Would School District Consolidation Lead to Cost Savings in Major Metropolitan Counties?

A Cost Function Analysis

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Prepared by
Lori L. Taylor
Timothy J. Gronberg
Dennis W. Jansen

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Executive Summary

Senate Bill (SB) 2 (83rd Texas Legislature, Regular Session) added Section 12.1013(e) to the Texas Education Code (TEC). Among other provisions, this section required the Texas Education Agency (TEA) to provide “an analysis of whether the performance of matched traditional campuses would likely improve if there were consolidation of school districts within the county in which the campuses are located.” The requirement “applies only to a county that includes at least seven school districts and at least 10 open-enrollment charter schools.” The required report, which analyzed the potential gains from school district consolidation in the five counties that match the requirements (Bexar, Dallas, Harris, Tarrant and Travis), was prepared in August 2014. The current report updates the original analysis of the gains from school district consolidation in these five counties.

Gains are possible because there are well-recognized economies of scale in education. Research has demonstrated that the per-pupil cost of operating a very small school district is much higher than the per-pupil cost of operating a larger district.

On the other hand, consolidation reduces school choice, and the economics literature strongly suggests that school districts produce higher educational outcomes from the same level of resources (i.e., are more efficient) when there is more choice.

Thus, there is a trade-off. Consolidation could lower operating costs but it could also lower school district efficiency and thereby increase operating expenditures. Among very small districts, the benefits of consolidation are likely to outweigh the efficiency loss, but among larger districts the efficiency loss could outweigh any cost savings.

The historical experience with consolidation in Texas does not provide any evidence that can inform the proposed consolidation. There have been only 20 school district consolidations in Texas since 1994–95. In all but three of the 20 cases (Wilmer-Hutchins ISD, North Forest ISD, and La Marque ISD) the consolidation folded a single-campus district into another, larger district. None of the consolidations involved more than two districts.

Cost function analysis is a common strategy for quantifying both economies of scale and relative efficiency, and is therefore the best available strategy for determining whether or not the proposed consolidations would generate cost savings that could be used to improve student performance. In the educational context, a cost function describes the relationship between school spending and student performance, given the price of educational inputs (such as teachers or school supplies), student characteristics, and other determinants of the educational environment such as school district size.

As in the 2014 report, this report uses a cost function analysis approach to predicting the likely effects of consolidation of the type and scale identified in TEC Section 12.1013(e). The basic approach is to estimate a model of campus spending that yields estimates of a best practice cost function and estimates of campus deviations from that cost frontier. The model provides estimates of cost economies or diseconomies associated with changes in district enrollment due to consolidation and of inefficiencies associated with changes in the structure of the education market. The approach implements a simulation of the proposed consolidations based on the results of the formal cost function analysis of the relationship between school performance and school district size.

This analysis supports four key findings.

1. The cost function estimates indicate substantial scale economies up to a district size of around 7,700 students and diseconomies as district size increases beyond about 7,700 students.
2. The cost function estimates indicate that increased market concentration leads to inefficiency and increased spending over and above what the cost function indicates is necessary to achieve specific outcomes with given environmental conditions.
3. There are no expected cost savings from consolidation to the county level in any of the counties under analysis. County-level consolidation increases the predicted expenditure per pupil by 9.9% in Bexar, 8.9% in Dallas, 11.5% Harris, 9.9% in Tarrant, and 3.9% in Travis. In addition to the predicted increases in the consolidating districts, expenditures are also expected to rise in the rest of their metropolitan areas (due to the loss of competition in those education markets).
4. A more limited and focused consolidation of districts that are currently eligible for size adjustments under the school funding formula could generate savings in three of the five counties under analysis, but the impact is quite small. Only the consolidation of the three school districts serving military bases in San Antonio was predicted to reduce spending by more than $62 per pupil.

Although the estimated range of economies to size is greater in the current study than in the 2014 study (the diseconomies set in at 3,200 students in the 2014 cost function estimates), the estimated increase in predicted spending remains. The spending increase prediction is robust because significant per pupil cost savings from increasing district size are, basically, exhausted at a very small district size. The existing districts in the specific counties under analysis already enjoy substantial economies of scale. Any modest potential cost savings from increased size are eclipsed by the expected loss of cost efficiency from the weakening of competitive incentives due to consolidation and from the diseconomies associated with very large districts.

It is important to recognize that the simulation has been constructed assuming that the consolidated, countywide school districts did not close any campuses in the wake of consolidation. This is a reasonable assumption, given the political barriers to closing an existing operating neighborhood school. It is true however, that a possible response of some of the new countywide districts will be to eliminate some small campuses with an attendant increase in average campus size. The cost function analysis indicates that there can be substantial cost savings from campus consolidation (If nothing else changes, combining two 200-student campuses into one 400-student campus, for example, is expected to reduce operating costs by 14% on average).The simulation thus likely overstates somewhat the increase in expenditures that would arise from county-level consolidation for Bexar, Dallas, Harris, Tarrant and Travis counties.

Given the lack of cost savings under the simulation, it is highly unlikely that student performance would improve if there were consolidation in the designated counties. This result does not imply that there are no potential cost-reducing consolidations. The second limited and targeted simulation illustrates this point.

The fundamental conclusion of the 2014 Report remains intact: there is no reason to believe that the proposed five countywide consolidations would lead to improvements in student performance, and there is good reason to believe that student performance would fall.

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Glossary of Terms

Control Function: A statistical technique used to control for bias generated by a potential correlation between an independent variable and the error term in a regression analysis. A control function is an alternative strategy for specifying an instrumental variables model.

Core-Based Statistical Area (CBSA): A term used by the U.S. Office of Management and Budget and U.S. Census Bureau to refer collectively to all metropolitan and micropolitan areas. A metropolitan area is a county or cluster of counties with a central, urbanized area of at least 50,000 people. A micropolitan area is a county or cluster of counties with a central city of at least 10,000 people. Two counties are considered part of the same CBSA whenever commuting patterns indicate that the counties are part of the same integrated labor market area. In Texas, College Station-Bryan is a metropolitan area, and Nacogdoches is a micropolitan area.

Cost Function: A mathematical description of the relationship between the inputs, outputs and costs of operating a fully efficient firm. In the educational context, a cost function describes the relationship between (efficient) school spending and student performance, given the price of educational inputs (such as teachers or school supplies), student characteristics, and other determinants of the educational environment such as school district size.

Cost Function Analysis: The estimation of a cost function using statistics or some other data-driven technique.

Economies of scale: Economies of scale exist when it is possible to reduce per-pupil costs by increasing the size of the school or district.

Efficient: A school or district is efficient (i.e., behaving efficiently) when it is not possible to increase educational outputs without increasing expenditures on purchased inputs.

Herfindahl Index: A measure of the amount of competition in a market. In the education context, it is defined as the sum of the squared local education agency (LEA) enrollment shares, where an LEA's enrollment share is its own enrollment divided by the total enrollment in the CBSA. The Herfindahl index increases as the level of enrollment concentration increases (i.e., as the level of competition decreases). A Herfindahl index of 1.00 indicates a metropolitan area with a single LEA; a Herfindahl index of 0.10 indicates a metropolitan area with 10 LEAs of equal size.

Inefficient: A school or district is inefficient when it is possible to increase educational outputs without increasing educational expenditures.

Inputs: The equipment, personnel or raw materials used to produce outputs/outcomes.

Outputs/Outcomes: The goods or services produced. In the education context, the primary outcome is total student performance, which can be measured by average student performance times the number of students served.

Stochastic Frontier Analysis (SFA): SFA is a statistical technique used to describe the best—as opposed to average—practice in the data. In this project, the cost function is estimated using SFA. Other statistical approaches to cost function estimation assume that, on average, school spending equals the cost of education. SFA explicitly allows for the possibility that spending could be systematically higher than cost, and the difference is labelled as due to ‘inefficiency.’ If school districts are behaving efficiently, SFA yields the same cost function estimates as other techniques.

Introduction

Senate Bill (SB) 2 (83rd Texas Legislature, Regular Session) added Section 12.1013(e) to the Texas Education Code (TEC). Among other provisions, this new section requires the Texas Education Agency (TEA) to provide "an analysis of whether the performance of matched traditional campuses would likely improve if there were consolidation of school districts within the county in which the campuses are located." The analysis requirement "applies only to a county that includes at least seven school districts and at least 10 open-enrollment charter schools." There are five Texas counties that fit that description—Bexar, Dallas, Harris, Tarrant and Travis.[1] This report represents the required analysis of the gains from school district consolidations in those five targeted counties.

Gains are possible because there are well-recognized economies of scale in education. Research has demonstrated that the per-pupil cost of operating a very small school district is much higher than the per-pupil cost of operating a larger district.[2] And smaller school districts in Texas clearly spend more per pupil on operations than larger ones. As Table 1 illustrates, total operating expenditures per pupil are lowest (on average) for districts with at least 5,000 students, and highest (on average) for districts with less than 500 students. In 2015–16, the smallest district in the state, Doss

Table 1: Total Operating Expenditures per Pupil and General Administration Expenditures per Pupil for Traditional Public School Districts, All Funds, 2015-16, by Size Category

Fall Enrollment	Number of Districts	Total Operating Expenditures per Pupil	General Administration Expenditures per Pupil	General Administration as a Share of Total Operating
10,000 and Above	107	$9,266	$234	2.6%
5,000 to 9,999	72	$9,091	$324	3.7%
1,000 to 4,999	323	$9,742	$416	4.7%
500 to 999	199	$10,835	$607	5.9%
Less than 500	323	$12,824	$1,240	9.5%

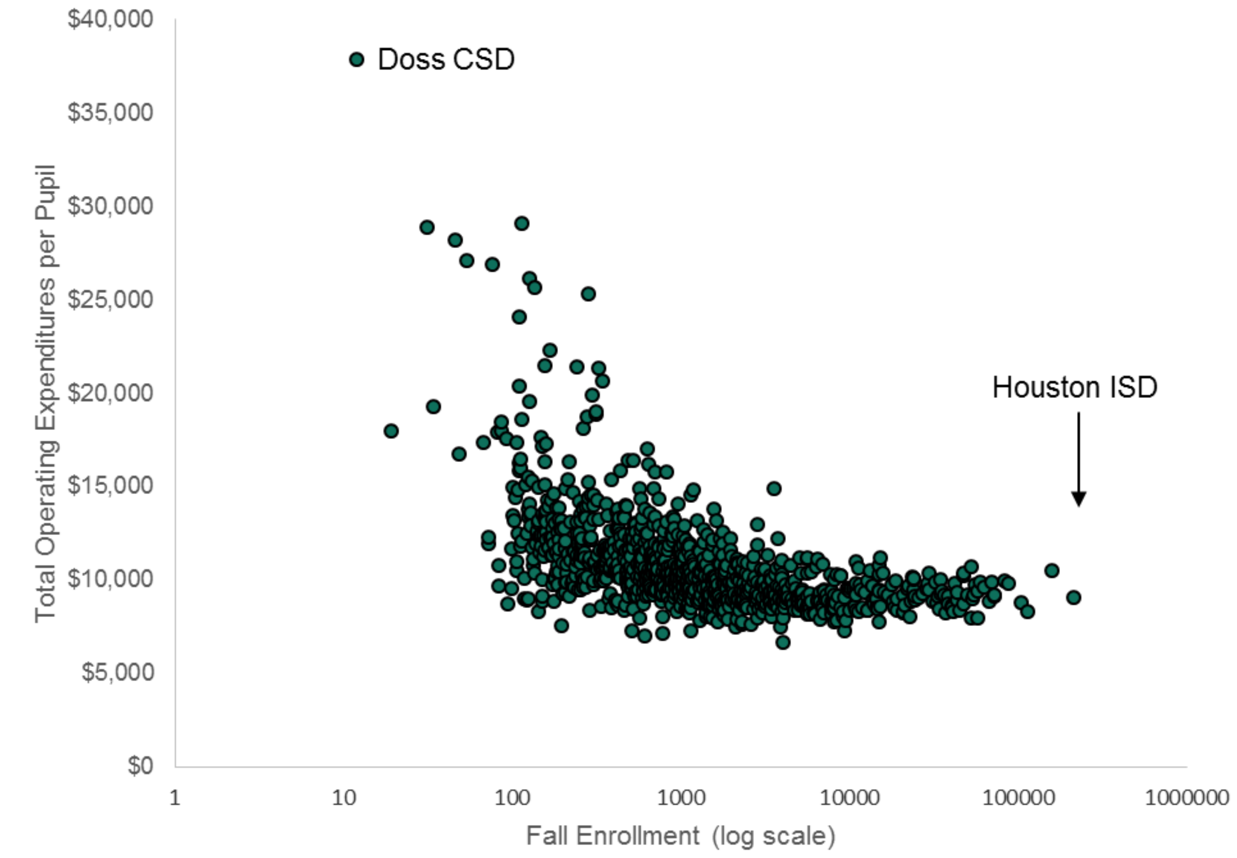
Source: Authors' calculations from Texas Education Agency (2017).

[1] Although only nine open-enrollment charter schools are headquartered in Tarrant County, another six open-enrollment charter schools are based elsewhere but operate campuses in Tarrant County. Therefore, Tarrant County also includes at least 10 open-enrollment charter schools.

[2] For a survey, see Taylor et al. 2014 or Gronberg et al. 2015.

Consolidated School District (CSD), spent more than four times as much per pupil as did the largest district in the state, Houston Independent School District (ISD). (See Figure 1).

Figure 1: Total Operating Expenditures per Pupil for Traditional Public School Districts, All Funds, 2015–16



Source: Texas Education Agency (2017).

At least some of that difference in operating expenditures per pupil can be attributed to the fixed costs of running a school district. Regardless of size, a district needs a school board, a superintendent and a central office, and those costs are distributed over a much smaller student body in a small district than they are in a larger district. On average, general administration expenditures per pupil are twice as high for districts with less than 500 students as for districts with between 500 and 999 students, and more than five times as high as for districts with at least 10,000 students (Table 1).

Consolidation would allow school districts to avoid bureaucratic duplication and therefore should lead to lower general administration costs. It could also allow school districts to reap additional savings by right-sizing campuses and classrooms or by exploiting their enhanced purchasing power in the markets for electricity or school supplies and materials.

On the other hand, consolidation reduces school choice, and the economics literature strongly suggests that school districts are able to produce higher educational outcomes from the same level of resources (i.e., are more efficient) when there is more choice.[3]

Thus, there is a trade-off. Consolidation could lower operating costs but it could also lower school district efficiency and thereby increase operating expenditures. Among very small districts, the benefits of consolidation are likely to outweigh the efficiency loss, but among larger districts the efficiency loss could overwhelm any cost savings.

Cost function analysis is a common strategy for quantifying both economies of scale and relative efficiency, and is therefore the best available strategy for determining the tipping point at which cost savings are offset by efficiency losses. In the educational context, a cost function describes the relationship between school spending and student performance, given the price of educational inputs (such as teachers or school supplies and materials), student characteristics, and other determinants of the educational environment such as school district size.

This report proceeds as follows. The first section presents a review of the academic literature on the expected effects of school district consolidation. The next two sections describe the recent history of school district consolidation in Texas and the consolidations proposed in TEC Section 12.1013(e). The fourth section describes the cost function analysis underlying the consolidation simulation, and the fifth section describes that simulation. The final section concludes and provides policy recommendations.

Note that the simulations have been constructed assuming that the consolidated school districts did not close any campuses in the wake of consolidation. That is a reasonable assumption given the political difficulties associated with closing a viable, neighborhood school, and the near impossibility of accurately predicting the nature of any school-level consolidations. The recent history of school district consolidations in Texas provides no guidance to a more appropriate set of assumptions about the nature of any campus-level consolidations.

Note also that most of the potential gains from consolidation will accrue to the districts, not the state. Under TEC Sections 13.281 and 13.282, consolidating districts are entitled to receive incentive aid. That incentive aid is structured so that for 10 years the state must pay at least as much under the Foundation School Program (the Texas school funding formula) after consolidation as it would have paid prior to consolidation. Thus, there are no expected financial gains to the state from consolidation, although the state would clearly benefit from any improvements in student performance.

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[3] For example, see Belfield & Levin (2002); Dee (1998); Gronberg, Jansen, Karakaplan & Taylor (2013); Gronberg, Jansen, Taylor & Karakaplan (2010); Grosskopf, Hayes, Taylor & Weber (2001); Kang & Greene (2002); or Millimet & Collier (2008).

If the incentive aid provisions (TEC Sections 13.281 and 13.282) were repealed, then the state would benefit directly from consolidation because it would no longer be obliged to pay the small and midsized funding supplements to the districts that were consolidated. (See the box for a brief description of the size adjustments in the Texas school funding formula.) However, the potential financial gains to the state from the proposed consolidations would be modest even if the incentive aid provisions were eliminated because so few of the districts potentially affected by the proposed consolidation receive size adjustments. Less than 1.5% of the more than 2 million students in the five target counties attend districts that receive the small or midsized funding supplements.

The Literature

Given the potential tradeoffs associated with increasing school district size, the question of whether bigger is better is an empirical one. A substantial literature has sprung up to examine the two dimensions in which consolidation could impact school districts: economies of scale and a loss of competition.

Consolidation and Economies of Scale

A small number of researchers have examined economies of scale in education by examining the effects of actual school district consolidations. Most found evidence of substantial cost savings or student performance gains in the wake of consolidation. For example, Duncombe and Yinger (2007) used data from rural school districts in New York to estimate the impact of the twelve consolidations that occurred from 1987 to 1995. They found that doubling enrollment cut operating costs per pupil by 62% for a 300–pupil district and by 50% for a 1,500–pupil district (all other things being equal). Berry and West (2010) examined the relationship across U.S. states between long-term student outcomes (earnings as an adult and years of schooling completed) and consolidations at the campus or district levels. They found small gains from district consolidation,

Size Adjustments in Texas' School Funding Formula

The Foundation School Program, Texas' school funding formula, provides additional per-student funding to smaller districts. The small district adjustment provides supplemental funding, per pupil, to school districts with fewer than 1,600 students in average daily attendance (ADA). Small districts that encompass more than 300 square miles receive a higher adjustment. Very small schools with less than 130 students in ADA can qualify for the sparsity adjustment, which qualifies them for increased regular program ADA. Districts with more than 1,600 but less than 5,000 students in ADA (regardless of geographic size) qualify for the less-generous, mid-sized district adjustment. The small and mid-sized adjustments shrink as districts get larger, so the smallest districts receive the largest benefits of the adjustments—which can be substantial. For example, in 2015–16, the small and sparse district adjustments more than doubled the state aid received by the tiny San Vicente ISD. Charter schools are not eligible for the size adjustments under the funding formula.

but losses from campus consolidation, suggesting there may be long-term benefits from both larger districts and smaller schools. De Haan, Leuven, and Ooasterbeek (2016) analyzed a 15% reduction in the number of primary schools that occurred in the Netherlands during the 1990s. They found that the reform led to improved student achievement on a nationwide exit exam and that cost savings from economies of scale were the source of those achievement gains. On the other hand, Gordon and Knight (2008) examined administrative consolidations of school districts in Iowa and found no evidence of improvements in either cost or student performance, and Beauchert et al. (2016) found that school consolidation in Denmark had adverse effects on student performance, particularly among students exposed to school closings.

Hanley (2007) used linear programming techniques to explore the impact of school district consolidation on school bus routes and therefore school district transportation costs. He simulated the consolidation of school districts in Iowa up to a target enrollment of between 500 and 1,000 students and concluded that the increase in transportation costs would be large enough to offset at least half of the expected savings from administrative efficiencies.

Other researchers have used cost function analyses to simulate potential consolidations. For example, Dodson and Garrett (2004) simulated the savings from consolidating four small rural Arkansas districts into a single county district. Based upon their estimated cost function, they found per-pupil cost savings of between 19% and 54%. Duncombe, Miner and Ruggiero (1995) simulated the consolidation of New York school districts with fewer than 500 students and found large potential cost savings. Zimmer, DeBoer and Hirth (2009) also found large potential gains from their simulated consolidation of smaller (i.e., fewer than 1,000 pupils) districts in Indiana. Gronberg et al. (2015) simulated consolidation to the county level throughout Texas and found that consolidation would reduce per-pupil costs in many rural Texas counties, but raise per-pupil costs in most metropolitan counties. Taylor et al. (2014) simulated county-level consolidation in Texas five largest counties, and concluded that such consolidations would lead to dysfunctionally large districts and an increase in educational costs. Karakaplan and Kutlu (2016) simulated the consolidation of very small (<100 student) school districts in California, and concluded that the cost savings due to economies of scale would be more than offset by increased inefficiency due to the loss of competition.

Additional evidence on the likely impact of school district consolidation comes from studies that did not simulate consolidation but did estimate the relationship between school district size and the cost of education. Andrews, Duncombe and Yinger (2002) surveyed 10 cost studies that were published between 1985 and 1999, and concluded that per-pupil cost was very high for school districts with fewer than 500 students, lowest for school districts in the 2,000 to 5,000 student range, and somewhat higher for school districts with more than 5,000 students.

More recent cost-function analyses have reached similar conclusions about the high cost of operating small districts, but offer contradictory findings about the least-cost district configuration. For example, Imazeki and Reschovsky (2006) found that most of the savings from economies of scale were realized by the time the district reaches 10,000 students, but that costs continued to decline with size until enrollments reached approximately 85,000. Gronberg, Jansen, and Taylor (2011a) and Eom et al. (2016) found that costs continued to decline with size for even the largest districts.

