The Relative Efficiency of Charter Schools: A Cost Frontier Approach

Revised June 2011

by

Timothy J. Gronberg[a]
Department of Economics
4228 TAMU
Texas A&M University
College Station, TX 77843-4228
tjg@econmail.tamu.edu
979-845-8849

Dennis W. Jansen
Department of Economics
4228 TAMU
Texas A&M University
College Station, TX 77843-4228
dennisjansen@tamu.edu
979-845-7375

and
Lori L. Taylor*
The Bush School of Government and Public Service
4220 TAMU
Texas A&M University
College Station, TX 77843-4220
lltaylor@tamu.edu
979-458-3015

[a] Corresponding author

Abstract

Charters represent an expansion of public school choice, offering free, publicly funded educational alternatives to traditional public schools. One relatively unexplored research question concerning charter schools asks whether charter schools are more efficient suppliers of educational services than are traditional public schools. The potential relative efficiency advantage of charters vis-a-vis traditional publics is one of the mechanisms that supports the hypotheses that charters could improve performance for their students while using the same or fewer resources, and that the systemic effect of charters could lead to improved outcomes for traditional public students without requiring an increase in education sector resources.

In this paper, we provide evidence as to the cost efficiency of charter schools relative to traditional public schools, and explore the extent to which those differences are attributable to differences in hiring and compensation practices, or to differences in the length of time a campus has been operating. We generate estimates of efficiency using a stochastic cost frontier approach. We estimate a translog stochastic cost frontier model using panel data for charter campuses and traditional public campuses in Texas over the five-year period 2005-2009.

Our main findings suggest that charter schools are able to produce educational outcomes at lower cost than traditional public schools—probably because they face fewer regulations—but are not systematically more efficient relative to their frontier than are traditional public schools.

JEL Classification: I22, H75
Keywords: charter schools; costs; school choice; efficiency; teacher salaries

1. Introduction

Public schools in high-poverty neighborhoods are often characterized as substandard educational environments. These schools joust with the challenges of attracting high-quality teachers and successfully educating poor and minority students (U.S. Department of Education, 2007). The concept of charter schools emerged in response to these challenges. Charters represent an expansion of public school choice, offering free, publicly funded educational alternatives to traditional public schools. Charter schools are allowed to operate free from many of the rules and regulations that apply to traditional public schools, although they remain subject to academic and fiscal accountability to state governments. In principle, charters are also held tightly accountable by parents who are evaluating their charter choice relative to their guaranteed outside option, a seat in a traditional public school.

Charter schools have been offered to certain students and families in the United States as an alternative to their traditional neighborhood public schools since 1991. In 2009, more than 4,700 charter schools enrolled over 1.4 million children in 40 states and in Washington DC, and queues for admission to charter schools are common (Center for Research on Education Outcomes [CREDO], 2009).

Three first order research questions are raised by the emergence of the charter school sector. First, do charter schools improve academic achievement for their students? That is, does the expansion of choice lead to improved outcomes for the choosers? The best of the quasi-experimental studies utilize panel data on individual student performance to estimate student fixed-effect education production models of test score improvements to generate an estimated charter school impact. The summary evidence from these studies is that there is no systematic positive or negative impact of charters on charter subscribers and that the size of the estimated effects, independent of direction, is small.[1] The results from a small number of studies that exploit randomization of charter assignment through lottery allocations of charter seats in the presence of excess demand find positive and larger charter school impacts of charter student achievement,[2] but charter schools with a waiting list large enough to support such an analysis may be systematically different from the typical charter school.

The second question asks: Does the presence of charter schools lead to improved achievement for traditional public school students? If the entry of charter schools leads to changes in performance among students who remain in traditional public schools, then the systemic effect of charters can be much larger than the direct effect. Whether the spillover effects are positive or negative is, however, a nontrivial issue at both the theoretical and empirical levels. Results from the small set of studies that use panels of student-level data to assess the impact of charter competition on traditional public school performance are similar to those for the impact of charters on charter students. The estimated impact of charter competition is sometimes positive, sometimes negative, but always small.[3]

There is, however, a third major and relatively unexplored research question concerning charter schools: Are charter schools more efficient suppliers of educational services than are traditional public schools? The potential relative efficiency advantage of charters vis-a-vis traditional publics is one of the mechanisms that support the hypotheses that charters could improve performance for their students while using the same or fewer resources, and that the systemic effect of charters could lead to improved outcomes for traditional public students

---

[1] Booker et al. (2007) find that charter schools outperform traditional public schools, but other researchers (e.g. Hanushek et al. 2005, Bifulco and Ladd 2006, Sass 2006, Zimmer et al., forthcoming, or Carnoy et al. 2005) find that charter school students perform no better—and in some cases worse--than demographically comparable students in traditional public schools. For a complete review of the literature, see Gronberg and Jansen (2009) or Zimmer et al. (forthcoming).

[2] For example, see Hoxby and Rockoff (2004), Hoxby and Murarka (2009), or Abdulkadiroglu et al. (2009).

[3] For example, see Booker et al. (2008), Sass (2006), Bettinger (2005) or Ni (2009).

without requiring an increase in education sector resources. The fundamental maintained hypothesis is that traditional public school suppliers may not be cost efficient, perhaps due to the weak incentive environment within which they operate. Charter suppliers can arbitrage the differential between expenditure and (minimum) cost to produce competitive quality seats. If the entry of charter schools generates a behavioral response from traditional public suppliers that moves them towards their cost frontier, then across-the-board improvements in outcomes are possible, while holding total sectoral spending constant. Differential cost efficiency seems to be a fundamental feature of informal theorizing about charter schools, yet the evidence supporting the existence of such a differential is lacking. While the efficiency of public schools has been widely studied (e.g., Gronberg et al. 2006, Primont and Domazlicky 2006, Grosskopf and Moutray 2001 or Conroy and Arguea 2008), the evidence on the relative efficiency of charters is sparse. We are aware of only a single study on the subject by Grosskopf et al. (2009); they find evidence that charter schools are significantly more efficient than traditional public schools.

In this paper, we provide evidence as to the cost efficiency of charter schools relative to traditional public schools, and explore the extent to which those differences are attributable to differences in hiring and compensation practices, or to differences in the length of time a campus has been operating. We generate estimates of efficiency using a stochastic cost frontier approach. We estimate a translog stochastic cost frontier model using panel data for charter campuses and traditional public campuses in Texas over the five-year period 2005-2009.

2. The Texas Charter School Sector

In 1995, the 74th Texas Legislature authorized the State Board of Education (SBOE) to establish charter schools in the state. Texas charter schools are exempt from many of the laws and rules that apply to other public schools. The increased degrees of freedom are designed to encourage innovation in educational techniques. The reduction in the regulation of inputs and production processes is coupled with careful monitoring of outputs. Like other public schools in Texas, charter schools are monitored and accredited under the statewide testing and accountability system.

Texas Education Code (TEC) §12.001 outlines five purposes for the creation of public charter schools: (a) to improve student learning, (b) to increase the choice of learning opportunities within the public school system, (c) to create professional opportunities that will attract new teachers to the public school system, (d) to establish a new form of accountability for public schools, and (e) to encourage different and innovative learning methods. In exchange for the increased flexibility offered to them, charter schools are held accountable to student achievement goals.

There are two basic types of charters in Texas--district or campus charters, and open-enrollment (OE) charters.[4] District charters are operated by traditional public school districts. OE charters may be operated by institutions of higher education, governmental entities, or non-profit corporations. The state maintains authority over OE charter schools, with the contract being between the State Board of Education and the charter school operator. OE charter schools may draw their enrollment from across school district lines and many operate multiple campuses. Like traditional public school districts, OE charters may not charge tuition. Unlike traditional school districts, OE charters may operate in more than one metropolitan area, may serve only a subset of grades, and may place limits on the number of children allowed to enroll.[5]

---

[4] Under Texas law, there can also be home rule charters and college or university charters. The only functional difference between a college or university charter and the other OE charters is that the state has no limit on the number of college and university charters whereas there is a limit on the number of OE charters that can be issued. We treat the three college or university charter schools as OE charters for the purposes of this analysis. There are no home rule charters.

[5] Only OE charter schools with the appropriate provisions in their charter may operate in multiple metropolitan areas. There are 23 charter schools with campuses in more than one metropolitan area.

OE charter schools are, by far, the most prevalent type of charter school, and we will focus our study on them. During the inaugural year of charter schools, 16 OE charter campuses opened their doors in the 1996-97 school year and another 3 opened the following year. The number of OE charter campuses more than tripled during the 1998-99 school year (to 66) and expanded to 176 the following year. For the 2008-09 school year, there were 436 OE charter school campuses operating in Texas (Figure 1).

The growth in OE charter school enrollment is striking. The number of students attending OE charter campuses increased from 2,412 in 1996-97 to 102,249 in 2008-09. Over the last 10 years (from 1998-99 to 2008-09), the number of students attending Texas OE charter campuses grew by 736.3%, while enrollment in other Texas public schools grew by only 17.6%. The line in Figure 1 illustrates the rapid growth in OE charter school enrollment.

The 436 OE charter school campuses serve many different grade levels. Table 1 provides information about the composition of OE charter school campuses. As the table illustrates, a disproportionate number of OE charter campuses are classified as alternative education campuses (AECs). AECs are campuses that (1) are dedicated to serving students at risk of dropping out of school; (2) are eligible to receive an alternative education accountability (AEA) rating; and (3) register annually for evaluation under AEA procedures (TEA 2009). Twenty-two of the 24 AECs that are either elementary or early elementary schools are OE charter campuses. More than half of the residential AECs in Texas are OE charter school campuses, and nearly 12 percent of the OE charter campuses are residential. Because they are obviously different from other campuses, we exclude all alternative education campuses from this analysis.

2.1 Student Demographics

As illustrated in Table 2, the students who attend non-alternative OE charter schools in Texas are systematically different from those who do not. Regardless of grade level, non-alternative OE charter schools served a student population that was disproportionately Black, and low income, with a significantly smaller share of special education students.[6] At the elementary level, OE charter schools also had a significantly smaller share of limited English proficient students than did other public schools.

There were also significant differences between OE charter schools and other public schools with respect to the share of students identified as at risk of dropping out of school. Students are identified as "At Risk" based on statutory criteria including poor performance on standardized tests, a history of being held back in school, limited English proficiency, pregnancy, homelessness, placement in an alternative education program, or residence in a residential placement facility (AEIS Glossary). At both the elementary and the non-elementary levels, the share of students who were classified as "At Risk" was significantly lower at the non-alternative OE charter schools than it was at the non-alternative traditional public schools.

