confidence level.

Table 7
Analysis of Variance

	Inefficiency Measures					
	Technical		Allocative		Scale	
	$\tau=1$	$\tau<1$	$\kappa=1$	$\kappa>1$	$\epsilon=1$	$\epsilon<1$
Competition Measures						
Market = Metropolitan Area						
Herfindahl Index	23.8	20.1	20.6	19.9	20.0	21.2
F-value	0.22		0.12		0.27	
Concentration Ratio	72.4	65.5	66.1	65.3	64.8	69.0
F-value	0.59		0.13		2.16	
Market Share	16.0	11.3	11.4	11.4	12.2	7.7
F-value	0.21		0.00		2.09	
Number of observations	3	198	69	132	164	37
Market = County						
Herfindahl Index	39.9	37.2	36.1	37.7	36.4	40.2
F-value	0.04		0.29		1.36	
Concentration Ratio	84.4	84.5	82.6	85.3	84.1	85.6
F-value	0.00		2.53		0.52	
Market Share	39.2	34.8	30.9	36.7	34.1	37.6
F-value	0.06		2.23		0.65	
Number of observations	3	303	96	207	237	66

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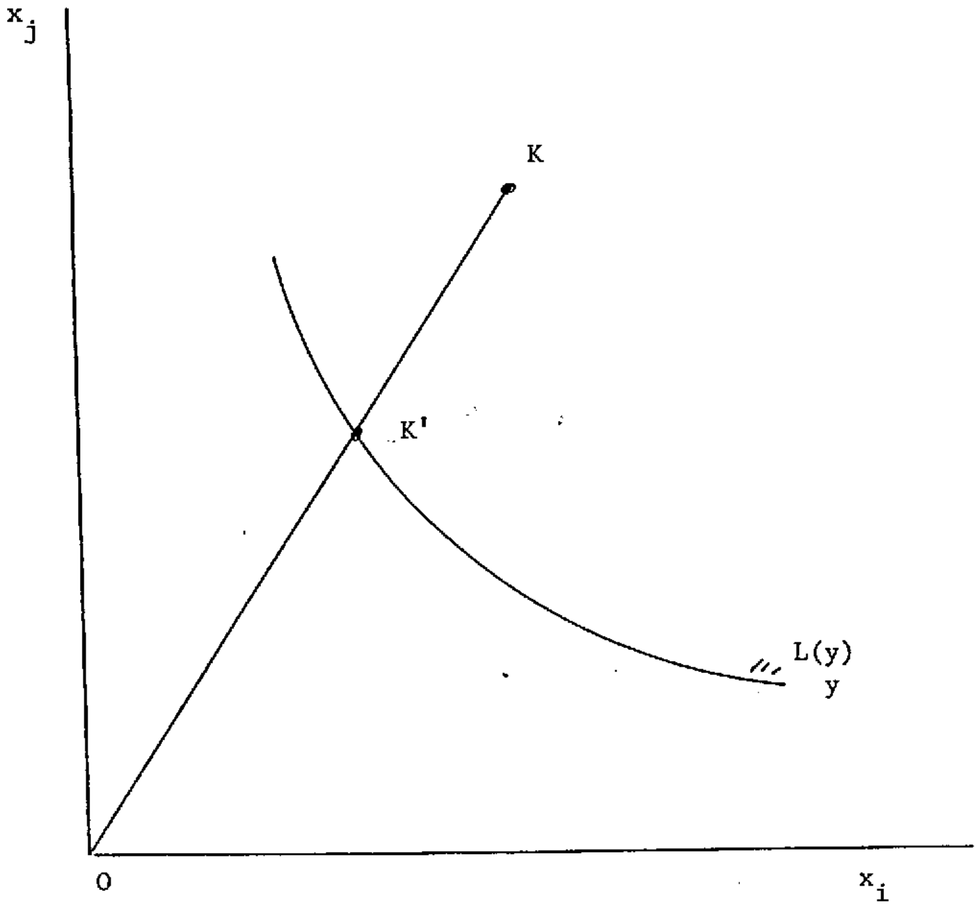
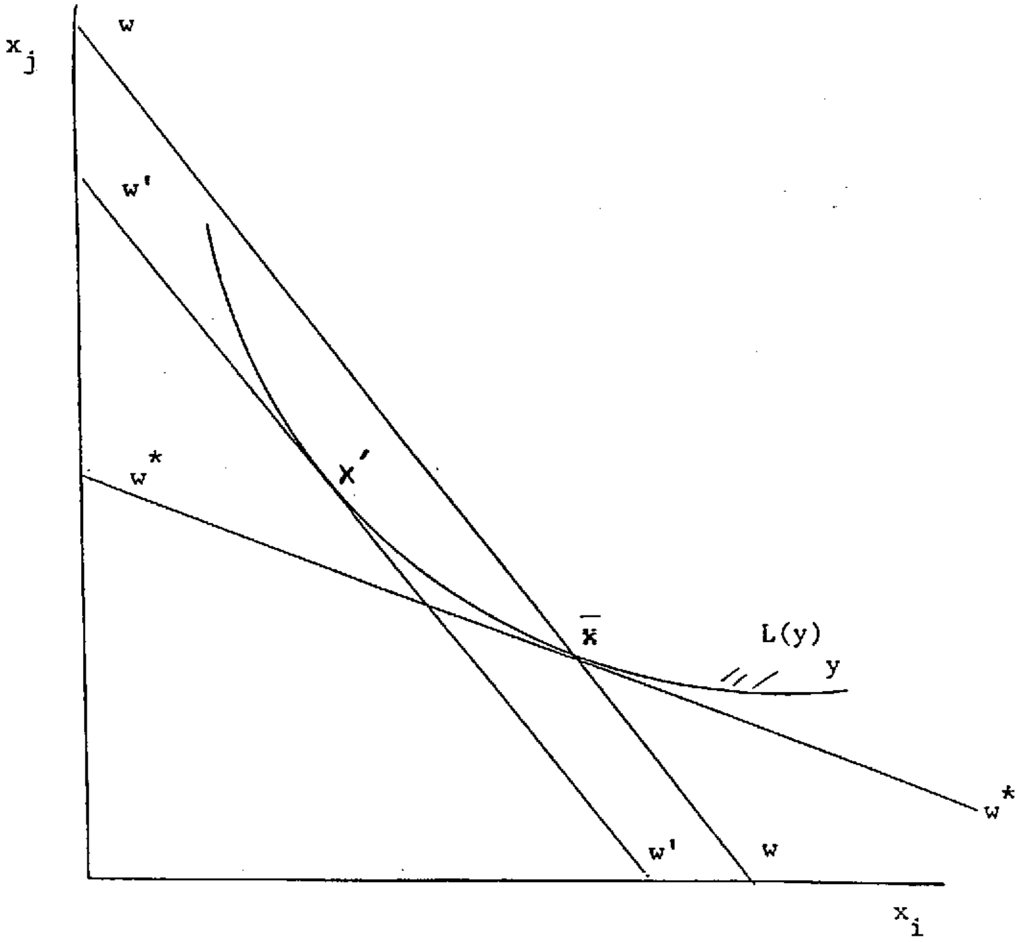
Figure 1



Input Distance Function: $D(y^K, x^K) = OK/OK'$

Figure 2



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