The above studies look at economies of scale for district size without controlling for campus size. In later papers that include controls for campus size, district-wide economies of scale are found to be exhausted at much lower levels of enrollment. Again, using Texas data, Gronberg, Jansen, and Taylor (2012) found that the economies of scale were fully exhausted when district enrollment reached 1,200 students, and Taylor et al. (2014) found that economies of scale were fully exhausted when district enrollment reached 3,200. Gronberg Jansen and Taylor (2017) compared alternative education campuses operated by traditional public school districts with those operated by open-enrollment charter schools, and concluded that the cost of alternative education fell with campus size but rose with district size once district size reached 570.

Thus, there is a consensus in the literature that small school districts are much more expensive to operate than midsized or larger school districts, and therefore that consolidating small districts should lower the cost of education. There is much less agreement in the literature about whether or not consolidating midsized or larger school districts would be expected to lead to cost savings.

Consolidation and the Loss of Competition in Education

Although school district consolidation may lower the cost of education by allowing the consolidated school district to exploit economies of scale, it also reduces school choice. Although the evidence is not uniform, researchers have generally found that a lack of choice among educational providers reduces the efficiency of the public school system.[4] Much of the work has been done in Texas. For example, Grosskopf, Hayes, Taylor, and Weber (1999), Grosskopf et al. (2001), Gronberg et al. (2015) and Taylor et al. (2014) found that Texas school districts were less efficient (i.e., got less educational bang for the buck) when they were located in metropolitan areas with less choice.

Competition has also been found to effect school district efficiency in other states. Misra, Grimes, and Rogers (2012) found that elementary and secondary schools in Mississippi were more efficient in urban areas where competition from private schools was higher. Kang and Greene (2002) analyzed school districts in New York and concluded that efficiency was lower in counties with less competition. Hoxby (2003) studied school districts in Michigan and found less efficiency in school markets with less

[4] For surveys of the literature, see Belfield & Levin (2002) or Taylor (2000).

charter school competition. A recent paper by Jinnai (2014) finds a positive effect of charter school entry on student achievement in overlapping/matched grades in neighboring traditional public schools in North Carolina. Millimet and Collier (2008) and Karakaplan and Kutlu (2016) reached similar conclusions about the relationship between competition and school district efficiency in the states of Illinois and California, respectively.

Recent evidence suggests that another form of school choice—vouchers—leads to positive competitive effects. An important paper by Figlio and Hart (2014) found evidence that an increase in the competitiveness of private schools due to the introduction of a means-tested voucher program in Florida led to a modest increase in public school student performance. Figlio and Karbownik (2016) and Carr (2011) found similar results for scholarship voucher programs in Ohio, while Egalite (2016) found similar competitive effects in Louisiana.

Twenty Years of School District Consolidations in Texas

Twenty school district consolidations occurred during the twenty-year period from 1996–97 through 2015–16 (Table 2). Only four of those 20 consolidations involved school districts in major metropolitan areas—Wilmer-Hutchins ISD was annexed to Dallas ISD in 2006; Kendleton ISD was annexed to Lamar Consolidated ISD in 2010; North Forest ISD consolidated with Houston ISD in 2013; and La Marque ISD was annexed to Texas City ISD in 2016.

Table 2: Texas School District Consolidations since 1996–97

Consolidating Districts	Total Enrollment in the Smaller District Before Consolidation	Total Enrollment After Consolidation
Allison ISD and Fort Elliott CISD	36	155
Asherton ISD and Carrizo Springs CISD	364	2,534
Bledsoe ISD and Whiteface CISD	20	536
Byers ISD and Petrolia ISD	47	476
Goree ISD and Munday ISD	47	468
Kendleton ISD and Lamar CISD	78	24,552
Lakeview ISD and Memphis ISD	50	568
La Marque ISD and Texas City ISD	2,284	8,945
Marietta ISD and Pewitt CISD	31	966
Megargel ISD and Olney ISD	64	828
Mirando City ISD and Webb CISD	50	402
North Forest ISD and Houston ISD	6,690	211,552
Novice ISD and Coleman ISD	74	873
Rochester County Line ISD and Haskell CISD	40	642
Samnorwood ISD and Wellington ISD	27	585
Spade ISD and Olton ISD	74	705
Star ISD and Goldthwaite ISD	51	601
Three Way ISD and Sudan ISD	78	375
Wellman ISD and Union ISD	129	238
Wilmer-Hutchins ISD and Dallas ISD	2,916	160,746

Sources: School District Consolidations and Annexations (TEA 2016); Academic Excellence Indicator System (AEIS) 1996–97 through 2011–12; Texas Academic Performance Reports (TAPR) 2012–13 through 2016–17; and the Texas Education Directory (2017).

In all but three of the 20 cases (Wilmer-Hutchins ISD, North Forest ISD and La Marque ISD) the consolidation folded a single-campus district into another, larger district. Frequently, the combined district operated one fewer campus than the two districts had operated when they were separate. For example, when Allison ISD and

Fort Elliott CISD combined, Allison School (which had an enrollment of 36 students) ceased operations. However, that was not always the case. When Bledsoe ISD (with its single campus) combined with Whiteface CISD (with its three campuses), the consolidated district operated four campuses—one of which was named Whiteface Elementary, Bledsoe Campus.

Three of the 20 consolidations in the last 20 years combined two districts that both had more than a single campus. In all three cases, academic shortcomings triggered the forced annexation.

Wilmer-Hutchins ISD was officially annexed to Dallas ISD in July 2006, but had actually ceased operations the year before. All nine Wilmer-Hutchins campuses closed at the end of the 2004–05 school year. The students who lived in Wilmer-Hutchins ISD were bused to Dallas ISD schools during the 2005–06 school year. The Texas Education Commissioner ordered the annexation because Wilmer Hutchins had been academically unacceptable for two years and was insolvent. At the time of the annexation, the Commissioner stated that "the district's problems have escalated from bad to worse over decades. These students have spent their school years in a district racked by scandal and mismanagement. I cannot in good conscience allow any child to be educated in this inadequate system. I believe Dallas ISD is the best solution for the children of Wilmer-Hutchins" (TEA 2005).

North Forest ISD was annexed to Houston ISD in July 2013 due to “chronic underperformance” (TEA 2013). Of the nine campuses that North Forest ISD operated in 2012–13, four—North Forest High School, Forest Brook Middle School, Shadydale Elementary School, and Hilliard Elementary School—continued to operate under the same name after consolidation. Marshall Early Childhood Center, Fonwood Elementary School and Elmore Middle Schools in North Forest ISD morphed into Marshall Elementary, Fonwood Early Childhood Center and Elmore Elementary School after consolidation. Lakewood Elementary ceased operations and YES Prep North Forest Campus (which had been operated as a district charter school when it was part of North Forest ISD) became part of YES Prep Public Schools, Inc., an open-enrollment charter school independent of Houston ISD.

La Marque ISD was annexed to Texas City ISD in July 2016 because La Marque’s accreditation had been revoked (TEA 2015). Texas City ISD continued to operate most of the La Marque campuses under the same name after consolidation. Starting in fall 2016, Texas City ISD operated La Marque High School, La Marque Middle School, La Marque Elementary School and La Marque Primary School, as well as all of the campuses it had operated before consolidation. La Marque Primary School in Texas City ISD evolved from La Marque ISD’s Early Childhood Learning Center. However, La Marque ISD’s Renaissance Academy ceased to exist after the consolidation.

The bottom line is that Texas' previous experience with school district consolidation provides little guidance as to the potential impact of consolidating academically acceptable, financially viable school districts in the core county of a major metropolitan area. There are examples of consolidated school districts that redrew attendance zones and closed at least one existing campus, but there are also examples of consolidated school districts that left the campuses largely intact while consolidating central administration. Meanwhile, there are no examples of what happened when many large school districts consolidated simultaneously, and only three special cases involving consolidations of districts as large as those in Bexar, Dallas, Harris, Tarrant or Travis counties. Therefore, responding to TEC Section 12.1013(e) requires a simulation based on a formal analysis of the relationship between school district expenditures, student achievement and economies of scale.

The Consolidation Proposal

TEC Section 12.1013(e) applies to five counties that are the core of Texas' largest metropolitan areas: Bexar, Dallas, Harris, Tarrant and Travis. Those five counties contain 71 traditional public school districts and 121 open-enrollment charter schools.[5] Because TEC Section 12.1013(e) distinguishes between school districts and open-enrollment charter schools, and specifically references the consolidation of school districts, it seems clear that open-enrollment charter schools in the designated counties would not have their charters revoked and would continue to operate independently under this proposal. Therefore, this analysis focuses on the likely impact of a consolidation among the 71 traditional public school districts in Bexar, Dallas, Harris, Tarrant and Travis counties.

Previous analysis of the potential gains from consolidation in non-rural Texas (Taylor et al. 2014) indicated that cost savings could be expected for consolidations involving districts with fewer than 3,200 students, but not for consolidations involving larger districts. As Table 3 illustrates, only a half dozen of the school districts in these five counties are smaller than 3,200 students. Three of the six districts that are small enough—Lackland Independent School District (ISD), Randolph Field ISD and Ft. Sam Houston ISD—are located on military bases in Bexar County. The other small districts are Sunnyvale ISD in Dallas County, Kennedale ISD in Tarrant County and Lago Vista ISD in Travis County.

[5] Although many Texas school districts cross county lines, TEA officially associates each school district with a single county. Those official designations have been used to identify the traditional public school districts eligible for consolidation under TEC Section 12.1013(e).

Table 3: Independent School District (ISD) Enrollments in Bexar, Dallas, Harris, Tarrant and Travis Counties

	Enrollment Fall 2016		Enrollment Fall 2016
Bexar County		Galena Park ISD	22,784
Alamo Heights ISD	4,857	Goose Creek CISD	23,926
East Central ISD	10,227	Houston ISD	216,106
Edgewood ISD	10,881	Huffman ISD	3,443
Ft Sam Houston ISD	1,597	Humble ISD	41,224
Harlandale ISD	14,831	Katy ISD	75,428
Judson ISD	23,037	Klein ISD	51,810
Lackland ISD	1,038	La Porte ISD	7,713
North East ISD	67,531	Pasadena ISD	56,282
Northside ISD	106,145	Sheldon ISD	8,884
Randolph Field ISD	1,429	Spring Branch ISD	35,079
San Antonio ISD	52,514	Spring ISD	36,698
Somerset ISD	4,067	Tomball ISD	14,932
South San Antonio ISD	9,631	**Tarrant County**	
Southside ISD	5,713	Arlington ISD	62,181
Southwest ISD	13,891	Azle ISD	6,345
Dallas County		Birdville ISD	23,857
Carrollton-F.B. ISD	25,276	Carroll ISD	8,208
Cedar Hill ISD	7,866	Castleberry ISD	4,003
Coppell ISD	12,391	Crowley ISD	15,215
Dallas ISD	157,886	Eagle Mt-Saginaw ISD	19,653
Desoto ISD	9,747	Everman ISD	5,889
Duncanville ISD	12,824	Fort Worth ISD	87,428
Garland ISD	57,133	Grapevine-Colleyville	13,857
Grand Prairie ISD	29,344	Hurst-Euless-Bedford	23,120
Highland Park ISD	7,044	Keller ISD	34,660
Irving ISD	34,792	Kennedale ISD	3,140
Lancaster ISD	7,640	Lake Worth ISD	3,507
Mesquite ISD	41,038	Mansfield ISD	34,309
Richardson ISD	39,268	White Settlement ISD	6,797
Sunnyvale ISD	1,738	**Travis County**	
Harris County		Austin ISD	83,067
Aldine ISD	69,768	Del Valle ISD	11,278
Alief ISD	46,376	Eanes ISD	8,134
Channelview ISD	9,529	Lago Vista ISD	1,449
Crosby ISD	5,992	Lake Travis ISD	9,825
Cypress-Fairbanks	114,868	Manor ISD	8,870
Deer Park ISD	13,185	Pflugerville ISD	24,591

Source: Texas Education Directory (2017).

Furthermore, only 11 of the 71 districts in the five major metropolitan counties are small enough to receive size adjustments through the state's funding formula. In addition to the six described above, there were Alamo Heights ISD and Somerset ISD in Bexar County, Huffman ISD in Harris County, and Castleberry ISD and Lake Worth ISDs in Tarrant County.

Consolidating to the county level of all traditional public school districts in the five counties that are referenced by TEC Section 12.1013(e)—as appears to be the intent of the section—would create new districts that were very large by Texas and national standards. With an enrollment of 854,027 students, the consolidated Harris County ISD would be the second largest school district in the country (behind only New York City Schools).[6] The consolidated Dallas County ISD (enrollment 443,987) would be the fourth largest school district in the country, ahead of the Chicago Public School system, but smaller than Los Angeles Unified School district (which would be the third largest district). The consolidated Tarrant (352,169) and Bexar (327,389) County ISDs would be the nation's seventh and eighth largest districts, respectively, while the consolidated Travis County ISD (147,214) would be among the 25 largest districts nationwide.

Alternatively, one could consider only consolidating the districts in the five counties that receive size adjustments under the school funding formula. These are the districts for which consolidation is likely to have the largest positive effects and the only districts in the designated counties where the state funding could be reduced by consolidation (once the hold harmless provisions expire). If the three military base districts in Bexar County were consolidated, the resulting Department of Defense School District would have a combined enrollment of 4,064. Similarly, if the other size-adjusted districts were consolidated with their smallest, same-county neighbor that was not a military base district, then Sunnyvale ISD would consolidate with Mesquite ISD; Kennedale ISD would consolidate with Everman ISD; Lago Vista ISD would consolidate with Lake Travis ISD; Alamo Heights would consolidate with San Antonio ISD; Somerset ISD would consolidate with Southside ISD; Huffman ISD would consolidate with Crosby ISD; and Castleberry ISD and Lake Worth ISD would consolidate with each other. Consolidating with the smallest neighbor preserves as much competition as possible so it represents the most likely case for net benefits from consolidation.

The Cost Function Analysis

Cost function analysis provides a formal, analytic framework in which to simulate the impact of school district consolidation. Cost function analysis has been widely used in all sorts of contexts for more than 60 years, and in education contexts for at least 30 years. As discussed in Gronberg et al. (2015) and Taylor et al. (2014), when properly

[6] Data on school district enrollment outside of Texas come from the Digest of Education Statistics 2015 (Snyder, De Bray and Dillow, 2016).

specified and estimated using stochastic frontier analysis (SFA), the educational cost function is a theoretically and statistically reliable method for estimating the relationship between school district size and the cost of education.

Table 4: Key Components of the Educational Cost Function

Component	Measured by
Units of Analysis	All Standard Campuses in Traditional Public School Districts Located in any Metropolitan or Micropolitan Area Five Most Recent School Years (2011–12 through 2015–16)
Expenditures	Operating Expenditures Excluding Food and Transportation
Outcomes	Average Conditional NCE Scores on State Assessments Campus Number of Students Enrolled
Input Prices	Teacher Salary Index Distance to the Center of the Nearest Metropolitan Area
Environmental Factors	Campus % Economically Disadvantaged Campus % Ever Limited English Proficient (Ever-LEP) Campus % High Needs Special Education Campus % Other Special Education Campus Type School District Size
Controls for Inefficiency	Stochastic Frontier Analysis Degree of School Choice K–8 District Status

Source: Appendix A.

The key components of the cost function analysis are summarized in Table 4, and described in the sections below. For a technical description of the cost function analysis, see Appendix A.

Units of analysis

TEC Section12.1013(e) specifically requires a report on likely outcomes for individual campuses. Therefore, this simulation is based on a campus-level analysis of the cost function. The analysis covers the five most recent school years with complete data (2011–12 through 2015–16).

To develop the best possible estimates of the size-cost relationship, the cost-function analysis includes all standard accountability campuses in traditional public districts located in a metropolitan or micropolitan core-based statistical area (CBSA).[7,8] Standard accountability campuses are subject to all the rules and regulations pertaining to the Texas Accountability Rating System and therefore share a similar set of goals, objectives and educational processes (TEA, 2014). Alternative Education Accountability (AEA) campuses (e.g., juvenile justice campuses, disciplinary education campuses, residential campuses and all other alternative education campuses) have been excluded because they are subject to different accountability requirements and may have different cost structures than other campuses. Schools in rural areas (i.e., counties without a central city of at least 10,000 people) were not included because TEC Section 12.1013(e) specifically focuses on estimating the effects of consolidation in major metropolitan areas and limiting the analysis in this way provides additional validity (by making the cost and competitive environments for the campuses more similar). Because they operate under a different set of rules and regulations than traditional public school districts and consolidation does not imply deregulation, open-enrollment charter schools have also been excluded from the data set.

Expenditures

The educational cost function seeks to explain variations in educational expenditures using data on educational outcomes, input prices and environmental factors. Here, educational expenditures are measured as operating expenditures per pupil, excluding food and student transportation expenditures. It is customary to exclude food and transportation expenditures from the measure of expenditures used in cost function analyses because those categories of expenditures are unlikely to be explained by the same factors that explain student performance, and therefore add unnecessary noise to the analysis.[9] (As discussed in Appendix A, including these categories has no qualitative effect on the key parameters of the cost function, but does reduce both the precision of the estimates and the estimate of cost efficiency.)

[7] Although many Texas school districts cross county lines, TEA officially associates each school district with a single county. Those official designations have been used to identify CBSA locations for campuses in traditional public school districts, using the July 2015 CBSA definitions developed by the U.S. Office of Management and Budget and published by the U.S. Census Bureau. A metropolitan area is a county or cluster of counties with a central, urbanized area of at least 50,000 people. A micropolitan area is a county or cluster of counties with a central city of at least 10,000 people. Two counties are considered part of the same CBSA whenever commuting patterns indicate that the counties are part of the same integrated labor market area. In Texas, College Station-Bryan is a metropolitan area, and Nacogdoches is a micropolitan area.

[8] Virtual campuses and campuses that lack reliable data on student performance (such as elementary education campuses that serve no students in tested grades, or very small campuses) have also been excluded.

[9] For examples, see Gronberg, Jansen & Taylor (2011a, 2011b), Gronberg, Jansen, Taylor & Booker (2004, 2005); or Imazeki & Reschovsky (2006).

The actual expenditures data come from the Public Education Information Management System (PEIMS) and have been adjusted to account for school districts that serve as a fiscal agent for another school district or group of districts.[10] All expenditures have also been adjusted to account for the fact that districts differ in the percentage of their total spending they attribute to specific campuses. Some districts provide maintenance services centrally, for example, whereas other districts assign maintenance personnel to specific buildings. To ensure that all of the educational resources in a district are accounted for, school district expenditures that were not associated with a specific campus have been allocated to the district's campuses on a per pupil basis.[11] Thus, for example, if Little Elementary serves 20% of the students in its district, it is presumed to be responsible for 20% of the unallocated spending.

Figure 2 illustrates the distribution of operating expenditures per pupil for the standard accountability campuses used in this analysis.[12] As the figure illustrates, operating expenditures in 2015–16 ranged from $5,000 to more than $20,000, per pupil. Expenditures per pupil were significantly higher for multi-grade campuses (those that could not be classified as elementary, middle or high schools) than for any other type of campus, largely because this category includes a number of small, single campus districts such as Harrold ISD in the Vernon, Texas micropolitan area.[13] On average, spending was significantly higher in high schools (where the mean in 2015–16 was $9,749) than in elementary schools (where the mean was $8,375) or middle schools (where the mean was $8,610). The difference in average spending between elementary and middle schools was also statistically significant.

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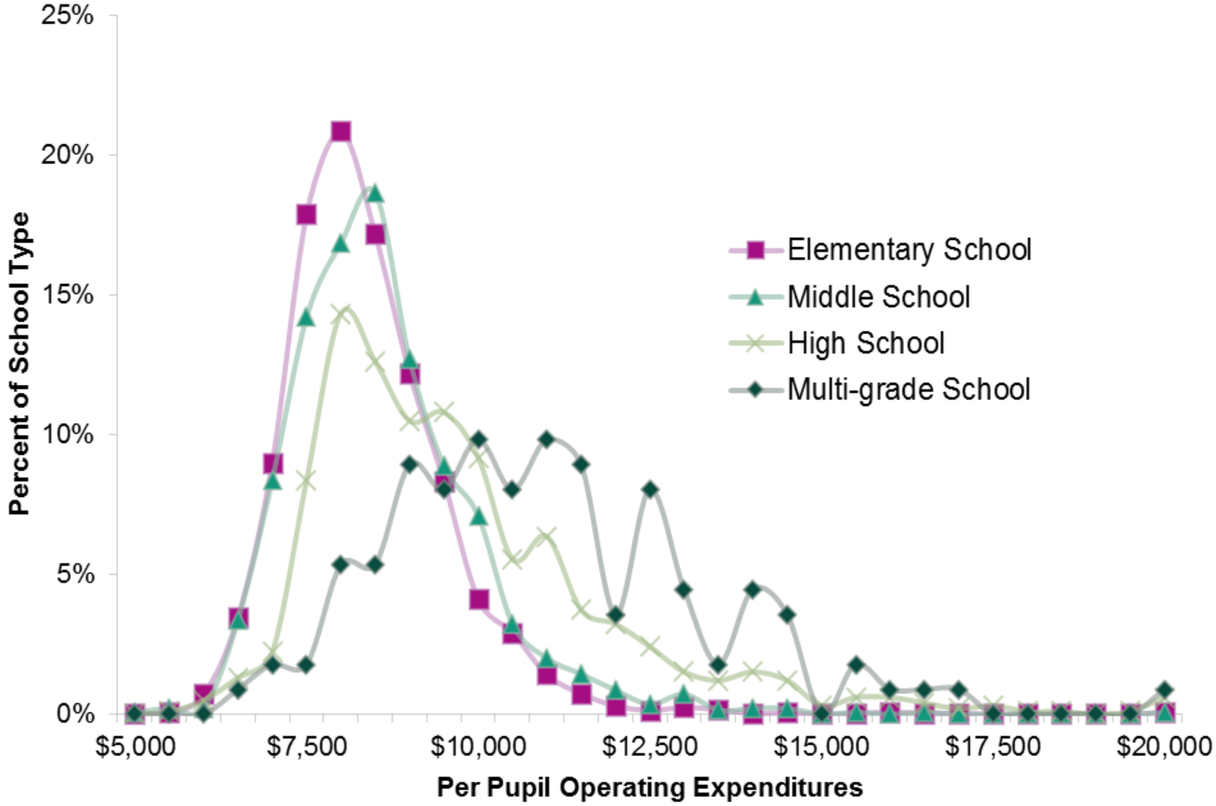
[10] Fiscal agents collect funds from member districts in a shared service agreement, and make purchases or pay salaries with those shared funds on behalf of the member districts. As a result, spending of fiscal agents is artificially inflated while the spending by member districts is artificially suppressed. See Appendix A.