2.2 Funding

The finance mechanisms for OE charter schools and for traditional school districts are quite different. OE charter schools do not have a tax base from which to draw funds and are therefore solely dependent on state and federal transfers, charitable donations, and other non-tax

---

[6] It is also likely that the mix of special education students differs between traditional public schools and charter schools, and that traditional public school districts have a higher proportion of high-needs special education students. This could make traditional public school districts appear more inefficient because it would lead to greater costs and no change in measured output quality. On the other hand, differences in the mix of special education students will not necessarily bias our test result measure, because many special education students, especially those severely challenged with learning disabilities, have historically been exempt from inclusion in standardized testing, and because our test result measure compare students only with other students who had the same pretest score.

revenues such as food service activity. Traditional school districts receive funds from their own local tax base, as well as all of the sources available to OE charter schools.

Texas' school finance formula heavily influences funding levels for both OE charter schools and traditional school districts. The funding formula guarantees each OE charter school and traditional school district a minimum level of revenue per pupil and directs additional revenues to charter schools and traditional school districts with more students participating in special education, career and technology education, bilingual/ESL education, state compensatory education, and/or gifted and talented education programs. OE charter schools and traditional school districts that choose to provide transportation to students receive additional state funds.

Traditional school districts—and only traditional school districts—receive a number of additional funding adjustments. Traditional school districts that are small (those with average daily attendance below 1,600) and midsized (those with average daily attendance below 5,000) receive the small and midsized funding adjustments. All traditional districts have a cost-of-education index (CEI) value that is used to adjust funding upward in high cost areas.[7] Traditional districts may receive additional funding if they choose to levy a higher enrichment tax rate. They are also eligible to participate in programs that assist with facilities funding.[8]

OE charter schools have neither a CEI nor an enrichment tax rate and are not eligible for the district size adjustments or the facilities aid programs. For the 65 OE charter schools that began operating after September 1, 2001, state aid in 2008-09 was based on the statewide average values for the CEI, the small and midsize district adjustments, and the enrichment tax rate. For the 139 OE charter schools that began operating on or before September 1, 2001, 60% of their state aid in 2008-09 was based on those statewide average values, but 40% of their state

[7] For more on the Texas CEI, see Alexander et al. (2000) and Taylor et al (2002).
[8] Those programs are the Instructional Facilities Allotment program and the Existing Debt Allotment program. It is particularly important to note that charter schools in Texas do not have access to these facilities funding programs.

aid was based on the CEIs, size adjustments, and enrichment tax rates of the traditional districts their students would otherwise attend.

Figure 2 illustrates per pupil revenues and operating expenditures for OE charter schools and traditional school districts.[9] The solid lines indicate revenues and expenditures for traditional school districts; the dashed lines indicate revenues and expenditures for OE charter schools. All sources of revenue—including charitable donations and federal grants—have been included in this analysis and are reflected in this figure.

As the figure shows, operating expenditures per pupil have been very similar across the two types of districts, whereas per pupil revenues have been dissimilar. In 2008-09, OE charter schools received an average of $9,654 in revenues and spent $8,700 per pupil on operations, while traditional school districts received $10,281 and spent $8,490.

In 2008-09, OE charter and traditional school districts received similar amounts of federal funding per pupil. OE charter schools received a larger share of revenue from the state and a smaller share from local sources (e.g., charitable donations, local taxes, and other local sources) than did other school districts. Most of the local revenue for traditional districts came from local taxes. Approximately half of the local revenue for OE charter schools came from charitable donations. However, that charitable revenue was not evenly distributed across the OE charter schools in the state. Most OE charter schools (80%) received less than $100 per pupil in charitable donations in 2008-09, while a handful of OE charter schools received more than $2,000 per pupil. For example, KIPP Aspire Academy reported more than $11,000 per pupil in charitable donations in 2008-09.

[9] Data on revenues and expenditures come from TEA's Public Education Information Management System (PEIMS). Charter schools and traditional public school districts are required to report all revenues and expenditures by function (instruction, campus administration, etcetera), object (payroll, rent, etcetera) and fund(charitable donations, state funding formula, federal Title I funding, etcetera). The data are available for download at http://www.tea.state.tx.us/index2.aspx?id=2147494789

Although the level of operating expenditures per pupil was very similar between OE charter schools and traditional public schools, the pattern of expenditures was very different. On average, OE charter schools spent significantly more than traditional school districts on non-personnel items like rent and supplies, and spent significantly less than traditional districts on instructional and non-instructional personnel. (See Table 3.)

3. The Cost Function Model

Schools produce education outcomes using both input factors that are purchased (for example, teachers and other personnel) and environmental input factors that are not purchased (for example, student skills acquired in an earlier grade). They must take the quantities of environmental inputs as given, so we treat them as quasi-fixed factors in our analysis. Thus, we model educational cost as a function of the quantity and quality of outcomes produced, the prices of variable inputs and the quantities of the environmental factors that directly influence the education production process.

Our baseline model uses a (modified) translog stochastic frontier specification. This model nests the popular Cobb-Douglas as a special case, as well as the modified Cobb-Douglas specification including a limited set of quadratic terms that has been used by Imazeki and Reschovsky (2004), among others. It also nests the classical (non-frontier) linear regression specification of the translog (if the one-side error term is restricted to be identically zero).

We model school expenditures per pupil as a function three output indicators (q), two measures of input prices (w) and five environmental factors (x). To enhance the flexibility of the specification, we also include year and metropolitan area fixed effects (which are not indicated in equation (1). Formally, our model is:

$$\ln(E_i) = a_0 + \sum_{j=1}^{3} a_j q_j + \sum_{j=1}^{2} b_j w_j + \sum_{j=1}^{5} c_j x_j + 0.5\sum_{j=1}^{3}\sum_{k=1}^{3} d_{jk} q_j q_k$$
$$+ \sum_{j=1}^{3}\sum_{k=1}^{2} e_{jk} q_j w_k + 0.5\sum_{j=1}^{2}\sum_{k=1}^{2} f_{jk} w_j w_k + \sum_{j=1}^{5}\sum_{k=1}^{2} g_{jk} x_j w_k \quad (1)$$
$$+ \sum_{j=1}^{3}\sum_{k=1}^{5} h_{jk} q_j x_k + 0.5\sum_{j=1}^{5}\sum_{k=1}^{5} m_{jk} x_j x_k + k_6 x_1^2 + v_i + \mu_i$$

where v_i is a random noise component (representing an exogenous random shock, such as a rainy testing day), and u_i is a one-sided error term that captures inefficiency.[10] We impose the usual symmetry restrictions ($d_{ij} = d_{ji}$, $f_{ij} = f_{ji}$, and $k_{ij} = k_j$) and assume that the one-sided error u_i has a half-normal distribution. Inefficiency increases cost above minimum cost, so $u_i \geq 0$, and cost efficiency is defined as $\exp(-u_i) \leq 1$.

The stochastic frontier methodology is particularly well-suited to the analysis of educational cost functions because the literature strongly suggests that public schools are inefficient. The stochastic frontier approach allows the data to reveal information about the degree of cost inefficiency while identifying properties of the true cost function. The advantages and the challenges of applying the stochastic frontier methods to school cost function estimation are discussed in a recent paper by Gronberg, Jansen, and Taylor (2011a).

The stochastic cost frontier framework can accommodate impacts of exogenous environmental factors on efficiency via modeling of the one-sided error term, u. In particular, we can specify that

$$u = u(x, \delta) \text{ with } u \geq 0 \quad (2)$$

where x is a vector of environmental efficiency factors and δ is a parameter vector. Wang and Schmidt (2002) argue that an attractive specification for (2) is of the form

$$u(x, \delta) = h(x, \delta)u^*, \quad (3)$$

[10]To accommodate the extraordinary range of this variable and to enhance the flexibility the model, we also include the cube of the first environmental factor—school district enrollment.

where $h(x, \delta) \geq 0$ and where u* is distributed independent of x. Wang and Schmidt refer to this condition as the scaling property and the distribution u* as the basic distribution. In this paper we will assume particular functional forms for h(•) and u*

$$u_i = (\delta x_i)u_i^* \text{ with } u_i^* \text{ i.i.d. } N(0, 1)+ \quad (4)$$

Our final model thus consists of equations (1) and (4).

Because school quality is frequently thought of as a choice variable for school district administrators, the possible endogeneity of school quality indicators is a common concern for researchers estimating educational cost functions. (For example, see the discussion in Duncombe and Yinger 2011, 2005, Imazeki and Reschovsky 2004 or Gronberg, Jansen and Taylor 2011a.) Unfortunately, the econometric literature provides little guidance as to the proper way to address these concerns in a stochastic frontier setting. Furthermore, the translog specification means that not only do we need instruments for the two quality indicators we also need instruments for all of the quality interaction terms—a total of 25 variables in all. The large number of potentially endogenous variables compounds the usual problems associated with weak instruments.[11]

Following the literature, we explored using likely determinants of the local demand for education—the percent of the adult population with at least a bachelors' degree, the percentage of households with school age children, the percentage of the population over age 65, the percentage of households with school age children and the percentage of households that are owner occupied—and their interactions with the exogenous variables as potential instruments for the school quality indicators and their interactions with the exogenous variables. We also explored using two measures of yardstick competition—the share of students passing the Texas

[11] The references on weak instruments include classic early papers such as Nelson and Startz (1990) and more recent papers on constructing confidence intervals with weak instruments such as Staiger and Stock (1997) and Zivot, Startz and Nelson (1998). Murray (2006) has a fairly recent survey paper on instruments.

Assessment of Knowledge and Skills (TAKS) in reading and in mathematics in surrounding districts two years previously—and their interactions as possible instruments. No combination of potential instruments passed a weak instruments identification test (based on the Cragg-Donald Wald F statistic from traditional, two-stage least squares estimation). Because weak instruments are often worse than no instruments at all, we treat all of the independent variables as exogenous in our estimation.[12]

4. The Data

The data for our analysis come from administrative files and public records of the Texas Education Agency and cover the five-year period from 2004-05 through 2008-09. The unit of analysis is the metropolitan area campus, and the analysis includes all standard accountability campuses with complete data during the analysis period. Alternative education campuses have been excluded from the analysis as have the 11 standard accountability charter campuses outside of metropolitan areas. Table 1 provides descriptive statistics on the variables used in this analysis.

4.1 The Dependent Variable

The dependent variable used in the analysis is the log of actual current, per-pupil operating expenditures excluding food and student transportation expenditures. As in Imazeki and Reschovsky (2004) and Gronberg et al (2004 and 2005), we exclude transportation expenditures on the grounds that they are unlikely to be explained by the same factors that explain student performance, and therefore that they add unnecessary noise to the analysis. We exclude food expenditures on similar grounds. Because not all school district expenditures are allocated to the campus level, and the share of allocated expenditures varies from district to district, we distribute

[12] We note that this approach was also taken in Gronberg, Jansen and Taylor (2011b).

unallocated school district expenditures to the campuses on a per pupil basis. Per-pupil operating expenditures below $3,000 or above $30,000 were deemed implausible and treated as missing.

We note that the dependent variable includes all operating expenditures in the designated categories, regardless of the sources of revenue. Charitable donations, federal grants, local tax revenues and state funding formula aid are all included.