[11] Taylor et al. (2014) and Gronberg et al. (2015) also followed this approach.

[12] Per-pupil operating expenditures less than $3,500 or more than $33,000 were deemed implausible and treated as missing in this analysis.

[13] Throughout this report, the term "significantly" indicates something that is statistically significant at the 5% level, meaning that there is less than a 5% chance that the difference is due to chance alone.

Figure 2: Operating Expenditures per Pupil for Standard Accountability Campuses in Core Based Statistical Areas, by School Type, 2015–16

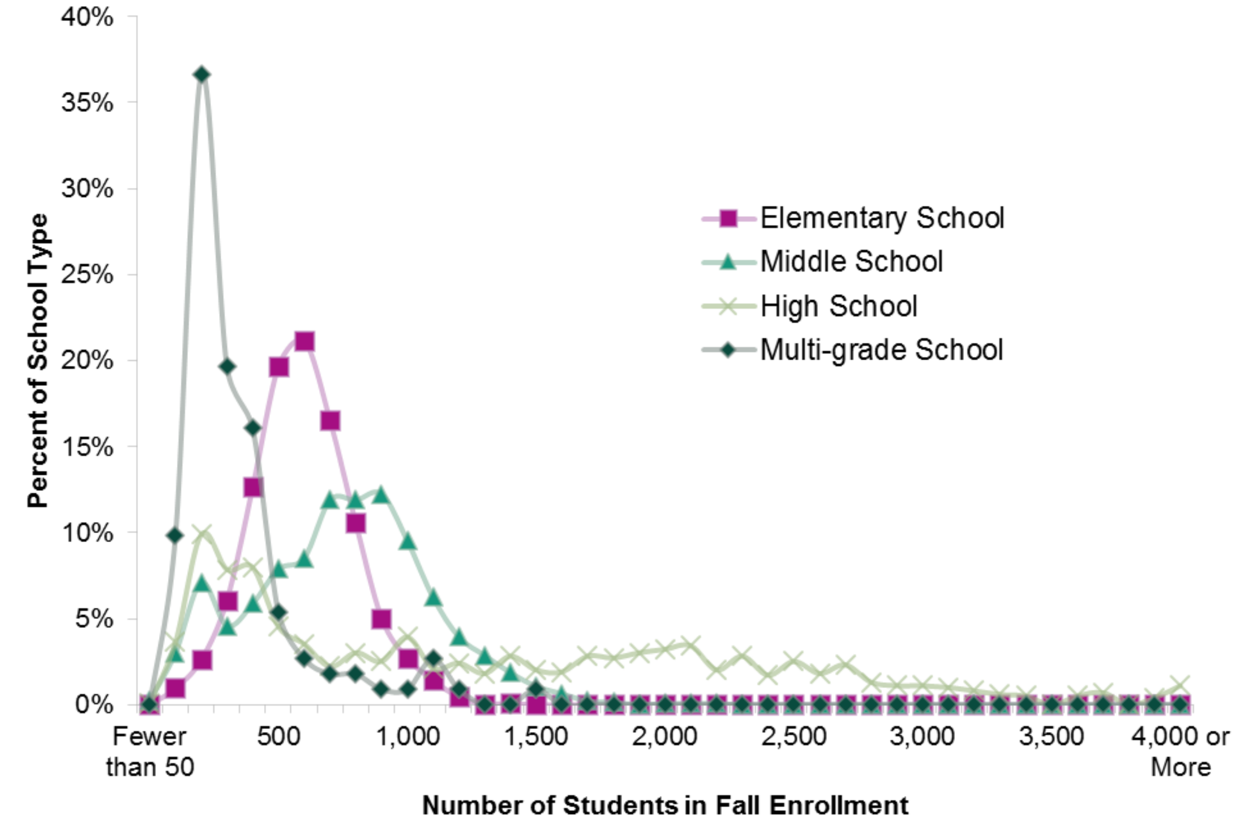


Source: Public Education Information Management System (PEIMS) and Texas Accademic Performance Report (TAPR) 2015–16.

Outcomes

If schools are behaving efficiently, then increases in educational outcomes will require increases in educational expenditures. Total educational outcomes have both a quantity and a quality dimension. Quantity is measured using the number of students in fall enrollment at the campus. In 2015–16, campus enrollment in the estimation sample ranged from 37 to 4,743 students; the average campus had 742 students (Figure 3). On average, elementary schools were significantly smaller than middle schools which in turn were significantly smaller than high schools. Typically, multi-grade schools were the smallest type of all, but there were a few exceptions to this rule. For example, Westchester Academy for International Studies in Spring Branch ISD (which serves Grades 6–12) was a multi-grade campus with an enrollment above 1,000 in 2015–16.

Figure 3: Campus Enrollment for Standard Accountability Campuses in Core Based Statistical Areas, by School Type, 2015–16



Source: Texas Academic Performance Report (TAPR) 2015–16.

The quality measure used in this analysis captures differences in average student performance in reading and mathematics. This measure is based on student performance on the required State of Texas Assessments of Academic Readiness (STAAR®) Grades 3–8 and end-of-course (EOC) exams.[14] Although schools clearly produce outcomes that may not be reflected in mathematics and reading test scores, these are performance measures for which districts are held accountable by the state, and the most common measures of school district outcome in the literature.[15] Therefore, they are reasonable outcome measures for cost analysis.

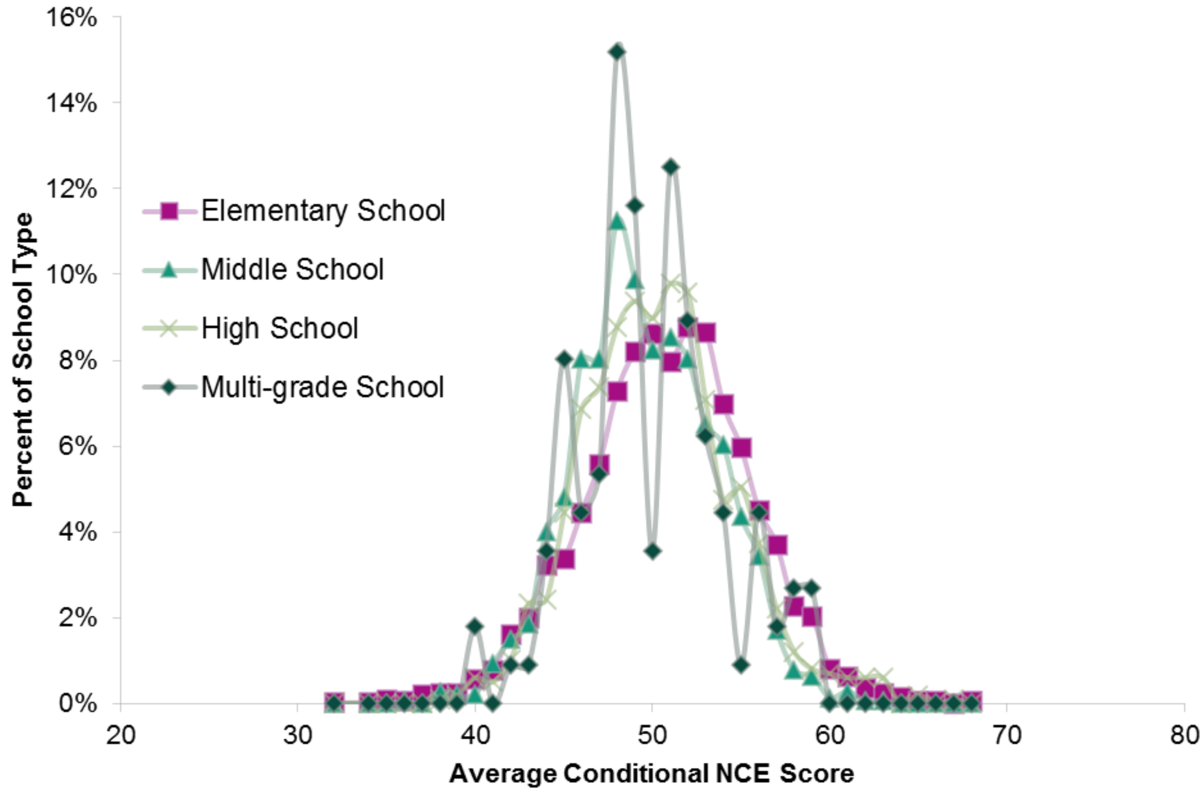
STAAR Grades 3–8 and EOC scores can be difficult to compare across grades, years or testing regimes. Therefore, the various test scores have been transformed into conditional normal curve equivalent (NCE) scores.[16] A conditional NCE score describes a student's performance relative to what would have been expected given his or her

[14] Only state-mandated assessments in reading and mathematics are included.
[15] For example, see Gronberg et al. (2011a, 2011b); Grosskopf et al. (2013); Grosskopf, Hayes & Taylor (2014); or Imazeki & Reschovsky (2006).
[16] For more on the construction of conditional NCE scores, see Appendix A.

prior test score (i.e., conditional on the prior test score). A conditional NCE score of 50 indicates that the student performed at the 50th percentile (i.e., exactly as expected given his or her prior test performance) and a conditional NCE score of 90 indicates that the student performed as well or better than 90% of his or her academic peers. The average conditional NCE score in mathematics and reading for each campus is the quality measure used in this analysis.

Figure 4 illustrates the distribution of average conditional NCE scores in 2015–16. As the figure illustrates, the distribution of average conditional NCE scores is bell-shaped, with most standard accountability campuses in CBSAs having average conditional NCE scores between 40 and 60.[17]

Figure 4: Campus Average Conditional NCE Scores for Standard Accountability Campuses in Core Based Statistical Areas, by School Type, 2015–16



Source: Authors' calculations from State of Texas Assessments of Academic Readiness (STAAR) 3-8 and STAAR EOC, 2014–15 and 2015–16.

[17] In the interests of statistical reliability, campuses with fewer than 25 students for whom a conditional NCE could be calculated were excluded from the analysis.

Input Prices

One key to estimating an educational cost function is identifying a measure of the price schools must pay for their most important input—teachers. Unfortunately, the average salary in a campus or district is not a good measure of price because it reflects the mix of teacher characteristics. For example, the average salary in a district that employed only inexperienced teachers would be lower than the average salary in a district that employed only highly experienced teachers, even if the price each district paid for each type of teacher (i.e., the steps on the salary schedule) were identical.

A common strategy for generating a price measure that does not reflect personnel choices is to estimate a hedonic wage model. (See Appendix B.) A hedonic wage model can be used to isolate the part of teacher salaries that is outside of school district control. Hedonic wage models have a long history in labor economics, and have been used in education finance contexts for more than 30 years. The Texas Cost of Education Index (which is a component of the Foundation School Program) is based on a hedonic wage model (Taylor, Alexander, Gronberg, Jansen & Keller, 2002).

The hedonic wage model used in this analysis describes the observed pattern of teacher salaries in Texas' CBSAs as a function of labor market characteristics, job characteristics, and individual teacher characteristics. Using the model, one can predict how much each campus must pay, each year, in order to hire a teacher with standard characteristics (i.e., a master's degree and 10 years of experience, or a bachelor's degree with zero years of experience). The Teacher Salary Index (TSI) for each campus (each year) is the predicted salary at that campus for a teacher with a standard set of characteristics, divided by the minimum predicted salary in a CBSA (for that year).[18] Each year during the five-year analysis period, the TSI ranged from 1.00 to 1.33 indicating that the cost of hiring teachers was up to 32% higher in some of the CBSA campuses under analysis than in others.

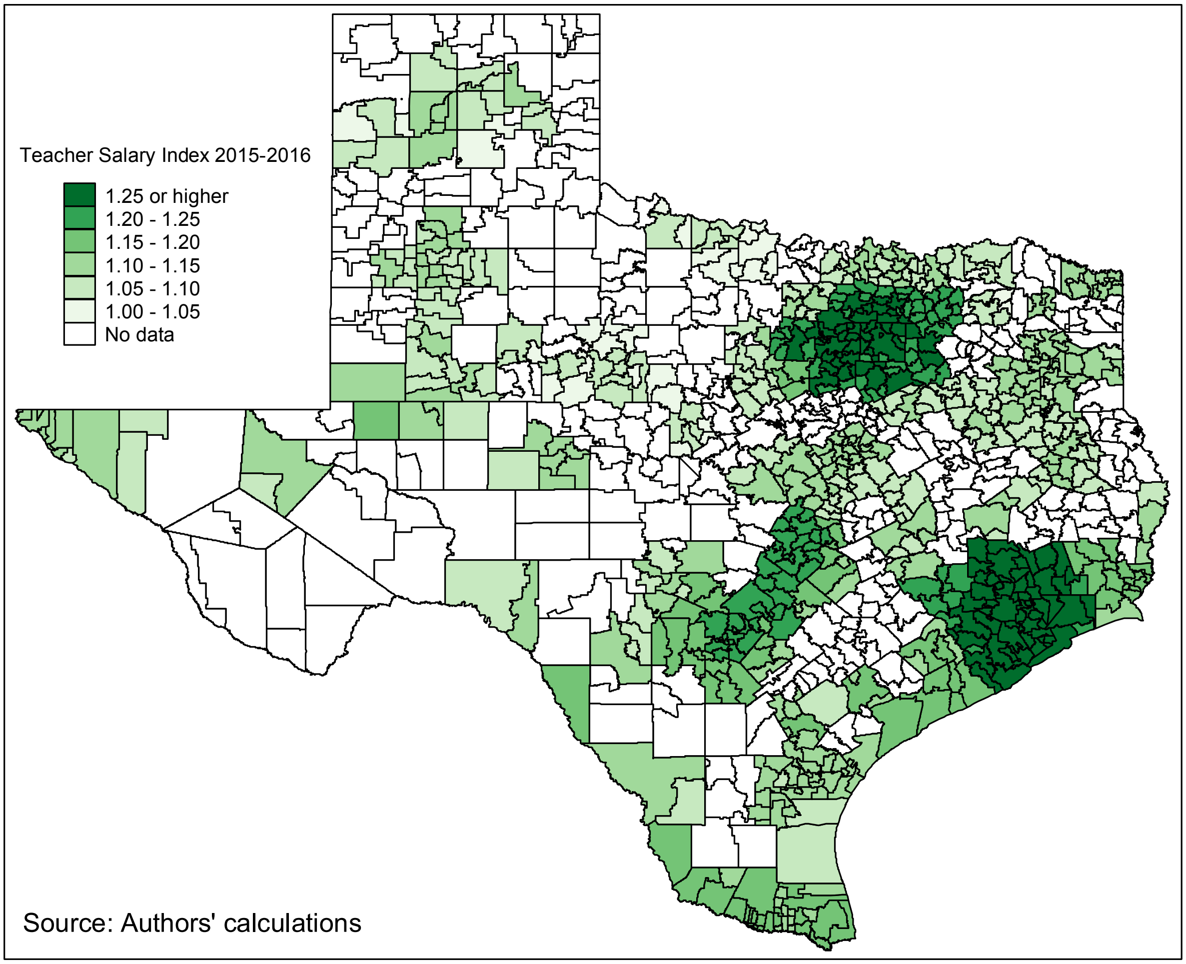
Figure 5 maps the average TSI values, by school district, for the 2015–16 school year. As the figure illustrates, on average the TSI is highest in the Houston, Dallas and Fort Worth metropolitan areas and lowest in the Vernon and Sulphur Springs micropolitan areas

Ideally, the analysis would also include direct measures of local prices for instructional equipment and classroom materials. Unfortunately, such data are not available. However, prices for pencils, paper, computers, and other instructional materials are largely set in a competitive market (and therefore unlikely to vary across schools), and prices for nonprofessional labor or building rents are largely a function of school location (and therefore likely to be highest in the central cities and lowest in the

[18] The TSI would be identical if it were constructed based on the predicted wage for a teacher with 10 years of experience and a master's degree or zero years of experience and a bachelor's degree. All that matters in the construction of the index is that the wage projections be based on a common set of teacher characteristics.

suburbs or the micropolitan areas). Therefore, as in in Gronberg et al. (2015) and Taylor et al. (2014) the cost analysis includes the distance to the center of the nearest metropolitan area as a proxy for differences in the cost of non-labor inputs.[19]

Figure 5: The Teacher Salary Index for Core Based Statistical Areas, 2015–16

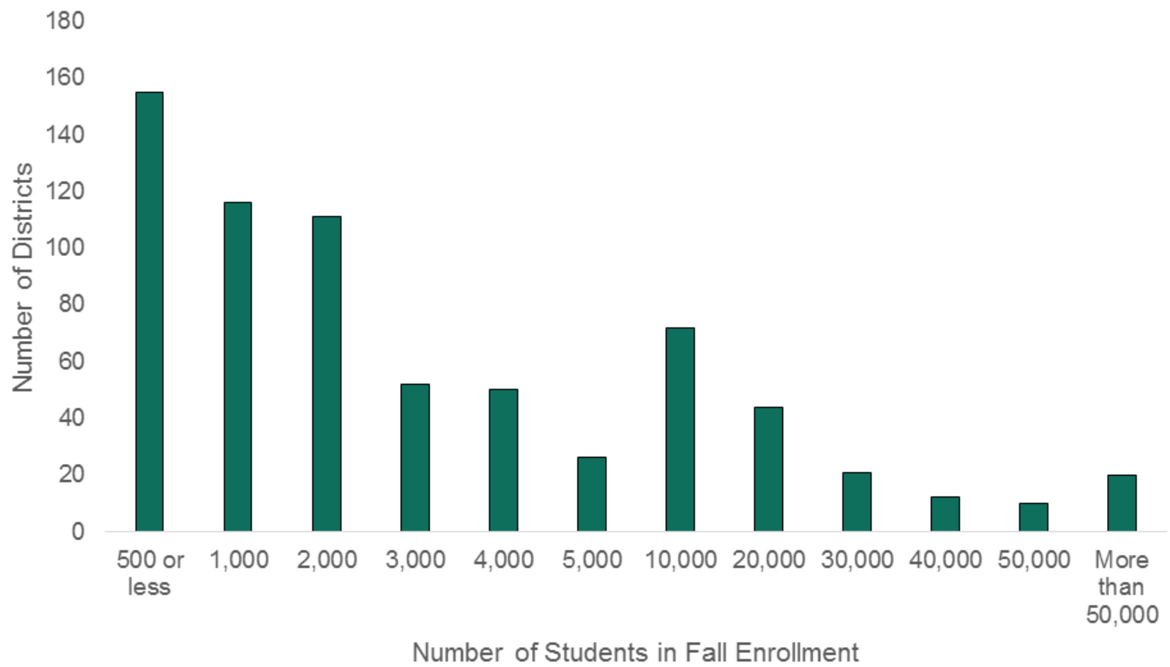


Environmental Factors

There are several environmental factors that influence the cost of education but are not purchased inputs. One such factor is the size of the school district. As Figure 6 illustrates, district enrollment for the campuses used in this analysis ranges from fewer than 1,000 students to more than 200,000 students. The median school district in a Texas CBSA has fewer than 1,700 students and three quarters of the districts have fewer than 5,000 students.

[19] Miles to the center of the nearest metropolitan area was calculated as-the-crow-flies for each campus using latitude and longitude information.

Figure 6: The Distribution of Enrollments for School Districts in Core Based Statistical Areas, 2015–16



Source: Texas Academic Performance Report (TAPR), 2015–16.

The other factors identified as influencing the educational environment are student need and school type. To capture variations in cost that derive from variations in student need, the analysis includes four measures of student demographics for each campus—the percentages of students who were identified as economically disadvantaged, high needs special education, other special education or limited English proficient (LEP). [20,21] To capture differences in the cost of education that arise from differences in mandatory class sizes, or the scope of instruction, the analysis also includes indicators for elementary, middle and multi-grade schools.

Controlling for inefficiency

One of the keys to cost function analysis is the choice of estimation strategy. This analysis relies on SFA because, unlike other statistical techniques, SFA explicitly allows for the possibility that spending could be systematically higher than cost. If schools are

[20] Following Gronberg et al. (2005), high needs special education students are special education students who have any classification other than learning disability or speech-language disability.
[21] For statistical reasons, the measure of LEP status used in this analysis includes not only students who are currently LEP, but also any students who have ever been identified as LEP by the Texas school system. The percentage of students who had ever been identified as LEP greatly exceeds the percentage of students currently identified as LEP in some campuses.

behaving efficiently, then SFA generates the same cost function estimates as other estimation techniques. Therefore, SFA can be thought of as a more general approach.

When the educational cost function is estimated using SFA, school spending is presumed to depend not only on the direct determinants of educational cost (outcomes, input prices and environmental factors) but also on a set of factors that could lead one school district to behave more efficiently than another. Because previous researchers have found that competition affects cost efficiency, this analysis includes a measure of educational competition as one of the factors that might influence school district efficiency. [22, 23]

As is common in the literature, the degree of educational competition is measured using a Herfindahl index of enrollment concentration in the local labor market.[24] A Herfindahl index of 1.00 indicates a metropolitan area with a single local education agency (LEA); a Herfindahl index of 0.10 indicates a metropolitan area with 10 LEAs of equal size. Thus, the Herfindahl index increases as the level of enrollment concentration increases (or equivalently, as the level of educational competition decreases).

Figure 7 illustrates the distribution of educational competition among Texas' school districts. As the figure indicates, most non-rural Texas school districts are located in a highly competitive education markets—such as the Dallas and Houston metropolitan areas. Such markets have a Herfindahl index below 0.10. Other districts are located in highly concentrated markets—such as the Andrews or Eagle Pass micropolitan areas—where the Herfindahl index is above 0.90.

The five counties referenced in TEC Section 12.1013(e) are the core counties of Texas' five largest metropolitan areas—Austin, Dallas, Fort Worth, Houston and San Antonio. As the figure shows, these five major metropolitan areas are among the most competitive of Texas' education markets.

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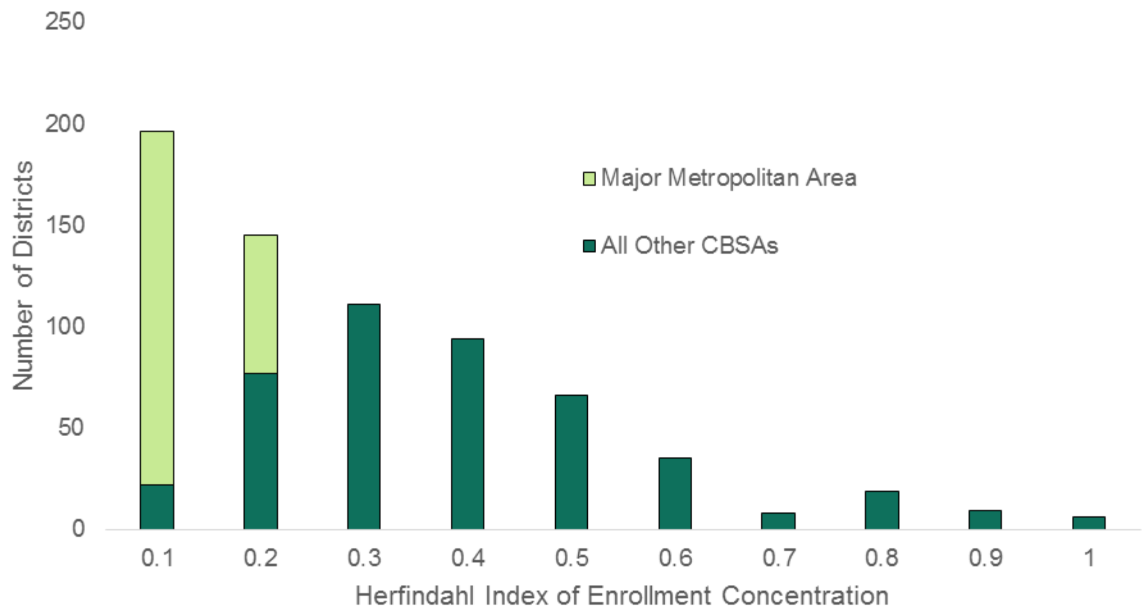
[22] For example, see Belfield & Levin (2002); Millimet & Collier (2008); or Taylor (2000).

[23] Another factor included to control for school district efficiency is an indicator for whether or not the district served a limited grade range. This indicator was included to control for the possibility that a district without a high school could specialize more than other districts of similar size, and therefore be more cost efficient. The one traditional public school district that does not serve elementary grades, South Texas ISD, has been excluded from the analysis.

[24] A Herfindahl index is defined as the sum of the squared local education agency (LEA) enrollment shares, where an LEA's enrollment share is its own enrollment divided by the total enrollment in the CBSA. Both traditional public school districts and open-enrollment charter schools are included in the calculation of enrollment concentration because both are included in the public school choices available to parents

Figure 7: Herfindahl Index of Educational Competition for Districts in Core Based Statistical Areas, 2015–16



Source: Author's calculations from Texas Academic Performance Reports (TAPR) 2015–16.

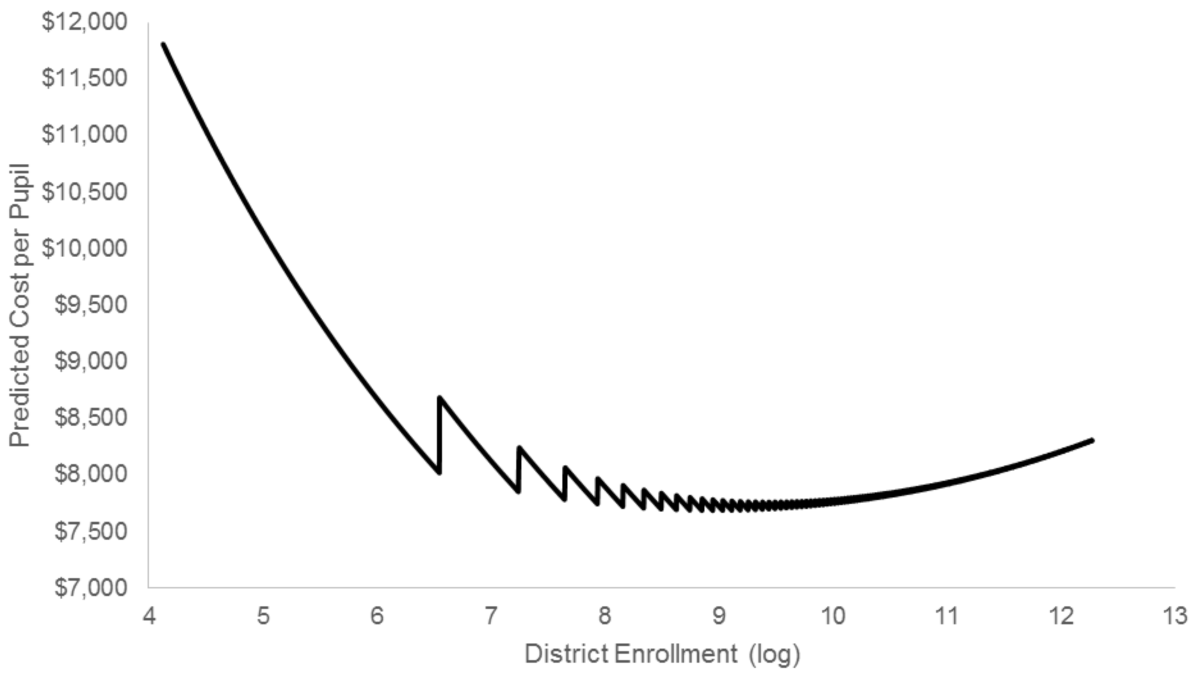
Cost Function Results

As discussed in Appendix A, the cost function analysis yields a reasonable picture of the educational process in Texas. According to the cost function estimates, increases in average student performance require increases in educational expenditures. Campuses with a higher TSI have a higher cost of education. Students with greater needs are more costly to educate, and high schools are more costly to operate than elementary or middle schools.

The analysis revealed significant economies of scale for both campuses and districts. As a general rule and holding everything else constant, increases in campus size led to decreases in the cost of education. For example, the cost function indicated that all other things being equal, a 200-student campus cost 14% more to operate than a 400-student campus. Similarly, a 1,500-student campus cost 9% more to operate than a 3,000-student campus.

The relationship between district enrollment and predicted cost is more complicated, and easiest to understand with the aid of a picture. Figure 8 presents predicted per-pupil cost, holding all of the inputs, outputs and environmental factors except campus and district enrollment constant at their sample means. Because it is not possible for a district with 500 students to have an average campus size of 700 (roughly the sample mean), and nearly as implausible to assume that a district with 900 students could have an average campus size of 700, the figure was constructed using a plausible relationship between campus and district size. For the purposes of this illustration, it was assumed that districts increase the number of campuses by one whenever campus enrollment reaches the (admittedly arbitrary) threshold of 700 students. (Note that the largest district in Texas, Houston ISD, had an average campus enrollment of 782 and the average CBSA campus had an enrollment of 732.) The saw-tooth pattern in the figure reflects the abrupt changes in campus size necessitated by the assumption that campus size never exceeds 700. For example, as district enrollment increased from 700 students to 701 students, the district was presumed to add a second campus, dropping average campus enrollment from 700 to 350.5 (=701/2) and increasing the predicted per-pupil operating cost from $8,021 to $8,684.

Figure 8: The Estimated Relationship between Per Pupil Cost and School District Enrollment, Holding Campus Size at or Below 700



Source: Authors' calculations from Appendix C.

As the figure illustrates, costs are highest for very small districts, but holding campus size constant, the differences are not large. A district with one campus and 700 students, for example, is predicted to cost 2.1% more to operate than a district with two campuses and 1,400 students. Similarly, a district with five campuses and 3,500 students was predicted to cost 0.5% more to operate than a district with ten campuses and 7,000 students. As district size increases, costs tend to fall until the log of district enrollment reaches a value of 8.95 (or 7,700 students). As district enrollment increases beyond that point (holding campus size at or below 700 students) costs per student rise. Thus, there are clear economies of scale in Texas education, but, consistent with the literature discussed above, the cost savings from increases in district size are largely exhausted at relatively low levels of district enrollment.

The analysis also found clear evidence that expenditures exceeded what would be expected if campuses were operating efficiently, and that the degree of inefficiency (i.e., the extent of the unexplained expenditures) was an increasing function of enrollment concentration. In other words, the analysis supports the hypothesis that more choice leads to more efficiency in the Texas public education system.

One important caveat to the results discussed above is the exclusion of implicit transportation costs from the analysis. Transportation costs in the public school setting consist of both explicit and implicit costs. The direct costs, such as the cost of providing buses and drivers, are borne by the district. The implicit costs fall on the households of students in the district, and include the time costs of parents providing transportation services to their children or the effort and time students spend on their own transportation. Districts that are sparsely populated may face large direct and indirect per student costs of transportation. Districts that are densely populated, perhaps many urban districts, may find their transportation costs per student are lower. The optimal campus size for a district will involve a balancing of transportation costs and campus operating costs, with the optimal balance varying with the spatial distribution of the district population. The key point here is that the ability of a district to appropriate operating cost size economies, which in turn assumes an ability to form operating cost efficient campuses, may be attenuated by transportation cost diseconomies. Spatial considerations can be an important piece of a comprehensive consolidation evaluation.

Simulating Consolidation

This analysis explores two possible consolidation scenarios. The first, which was also examined in Taylor et al. (2014), simulated the consolidation to the county level of all traditional public school districts in the five counties (Bexar, Dallas, Harris, Tarrant and Travis) that are referenced by TEC Section 12.1013(e). The second scenario simulated the consolidation of each district (in the five counties) that is currently eligible for size adjustments under the state funding formula with its smallest neighbor. The simulations, which are described in greater detail in Appendix A, compared the predicted spending before and after consolidation for each campus in the five affected metropolitan areas.

For each scenario, the simulation predicted the change in expenditures per pupil for all of the campuses impacted by the consolidation. There were two types of impacted campuses: those that were part of the consolidation and those that were located in a metropolitan area where consolidation occurred. For campuses that were part of the consolidation, there were two impacts.

1. District size increased, which was expected to reduce the per-pupil cost of education for campuses in small and midsized districts, but increase the per-pupil cost of education for campuses in larger districts.
2. Enrollment concentration increased, which had no effect on cost, but was expected to increase inefficiency and therefore expenditures.

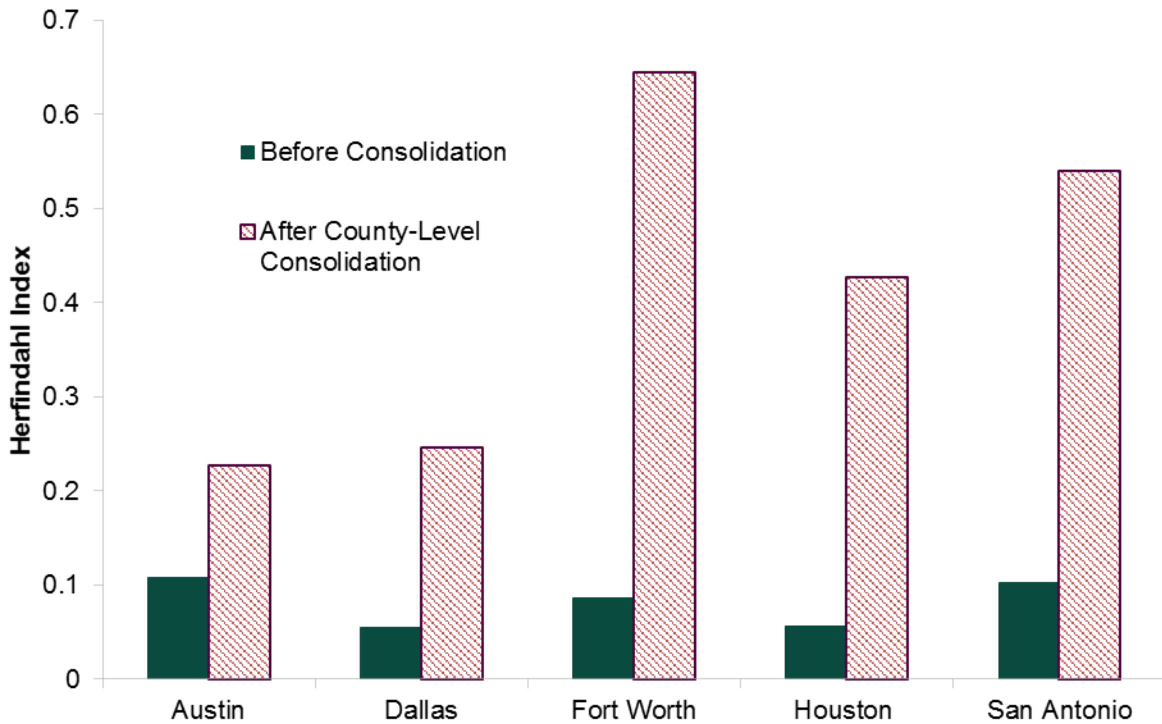
Campuses that were located in an affected metropolitan area but not an affected county would experience the second impact but not the first. Therefore, inefficiency in those campuses would unambiguously be expected to rise, leading to an increase in predicted spending (assuming they maintained their current levels of student performance).

In all cases, the scenario was constructed assuming that campus characteristics remained unchanged and the newly consolidated school districts did not close any campuses in the wake of consolidation. Given the political difficulties associated with closing a viable, neighborhood school and the lack of historical precedents, it is not possible to predict the nature of any school-level consolidations as a result of the proposed consolidations, and therefore not possible to develop more credible assumptions about the nature of any campus-level consolidations.

Consolidation to the County Level

Consolidation to the county level would clearly change the level of enrollment concentration in the affected metropolitan areas. Figure 9 compares the Herfindahl index for the five affected metropolitan areas before and after all traditional public school districts in the core county have been consolidated. As the figure illustrates, consolidating the traditional public school districts in these five counties would have a large impact on the level of enrollment concentration in their metropolitan areas. Currently, the metropolitan areas affected by the proposed consolidations are five of the seven most competitive education markets in Texas. (The other two are Longview and McAllen.) After consolidation, the Herfindahl index would more than double for the Austin metropolitan area, and would more than quadruple for the other metropolitan areas. Consolidation to the county level would have a particularly large effect on enrollment concentration in the Fort Worth and Houston metropolitan areas, where the Herfindahl index would increase more than sevenfold (from 0.09 to 0.65 for Fort Worth and from 0.06 to 0.43 for Houston).

Figure 9: The Effect of Consolidation on Enrollment Concentration in Referenced CBSAs



Source: Authors' calculations from Texas Academic Performance Reports (TAPR) 2015–16.

The simulation exercise compared the predicted expenditure per pupil in a campus before consolidation with the predicted expenditure per pupil in that campus after consolidation. In addition, in order to see the overall impacts of the consolidation, the pre-consolidation predicted total expenditures in a county were compared with the post-consolidation predicted total expenditures in that county. (The assumptions that underlie the simulation are described in Appendix A.)

To illustrate the extent of the potential gains, consider Lake Travis High School in Travis County which had 2,694 students in 2015–16. Predicted per pupil expenditure before consolidation was $8,266, and predicted per pupil expenditure after consolidation was $7,539. Hence the simulation is predicted to generate savings of $727 per pupil (8.8%).

On the other hand, consider Hill Elementary School in Arlington ISD, which had an enrollment of 575 students in 2015–16 and which under the consolidation would become part of the Tarrant County consolidated school district. The school's predicted expenditure per pupil was $7,881 before consolidation, and $8,828 afterwards, or an increase in per pupil expenditures of $947 (12.0%).

Finally, consider Celeste Junior High in Hunt County, which had an enrollment of 111 students in 2015–16. The school's predicted expenditure per pupil is $10,283 before consolidation, and $10,449 after consolidation, or a predicted increase in per pupil expenditures of $166 (1.6%). This increase is completely attributable to the predicted increase in inefficiency due to a loss of competition in the Fort Worth metropolitan area.

Only high schools were predicted to benefit from consolidation to the county level. None of the elementary, middle or mixed grade campuses under analysis were predicted to spend less after county-level consolidation than they did before. Furthermore, less than a third of the secondary schools in the consolidating counties were expected to achieve cost savings. On average, the high schools that were predicted to spend less after county-level consolidation were significantly larger and served a significantly less economically disadvantaged student body than the other high schools in the consolidating counties.

Table 5 summarizes the change in predicted expenditures per pupil for each of the five counties and metropolitan areas. Consolidation increased the predicted expenditure per pupil by 10.0% in Bexar County, 8.7% in Dallas County, 11.2% in Harris

Table 5: Simulated Impact of Consolidation to the County Level

	Total Predicted Expenditures Without Consolidation (in millions)	Change in Predicted Expenditures (in millions)	% Change
Bexar County	$2,733	$272	10.0%
Rest of San Antonio CBSA	761	16	2.1%
Dallas County	3,844	336	8.7%
Rest of Dallas CBSA	3,389	55	1.6%
Harris County	6,727	756	11.2%
Rest of Houston CBSA	3,199	75	2.3%
Tarrant County	2,897	289	10.0%
Rest of Fort Worth CBSA	600	15	2.5%
Travis County	1,257	49	3.9%
Rest of Austin CBSA	1,378	12	0.8%

Note: The rest of the CBSA refers to the school districts in the designated metropolitan area, but outside of the core county.
Source: Authors' calculations

County, 10.0% in Tarrant County, and 3.9% in Travis County. After consolidation, the expected increase in total county expenditure ranged from $49 million in Travis County to $756 million in Harris County.

Consolidation would have the biggest impact on choice in the Houston and Fort Worth metropolitan areas, so it is not surprising that the simulation indicated that those consolidations would have the greatest impact on non-consolidating districts. Expenditures were predicted to increase by 2.3% for the districts in the Houston metropolitan area that are outside of Harris County, and by 2.5% for the districts in the Fort Worth metropolitan area that are outside of Tarrant county.

Consolidation among Small and Midsized Districts

The second scenario consolidates only the eleven districts in the five counties that receive size adjustments under the school funding formula. These are the districts for whom consolidation is likely to have the largest positive effects. The simulation indicates that there would be very modest benefits from consolidation under this scenario.

Table 6 illustrates the simulated impact of consolidating the small and midsized districts with their smallest neighbors in five counties. As the table illustrates, consolidating the small and midsized districts with their smallest neighbors is expected to increase expenditures in the San Antonio and Dallas metropolitan areas, and decrease expenditures in the Houston, Fort Worth and Austin metropolitan areas. In all five counties or metropolitan areas, the change in predicted expenditures represents less than one tenth of one percent of the total predicted expenditures without consolidation.

Table 6: Simulated Impact of Consolidating Small and Midsized Districts in Five Counties

	Total Predicted Expenditures Without Consolidation (in millions)	Change in Predicted Expenditures	Number of Campuses with Lower Expenditures After Consolidation
Bexar County	$2,733	$1,400,679	10
Rest of San Antonio CBSA	761	214,255	0
Dallas County	3,844	292,950	6
Rest of Dallas CBSA	3,389	87,258	0
Harris County	6,727	-556,842	4
Rest of Houston CBSA	3,199	12,208	0
Tarrant County	2,897	-275,603	7
Rest of Fort Worth CBSA	600	22,911	0
Travis County	1,257	-264,041	3
Rest of Austin CBSA	1,378	30,260	0

Note: The rest of the CBSA refers to the school districts in the designated metropolitan area, but outside of the core county.
Source: Authors' calculations,

Only 30 campuses were predicted to have lower spending in the wake of this consolidation. Most of them are high schools. For example, per pupil expenditures in Sunnyvale High School in Dallas County were predicted to drop by $947 (9.5%), per pupil expenditures in Everman High School in Tarrant County were predicted to drop by $162 (1.7%), and per pupil expenditures in West Mesquite High School were predicted to drop by $4 (0.05%).