We also note that the dependent variable includes all types of operating expenditures in the designated categories. Thus, it includes not only direct salary expenditures, but also contributions to the statewide teacher pension system, payments for group health and life insurance, and other outlays for employee benefits. It includes payments for contracted workers as well as employees. It also includes payments for rents, utilities and supplies. (For more on the types of operating expenditures see the composition of expenditures by object in table 3.) It does not include capital outlays or debt service.

4.2 Outputs

As noted above, our independent variables include both a quantity dimension of output — the number of students served — and two quality dimensions. We measure quantity as the number of students in fall enrollment for the campus. The enrollment variable ranges from 29 to 5,094, with a mean of 731 and a median of 622.

We measure quality using a normalized gain score indicator of student performance on the TAKS.[13] Every year, Texas administers tests of student achievement in mathematics and

[13] Our use of standardized test scores as an indicator for the quality of district output – the quality of the educational experience districts offer to students – is mandated by data availability. While standardized tests provide a measure of student achievement, they typically measure minimal expected learning, and emphatically do not measure deeper learning or student performance at the highest end of the achievement scale.

reading/language arts in grades 3-11.[14] We have data on the TAKS scores of individual students in reading and math from 2003 through 2009 and use those data to generate our measure of school quality. Although we recognize that schools produce unmeasured outcomes that may be uncorrelated with math and reading test scores, and that standardized tests may not measure the acquisition of important higher-order skills such as problem solving, these are the performance measures for which districts are held accountable by the state, and the most common measures of school district output in the literature (e.g. Gronberg, Jansen and Taylor 2011a, and 2011b or Imazeki and Reschovsky 2004). Therefore, we rely on them here.

As an approach to dealing with mean reversion, we normalize the annual gain scores in each subject a la Reback (2008). In this normalization, we use test scores for student (i), grade (g), and time or year (t), denoted as S_{igt}. We measure each student's performance relative to others with same past score in the subject as:

$$Y_{igt} = \frac{S_{igt} - E(S_{igt} \mid S_{i,g-1,t-1})}{[E(S_{igt}^2 \mid S_{i,g-1,t-1}) - E(S_{igt} \mid S_{i,g-1,t-1})^2]^{0.5}} \qquad (5)$$

In calculating Y_{igt} for math, we calculate the average test score in math at time t, grade g, for students scoring $S_{i,g-1,t-1}$ in math at time t-1, grade g-1. Thus, for example, we consider all tenth-grade students with a given ninth-grade score in math, and calculate the expected score on the tenth-grade test as the average math score at time t for all tenth-grade students with that common lagged score. Our variable Y_{ijgt} measures individual deviations from the expected score, adjusted for the variance. This is a type of z-score. Transforming individual TAKS scores into z-scores allows us to aggregate across different grade levels despite the differences in the content of the various tests. We construct two measures of output—the campus average Y_{igt} in math, and the campus average Y_{igt} in reading/language arts.

[14] Tests in other subjects such as science and history are also administered, but not in every grade level.

4.3 Input Prices

Teachers are obviously the most important educational input, and one of the ways in which charter schools differ from traditional public schools is in their teacher hiring and compensation practices. Table 4 compares the mean salaries and demographic characteristics for charter school teachers with those for traditional public school teachers in Texas. As the table illustrates, charter schools pay much lower full-time-equivalent salaries, on average, than do traditional public schools. The lower salaries are at least partially explained by the fact that the average teacher in a charter school is less experienced, less highly educated and less likely to hold a teaching certificate than the average teacher in a traditional school district.[15]

If there were a teacher type that was hired by all charter schools and traditional public schools—say, for example, a teacher with a bachelor's degree from a selective university and two years of experience—then arguably we would be best served by using the wages paid to those teachers as our input price measure. However, it is impossible to identify a teacher type that is hired by all the charter schools and traditional public school districts under analysis, and any observed average wage—such as the average salary for beginning teachers—would reflect school and district choices about the mix of teachers to hire

Dealing with this source of potential endogeneity requires a wage index that is independent of school and district choices. To construct such an index, we developed a hedonic wage model for teacher salaries and used that model to predict the wages each school would have to pay to hire a teacher with constant characteristics.[16]

[15] Texas has a minimum salary scale for teachers that does not apply to charter schools. However, the salary scale is generally not binding for Texas' metropolitan districts either. Less than 0.3 percent of metropolitan area teachers in Texas received the state's minimum salary during the analysis period.

[16] We note that teachers in charter schools participate in the same statewide teacher retirement system as teachers in traditional public schools, and that years of service in the system are counted without regard as to whether the employer was a charter school or a traditional public school district. Thus, teachers can move from one traditional school district to another, or from a charter school to a traditional public school district without affecting their

The hedonic model is a very simple one, wherein wages are a function of labor market characteristics, job characteristics, observable teacher characteristics, and unobservable teacher characteristics. Formally, the specification can be expressed as:

$$\ln(W_{idjt}) = \alpha_i + D_{dt}\delta + T_{it}\gamma + \mu_j + \varepsilon_{idjt}$$

where the subscripts i,d,j and t stand for individuals, districts, labor markets and time, respectively, W_{idjt} is the teacher's full-time-equivalent monthly salary, D_{dt} is a vector of job and labor market characteristics that could give rise to compensating differentials, T_{it} is a vector of individual characteristics that vary over time, the μ_i are labor market fixed effects and the α_i are individual teacher fixed effects. Any time-invariant differences in teacher quality will be captured by the fixed effects.

Arguably, charter schools could differ from traditional public schools in the premium they pay for teacher characteristics, so the estimating equation becomes

$$\ln(W_{idjt}) = \alpha_i + \nu + D_{dt}\delta + T_{it}\gamma + C_t T_{it}\gamma_c + \mu_j + \varepsilon_{idjt}$$

where C_t is an indicator variable that takes on the value of one if a teacher is employed by a charter school in year t, and zero otherwise, the subscript c indicates the coefficient on the corresponding interaction term, and ν is the coefficient on a charter school intercept. If charter schools systematically pay a premium (or a discount) for observable teacher characteristics, then the elements of γ_c should be significantly different from zero.

The data on teacher salaries and individual teacher characteristics come from the Texas Education Agency (TEA) and Texas' State Board for Educator Certification (SBEC). The measure of teacher salaries that is used in this analysis is the total full-time equivalent monthly

---

pension eligibility or their credited years of service. Contributions to the teacher retirement system are a function of the salaries paid to individual teachers, so the price index for teacher salaries should be highly correlated with a price index for teacher salaries and benefits.

salary, excluding supplements for athletics coaching. The hedonic model includes controls for teacher experience (the log of years of experience, and the square of log experience) and indicators for the teacher's gender, race (black, Hispanic or Asian/Indian), educational attainment (no degree, master's degree or doctorate), teaching assignment (math, science, special education, health and physical education or language arts) and certification status (certified in any subject, and specifically certified in mathematics, science, special education or bilingual education). Only teachers with complete data who worked at least half time for a charter school or traditional Texas school district during the analysis period are included in the analysis. The hedonic wage analysis covers the same five year period as the cost-function analysis (2004–05 through 2008–09).

The job characteristics used in this analysis allow for teachers to expect a compensating differential based on student demographics, school size, school type or district size. The student demographics used in this analysis are the percentage of students in the district who are economically disadvantaged, limited English proficient, black and Hispanic. We measure school size as the log of average campus enrollment in the district. There are three indicators for school type (elementary schools, middle schools, high schools). The analysis also includes four indicators for school district size—one indicator variable for very small districts (those with less than 800 students in average daily attendance), one for small districts (those with at least 800, but less than 1,600 students), one for midsized school districts (those with at least 1,600 but less than 5,000 students) and one for very large school districts (those with more than 50,000 students in average daily attendance

In addition to the metropolitan area fixed effects, we include three indicators for local labor market conditions outside of education. We updated the National Center for Education

Statistics' Comparable Wage Index to measure the prevailing wage for college graduates in each school district (Taylor and Fowler, 2006). We include the Department of Housing and Urban Development's estimate of Fair Market Rents (in logs) and the Bureau of Labor Statistics measure of the metropolitan area unemployment rate,

Table 5 presents the coefficient estimates and robust standard errors for the hedonic wage model. As the table illustrates, there are systematic differences between OE charter schools and traditional public schools in the premiums paid for teacher characteristics. On average, even after adjustments for teacher, job and location characteristics, OE charter schools pay lower salaries than traditional public schools. Compared with other public schools, OE charter schools pay a larger premium for certified teachers, particularly those with bilingual/ESL or science certification, a smaller premium for health and physical education teachers, and a much larger premium for teachers with a bachelor's degree. There are no differences between OE charter schools and other public schools with respect to the premiums paid for advanced degrees.

OE charter schools also pay a much smaller premium for teacher experience than do traditional public school districts. Figure 3 illustrates the relationship between years of teaching experience and teacher salaries for OE charter and traditional public school districts. As the figure illustrates, salaries rise more rapidly with experience for beginning teachers in OE charter schools, but more slowly with experience for experienced teachers in OE charter schools. In other words, OE charter schools pay a much smaller premium for highly experienced teachers. We estimate that if traditional public schools had paid their teachers on the charter school salary schedule, spending on teacher payrolls in the state would have been 6 percent lower, all other things being equal.

The teacher salary index for each campus is based on the predicted wage for a teacher with zero years of experience and a bachelor's degree, holding all other observable teacher characteristics constant at the statewide mean, and suppressing any charter school differentials. Thus, the predicted wage for an OE charter school is the same as the predicted wage for an otherwise equal traditional public school. The predicted wage is then divided by the average predicted wage to yield the salary index.

As our measure of non-teacher price, we use an index of prevailing wages for high school graduates in each labor market that was developed by Taylor (2008) following the methodology in Taylor and Fowler (2006). The salaries of administrators and other professional staff are too highly correlated with those of teachers to include them separately in the model.

4.4 Other Environmental Factors

The model includes indicators for several environmental factors that influence district cost but which are not purchased inputs. Because previous researchers have found significant economies of scale in district-level cost functions (Andrews, Duncombe and Yinger 2002), we include the log of school district enrollment. To capture variations in costs that derive from variations in student needs, we include the percentages of students in each district who were limited English proficient (LEP), special education or economically disadvantaged students. To allow for the possibility that the education technology shifts according to the grade level of the school, we include indicators for elementary, middle and high schools. Finally, in some models, we include an indicator for whether or not the school is a charter school to allow for the possibility that the unregulated charter school technology is different from that of traditional public schools.