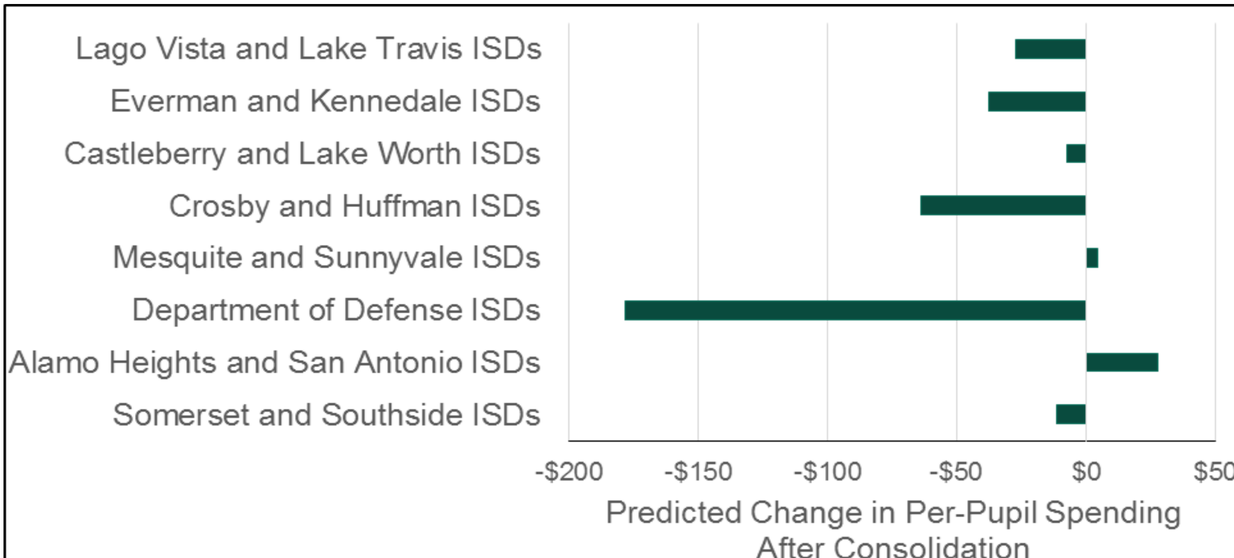
Randolph Field ISD is the only district where all of the campuses are predicted to spend less after consolidation than they did before. Consolidation with the two other military base districts in San Antonio (Lackland ISD and Ft. Sam Houston ISD) was predicted to cut per pupil spending by $116 (1.1%) at Randolph Elementary School, by $67 (0.1%) at Randolph Middle School and by $789 (5.8%) at Randolph High School.

More commonly, the simulation indicated that consolidation would increase spending in at least some campuses of the consolidating districts. For example, the scenario called for consolidating Alamo Heights ISD with its smallest non-military neighbor, San Antonio ISD. Such a consolidation was predicted to decrease per pupil spending at Alamo Heights High School by $832 (9.1%) and at Travis Early College High School by $3 (0.03%). It was predicted to increase per pupil spending at all other campuses in the two districts. Per pupil spending was predicted to increase by more than $750 per pupil in Howard Elementary in Alamo Heights ISD.

Harris County would benefit more from a small and midsized district consolidation than any other county. All of those predicted benefits arise from a single consolidation: Huffman ISD with Crosby ISD. The simulation predicted that per pupil spending would decrease at two of the three secondary schools in the combined district (Hargrave High School and Crosby High School) and two of the three middle schools (Crosby Middle School and Huffman Middle School). However, spending was predicted to rise at all seven of the elementary schools in Crosby and Huffman ISDs. Because this consolidation would have a negligible impact on competition in the Houston metropolitan area (the Herfindahl index would only increase from 0.05595 to 0.05598) it would also have a negligible impact on spending outside of the two consolidating districts.

On average, spending was predicted to decline for all of the consolidations where both parties had fewer than 10,000 students before consolidation. (Spending was predicted to increase for the Alamo Heights-San Antonio and Mesquite-Sunnyvale consolidations, wherein the larger partner had pre-consolidation enrollments above 40,000.) However, most of the simulated consolidations would yield very modest expenditure reductions (Figure 10). Only the consolidation of the three districts serving San Antonio military bases would be expected to reduce per pupil spending by more than $64 per pupil, and none of the consolidations would be expected to reduce per pupil spending by more than $180.

Figure 10: The Effect of Consolidating Small and Midsized Districts in Five Counties, by District



Source: Authors' calculations.

Conclusions

This report presents findings from a formal analysis of the potential gains from a targeted policy of school district (but not campus) consolidation. The analysis supports four key findings.

- Cost savings can be expected for consolidations involving small districts, but as the size of the consolidated district increases past 7,700 students, costs are expected to rise, not fall.
- Competitive pressure leads to greater school district efficiency in Texas, so any consolidation is expected to lead to a loss of school district efficiency.
- There are no expected cost savings from consolidating to the county level in Bexar, Dallas, Harris, Tarrant or Travis counties. Instead, expenditures are expected to increase by up to 11.2%, depending on the county. Expenditures are expected to rise not only in the consolidating districts, but also in all of the other districts in the corresponding metropolitan areas (due to the loss of competition in those education markets).
- Consolidating districts that are currently eligible for size adjustments under the school funding formula could generate savings in three of the five counties under analysis, but the impact is not large. Only the consolidation of the three school districts serving military bases in San Antonio was predicted to reduce spending by more than $64 per pupil.

Given the lack of cost savings under the first simulation and the very small level of cost savings under the second, it is highly unlikely that performance would improve markedly if there were consolidation in the designated counties. While there are many counties in Texas where all of the districts are small enough to unambiguously gain from consolidation, the existing districts in the specific counties under analysis already enjoy substantial economies of scale and would lose important incentives to behave efficiently were they to be consolidated. Therefore, there is no reason to believe that this proposal would lead to improvements in student performance, and good reason to believe student performance would fall.

Importantly, this simulation has been constructed assuming that the consolidated school districts did not close any campuses in the wake of consolidation. That is a reasonable assumption because “there is little that causes more strife and political pain in education than school closures” (Lake & Opalka 2017). After all, most of the districts in the potentially consolidating counties already have the option of campus consolidation, and have chosen not to use it. However, it is likely that at least some campuses in the newly consolidated school districts would be eliminated, allowing the average campus size to grow. As the cost function analysis indicates, there can be substantial cost savings from campus consolidation—if nothing else changes, combining two 200 student campuses into one 400 student campus is expected to reduce operating costs by 14%, for example. Therefore, the estimates in Table 5 likely overstate somewhat the increase in expenditures post consolidation for Bexar, Dallas, Harris, Tarrant and Travis counties, and the estimates in Table 6 likely understate somewhat the savings from consolidation among the small and midsized districts in those counties.

That said, the best available evidence suggests that consolidating the school districts in the core counties of major metropolitan areas would not generate large expenditure savings that could be turned into achievement gains. Instead, expenditures are expected to rise if districts were consolidated to the county level, and at best fall slightly if only small and midsized districts were consolidated. If expenditures were unable to rise as predicted after consolidation, then the simulation suggest that student performance would fall in the Dallas and San Antonio metropolitan areas under either simulation scenario, and in the Austin, Fort Worth and Houston metropolitan areas under the county-level consolidation scenario.

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Technical Appendix A: The Cost Function Model

This analysis follows Taylor et al. (2014) and uses stochastic frontier analysis (SFA) to estimate an educational cost function for Texas. A cost function—a cost frontier—specifies the minimum cost necessary to achieve certain outcomes with specified inputs and specified environmental factors. A standard empirical cost function can be written as:

$$C = C(Z \mid \beta) \cdot e\exp(\varepsilon) \quad (1)$$

where C is cost, $C(Z \mid \beta)$ is the cost function or cost frontier, $Z = \{w_1, \dots, w_k;\ z_1, \dots, z_m; y\}$ is a vector of variables affecting the frontier level of cost, where, w_l are input prices, z_j are quasi-fixed inputs including environmental factors, y is a vector of outcomes, β is the cost parameter vector to be estimated, and ε is a random noise component representing exogenous random shocks (e.g., a rainy testing day). The error term, ε, indicates random deviations from the cost frontier due to measurement error and unforeseen random changes in cost due to factors not modeled in the cost function, $C(Z \mid \beta)$.

In the stochastic frontier approach, the cost function in (1) is regarded as a frontier, a minimum cost of attaining given outputs with given inputs including environmental factors. Spending may then deviate from this cost frontier, exceeding the minimum cost specified in the cost frontier. Thus the stochastic frontier approach starts with (1) and adds the assumption that spending exceeds the cost frontier due to random errors or inefficiency. The stochastic frontier approach basically takes equation (1) and assumes that the random error, ε, consists of two parts, a standard two-sided random error that can be positive or negative and on average is zero, and a one-sided error that is always positive (or at least not negative). The one-sided error captures the idea that schools or districts can at best be on the cost frontier, if they are fully efficient, and if they are inefficient this is captured or modelled by the one-sided error. The larger the one-sided error, the further a school or district is from the frontier, and hence the more inefficient it is.

To model this, equation (1) is altered to specify the error term, ε, as consisting of two components, *v* plus *u.* The two sided error is *v*, and the one-sided error is *u*. Because inefficiency increases cost above the frontier (i.e., above the minimum possible cost), $u_i \geq 0$, where i indicates the specific decision making unit.

The stochastic frontier cost function is given as:

$$E = C(Z \mid \beta) \cdot \exp(v + u), \quad (2)$$

where E is actual or observed spending and $C(Z \mid \beta)$ is the cost frontier as described above. Here v is a random noise component representing an exogenous random shock (e.g., a rainy testing day) and u is a one-sided error term that captures cost inefficiency. Then cost efficiency is defined as $CE_i = \exp(-u_i) \leq 1$.

Cost frontier estimates indicate the cost of achieving certain educational outcomes after controlling for cost and other environmental factors. The educational outcomes include a quantity dimension—the number of students served—and a quality dimension. The quality dimension considered here is a measure of the gains in student performance relative to an expected level of performance based on past scores.

It is common to estimate stochastic frontier cost functions for education in per-pupil terms—see Andrews, Duncombe and Yinger (2002) or Gronberg, Jansen, Karakaplan and Taylor (2015). Here, the unit of observation is the campus, so here N denotes *campus* enrollment and S denote student achievement. The per-pupil stochastic frontier model is:

$$E^* \equiv \frac{E}{N} = \frac{C(\, w_1, \ldots \,, w_k;\; z_1, \ldots \,, z_m;\; S, N \mid \beta) \cdot \exp(v + u)}{N} \tag{3}$$

Taking natural logarithms of equation (3) gives

$$\ln E^* = \ln C(\cdot) - \ln N + v + u \tag{4}$$

The economic concept of “economies of scale” is, in principle, measured with respect to both dimensions of output—campus enrollment (N) and school quality (S)—simultaneously. However, most researchers focus exclusively on the quantity dimension. Andrews, Duncombe and Yinger (2002) refer to this as economies of size. This paper considers both economies of size with respect to campus enrollment and with respect to district enrollment. Economies of size is defined here as the enrollment elasticity of per pupil expenditures ($\eta = \partial \ln E^* / \partial \ln N$), holding constant student achievement (S), input prices (w), quasi-fixed inputs (z) and cost inefficiency. Using equation (4), this yields

$$\eta = \theta - 1, \tag{5}$$

where $\theta = \partial \ln C / \partial \ln N$ is the enrollment elasticity of total cost. Economies of size exist if $\eta < 0$, or correspondingly if $\theta < 1$.

An important feature of the decision-making environment facing school officials is the competitiveness of the district’s relevant education market. Indeed, the literature finds that competition is one factor that can influence a school district’s cost inefficiency.[25] The argument is that competition serves to discipline the tendency of

[25] For example, see Belfield & Levin (2002); Dee (1998); Gronberg et al. (2015); Gronberg, Jansen, Taylor & Karakaplan (2010); Grosskopf, Hayes, Taylor & Weber (2001); Kang & Greene (2002); or Millimet & Collier (2008).

districts to engage in excessive spending. This implies a negative relationship between the competitiveness of a district's education market and the magnitude of that district's cost inefficiency.

The stochastic cost frontier framework can accommodate models of how factors impact the one-sided error term (u). In particular, suppose that

$$u = u(x, \delta), with\, u \geq 0 \tag{6}$$

where x includes factors impacting inefficiency, such as a measure of competition, and δ is a parameter vector. Substituting (6) into the per pupil expenditure equation (4) yields

$$\ln E^* = \ln C(\cdot) - \ln N + v + u(x, \delta) \tag{7}$$

Equation (7) can be used to examine the effects of a school district consolidation on per pupil expenditures. Consolidation involves a direct change in N but also a potential change in school district market competitiveness and with it a change in efficiency.

Letting x_1 denote a measure of competition measure and differentiating equation (7) with respect to ln$N$ yields

$$\eta = (\theta - 1) + \left(\frac{\partial u}{\partial x_1}\right) \cdot \left(\frac{\partial x_1}{\partial N}\right) \cdot N \tag{8}$$

As discussed in Gronberg et al.(2015), the spending response to consolidation can be decomposed into two effects, a cost economy effect $(\theta - 1)$ and a competitive efficiency effect $(\partial u/\partial x_1) \cdot (\partial x_1/\partial N) \cdot N$. The competitive efficiency hypothesis implies both $(\partial u/\partial x_1) < 0$ and $(\partial x_1/\partial N) < 0$, so when $(\theta - 1) < 0$ the potential per pupil cost savings from consolidation will be dampened by the spending increase from increased inefficiency.

Specification of the Econometric Model

This analysis estimates a (slightly modified) translog frontier cost function. As indicated above, the dependent variable is operating expenditures per pupil (E^*). The explanatory variables—the right-hand-side variables—include n_1 output variables (enrollment, $N = q_1$, and the quality measures q_i) , n_2 input prices denoted by w_l, and n_3 environmental factors denoted by z_j. All variables except those already expressed as percentages or percentage points are in natural logarithms.

The model for campus expenditures per pupil is:

$$\ln E^* = \alpha_0 + \sum_{i=1}^{n_1} \alpha_{1i} q_i + \sum_{i=1}^{n_2} \alpha_{2i} w_i + \sum_{i=1}^{n_3} \alpha_{3i} z_i + 0.5 \sum_{i=1}^{n_1} \sum_{j=1}^{n_1} \alpha_{4ij} q_i q_j + 0.5 \sum_{i=1}^{n_2} \sum_{j=1}^{n_2} \alpha_{5ij} w_i w_j + 0.5 \sum_{i=1}^{n_3} \sum_{j=1}^{n_3} \alpha_{6ij} z_i z_j + \sum_{i=1}^{n_1} \sum_{j=1}^{n_2} \alpha_{7ij} q_i w_j + \sum_{i=1}^{n_1} \sum_{j=1}^{n_3} \alpha_{8ij} q_i z_j + \sum_{i=1}^{n_2} \sum_{j=1}^{n_3} \alpha_{9ij} w_i z_j + \alpha_{10} \cdot z_1^3 + v + u \qquad (9)$$

where usual symmetry restrictions ($\alpha_{ij} = \alpha_{ji}$) apply. Equation (9) includes both district and campus enrollment. Campus enrollment interacts with all other variables as well as entering as a quadratic. District enrollment is modeled similarly, except that, as school district size in Texas varies so greatly, a cubic term for enrollment is added.[26]

Equation (9) 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 (2006), 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). Thus, the general specification used in this analysis allows researchers to test empirically for alternative specifications common in the literature.

It bears emphasis, however, that many previous cost function estimates have been at the district level. Here, equation (9) is estimated for campus-level observations, and hence the direct economies-of-scale issue is with respect to campus enrollment. That said, district enrollment is an important environmental variable impacting campus costs, and district size is at the heart of consolidation issues.

Endogeneity

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 & Yinger (2005, 2011); Imazeki & Reschovsky (2004); or Gronberg et al. (2011a).) Campus size is also plausibly under the control of the school district—at least in the longer run. After all, larger school districts choose whether to have four 600 student high schools or two 1,200 student high schools. Districts also determine the mix of grades at a particular location. A district decides whether to have elementary schools that serve kindergarten through sixth grade and

[26] Gronberg et al. (2011a and 2015) and Taylor et al. (2014) also use this cubic specification for enrollment. Other researchers have dealt with this issue by excluding the largest Texas districts from analysis (e.g., Imazeki & Reschovsky (2004)). That option is not viable for this analysis because Dallas and Houston ISDs are among the districts to be included in the consolidation simulation.

other schools for seventh and eighth graders, or to have mixed-grade schools that serve kindergarten through eighth grade. This analysis follows Gronberg et al. (2015) and Gronberg, Jansen and Taylor (2017) and adopts a control function approach to accommodate the potential endogeneity of these key variables.[27]

Data

The data for this analysis come from administrative files and public records of the Texas Education Agency (TEA), the Education Research Center at the University of Texas at Dallas, the National Center for Education Statistics (NCES), the U.S. Bureau of Labor Statistics (BLS), the U.S. Department of Housing and Urban Development (HUD) and the U.S Census Bureau. The analysis covers the five-year period from 2011–12 through 2015–16.

The unit of analysis is the standard accountability campus in all traditional public districts located in a core based statistical area (CBSA).[28] The sample is restricted to the 26 metropolitan and 41 micropolitan areas in Texas because TEC Section 12.1013(e) specifically focuses on estimating the effects of consolidation in major metropolitan areas and limiting the analysis in this way provides additional validity (by making the cost and competitive environments for the districts more similar). Alternative Education Accountability (AEA) campuses (e.g., juvenile justice campuses, disciplinary education campuses, residential campuses and all other alternative education campuses) have been excluded because they are subject to different accountability requirements and may have different cost structures than other campuses (TEA 2014). Because they may have a different education technology that will not be available to traditional school districts (either before or after consolidation), open-enrollment charter schools have also been excluded from the cost function analysis (although they are included in the measure of educational competition). Virtual campuses and campuses that lack reliable data on student performance (such as elementary education campuses that serve no students in tested grades, or very small campuses) have also been excluded.

[27] See also Heckman and Navarro-Lozano, 2004.

[28] TEA officially associates each school district with a single county. Those official designations have been used to identify CBSA locations for campuses in traditional public school districts, using the CBSA definitions developed by the U.S. Office of Management and Budget and published by the U.S. Census Bureau.

Table A1 provides means and standard deviations for the variables use in this analysis. Enrollment (both campus and district), the teacher salary index, and miles to the metro center enter the stochastic frontier regression in logs, while variables already in percentages and the indicator variables are not logged before entering the stochastic frontier regression.

Table A1: Descriptive Statistics for Campuses in Texas' Core Base Statistical Areas, 2011–12 to 2015–16

	Mean	Std. Dev.	Minimum	Maximum
Per-pupil operating expenditure	8102.65	1621.77	4026.35	32024.56
Campus enrollment	732.24	512.66	28.00	4774.00
Average Conditional NCE,	0.50	0.05	0.13	0.73
Teacher salary index	1.20	0.07	1.00	1.33
Miles to the metro center	19.46	15.68	0.22	143.59
District enrollment	40404.51	49962.50	62	214,891
% Economically disadvantaged	0.61	0.27	0.00	1.00
% Ever limited English prof.	0.28	0.23	0.00	1.00
% High needs special education	0.04	0.02	0.00	0.22
% Other special education	0.05	0.02	0.00	0.19
Elementary campus	0.59	0.49	0.00	1.00
Middle school campus	0.23	0.42	0.00	1.00
Mixed grade campus	0.02	0.13	0.00	1.00
Military base district	0.00	0.03	0.00	1.00
Major Urban Area	0.62	0.49	0.00	1.00
Micropolitan Area	0.10	0.30	0.00	1.00
Herfindahl Index	0.18	0.18	0.05	1.00
K–8 district	0.01	0.07	0.00	1.00
Share of spending unallocated	0.19	0.06	0.00	0.61
Number with test scores	353.54	351.18	25	2,962
Square Miles	204.73	268.99	5.13	2454.90
Number of potential employers in campus zip code	600.23	516.70	0.00	3,027
Number of restaurants in zip	56.58	51.12	0.00	345
Number of observations	30,542			

Note: Open-enrollment charter, virtual school, alternative education, juvenile justice and disciplinary justice campuses have been excluded, as have all campuses with fewer than 25 students for whom conditional normal curve equivalent (NCE) scores could be calculated.
Sources: Academic Excellence Indicator System (AEIS) 2011–12; Texas Academic Performance Reports (TAPR) 2012–13 through 2015–16; Public Education Information Management System (PEIMS); National Center for Education Statistics (NCES); and Appendix B.

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 (2006), Gronberg et al. (2011b) or Gronberg, Jansen and Taylor (2017), food service expenditures have been excluded 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. Transportation expenditures have been excluded on similar grounds.

All expenditures data have been adjusted to account for school districts that serve as a fiscal agent for another school district or group of districts.[29] Fiscal agents collect funds from member districts in a shared service agreement, and make purchases or pay salaries with those shared funds on behalf of the member districts. As a result, the spending of fiscal agents is artificially inflated while the spending by member districts is artificially suppressed. However, fiscal agents report annually to TEA about the amounts they spent on behalf of their member districts. These distribution data have been used to allocate spending by fiscal agents to their member districts on a proportional basis.[30]

Because not all school district expenditures are allocated to the campus level, and the share of allocated expenditures varies from district to district, researchers have distributed unallocated school district expenditures to the campuses on a per pupil basis.[31] Thus, for example, if Little Elementary serves 20% of the students in its district, it is presumed to be responsible for 20% of the unallocated spending.

Outputs

As noted above, the independent variables measuring education output include both a quantity dimension of output—enrollment—and a quality dimension. Quantity is measured as the number of students in fall enrollment at the campus. The campus enrollment variable ranges from 28 to 4,774 with a mean of 732.

The quality measure captures differences in student performance. The measure is a normalized gain score indicator of student performance on the State of Texas Assessments of Academic Readiness (STAAR®) Grades 3–8 and end-of-course (EOC) exams. Although schools clearly produce unmeasured outcomes that may be uncorrelated with mathematics and reading test scores, and standardized tests may not measure the acquisition of all important higher-order skills, these are 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 & Taylor,

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[29] For more on the allocation procedure, see Texas Smart Schools (2017)
[30] Due to data limitations, spending by fiscal agents could not be allocated back to specific campuses within member districts.
[31] Gronberg, Jansen & Taylor (2012) and Grosskopf, Hayes, Taylor & Weber (2013) also followed this approach.

2011a, 2011b, 2017 or Imazeki & Reschovsky, 2006). Therefore, they are reasonable output measures for cost analysis.

STAAR Grades 3–8 and EOC scores can be difficult to compare across grades, years or testing regimes. Therefore, this analysis relies on normalized (or equivalently, standardized) test scores. The normalization follows Reback (2008) and yields gain score measures of student performance that are not biased by typical patterns of reversion to the mean.[32]

The calculation of normalized gain scores proceeds in three steps. First, transform the scores of individual students into conditional z-scores. Denote the test scores for student (i), grade (g), and time or year (t), as S_{igt}, and measure each student's performance relative to others with same prior score in the subject as:

$$Y_{igt} = \frac{S_{igt} - E(S_{igt}|S_{i,g-1,t-1})}{[E(S_{igt}^2|S_{i,g-1,t-1}) - E((S_{igt}|S_{i,g-1,t-1})^2]^{.5}} \quad (10)$$

For example, consider all Grade 6 students who had a raw score of 30 on the prior year's Grade 5 STAAR-Mathematics. For this subgroup of students with a Grade 5 score of 30, calculate the mean and standard deviations of the Grade 6 scores for STAAR-Mathematics. The mean is the expected score in Grade 6 ($E(S_{igt}|S_{i,g-1,t-1})$) for someone with a Grade 5 score of 30; the standard deviation is the denominator in equation (10). Thus, the variable Y_{ijgt} measures individual deviations from the expected score, adjusted for the variance in those expected scores. This is a type of z-score. Transforming individual STAAR scores into z-scores in this way allows researchers to aggregate across different grade levels, test subjects and test regimes despite the differences in the content or scaling of the various tests. It also provides a common frame of reference for incorporating the scores of students who, for example, took the STAAR-Mathematics in Grade 7, but the Algebra 1 EOC in Grade 8.[33]

Second, calculate the average conditional z-score (i.e., the average Y_{igt}) across all required mathematics and reading tests for all of the students attending each school.[34] An average conditional z-score of 1 indicates that, on average, the students at Little Elementary scored one standard deviation above the expected score for students with their prior test performance. An average conditional z-score of -1 indicates that, on average, the students scored one standard deviation below expectations.

[32] All students in the state, not just those in CBSAs were included in the calculation of standardized scores.
[33] Y_{igt} for this population is calculated by taking the mean and standard deviations of the Algebra 1 EOC scores among all of the students who took the Algebra 1 EOC and shared a common score on the prior year's STAAR-Mathematics.
[34] Only students in the accountability subset (i.e., students who attended the same campus in the fall of the academic year as they did in the spring) are included in the campus average.

Finally, for ease of interpretation, transform the z-scores into conditional normal curve equivalent (NCE) scores. NCE scores (defined as 50+21.06*z) are a monotonic transformation of z-scores that are commonly used in the education literature and can be interpreted as percentile ranks.[35] A conditional NCE score of 50 indicates that (on average) the students performed exactly as expected given their prior test performance; and a conditional NCE score of 90 indicates that (on average) they performed as well or better than 90% of their peers.

For estimation purposes, the conditional NCE scores are expressed as percentages. As Table A1 documents, the campus-level average conditional NCE score had a mean of 0.50 with a minimum of 0.13 and a maximum of 0.73.

Input Prices

The most important education inputs are teachers, and the cost function model includes the required teacher wage variable. Public schools take differing approaches to hiring teachers. If there were a teacher type hired by all traditional public schools—for example, a teacher with a bachelor's degree from a selective university and two years of experience—then arguably the model should use the wages paid to those teachers as the labor price measures. However, it is not possible to identify a teacher type that is hired by all the school districts under analysis, and any observed average wage—such as the average salary for beginning teachers—reflects school and district choices about the mix of teachers to hire and the salaries offered to teachers in the hiring process.

This issue can be dealt with using a wage index that is independent of school and district choices. Such an index is constructed here by estimating a hedonic wage model for teacher salaries and using that model to predict the wages each school would have to pay to hire a teacher with constant characteristics (see Appendix B). The resulting teacher price index ranges from 1.00 to 1.33 and indicates that the cost of hiring teachers is 33% higher in some of the metropolitan and micropolitan campuses under analysis than it is in others.[36]

In an ideal situation, the estimated cost function would include direct measures of local prices for instructional equipment and classroom materials. Such data are, unfortunately, not available to researchers. However, prices for pencils, paper, computers, and other instructional materials are largely set in a competitive market (and therefore unlikely to vary across schools), and prices for nonprofessional labor or building rents are largely a function of school location. Therefore, the cost analysis includes a measure of the distance from the campus to the center of the nearest

[35] Technically, this interpretation only holds if the scores are normally distributed. Given the large number of students tested each year in Texas, normality is a reasonable assumption.

[36] In Texas, teachers participate in a single statewide teacher retirement system. Thus, teachers can move from one school district to another without affecting their 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. See Taylor (2004).

metropolitan area.[37] This variable had an average value of 19.5 miles, a minimum of 0.22 miles, and a maximum of 144 miles, indicating the rather large distances sometimes involved in Texas.

Other Environmental Factors

The model includes indicators for a variety of environmental factors that influence district cost but which are not purchased inputs. A major environmental factor in this study is district enrollment. District enrollment averaged 40,404 students, with a minimum of 62 and a maximum of 214,891. To capture variations in costs that derive from variations in student needs, the cost function includes the percentages of students in each district who were identified as ever having been limited English proficient (Ever-LEP), high needs special education all other special education, and economically disadvantaged.[38, 39] To allow for the possibility that the education technology differs according to the grade level of the school, the cost model includes indicators for school type (elementary, middle and mixed grade). An indicator for the three military base districts in San Antonio (Lackland, Ft. Sam Houston and Randolph Field ISDs) controls for the possibility that their special circumstances could lead to higher costs. Fixed effects for year control for inflation and other time trends in Texas education. Indicators for whether or not the campus is located in a major metropolitan area (Austin, Dallas, Fort Worth, Houston and San Antonio) or a micropolitan area have been included to control for other, unobserved differences in the educational environment. Indicators for the four districts with more than 100,000 students (Dallas, Houston, Cypress-Fairbanks and Northside ISDs) similarly capture unobserved differences in those districts.

Efficiency Factors

The error terms for all frontier specifications depend on a number of factors that theory suggests may explain differences in school efficiency. Prior research has demonstrated that competition can reduce inefficiency in public education (e.g., Belfield & Levin, 2002; Millimet & Collier, 2008; Gronberg et al. 2015). Therefore, the one-sided variance function is modeled as a linear combination of two variables—the degree of

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[37] Miles to the center of the metropolitan area for each campus was calculated as-the-crow-flies using latitude and longitude information. The latitude and longitude of metro centers come from the U.S. Census Bureau. Where available, latitude and longitude information for campuses are taken from the NCES' Common Core Database. The remaining campuses are assigned latitudes and longitudes according to the zip codes at their street address.

[38] Following Gronberg et al. 2005, high needs special education students are those with a classification other than speech-language difficulties or learning disabilities. Where the share of students with speech-language difficulties or learning disabilities was censored (due to privacy concerns) the researchers presumed that all of the special education students were high needs students.

[39] Students who perform well on the English/Language Arts tests are no longer considered LEP, making the percentage LEP endogenous and introducing potential estimation problems. Therefore, each student's complete academic history was used to identify those students who have been categorized as LEP, at some point during their experience in Texas (Ever-LEP). While only 18.5% of students statewide were identified as LEP in 2015–16, nearly 30% of the students could be identified as Ever LEP.

educational competition in the metropolitan or micropolitan area, and an indicator for campuses in a district that only serves Grades K–8.[40]

As is common in the literature, the degree of educational competition is measured with a Herfindahl index of enrollment concentration. A Herfindahl index (which is defined as the sum of the squared enrollment shares) increases as the level of enrollment concentration increases. A Herfindahl index of 1.00 indicates a metropolitan or micropolitan area with a single local education agency (LEA); a Herfindahl index of 0.10 indicates a metropolitan or micropolitan area with 10 LEAs of equal size. Both traditional public school districts and open-enrollment charter schools are included in the calculation of enrollment concentration. Table A1 reports the mean value for the Herfindahl index in the sample is 0.18, with a minimum value of 0.05 and a maximum of 1.00, indicating that some CBSAs in Texas have a single LEA.

The K–8 indicator takes on the value of one if the school district does not operate any high school grades, and zero otherwise. It has been included because the restricted grade range of a K–8 school district may allow it to allocate its personnel more efficiently than a district of similar size attempting to serve the full range of grades.[41]

Heteroskedasticity in the two-sided error may also arise. To capture such a possibility, the two-sided variance is modeled as a function of the share of campus expenditures that was not specifically allocated to the campus by the district. This variable has been included because measurement error in the dependent variable (a common source of heteroskedasticity) is likely to be a function of the extent to which the dependent variable was imputed. Also included is the number of students who had a conditional NCE score. The second factor has been included because the larger the number of tested students, the smaller is the potential for measurement error in this key independent variable.

Instrumental Variables

The key to implementing the control function corrections is the identification of viable instruments for school quality and campus size. Human capital theory suggests that local labor market conditions can influence the demand for educational quality and the opportunity cost of staying in school so, as in Gronberg, Jansen and Taylor (2016), this analysis uses labor market conditions in the vicinity of the school site as instruments for the conditional NCE scores. The indicators of labor market conditions—the number of employers in the campus zip code and the number of those employers that are restaurants—reflect industrialization and the availability of the types of jobs

[40] By assumption, the one-sided error term has a half-normal distribution. Jenson (2005) finds that specifying a half-normal distribution for the inefficiency term generates more reliable estimates of technical efficiency than other assumptions about the distribution of inefficiency

[41] The one traditional public school district that does not serve elementary grades, South Texas ISD, has been excluded from the analysis.

most commonly held by teenagers and comes from the ZIP Business Patterns produced by the Census Bureau.

This analysis uses the number of square miles in the school district as an instrument for campus size. Campuses are likely to be smaller (all else equal) in districts with larger geographic footprints, where the time costs of transporting students to scale-efficient campuses could be prohibitive. Therefore, the geographic size of the district is a credible instrument for campus size.

Results

While the translog specification has the benefit of flexibility and generality compared to, say, the Cobb Douglas or other simple forms, the coefficient estimates from the translog specification are not readily interpretable. Most researchers present the change in cost arising from a small change in each explanatory variable, the so-called marginal effects. These marginal effects depend on the values of all the explanatory variables.[42]

Table A2 indicates the marginal effects of a change in

[42] See Taylor et al. (2014) for details on the calculation of marginal effects.

Table A2: Means of the Marginal Effects

	Model 1	Model 1a
District Enrollment (log)	0.012	0.009
Joint p-value	0.000	0.000
Campus Enrollment (log)	-0.159	-0.129
Joint p-value	0.000	0.000
Average NCE	0.061	0.498
Joint p-value	0.000	0.000
Teacher Salary Index	0.289	0.192
Joint p-value	0.000	0.000
Miles to Metro Center (log)	-0.001	0.000
Joint p-value	0.000	0.000
% Students Econ. Disadv.	0.114	0.172
Joint p-value	0.000	0.000
% Ever-LEP	0.135	0.103
Joint p-value	0.000	0.000
% High Needs Special Ed.	1.787	1.764
Joint p-value	0.000	0.000
% Other Special Ed.	0.531	0.530
Joint p-value	0.000	0.000
Elementary Campus	-0.276	-0.277
Joint p-value	0.000	0.000
Middle School Campus	-0.286	-0.281
Joint p-value	0.000	0.000
Multi-grade Campus	-0.024	-0.033
Joint p-value	0.000	0.000
School Size Residual		-0.031
p-value		0.578
First Stage F-Statistic		21.67
School Quality Residual		-0.439
p-value		0.259
First-stage F-statistic		15.21
One-sided error		
Herfindahl Index (log)	0.392	0.398
p-value	0.000	0.000
K8 district Indicator	0.739	0.736
p-value	0.002	0.002
Constant	-4.533	-4.522
p-value	0.000	0.000
Number of observations	30,542	30,542

Note: All models also include year fixed effects, indicators for major urban and micropolitan counties, and indicators for large or military base school districts. P-values based on robust standard errors that were clustered by district and year
Source: Authors' calculations from Appendix C.

the various outputs, prices, and environmental variables on expenditures per pupil. For each explanatory variable, two entries are provided in each column. The first is the mean of the marginal effect of the variable in question, calculated for each data point in the sample. The second is the probability that all of the coefficients related to the variable in question (i.e., the direct effect and all interaction effects) are jointly zero. (The complete set of coefficient estimates and robust standard errors are presented in Appendix C.)

The first column presents the baseline model. It was estimated from campus level data treating NCE scores and campus enrollments as exogenous, as in Taylor et al. (2014).

The second column in table A2 presents a model in which campus size and student performance were treated as endogenous using a control function correction. The residual from a first stage regression of campus enrollment on the instruments and all of the exogenous explanatory variables was included as a regressor in this specification of the translog, as was the residual from a first-stage regression of the school quality measure (the average conditional NCE score) on the same set of instruments and exogenous variables.

As the table illustrates, the instruments met the necessary conditions for instrumental variables, being conceptually exogenous and well correlated with campus enrollment and school quality, as indicated by the first-stage F-statistics for the joint significance of the excluded instruments. (The rule of thumb is that the first stage F-statistics should exceed 10.)

The first-stage residuals for school quality and campus size were both individually and jointly insignificant at the 5-percent level in Model 1a.[43] This means that both of the outcome measures can be treated as exogenous, and makes Model 1 the preferred specification.

The first variable listed in Table A2 is the log of District Enrollment. Researchers calculated the marginal effect of an increase in district enrollment for every sample data point and then averaged those estimates to yield the mean of the marginal effects. Here a 1% increase in district enrollment had a mean marginal effect of 0.012, indicating that a 1% increase in district enrollment was associated with a mean increase of 0.012% in cost per student.

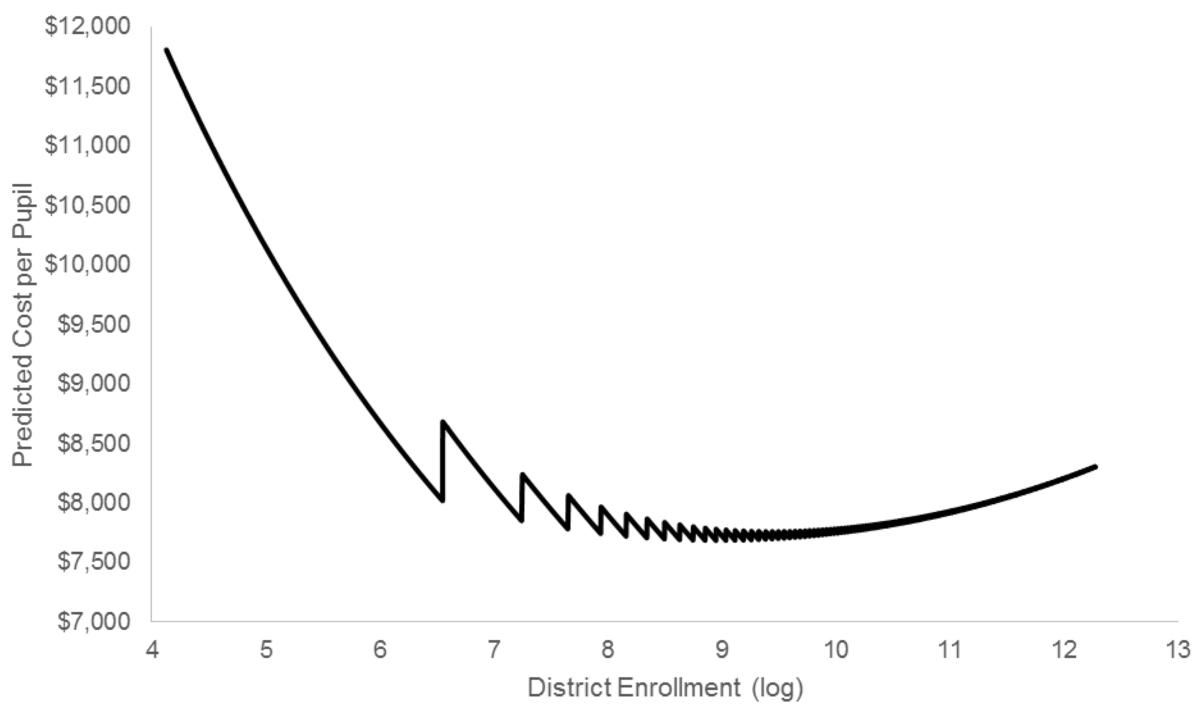
The joint p-value for the coefficients on district enrollment and its interactions was zero to three decimal places, indicating that the coefficients on district enrollment in the cost function are jointly statistically significant at better than the 1-percent level.

Figure A1 graphs the impact of changes in log district enrollment on predicted cost. In this figure, per-pupil cost was predicted holding all variables except campus and district enrollment constant at their sample means. Because it is not possible for a district with 500 students to have an average campus size of 700 (roughly the sample

[43] The probability that the school size residual and the school quality residual are jointly zero is 0.1107.

mean), and nearly as implausible to assume that a district with 900 students could have an average campus size of 700, it was necessary to construct the figure using a plausible relationship between campus and district size. For the purposes of this illustration, districts were assumed to increase the number of campuses by one whenever campus enrollment reaches the (admittedly arbitrary) threshold of 700 students. Note that the largest district in Texas, Houston ISD, has an average campus enrollment of 778

Figure 11: The Estimated Relationship between Per-Pupil Cost and School District Enrollment, Holding Campus Size at or Below 700

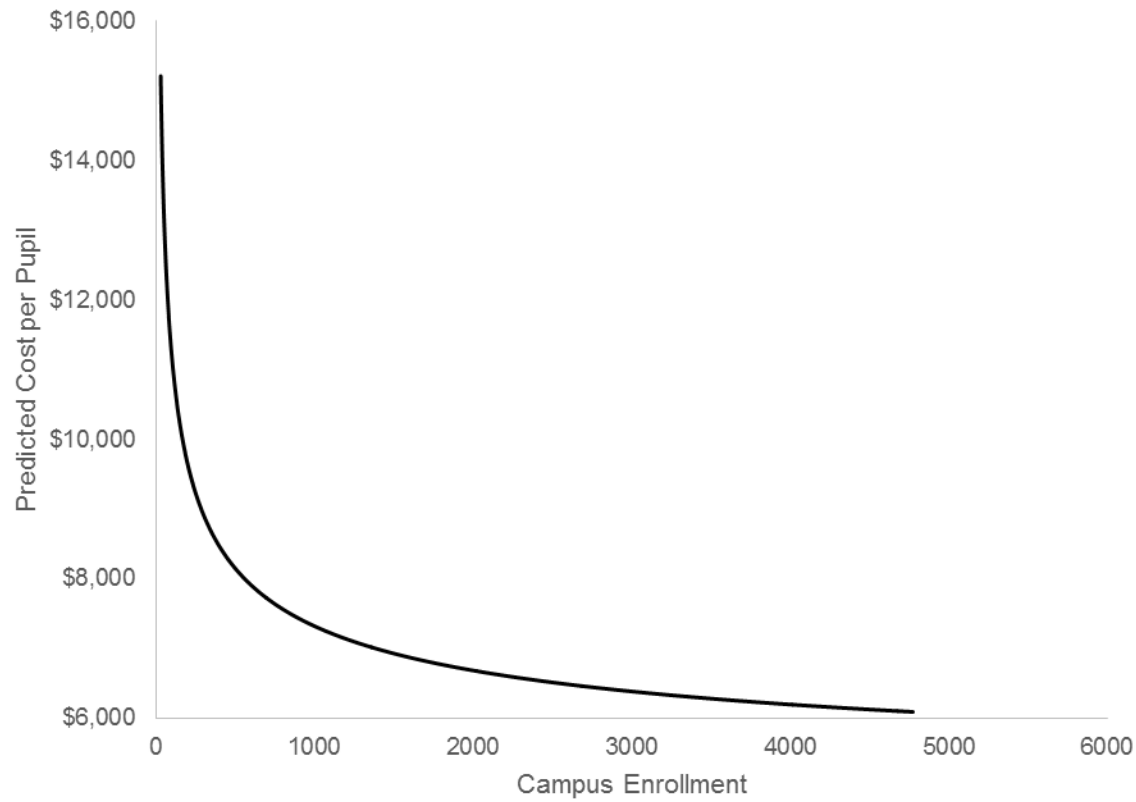


Source: Authors' calculations from Appendix C.