4.5 Efficiency Factors

The error terms for all frontier specifications depend on a number of factors that theory suggests may explain differences in school efficiency. We model the one-sided variance function as a linear combination of six indicator variables and two continuous variables. The first indicator variable takes on the value of one is the school is part of an OE charter district (and zero otherwise). It allows for the possibility that charter school efficiency may differ systematically from the efficiency of traditional public schools. The next two indicators are for size. One is for whether the school district has less than 1,600 students and the other is for whether a district has less than 5,000 students. These indicators were included because the small and midsized school adjustments in the finance formula could foster inefficiencies. The fourth indicator is an interaction between small school districts and the charter school indicator. This variable allows us to differentiate the effect of district size from any charter school effect.[17] The final two indicators allow for different efficiency of new entrants. One indicator is for whether the district is in its first year of operation, and the other is for whether the campus is in its first year of operation. These allow for inefficiencies arising from inexperience on the part of school and district personnel. The two continuous variables are time variables—one for charter schools and another for traditional public schools. These allow for different trends in charter and traditional school efficiency over time.

We model the two-sided variance as a function of quartile indicators for the number of students tested. This is included because measurement error is frequently a function of school size.

[17] All charter schools districts in Texas have less than 4,000 students, so it is not possible to include the interaction between the midsized district indicator and the charter school indicator.

5. Estimation Results

We estimated our model under several alternative assumptions, and marginal effects evaluated at the sample mean for three models are reported in Table 7. The first model assumes that OE charters and traditional public schools share a common cost frontier (i.e. a common cost function). In this specification the only difference between OE charters and other public schools is in the efficiency estimate, as we explicitly allow OE charters to have a different one-sided error term than other public schools. This model allows us to judge the relative efficiency of OE charters and other public schools assuming these schools share a common technology.

The second specification reported in Table 7 still estimates a common cost function but adds an indicator for OE charter schools to the explanatory variables in our modified translog cost function. In this case the charter school indicator is treated symmetrically with the indicators for elementary, middle, and high school campuses. That is, we interact the OE charter school indicator with all other variables in the model. This allows OE charter schools to differ somewhat from other public schools, while not estimating two distinct frontiers or cost functions.

The third specification reported in Table 7 is the traditional public school cost frontier from a model that estimates separate cost frontiers for charter and traditional public schools. Here we allow the translog cost frontier to differ completely between the two models, although we still estimate common features of the two-sided error distribution (including the year and metro area fixed effects), and we allow the one-sided error distribution to vary between charters and other public schools.

As the table illustrates, the models generally correspond to reasonable expectations. Math and reading output measures have positive and statistically significant impacts on cost.[18]

[18] Even in cases where the marginal effects are not statistically significant at the mean, we still reject the hypothesis that each quality indicator and all its interaction terms are jointly zero.

The salary indices have positive and statistically significant impacts on cost.[19] The school level indicators generally have the expected sign, and they indicate that elementary schools have a lower cost than middle schools (except at charters), and middle schools are lower cost than high schools. The student body characteristics we include – percent economically disadvantaged, percent limited English proficient, percent special education – are all associated with a higher average cost per student. Finally, campus enrollment at the mean has a negative impact on cost (after controlling for district enrollment, of course).

Table 8 reports efficiency estimates for the three models reported in Table 7. The top half of the table reports results for non-alternative campuses from traditional public school districts, while the bottom half reports results for non-alternative campuses from OE charter schools. It is clear that, as a group and regardless of specification, traditional public school campuses have a higher average efficiency compared to charter campuses. Looking a bit further, traditional public campuses have a tighter distribution of efficiency, a lower standard error and a higher minimum efficiency.

The results on efficiency can perhaps be seen best in a graph, and Figures 4 – 6 provide plots of the distribution of efficiency estimates for the common cost frontier specification (Figure 4), the charter as a characteristic specification (Figure 5), and the specification allowing separate cost functions for OE charter and other public schools (Figure 6). As Figure 4 illustrates, the mean and spread of the distribution is roughly similar for the two types of campuses, indicating that when we force OE charter and other public schools to have a common cost function we estimate charter and other public school efficiency to be similar. In Figure 5, when we begin to allow OE charters to have a different cost function than other public schools, we see that charters

[19] Although the marginal effect for the charter school model does not appear statistically significant at the mean, we reject the hypothesis that the teacher salary variable and all its interaction terms are jointly zero.

are estimated to be relatively less efficient, and the spread of efficiency measures at charters is noticeably larger than the spread at other public schools. In Figure 6, when we allow OE charter and other public schools to have completely separate cost functions, we continue to see that charters are on average less efficient relative to their frontier than are other non-alternative public schools, but the mean efficiency gap is more like that in Figure 4 than in Figure 5. We also see that charters continue to exhibit a greater range of estimated efficiencies, and a higher standard deviation.[20]

It is important to note that in Figure 5 and Figure 6 we are calculating efficiency relative to a frontier that differs between OE charter and other public schools. That is, OE charters have a lower estimated cost per student, and thus appear to be accessing a lower-cost technology for producing education. But OE charters are less efficient relative to their charter cost frontier than are traditional schools relative to their cost frontier.

Table 9 presents the estimated relationship between the one-sided errors and the model determinants of inefficiency. These are not coefficient estimates in the traditional sense. Rather, they represent the marginal effect of each variable on the standard deviation of the one-sided error. Nevertheless, a positive coefficient can be interpreted as indicating a factor that increases inefficiency, while a negative coefficient indicates a factor that decreases inefficiency.

As the table illustrates, there are significant differences in efficiency between charter and traditional school districts. Across all three specifications, small and midsized school districts are systematically less efficient than other districts. When we force the frontier to be the same for charters and traditional public school districts, we find that the one-sided error variance is smaller (i.e. efficiency is higher) for charter school districts with less than 1,600 students in

[20] As suggested by one of the referees, the smaller dispersion in the estimated efficiencies across public schools might be expected, given the common regulatory environment within which the traditional public schools operate.

average daily attendance (a category that includes most of the OE charter schools). However, when we allow the frontier to differ between charter and non-charter districts, we find that small OE charter school districts are significantly less efficient than other school districts of comparable size. In all cases, we find that midsized charter districts are significantly less efficient than small charter districts or midsized non-charter districts. We also find that charter districts in their first year of operation are significantly less efficient than other districts. On the other hand, there are no systematic differences in efficiency associated with new campuses, and no differences in the time trend of efficiency between charter and non-charter districts.

Finally, we would like to illustrate the nature of the differences in the cost functions for OE charter and other public schools. Figure 7 graphs cost per student to district enrollment, holding all variables constant at the charter means. For low values of district size, charters have a lower cost per student. As district size increases, our estimates indicate that charters eventually become more costly per student, but this part of our estimated cost function is unreliable, as no charter school has a district size above 4,000 students (8.3 in logs), so that the range to the right of 8 or so is outside our sample experience. We also an unusual initial region of the charter cost function for values of y below 4. There are only two OE charter districts (both single campuses) with fewer than 55 students. However, starting from y=4, we have declining costs for both charter and non-charter districts, with charter schools having lower costs than non-charter schools. Non-alternative charter schools reach the minimum per student costs at a district enrollment of 930 and then cost per student rises quickly with district size. Meanwhile non-charter districts have declining per student costs until (log) district enrollment exceeds 7.1 (1,200 students), at which point costs rise quite gradually. Again we emphasize that the shape of the cost function for charters is unreliable in the region about y=8 or so, because we have no observations on charters in that region.

Figure 8 graphs cost per student when charters are a characteristic of the cost function. Here charters are estimated to have lower costs throughout the observed range of district sizes, although again we note that there are no observations on charters with a district size above y=8.3.

As expected, there are a few important caveats to our analysis. First, the analysis applies only to non-alternative charter schools. Nearly half of the open-enrollment charter schools in Texas are alternative education campuses, and we have no information about the relative efficiency of alternative education charter schools. Second, the families of students make a conscious decision to attend charter schools instead of traditional public schools and charter schools may make a deliberate effort to attract students with specific demographic characteristics. As a result, charter school students may be systematically different from the students who remain in traditional public school districts. We address this concern as best we can by relying on school quality measures that are based on changes over time in the performance of individual students. However, our approach may not be sufficient to account for unobserved differences between OE charter and traditional public school students. Some of the differences in measured efficiency between OE charter and traditional public school districts may arise from differences in student and family inputs rather than from differences in the school districts. Finally, we note that our measures of school quality may not be capturing all of the important dimensions of school district output. Schools that appear relatively less efficient in this analysis may simply be producing outputs like art, music or athletics, that are costly to produce and uncorrelated with the basic academic outcomes measured here.

In the end, our results point to the interesting situation that charter schools have access to a lower cost technology that allows them to produce math and reading outcomes at a lower cost per student, at least in the relevant range. At the same time, charters are on average less efficient relative to their frontier than are non-charters relative to their frontier. We can only speculate on the reasons behind this finding. Possibly charters take advantage of their cost advantage by being less efficient and still providing lower cost education services than non-charters. Possibly charters face less competition from other charters, on average, than non-charters face from other non-charters and from charters themselves. The state of Texas limits the number of charters that it issues, making it more difficult for new charters to spring up and hence limiting competition among charters. This issue certainly bears further investigation in future research.

6. Conclusion

We investigated the relative efficiency of charter schools and traditional public schools over the period 2005-2009 in Texas. If we estimate a common cost frontier, we find that charter schools are more efficient than schools from traditional school districts of comparable size, but less efficient than the average non-charter campus. However, when we allow charter school districts to operate under a different educational technology, we find that the cost frontier is lower, but that charter schools are typically farther from that frontier than are traditional public schools. In other words, the evidence suggests that charter schools are able to produce educational outcomes at lower cost than traditional public schools—probably because they face fewer regulations—but are not systematically more efficient than traditional public schools.

7. References:

Abdulkadiroglu, A., Angrist, J., Cohodes, S., Dynarski, S., Fullerton, J., Kane, T. & Pathak, P. (2009). Informing the debate: Comparing Boston's charter, pilot and traditional schools. Report prepared for the Boston Foundation. Boston, MA (http://www.masscharterschools.org/advocacy/HarvardStudy_54pg.pdf).

Academic Excellence Indicator System (AEIS). (2009). *AEIS 2008-2009 Reports.* Austin, TX: Texas Education Agency (http://ritter.tea.state.tx.us/perfreport/aeis/).

Alexander, C. D., Gronberg, T. J., Jansen, D. W., Keller, H., Taylor, L. L. & Treisman, P. U. (2000). A study of uncontrollable variations in the costs of Texas public education: A summary report. Prepared for the 77th Texas Legislature, The Charles A. Dana Center, University of Texas – Austin, November.

Andrews, M., Duncombe, W., & Yinger, J. (2002). Revisiting economies of size in American education: Are we any closer to a consensus? *Economics of Education Review*, 21(3), 245-262.

Bettinger, E. P. (2005). The effect of charter schools on charter students and public schools. *Economics of Education Review*, *24* (2), 133–147.

Bifulco, R. & Ladd, H. F. (2006). The impacts of charter schools on student achievement: Evidence from North Carolina. *Education Finance and Policy*, *1* (1), 50–90.

Booker, T. K., Gilpatric, S. M., Gronberg, T. J. & Jansen, D. W. (2008). The effect of charter school competition on traditional public schools in Texas: Are children who stay behind left behind? *Journal of Urban Economics*, *64* (1), 123–145.

Booker, T. K., Gilpatric, S. M., Gronberg, T. J. & Jansen, D. W. (2007). The impact of charter school attendance on student performance. *Journal of Public Economics, 91 (5-6*), 849–876.

Carnoy, M., Jacobsen, R., Mishel, L. & Rothstein, R. (2005). The charter school dust-up: Examining the evidence on enrollment and achievement. Washington, DC: Economic Policy Institute.

Center for Research on Education Outcomes (CREDO). (2009). *Multiple choice: Charter school performance in 16 States*. Stanford, CA: Stanford University.

Conroy, S. J., & Arguea, N. M. (2008). An estimation of technical efficiency for Florida public elementary schools. *Economics of Education Review*, 27(6), 655-663.

Duncombe, W., Ruggiero, J., & Yinger, J. (1996). Alternative approaches to measuring the cost of education. In H. F. Ladd (Ed.) *Holding schools accountable: Performance-based reform in education.* Washington, DC: The Brookings Institution.

Duncombe, W.A. & Yinger, J. (2005). How much more does a disadvantaged student cost? *Economics of Education Review*, *24* (5), 513–532.

Duncombe, W.A. & Yinger, J. (2011). Are education cost functions ready for prime time? An examination of their validity and reliability. *Peabody Journal of Education*, *86* (1), 28-57.

Gronberg, T. J., Jansen, D. W. & Naufel, G. S. (2006). Efficiency and performance in Texas public schools. In T. J. Gronberg & D.W. Jansen (Ed.) *Improving school accountability: Checkups or choice*, vol. 14, *Advances in Applied Microeconomics*, Elsevier Science Press, pp. 81–101.

Gronberg, T. J., Jansen, D. W. & Taylor, L. L. (2011a). The adequacy of educational cost functions: Lessons from Texas. *Peabody Journal of Education, 86* (1), 3–27.

Gronberg, T., Jansen, D. W. & Taylor, L. L. (2011b). The impact of facilities on the cost of education. *National Tax Journal*, *64* (1), 193–218.

Gronberg, T. J, Jansen, D. W., Taylor, L. L. & Booker, K. (2004). School outcomes and school costs: The cost function approach. Texas Joint Select Committee on Public School Finance, Austin, TX; (http://bush.tamu.edu/research/faculty/TXSchoolFinance/).

Gronberg, T. J., & Jansen, D. W. (2009). *Charter schools: Rationale and research*. *Working Paper*. Columbia, MI: Show-Me Institute, University of Missouri.

Gronberg, T. J., Jansen, D. W., Taylor, L. L. & Booker, T. K. (2005). School outcomes and school costs: A technical supplement. *Texas Joint Select Committee on Public School Finance*, (Austin, TX, 2004). (http://bush.tamu.edu/research/faculty/TXSchoolFinance/).

Grosskopf, S., Hayes, K. J. & Taylor, L. L. (2009). The relative efficiency of charter schools. *Annals of Public and Cooperative Economics, 80* (1), 67–87.

Grosskopf, S., & Moutray, C. (2001). Evaluating performance in Chicago public schools in the wake of decentralization. *Economics of Education Review*, 20(1), 1-14.

Hanushek, E., A. Kain, J. F., Rivkin, S. G. & Branch, G. F. (2005). *Charter school quality and parental decision making with school choice. NBER Working Paper #11252.*

Hoxby, C. M. & Murarka, S. (2009). *Charter schools in New York City: Who enrolls and how they affect their student's achievement*. *NBER Working Paper #14852.* Cambridge, MA: National Bureau of Economic Research.

Hoxby, C. M. & Rockof, J. E. (2004). The impact of charter schools on student achievement. manuscript.

Imazeki, J., & Reschovsky, A. (2004). Is No Child Left Behind an un (or under) funded federal mandate? Evidence from Texas. *National Tax Journal*, 57(3), 571-588.

Murray, M. P. (2006). Avoiding invalid instruments and coping with weak instruments. *Journal of Economic Perspectives*, 20 (4), 111-132.

Nelson, C. R., & Startz, R. ( ) Some further results on the exact small sample properties of the instrumental variable estimator. *Econometrica*, 58 (4), 967-976.

Ni, Y. (2009). The impact of charter schools on the efficiency of traditional public schools: Evidence from Michigan. *Economics of Education Review*, 28(5), 571-584.

Primont, D. F., and Domazlicky, B. (2006). Student achievement and efficiency in Missouri schools and the No Child Left Behind Act. *Economics of Education Review*, 25(1), 77-90.

Reback, R. (2008). Teaching to the rating: School accountability and the distribution of student achievement. *Journal of Public Economics, 92,* (5-6), 1394–1415.

Sass, T. R. (2006). Charter schools and student achievement in Flordia. *Education Finance and Policy, 1 (*1), 91–122.

Staiger, D., and Stock, J. H. (1997). Instrumental variables regression with weak instruments. *Econometrica*, 65 (3), 557-586.

Taylor, L. L. (2008). Washington wages: An analysis of educator and comparable non-educator wages in the state of Washington. *Washington State Institute for Public Policy and the Joint Task Force on Basic Education Finance*.

Taylor, L. L., Alexander, C. D., Gronberg, T. J., Jansen, D.W. & Keller, H. (2002). Updating the Texas cost of education index. *Journal of Education Finance, 28* (2), 261–284.

Taylor, L. L. & Fowler, W.J. (2006). A comparable wage approach to geographic cost adjustment. National Center for Education Statistics Research and Development Report #2006-321.

Taylor L. L., Alford, B. L., Rollins, K. B., Brown, D. B., Stillisano, J. R. &Waxman, H. C. (forthcoming). *Evaluation of Texas charter schools 2009-10*, Report prepared for the Texas Education Agency, Austin, TX.

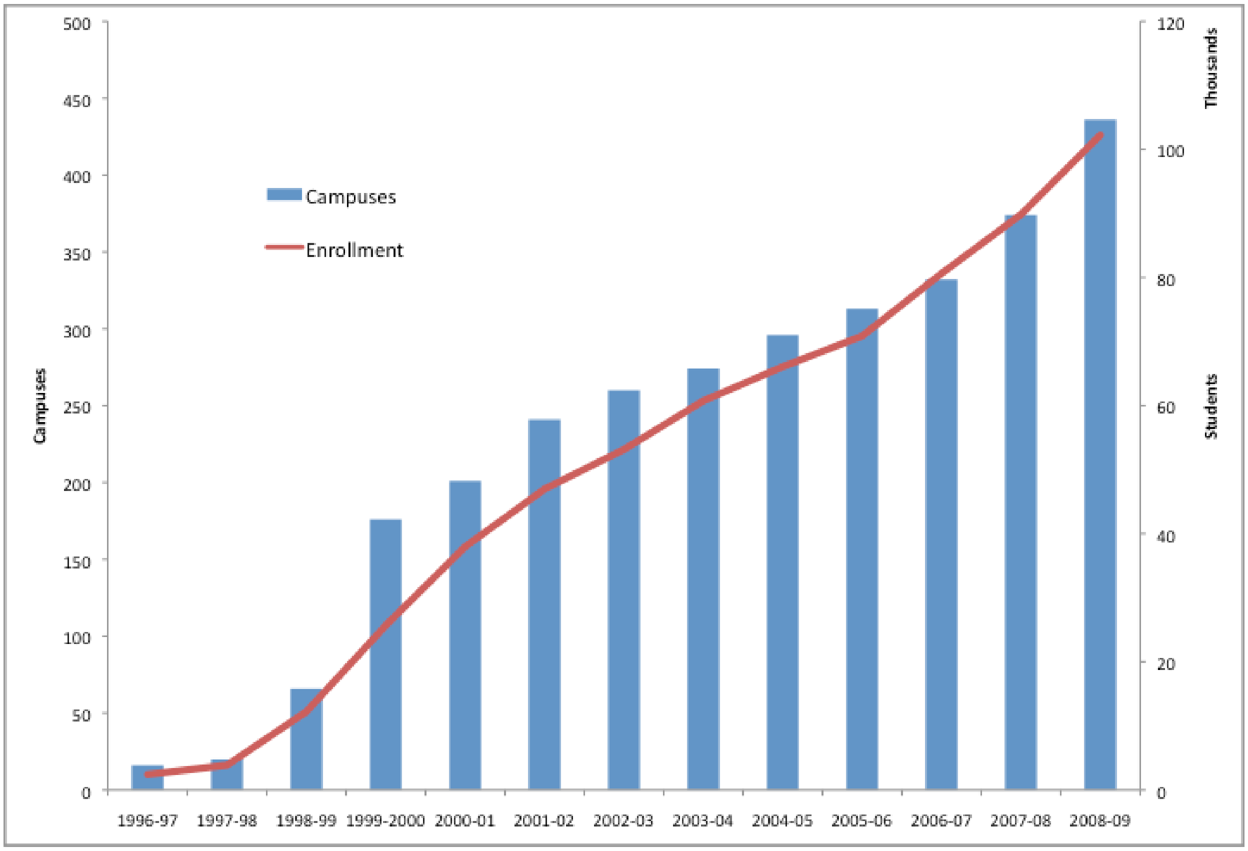
U.S. Department of Education. (2007*). K–8 charter schools: Closing the achievement gap*. Jessup, MD: Education Publications Center.

Wang, H. J. & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis, 18* (2), 129–144.

Zimmer, R., Gill, B., Booker, K., Lavertu, S. & Witte, J. (forthcoming) Examining charter student achievement effects across seven states. *Economics of Education Review*.