The slope of the graph is the marginal effect, and the shape of the graph in Figure A1 indicates that there are initial economies of scale as district size increases, up to a log value of 8.95 (or 7,700 students). As district enrollment increases beyond that point, predicted costs rise.

Figure A2 graphs the relationship between campus size and cost per student, holding all other variables at their sample mean values. To construct this figure, researchers predicted per-pupil cost, holding all variables except campus and district size constant at the sample mean. The log of district enrollment was set initially at the sample mean, but enrollment was presumed to incremented by one whenever campus enrollment incremented by one. Thus, the figure was constructed assuming that district enrollment for a campus with 1,800 students is 400 larger than the district enrollment for a campus with 1,400 students. This approach is equivalent to assuming that the enrollments do not change at the other campuses in the district.

Figure 12: The Estimated Relationship between Per-Pupil Cost and Campus Enrollment, Assuming Enrollments Do Not Change for Other Campuses in the District

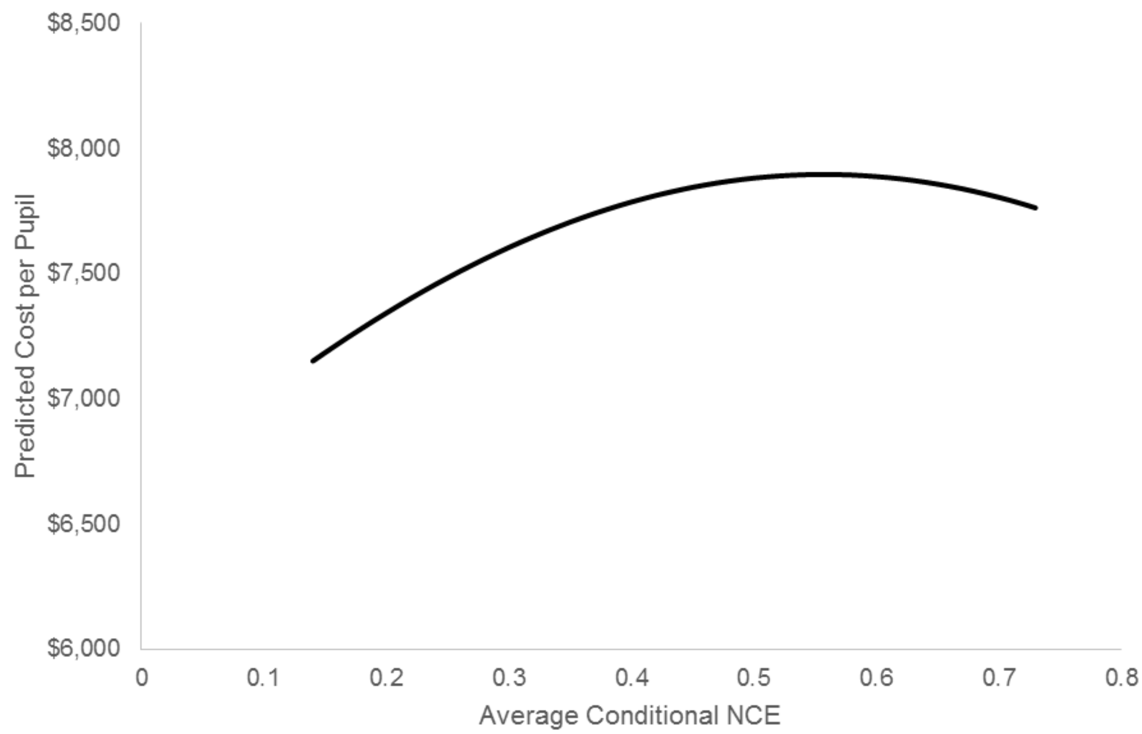


Source: Authors' calculations from Appendix C.

As the figure illustrates, campus enrollment had a strong negative impact on per student costs at the campus level. In other words, larger campus enrollments reduced cost per student. The cost function indicated that (all other things being equal) a campus with 200 students costs 14% more to operate than a campus with 400 students, which in turn costs 7% more to operate than a campus with 600 students.

Figure A3 presents a graph of how changes in campus average conditional NCE scores impact predicted cost. Recall that these conditional NCE scores ranged from 0.13 to 0.73, with a mean of 0.50. For conditional NCE scores ranging from 0.13 to 0.56, increasing the campus average required higher cost, but beyond that the estimated cost per student of an increase in the campus average actually declined somewhat.

Figure 13: The Estimated Relationship between Per-Pupil Cost and the Average Conditional NCE Score

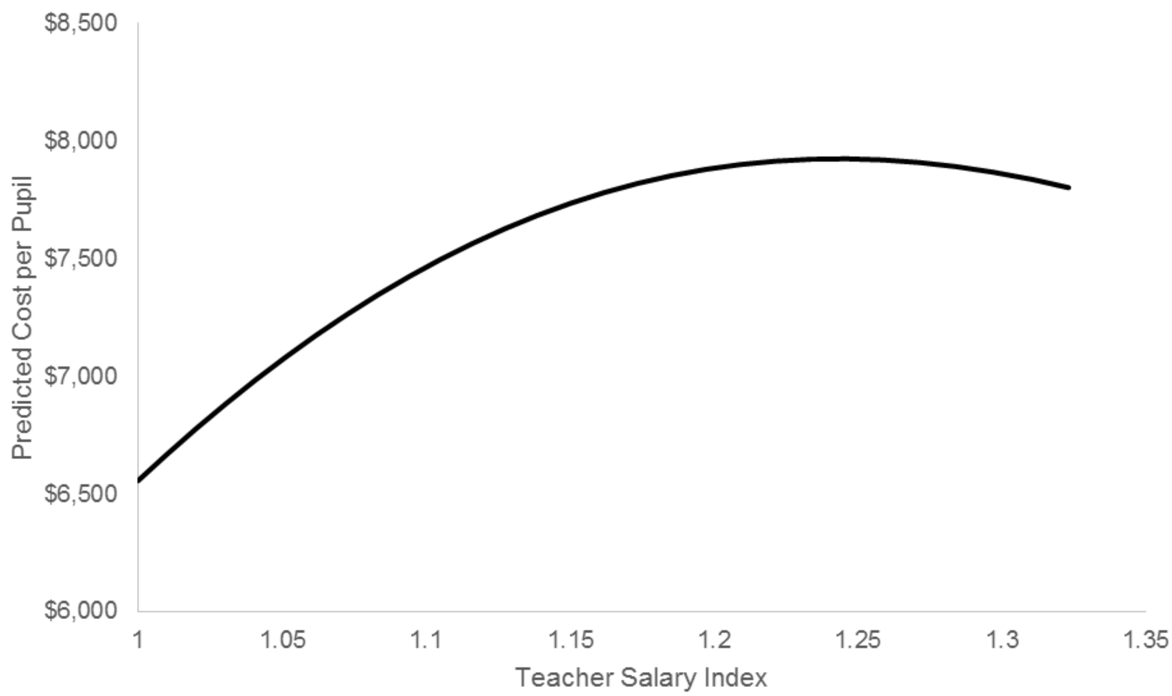


Source: Authors' calculations from Appendix C.

The teacher salary index (TSI) has a mean marginal effect about 0.29. On average, an increase in teacher salaries of 1% results in a 0.29% increase in per pupil costs, evaluated at the sample means. This large impact is to be expected with teacher salaries such a large component of school spending.

Figure A4 graphs the impact of the TSI on cost per student as the teacher salary index ranges from 1.00 to 1.33 in the sample. As the figure illustrates, increases in teacher salaries had a positive impact on cost per student over much of the relevant range, but the marginal effect was indistinguishable from zero at the high end of the range.

Figure 14: The Estimated Relationship between Per-Pupil Cost and the Teacher Salary Index



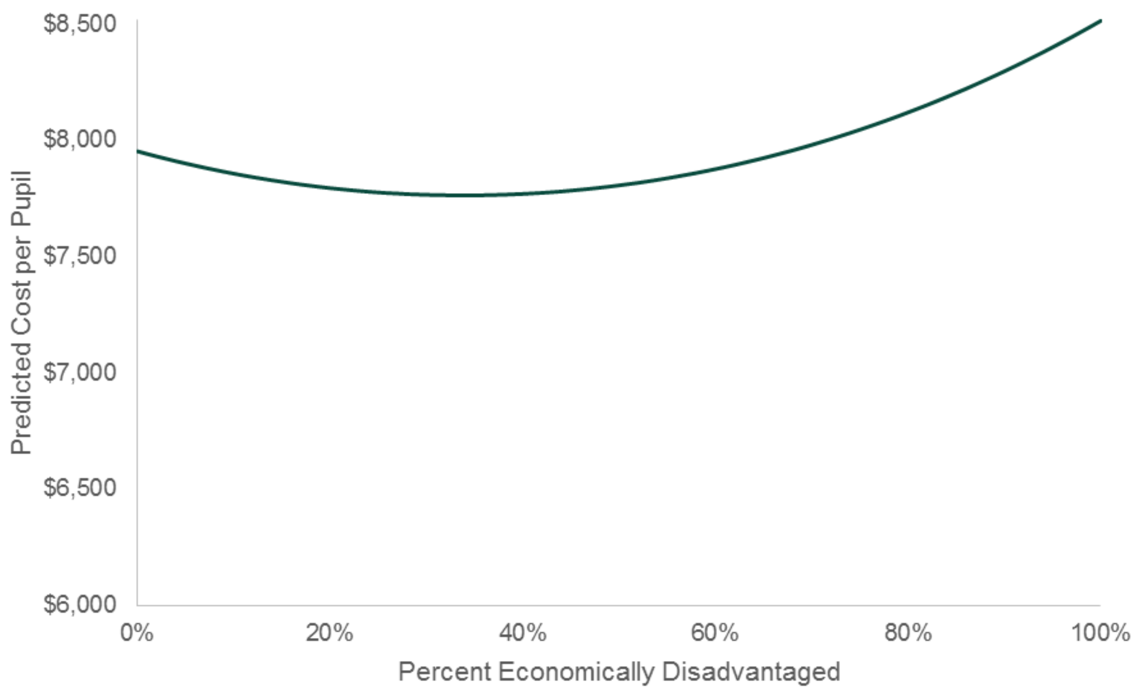
Source: Authors' calculations from Appendix C.

The Miles to Metro Center variable, in logs, had a statistically significant, but arguably negligible effect on cost. The model predicted that costs were highest for a campus situated roughly 6 miles from the center of the closest metropolitan area, and that a campus situated 6 miles from the metro center cost 0.5% more to operate than a campus located 100 miles from the metro center.

There are several other environmental variables, including the percentage of students classified as Economically Disadvantaged, the percentage of students who have ever been classified as LEP, and the percentage of high needs special education students and the percentage of other special education students. Increases in each of these four environmental variables all served to increase per student cost.

An increase in the percentage of economically disadvantaged students at a campus was associated with a percentage increase in campus per pupil costs of 0.114 times the increase in the percentage of economic disadvantage students. Thus, the analysis indicates that for a campus with average characteristics (i.e., a campus at the sample mean values for all of the explanatory variables) the cost of educating an economically disadvantaged student was 11% higher than was the cost of educating a student who was not economically disadvantaged.[44] However, the estimated effect was not linear. As Figure A.5 illustrates, the marginal cost of serving an increased percentage of economically disadvantaged students was sharply higher (i.e., the slope was steeper) for campuses that already had a high percentage of economically disadvantaged students.

Figure 15: The Estimated Relationship between Per-Pupil Cost and the Percentage Economically Disadvantaged Students



Source: Authors' calculations from Appendix C.

On average, an increase in the percentage of students ever classified as LEP was associated with a percentage increase in campus per pupil costs of 0.135 times the increase in the percentage of Ever-LEP students. Therefore, for a campus with average characteristics, the estimated cost of educating a student who has ever been

[44] This estimated marginal effect at the mean is smaller than the Foundation School Program weight for economically disadvantaged students (20%). This should not be interpreted as evidence that the Foundation School Program weight is too high because the cost function models marginal cost as nonlinear (meaning that the implied funding formula weights are different for different campus configurations) and the estimation does not include the one-third of Texas school districts located in rural areas.

designated LEP was 13.5% higher than the estimated cost of educating a student who has never been designated LEP.[45]

An increase in the percentage of high needs special education students was associated with a percentage increase in per student costs of 1.787 times the increase in the percentage of special education students. In other words, for a campus with average characteristics, the estimated cost of educating a special education student was nearly triple (179% higher than) the cost of educating a student who was not in the special education program.

Similarly, the estimated cost of educating a special education students who was not high needs was 53% higher than the cost of education a student who was not in the special education program.

The model also included indicators for elementary campus, middle school campus, and multi-grade campuses. The omitted category was high school campus. Elementary schools had 27.6% lower costs than high schools, and middle schools had 28.6% lower costs than high schools. Multi-grade campuses had 2.4% lower costs than high schools. These effects were all statistically significant.

Table A2 also reports the coefficient estimates of the variables impacting the one-sided error variances. These indicate that an increase in concentration (an increase in the (logged) Herfindahl index) leads to an increased variance of the one-sided error, and hence an increase in inefficiency. The impact of the Herfindahl index on the one sided error variance is highly statistically significant. The indicator variable for a K–8 district is also highly statistically significant, and indicates that the campuses in these districts have a higher one-sided error variance, and hence a higher inefficiency, than campuses not in K–8 districts.

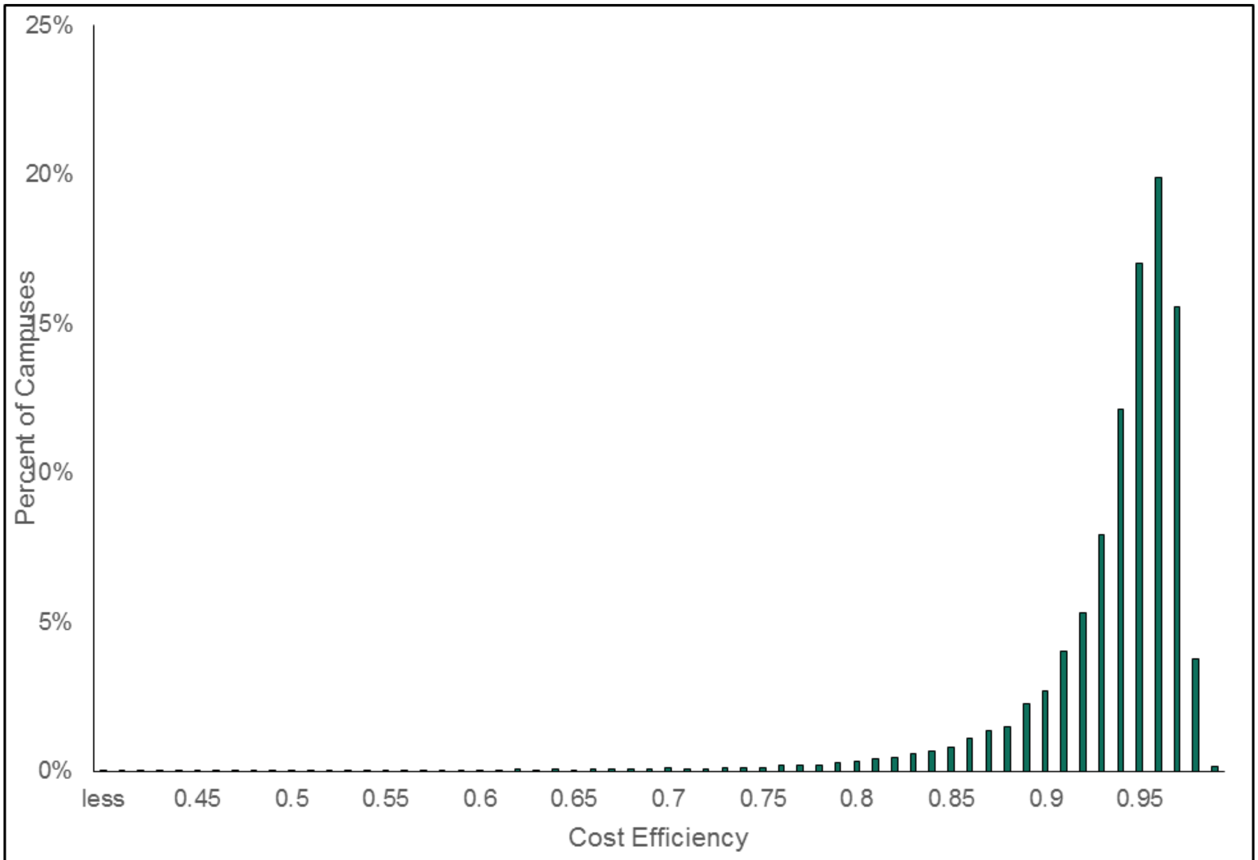
Efficiency Results

An important part of this study was the estimation of cost efficiency, or inefficiency. Figure A8 graphs the distribution of cost efficiency for the baseline model.[46] In Model 1, the average cost efficiency score was 0.933, indicating that campuses were producing 93% of their potential output, on average. Given that inefficiency in this context means unexplained expenditures, not necessarily waste, and that many campuses may have been producing outcomes that were not reflected in test scores, the average efficiency level was quite high. However, the minimum efficiency scores were well below 50%, suggesting that some campuses spend much more than could be explained by measured outcomes, input prices or student need.

[45] Again, this marginal effect is not strictly comparable to the Foundation School Program weight for students in bilingual education/English as a second language. The cost function models marginal cost as nonlinear (meaning that the implied funding formula weights are different for different campus configurations), the estimated marginal effect is based on the percentage of students who have ever been designated as LEP, not the percentage of students currently receiving services, and the estimation does not include the one-third of Texas school districts located in rural areas.

[46] Cost efficiency was estimated following Battese and Coelli (1995).

Figure 16: Histogram of Cost Efficiency Measures for Model 1



Source: Authors' calculations

Robustness

It is customary in the literature to demonstrate that an empirical model is robust by presenting coefficient estimates and marginal effects from alternative specifications. This analysis presents four alternative specifications:

1. The baseline, which is the preferred specification.
2. An alternative model that excludes school districts with more than 100,000 students. This alternative has been included to demonstrate that the results are not being driven by the cost and efficiency patterns in the state's largest school districts—Dallas, Houston, Cypress-Fairbanks and Northside ISDs.
3. An alternative model that excludes spending on athletics and extracurricular activities from the dependent variable, but otherwise mirrors the baseline specification. This alternative has been included to illustrate the extent to which measured inefficiency arises from spending on activities that may be only indirectly linked to student performance.
4. An alternative that adds transportation expenses to the expenditure measure in the baseline model. This alternative has been included to demonstrate that the

findings of the baseline model are not sensitive to the inclusion or exclusion of these expenditures that (much like athletics) may not be explained by the same factors that explain student performance.