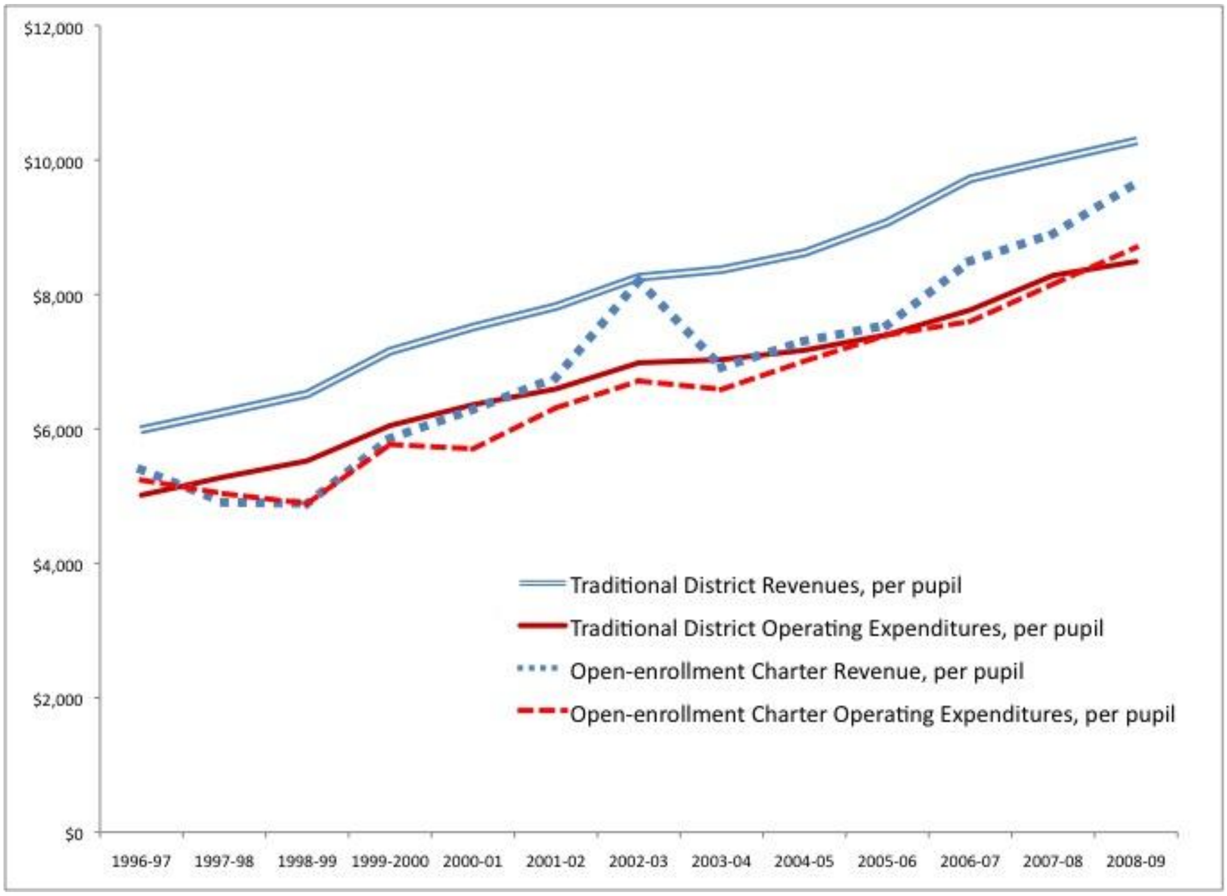
Zivot, E., Startz, R., and Nelson, C. R. (1998). Valid confidence intervals and inference in the presence of weak instruments. *International Economic Review* 39 (4), 1119-1144.

Figure 1
Growth in OE Charter Schools in Texas



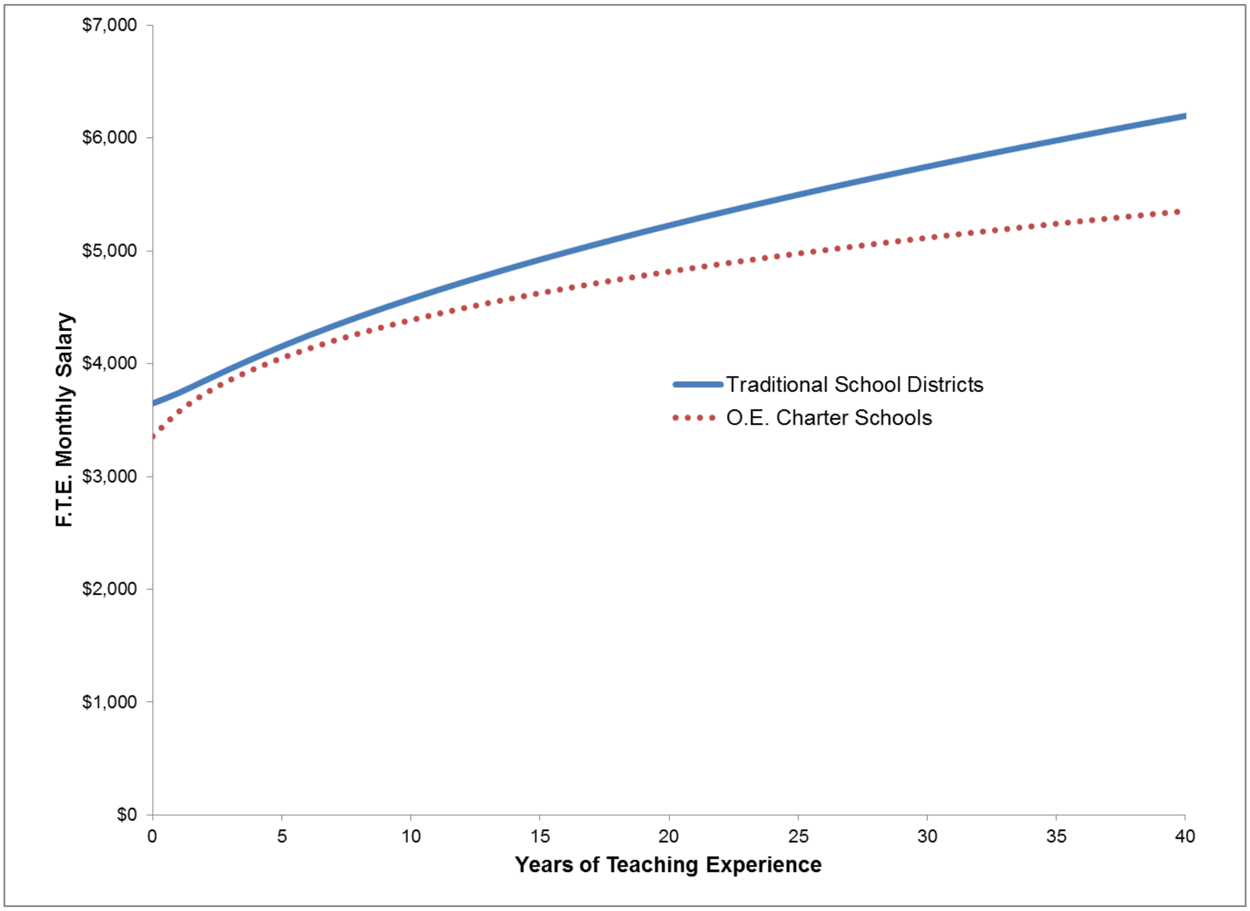
Source. Academic Excellence Indicator System (AEIS).

Figure 2
Per-Pupil Revenues and Operating Expenditures for OE Charter Schools and Traditional School Districts in Texas



Source. Public Education Information Management System (PEIMS) Actual Financial Records.
Note. Three OE charter schools that reported operating expenditures exceeding $250,000 per pupil in 1999-2000 have been excluded for that year due to data quality concerns.

Figure 3
Predicted Teacher Salaries by Years of Experience for Non-alternative OE Charter and Traditional Public Schools



Note: Teachers in alternative education campuses have been excluded from the analysis.

Figure 4
Efficiency Estimates, Non-Charter and Charter, from Common Cost Frontier Model

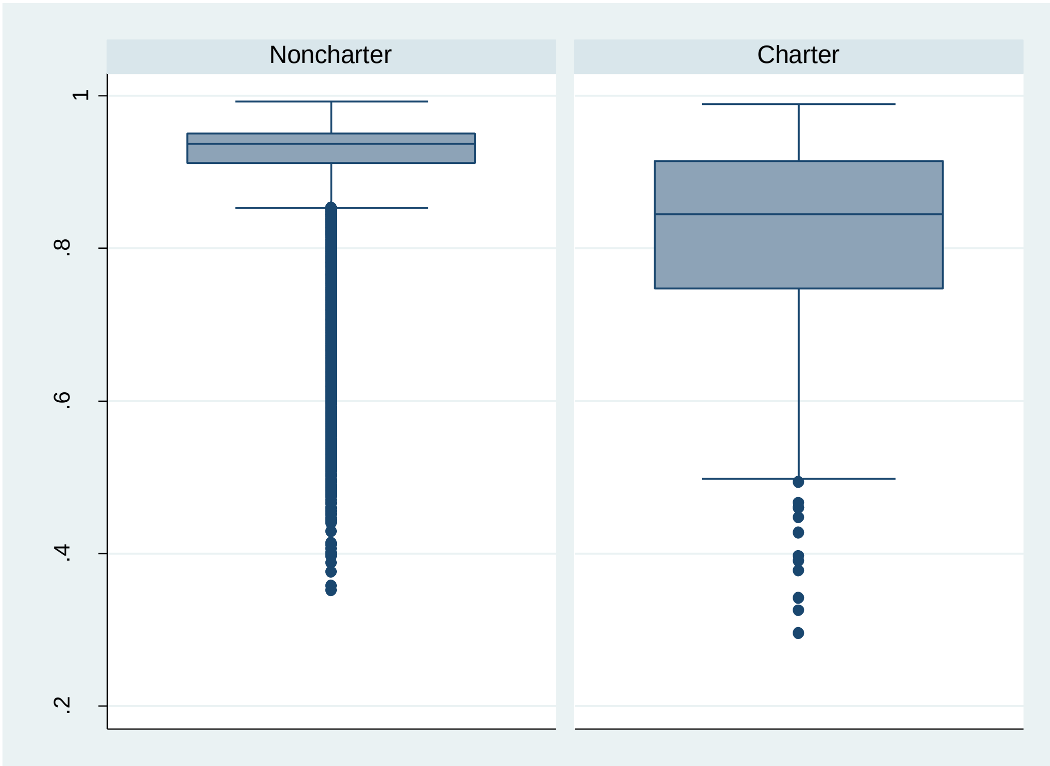


Figure 5
Efficiency Estimates, Non-Charter and Charter, from Model with Charter Treated as a Characteristic

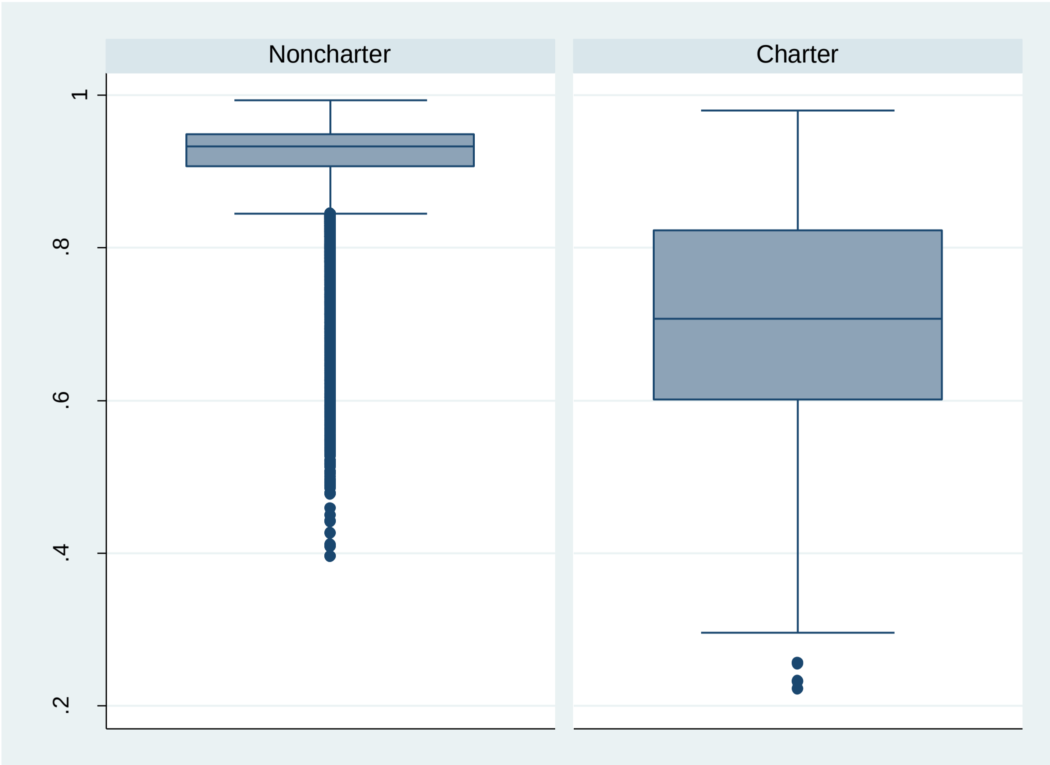


Figure 6
Efficiency Estimates, Non-Charter and Charter, from Model with Separate Cost Functions for Non-Charters and Charters

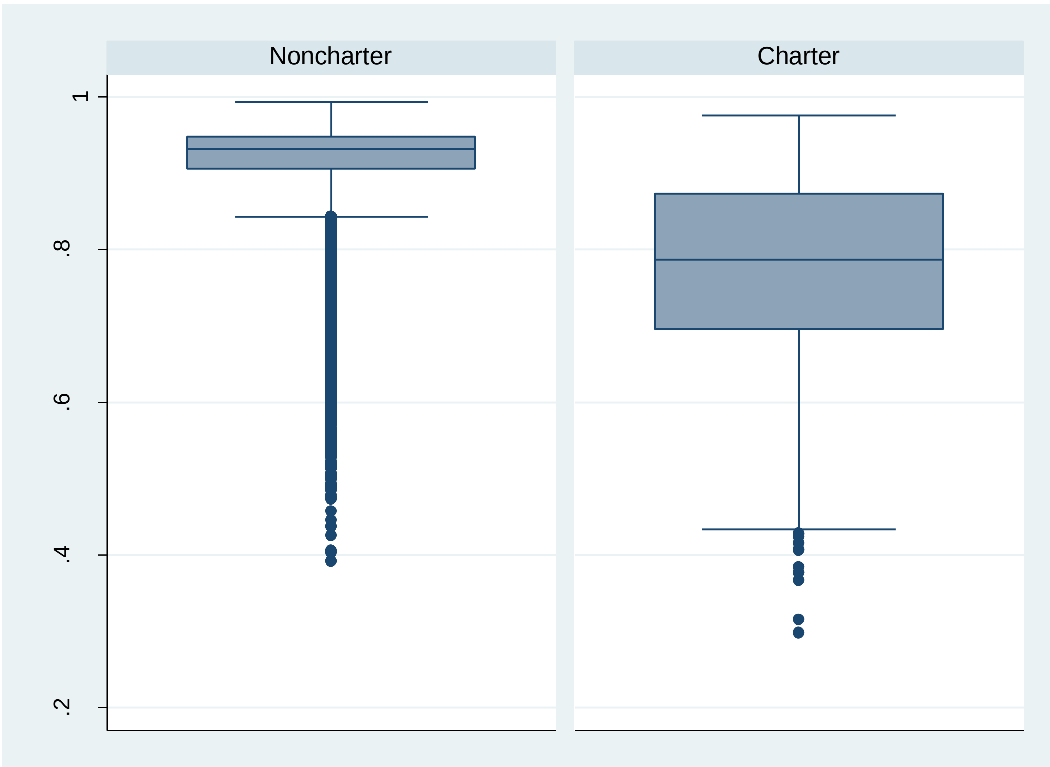
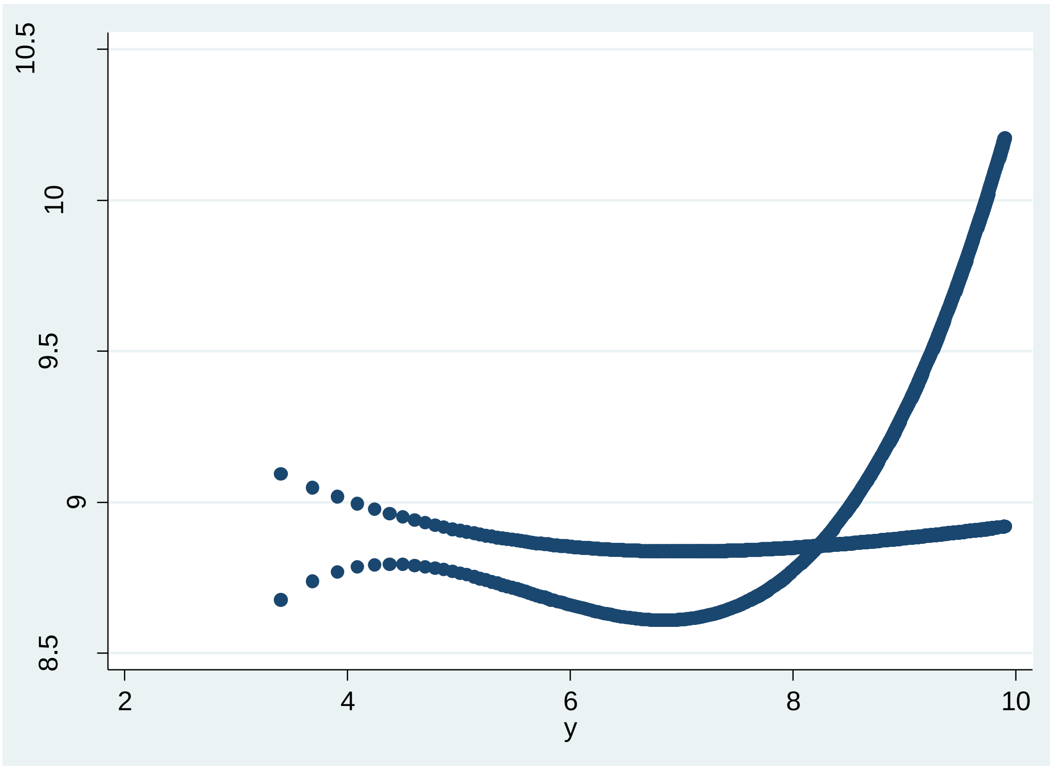
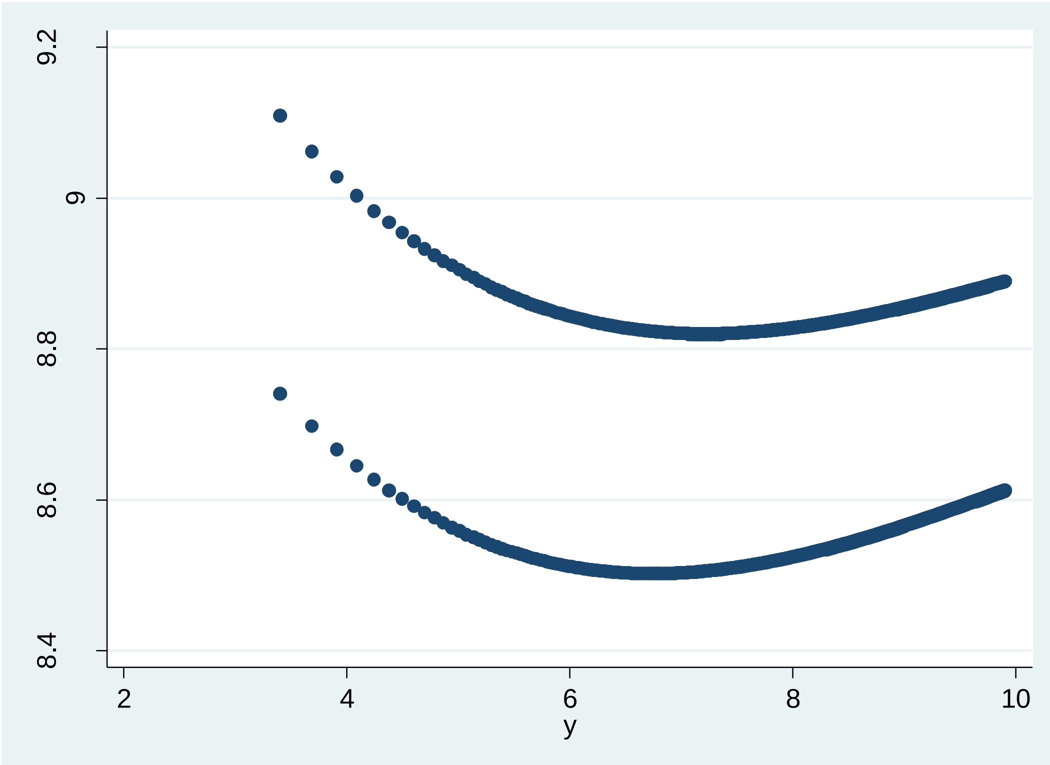


Figure 7
Graph of Cost Relative to (Log) District Size for Non-Charters and Charters for Model with Separate Charter and Non-Charter Cost Functions.



Note: All other variables held constant at the charter mean. Charter is lower cost

Figure 8
Graph of Cost Relative to (Log) District Size for Non-Charters and Charters for Model with Charter as Characteristic in Cost Function.



Note: All other variables held constant at the charter mean. Charter is lower cost.

Table 1: The Number of Campuses by Grade-level and AEC Type, 2008-09

	Standard Campuses	AEC of Choice	Residential AEC
OE Charter School Districts			
Early Elementary Schools	16	3	0
Elementary Schools	119	15	4
Middle Schools	30	6	1
Secondary Schools	20	75	15
Multi-level schools	62	38	32
Total	247	137	52
Traditional Public School Districts			
Early Elementary Schools	322	0	0
Elementary Schools	3,965	2	0
Middle Schools	1,569	10	1
Secondary Schools	1,295	175	27
Multi-level schools	309	7	15
Total	7,460	194	43

Note: Non-charter campuses with less than 5 students have been excluded
Source: AEIS and the Texas Education Directory.

Table 2: Student Demographics by Campus Type for Non-alternative Campuses, 2008-09

Percent of students who were:	**OE Charter School Districts**	**Traditional Public School Districts**
Elementary Schools		
Non-Hispanic White	14.048	31.530
Black	36.684	13.379
Hispanic	45.336	51.160
Other	3.932	3.932
Economically Disadvantaged	71.622	62.444
At Risk	40.939	49.788
Limited English Proficient	20.149	25.872
Special Education Program	5.146	8.065
Gifted Education Program	1.927	5.224
Bilingual Education Program	20.029	24.716
Career & Technology Program	0.056	0.065
Number of Campuses	135	4,287
Number of Students	36,035	2,327,287
Non-Elementary Schools		
Non-Hispanic White	20.225	37.388
Black	19.531	14.321
Hispanic	54.559	44.325
Other	5.688	3.966
Economically Disadvantaged	60.702	50.254
At Risk	32.567	46.287
Limited English Proficient	9.344	7.894
Special Education Program	6.347	10.780
Gifted Education Program	3.445	10.188
Bilingual Education Program	8.939	7.234
Career & Technology Program	9.276	43.460
Number of Campuses	112	3,173
Number of Students	35,594	2,278,288

Note: Pupil-weighted averages. Alternative education campuses and other public campuses with fewer than 5 students have been excluded.
Source: Academic Excellence Indicator System (AEIS) and authors’ calculations.

Table 3: Current Operating Expenditures per Pupil by Object and Function, 2008-09

	OE Charter School Districts	Traditional Public School Districts
Expenditures by function		
Instruction	$4,519	$4,948
Instructional resources and media services	$33	$133
Curriculum staff development	$130	$168
Instructional leadership	$127	$120
School leadership	$697	$477
Guidance counseling and evaluation	$180	$292
Social work services	$19	$24
Health services	$34	$85
Student (pupil) transportation	$158	$235
Food services	$387	$450
Extracurricular activities	$74	$229
General administration	$936	$249
Facility maintenance and operations	$1,149	$895
Security and monitoring services	$60	$67
Data processing services	$141	$117
Fund raising	$57	$0
Total current operating expenditures	$8,700	$8,490
Expenditures by object		
Personnel	$6,517	$7,261
Instructional payroll	$3,556	$4,561
Non instructional payroll	$1,858	$2,306
Contracted instructional Services	$317	$77
Contracted non-instructional Services	$787	$318
Rent	$535	$43
Utilities	$237	$294
Supplies	$813	$744
Other operating	$597	$149
Total current operating expenditures	$8,700	$8,490
Number of districts	201	1,030
Number of students	101,754	4,625,713

Notes. This table presents pupil-weighted averages for all districts with actual financial data in PEIMS. Instructional payroll is payroll expenditures in function 11 and contracted instructional services are contracted services in function 11.

Source: Taylor et al. (2011).

Table 4: The Characteristics of Texas Teachers in Metropolitan, Non-alternative Campuses, 2004-05 through 2008-09.

	OE Charter School Districts		Traditional Public School Districts	
	Mean	Std. Dev.	Mean	Std. Dev.
FTE Monthly Salary	3641.863	724.892	4560.173	767.684
Years of Experience	3.920	5.815	10.897	9.419
No degree	0.039	0.193	0.006	0.076
MA	0.133	0.339	0.216	0.411
Ph.D.	0.008	0.088	0.005	0.073
Certified in:				
Mathematics	0.034	0.182	0.087	0.282
Science	0.038	0.192	0.077	0.266
Bilingual/ESL	0.051	0.220	0.106	0.308
Special Education	0.066	0.249	0.147	0.355
Any teaching certificate	0.567	0.495	0.973	0.162
New hire	0.645	0.479	0.176	0.381
Teaching Assignment:				
Mathematic	0.189	0.392	0.169	0.375
Science	0.181	0.385	0.149	0.356
Special Education	0.032	0.176	0.060	0.237
Health and Physical Education	0.102	0.303	0.110	0.313
Language arts	0.222	0.416	0.223	0.416
Coach	0.012	0.110	0.081	0.273
Number of Observations		10,334		1,173,568

Note: Teachers assigned to alternative education campuses have been excluded. All of the variables are significantly different from each other at the 5-percent level except the share of language arts teachers.
Source: PEIMS.

Table 5: The Hedonic Model of Teacher Salary

	Baseline Coefficient	Charter Interaction Term
OE Charter School		-0.092
		(0.010)**
Years of Experience (log)	0.003	0.085
	(0.001)**	(0.010)**
Log Experience, squared	0.037	-0.027
	(0.000)**	(0.004)**
No Degree	0.004	-0.070
	(0.001)**	(0.016)**
MA	0.026	-0.002
	(0.000)**	(0.009)
Ph.D.	0.037	0.009
	(0.004)**	(0.040)
Mathematics certified	0.005	0.006
	(0.001)**	(0.016)
Science certified	0.004	0.034
	(0.002)**	(0.016)*
Bilingual/ ESL certified	0.004	0.051
	(0.001)**	(0.010)**
Special Education certified	0.004	-0.006
	(0.001)**	(0.015)
Certified teacher	0.005	0.020
	(0.001)**	(0.007)**
New Hire	-0.005	0.009
	(0.000)**	(0.004)*
Mathematics	0.001	-0.002
	(0.000)**	(0.008)
Science	0.000	-0.009
	(0.000)	(0.008)
Special Education	0.002	0.015
	(0.000)**	(0.015)
Health and P.E.	0.005	-0.029
	(0.000)**	(0.009)**
Language Arts	-0.000	0.002
	(0.000)	(0.006)
Coach	-0.030	0.000
	(0.001)**	(0.014)
Percent Economically Disadvantaged Students	0.003	
	(0.001)**	
Percent LEP students	0.006	
	(0.001)**	
Percent Special Education students	0.001	
	(0.003)	
Campus enrollment	0.005	

	(0.000)**
Very small district	-0.099
	(0.002)**
Small district	-0.089
	(0.002)**
Midsized district	-0.046
	(0.001)**
Big district	0.015
	(0.001)**
Elementary school	-0.008
	(0.001)**
Middle school	-0.003
	(0.001)*
Secondary school	-0.002
	(0.001)
Comparable Wage Index	-0.139
	(0.007)**
Fair market rent (log)	0.035
	(0.001)**
Unemployment rate	0.001
	(0.000)**
Observations	1,183,902
Number of teachers	352,755
R-squared	0.84

Note: Robust standard errors in parentheses. The model also includes individual teacher fixed effects, metropolitan area fixed effects and year fixed effects. The asterisks indicate a coefficient that is statistically significant at the * 5%; ** significant at 1%
Source: Authors' calculations from PEIMS.

Table 6: Descriptive Statistics for Non-alternative Public Schools in Texas, 2004-05-2008-09

	OE Charter School Districts		**Traditional Public School Districts**	
	Mean	Std. Dev.	Mean	Std. Dev.
Per-pupil expenditure (log)	8.896	0.280	8.884	0.178
District enrollment (log)	6.141	0.944	9.788	1.564
Math output	-0.119	0.445	0.015	0.262
Reading output	-0.096	0.322	0.006	0.212
Teacher salary index	0.340	0.066	0.406	0.082
Non-teacher salary index	0.270	0.088	0.230	0.106
Elementary school	0.492	0.500	0.612	0.487
Middle school	0.123	0.329	0.230	0.421
High school	0.081	0.273	0.151	0.358
Percent economically disadvantaged	0.638	0.295	0.569	0.288
Percent Limited English proficient	0.103	0.177	0.176	0.198
Percent special education	0.083	0.067	0.105	0.041
Campus enrollment (log)	5.520	0.705	6.430	0.597
Small school district	0.891	0.311	0.107	0.309
Midsized school district	0.109	0.311	0.100	0.300
First year of campus operation	0.135	0.342	0.024	0.154
First year of district operation	0.051	0.221	0.000	0.000
Number of Observations		681		25,358

Table 7: Marginal Effects at the Sample Mean

Variable	Common Cost Function	Charter Treated as a Characteristic	Separate Frontiers Model (Non-charter)	Separate Frontiers Model (Charters)
District enrollment (log)	0.020	0.021	0.020	-0.091
	(0.002)	(0.002)	(0.002)	(0.025)
Math output	0.018	0.015	0.015	0.034
	(0.004)	(0.004)	(0.004)	(0.028)
Reading output	0.006	0.009	0.007	0.113
	(0.005)	(0.005)	(0.005)	(0.042)
Teacher salary index	1.175	1.024	1.049	0.199
	(0.077)	(0.076)	(0.076)	(0.329)
Non-teacher salary index	0.366	0.449	0.442	0.596
	(0.092)	(0.089)	(0.089)	(0.252)
Elementary school indicator	-0.155	-0.172	-0.155	-0.076
	(0.014)	(0.015)	(0.017)	(0.025)
Middle school indicator	-0.088	-0.107	-0.086	-0.174
	(0.014)	(0.015)	(0.017)	(0.041)
High school indicator	0.071	0.054	0.073	0.219
	(0.014)	(0.016)	(0.018)	(0.074)
Percent economically disadvantaged	0.129	0.135	0.133	0.148
	(0.005)	(0.005)	(0.005)	(0.055)
Percent limited English proficient	0.066	0.065	0.062	-0.082
	(0.011)	(0.011)	(0.012)	(0.150)
Percent special education	0.817	0.764	0.758	0.237
	(0.024)	(0.024)	(0.024)	(0.221)
Campus enrollment (log)	-0.186	-0.183	-0.185	-0.035
	(0.002)	(0.002)	(0.002)	(0.025)
Charter school indicator		-0.305		
		(0.051)		

Note: All models also include fixed effects for year and metropolitan statistical area, and the separate frontiers models are estimated jointly. Marginal effects estimated at the sample mean for all cases except the charter version of the separate frontiers model, which is evaluated at the charter school mean.

Table 8: Efficiency Estimates

	Mean	Std. Dev.	Minimum	Maximum
Traditional Public School District Efficiency Estimates				
Common Cost Function	0.916	0.066	0.352	0.993
Charter Treated as a Characteristic	0.915	0.060	0.396	0.993
Separate Frontiers Model (estimated jointly)	0.915	0.061	0.391	0.993
OE Charter School District Efficiency Estimates				
Common Cost Function	0.818	0.123	0.296	0.990
Charter Treated as a Characteristic	0.701	0.154	0.223	0.980
Separate Frontiers Model (estimated jointly)	0.771	0.131	0.299	0.976

Table 9: The Determinants of School District Inefficiency

	Common Cost Function	Charter Treated as a Characteristic	Separate Frontiers Model
Time trend	0.171***	0.132***	0.130***
	(0.017)	(0.016)	(0.0156)
Charter * time trend	-0.0198	0.020	0.047
	(0.048)	(0.050)	(0.057)
Small district	2.614***	2.217***	2.222***
	(0.059)	(0.056)	(0.055)
Midsize district	1.125***	0.906***	0.900***
	(0.056)	(0.054)	(0.053)
Small district X charter	-1.069***	-1.505***	-1.572***
	(0.214)	(0.216)	(0.312)
First year of campus	0.0666	0.093	0.062
	(0.096)	(0.088)	(0.090)
First year of district	0.766***	0.538**	0.187
	(0.277)	(0.269)	(0.305)
Charter	0.899***	2.373***	1.762***
	(0.286)	(0.296)	(0.357)
Constant	-5.533***	-5.252***	-5.231***
	(0.077)	(0.070)	(0.070)

Note: Estimated effects on the standard deviation of the one-sided error component.