Table A3: Means of the Marginal Effects for Alternative Specifications

Variables	Model 1	Model 2	Model 3	Model 4
District Enrollment (log)	0.012	0.013	0.016	0.011
Joint p-value	0.000	0.000	0.000	0.000
Campus Enrollment (log)	-0.159	-0.165	-0.162	-0.151
Joint p-value	0.000	0.000	0.000	0.000
Average NCE	0.061	0.022	0.064	0.053
Joint p-value	0.000	0.000	0.000	0.000
Teacher Salary Index	0.289	0.319	0.268	0.273
Joint p-value	0.000	0.000	0.000	0.000
Miles to Metro Center (log)	-0.001	0.001	-0.001	0.002
Joint p-value	0.000	0.000	0.000	0.000
% Students Econ. Disadv.	0.114	0.119	0.123	0.114
Joint p-value	0.000	0.000	0.000	0.000
% Ever-LEP	0.135	0.139	0.138	0.129
Joint p-value	0.000	0.000	0.000	0.000
% High Needs Special Ed.	1.787	1.986	1.778	1.723
Joint p-value	0.000	0.000	0.000	0.000
% Other Special Ed.	0.531	0.550	0.504	0.458
Joint p-value	0.000	0.000	0.000	0.000
Elementary campus	-0.276	-0.295	-0.178	-0.274
Joint p-value	0.000	0.000	0.000	0.000
Middle school campus	-0.286	-0.300	-0.211	-0.282
Joint p-value	0.000	0.000	0.000	0.000
Multi-grade campus	-0.024	-0.007	0.030	-0.017
Joint p-value	0.000	0.000	0.000	0.000
One-sided error				
Herfindahl Index (log)	0.392	0.407	0.369	0.403
p-value	0.000	0.000	0.000	0.000
K8 district indicator	0.739	0.711	0.719	0.908
p-value	0.002	0.004	0.002	0.000
Constant	-4.533	-4.584	-4.567	-4.550
p-value	0.000	0.000	0.000	0.000
Number of observations	30,542	27,306	30,542	30,542

Note: All models also include year fixed effects, indicators for major urban and micropolitan counties, and indicators for large or military base school districts. P-values based on robust standard errors that were clustered by district and year

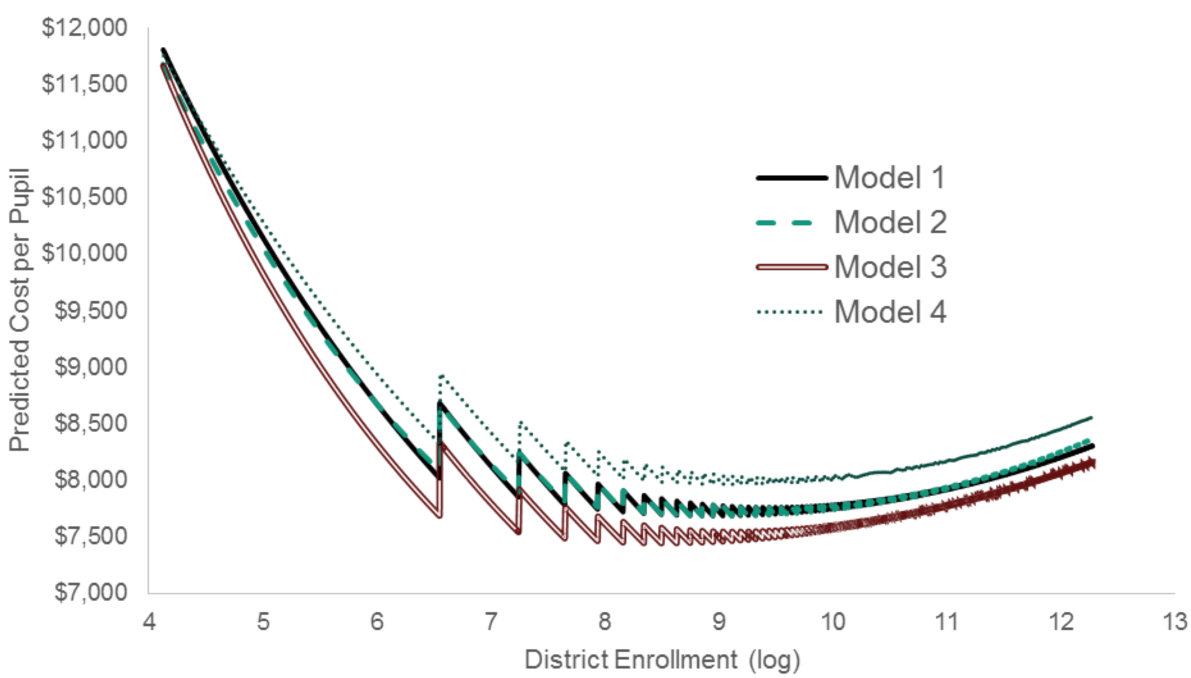
Source: Authors' calculations from Appendix C.

There are four columns of results reported in Table A3. The first column results are for the baseline model. They are reproduced from Table A2 for ease of comparison. The second column (Model 2) reports results when the four largest districts were excluded from the estimation. Model 3 reports results when spending on athletics and extracurricular activities were not included in the campus spending measure. The fourth column reports results when spending on transportation was added to the campus spending measure from the baseline model.

Comparing the results across columns indicates that while the estimated marginal effects do vary somewhat across the columns, there are strong regularities in the estimated marginal effects. The largest differences were for the school type fixed effects. In particular, when spending on athletics and extracurriculars was excluded from the model, the cost differential between high schools and elementary or middle schools narrowed sharply.

Figure A7 presents the estimated relationship between school district size and the cost of education for each of the four models. As the figure illustrates, holding all other campus characteristics constant at the mean, all four specifications indicate that cost was minimized for a district with log enrollment less than roughly 9.12 (9,100 students).

Figure 17: The Estimated Relationship between Per-Pupil Cost and District Enrollment for Alternative Specifications



Source: Authors' calculations from Appendix C.

Simulating Consolidation

The results of the cost function analysis presented in this report can be used to simulate different consolidation scenarios. For any simulation scenario, the cost function can be used to predict—on a campus-by-campus basis—expenditures before and after consolidation. A comparison between those two predictions represents the best available forecast of the financial impact of consolidation.

This section illustrates two possible consolidations. The first, which was also examined in Taylor et al. (2014), simulated the consolidation to the county level of all traditional public school districts in the five counties (Bexar, Dallas, Harris, Tarrant and Travis) that are referenced by TEC Section12.1013(e). The second scenario simulated the consolidation of all districts in those five counties that are currently eligible for size adjustments under the school finance formula. Assuming that each district consolidated with its smallest, same-county neighbor (and that the districts serving military bases consolidated with each other but not with non-military-base districts) then

- Sunnyvale ISD would consolidate with Mesquite ISD;
- Kennedale ISD would consolidate with Everman ISD;
- Lago Vista ISD would consolidate with Lake Travis ISD;
- Alamo Heights would consolidate with San Antonio ISD;
- Somerset ISD would consolidate with Southside ISD;
- Huffman ISD would consolidate with Crosby ISD;
- Castleberry ISD would consolidate with Lake Worth ISD; and
- Lackland ISD, Ft. Sam Houston ISD and Randolph Field ISD would consolidate with each other.

Note these simulations were conducted assuming that campus characteristics remained unchanged for both traditional public schools and charter schools. Such an assumption is necessary because there is no way to know how the newly consolidated district might choose to redraw attendance boundaries or how parents might respond to such changes. It is likely that a newly-consolidated district would close at least some campuses, but the previous history of school district consolidations in Texas provides no guidance as to which campuses would be closed. It is also highly likely that at least some parents might move in response to the consolidation, and that charter school enrollments could rise or fall, but again, there are no data as to how parents might respond. Rather than speculate wildly about campus-level changes, the researchers presumed that the consolidations leave the campuses unchanged, at least in the short run.

In addition, please note that consolidating to the county level (as in scenario 1) would be an unprecedented shock to the Texas education system. In all but one case (Travis County) the consolidated school district would be substantially larger than any other district currently operating in Texas. In order to conduct the simulation, one must assume that the estimated relationship between district size and the cost of education is sufficiently robust to support extrapolation to a district nearly four times larger than any observed in the data. Such an assumption may not be reliable.

The simulations proceed as follows: First, the campus pre-consolidation expenditure per pupil was predicted using the regression results from the estimated baseline model including the estimate of cost inefficiency. The pre-consolidation predicted per pupil cost used campus-level values of the variables in the baseline model. Any missing values of these variables were assumed to be at the state average, so that nearly all of the campus observations could be included in the analysis. Next, the campus post-consolidation expenditure per pupil was predicted using the regression results and campus characteristics, but assuming that district size increased to the consolidated level (for consolidating campuses) and the level of enrollment concentration increased to its post-consolidation level (for both consolidated campuses and other campuses in affected metropolitan areas). Finally, the two predictions were compared, campus by campus and in the aggregate.

Table A4 summarizes pre- and post-consolidation predicted expenditures per pupil at the county level and the increase (or decrease) in predicted expenditures of the five counties.[47] On average, consolidation to the county level increases the predicted expenditure per pupil by 10.0% in Bexar County, 8.7% in Dallas County, 11.2% in Harris County, 10.0% in Tarrant County, and 3.9% in Travis County. Consolidation under scenario 2 would lead to modest savings in Harris, Tarrant and Travis Counties, but modest increases in expenditures in Bexar and Dallas Counties.

Table A4: Consolidation Simulation Results for Five Counties

County	Total Predicted Expenditures Without Consolidation (in millions)	Change in Predicted Expenditures under Scenario 1	% Change under Scenario 1	Change in Predicted Expenditures under Scenario 2	% Change under Scenario 2
Bexar	$2,733	$272,433,472	10.0%	$816,112	<0.1%
Dallas	3,844	335,947,904	8.7%	203,208	<0.1%
Harris	6,727	756,354,304	11.2%	-582,220	<0.1%
Tarrant	2,897	288,946,624	10.0%	-380,886	<0.1%
Travis	1,257	48,938,328	3.9%	-289,823	<0.1%

Source: Authors' calculations.

[47] Only campuses included in the cost function analysis are included in the simulation.

Furthermore, the loss of competitive pressures would lead to a loss of efficiency in the remainder of the metropolitan area. Table A5 illustrates the net impact on the five affected metropolitan areas. As the table illustrates, the spillover effects on competition would increases the losses arising from county-level consolidation. For example the loss in San Antonio would increase from $272 million (in Bexar County alone) to $288 million (in the metropolitan area as a whole). The net benefits under scenario 2 would also shrink. Although the consolidations in Austin, Fort Worth and Houston could reduce net expenditures in those locales slightly, the net effect of consolidating all of the small and midsized districts in the five counties would be to increase expenditures.

Table A5: Consolidation Simulation Results for Five Metropolitan Areas

Metro	Total Predicted Expenditures Without Consolidation (in millions)	Change in Predicted Expenditures under Scenario 1	% Change under Scenario 1	Change in Predicted Expenditures under Scenario 2	% Change under Scenario 2
Austin	$2,635	$60,635,768	2.3%	-$233,781	<0.1%
Dallas	7,232	390,640,384	5.4%	380,208	<0.1%
Fort Worth	3,497	304,020,704	8.7%	-252,692	<0.1%
Houston	9,926	830,892,992	8.4%	-544,634	<0.1%
San Antonio	3,494	288,058,752	8.2%	1,614,933	<0.1%
Total	26,785	1,874,248,576	7.0%	964,035	<0.1%

Source: Authors' calculations.

Conclusion

The stochastic frontier cost function results presented here indicate that the cost function estimates provide an intuitively plausible and robust characterization of the cost frontier for public school campuses in the sample of Texas schools examined in this study, as well as plausible and robust characterization of the efficiency—or inefficiency—of these campuses. These cost function estimates, especially the impact of district size and the impact of competition summarized in the Herfindahl index, provide the basic inputs that lead to the simulation results and the conclusion regarding the impact of proposed consolidation on cost per pupil at these Texas campuses. In particular, the diseconomies of scale in the range of the proposed consolidation, and the increased concentration resulting from the proposed consolidation, both act to increase spending post consolidation.

Not surprisingly, given the patterns indicated by the cost function analysis, the simulation exercise indicates that consolidation to the county level increases educational expenditures in all five metropolitan areas referenced in TEC Section 12.1013(e). Thus, consolidating school districts in the core counties of major metropolitan areas is likely to have unintended, adverse effects in terms of per pupil and total expenditures. The overall increase in expenditures can be as high as 11.2% of the total expenditures. These increases in expenditures are due to diseconomies of scale among large school districts, sharp declines in the competitiveness in education markets and large increases in cost inefficiency.

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Technical Appendix B: Estimating the Teacher Salary Index

For more than 30 years, economists have used hedonic wage models and regression analysis to explain why labor costs differ from one school district to another. Those analyses suggest that differences in average teacher salaries can be explained by differences in teacher characteristics (such as their educational attainment and years of experience), job characteristics (such as the characteristics of the students being served), and locational characteristics (such as the local cost of living).[48]

The hedonic wage model used in this analysis, which updates the hedonic wage model used in Taylor et al (2014), describes wages as a function of labor market characteristics, job characteristics, observable teacher characteristics, and unobservable teacher characteristics. Formally, the model can be expressed as:

$$\ln\left(W_{idjt}\right) = D_{dt}\beta + T_{it}\delta + M_{jt} + \alpha_i + \varepsilon_{idjt} \qquad (1)$$

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 characteristics that could give rise to compensating differentials, T_{it} is a vector of individual teacher characteristics that vary over time, M_{jt} is a vector of labor market characteristics, and the α_i are individual teacher fixed effects. Any teacher characteristics that do not change over time—such as the teacher's verbal ability or the selectivity of the college the teacher attended—will be captured by the teacher fixed effects.

The data on teacher salaries and individual teacher characteristics come from the Public Education Information Management System (PEIMS). The hedonic wage analysis covers the same five-year period as the cost function analysis (2011–12 through 2015–16). As in the cost function analysis, data from open-enrollment charter campuses, virtual campuses and all alternative education campuses have been excluded. All teachers with complete data who worked at least half time for a traditional public district in a metropolitan or micropolitan area have been included in the analysis.[49]

The measure of teacher salaries that is used in this analysis is the total, full-time-equivalent (FTE) annual salary. It is calculated as the observed total salary divided by the percent FTE. Full-time equivalent salaries less than 90% of the state's statutory minimum were deemed implausible and treated as missing, as were full-time equivalent annual salaries in excess of $200,000.

[48] For more on the use of hedonic wage models in education, see Chambers (1998); Chambers & Fowler (1995); Goldhaber (1999); Stoddard (2005); or Taylor (2008a, 2008b, 2010, 2011).
[49] For purposes of this analysis, a teacher is someone with a PEIMS role code of 25, 29 or 87, who spends at least 95% of his or her time teaching.

Table B.1 presents the coefficient estimates and robust standard errors for the hedonic wage model.

As the table illustrates, the hedonic model includes controls for teacher experience (the log of years of experience, the square of log experience and an indicator for first-year teachers) and indicators for the teacher's educational attainment (no degree, master's degree or doctorate) and whether or not the individual is new to the district,

Job characteristics in the analysis include indicators for teaching assignment (general elementary, language arts, mathematics, science, social studies, health and physical education, foreign languages, fine arts, computers, vocational/technical subjects, special education and standardized-tested subjects or grades) and student populations served (non-graded students, elementary students, secondary students, pre-kindergarten students or kindergarten students). Any given teacher could have multiple teaching assignments (such as an individual teaching both mathematics and science) or serve multiple student populations (such as kindergarten and pre-kindergarten).

Other job characteristics in the analysis include an indicator for whether or not the individual was assigned to multiple campuses and indicators for whether or not the teacher had additional duties as a department head, administrator or professional staff member.

Some school districts pay higher wages than others based on factors that are largely outside of school district

Table B1: Hedonic Wage Model

	Coefficients
Years of experience (log)	0.0010
	(0.0014)
Years of experience (log), sq.	0.0207***
	(0.0008)
First year teacher	-0.0055***
	(0.0009)
No degree	0.0045***
	(0.0012)
Master's degree	0.0232***
	(0.0004)
PhD	0.0292***
	(0.0028)
New hire	-0.0054***
	(0.0002)
Assigned multiple campuses	0.0059***
	(0.0005)
General elementary teacher	0.0000
	(0.0003)
Language arts teacher	-0.0011***
	(0.0002)
Mathematics teacher	-0.0005**
	(0.0003)
Science teacher	-0.0008***
	(0.0003)
Social studies teacher	-0.0004*
	(0.0002)
Health & P.E. teacher	0.0140***
	(0.0004)
Foreign language teacher	-0.0046***
	(0.0005)
Fine arts teacher	0.0008**
	(0.0004)
Computer teacher	-0.0064***
	(0.0005)
Vocational/technical teacher	-0.0032***
	(0.0006)
Special education teacher	0.0009**
	(0.0005)
Tested grade or subject teacher	-0.0019***
	(0.0002)
Assigned non-graded students	-0.0020***
	(0.0003)
Assigned elementary students	-0.0025***
	(0.0003)

Table B1: Hedonic Wage Model, continued

	Coefficients
Assigned secondary students	0.0032***
	(0.0003)
Assigned pre-k students	-0.0025***
	(0.0006)
Assigned kindergarten students	-0.0032***
	(0.0003)
Department head	0.0038
	(0.0030)
Administrator	0.0614***
	(0.0158)
Support staff	0.0276***
	(0.0051)
Campus% econ. disadvantaged	-0.0024***
	(0.0010)
Campus% limited English	0.0259***
	(0.0012)
Campus% special education	0.0228***
	(0.0031)
Campus enrollment (log)	0.0165***
	(0.0004)
Elementary campus	0.0113***
	(0.0017)
Middle school campus	0.0168***
	(0.0017)
High school campus	0.0177***
	(0.0017)
ACS-CWI	0.3190***
	(0.0145)
HS-CWI	0.0453***
	(0.0216)
Fair market rent (log)	-0.0432***
	(0.0016)
Unemployment rate	0.0063***
	(0.0001)
Major urban area indicator	0.0678***
	(0.0019)
Observations	1,432,886
Number of teacher fixed effects	407,096
Adjusted R-squared	0.637

Note: The model also includes year indicators. Robust standard errors are in parentheses. Asterisks indicate a coefficient that is statistically significant at the 1%*** 5%** or 10%* levels.
Source: Authors' calculations.

control—namely, student demographics, school size and school type—so it is important to include those factors in the hedonic wage analysis. The student demographics used in this analysis are the percentage of students in the campus who are identified as economically disadvantaged, limited English proficient or special education students. School size is measured as the log of campus enrollment. There are three indicators for school type (elementary schools, middle schools, and high schools).

Finally, the hedonic wage model also includes six variables that describe various aspects of local labor market conditions. The ACS Comparable Wage reflects the prevailing wage for college graduates, and the HS Comparable Wage Index reflects the prevailing wage for high school graduates who do not have a college degree (Texas Smart Schools 2017). In addition, the U.S. Department of Housing and Urban Development's estimate of Fair Market Rents for a two-bedroom apartment (in logs) reflects deviations in the cost of living, while the U.S. Bureau of Labor Statistic's measure of the metropolitan area unemployment rate reflects job prospects outside of teaching. Finally, the model includes an indicator for whether or not the school district is located in a major metropolitan area (Austin, Dallas, Fort Worth, Houston and San Antonio).

The Teacher Salary Index (TSI) 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 teacher characteristics and job characteristics constant at the statewide mean, but leaving the campus and labor market characteristics unchanged. Dividing the predicted wage by the minimum predicted wage (each year) yields the TSI. It ranges from 1.00 to 1.33 indicating that the cost of hiring teachers is up to 33% higher in some core based statistical areas than in others. On average the TSI is highest in the Houston, Dallas and Fort Worth metropolitan areas and lowest in the Vernon and Sulphur Springs micropolitan areas.

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Technical Appendix C: The Coefficient Estimates for the Cost Function Analysis

Table C1: Coefficient Estimates and Robust Standard Errors for the Cost Function Models

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
District Enrollment (Log)	-0.0740	-0.1208	-0.0160	-0.1120	-0.0270
	(0.0939)	(0.1403)	(0.0976)	(0.0929)	(0.0981)
District Enrollment (Log), Squared	0.0086	0.0108	0.0082	0.0164	0.0037
	(0.0117)	(0.0129)	(0.0117)	(0.0117)	(0.0122)
District Enrollment (Log), Cubed	-0.0001	-0.0001	-0.0000	-0.0003	0.0001
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
District Enrollment (Log) *Campus Enrollment (Log)	-0.0166***	-0.0165***	-0.0245***	-0.0173***	-0.0172***
	(0.0045)	(0.0045)	(0.0035)	(0.0048)	(0.0044)
District Enrollment (Log) * Average NCE Score	-0.0106	-0.0111	-0.0855***	-0.0154	-0.0030
	(0.0245)	(0.0246)	(0.0249)	(0.0250)	(0.0241)
District Enrollment (Log) * % Other Special Ed.	0.3840***	0.3852***	0.3351***	0.3479***	0.4057***
	(0.0524)	(0.0578)	(0.0574)	(0.0521)	(0.0520)
District Enrollment (Log) * Teacher Salary Index (Log)	0.0390	0.0479	0.0649**	0.0289	0.0621*
	(0.0315)	(0.0328)	(0.0317)	(0.0316)	(0.0322)
District Enrollment (Log) * Miles to Metro Center (Log)	-0.0070***	-0.0074***	-0.0036	-0.0065***	-0.0089***
	(0.0022)	(0.0023)	(0.0026)	(0.0023)	(0.0022)
District Enrollment (Log) * % Economically Disadv.	0.0076	0.0123	0.0169*	0.0043	0.0057
	(0.0080)	(0.0107)	(0.0092)	(0.0081)	(0.0079)
District Enrollment (Log) * % Ever-LEP	-0.0141**	-0.0198**	-0.0142	-0.0155**	-0.0134**
	(0.0066)	(0.0094)	(0.0090)	(0.0066)	(0.0065)
District Enrollment (Log) * % High Needs Special Ed.	0.1949***	0.1739**	0.3820***	0.1555***	0.2043***
	(0.0543)	(0.0847)	(0.0639)	(0.0522)	(0.0546)
District Enrollment (Log) * Elementary Campus	0.0378***	0.0438***	0.0377***	0.0222***	0.0359***
	(0.0036)	(0.0103)	(0.0057)	(0.0034)	(0.0035)
District Enrollment (Log) * Middle School Campus	0.0372***	0.0402***	0.0420***	0.0240***	0.0354***
	(0.0032)	(0.0042)	(0.0048)	(0.0029)	(0.0031)
District Enrollment (Log) * Multi-Grade School Indicator	0.0200***	0.0272**	0.0429***	0.0092	0.0180**
	(0.0076)	(0.0139)	(0.0108)	(0.0071)	(0.0073)
Campus Enrollment (Log)	-0.1700***	-0.1367	-0.2788***	-0.2358***	-0.1727***

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
	(0.0617)	(0.0847)	(0.0627)	(0.0628)	(0.0600)
Campus Enrollment (Log), Squared	0.0176***	0.0177***	0.0287***	0.0216***	0.0185***
	(0.0050)	(0.0050)	(0.0044)	(0.0052)	(0.0049)
Campus Enrollment (Log) * Average NCE Score	-0.0152	-0.0190	0.1429**	-0.0140	-0.0237
	(0.0590)	(0.0589)	(0.0558)	(0.0606)	(0.0575)
Campus Enrollment (Log) * % * Other Special Ed.	-0.8006***	-0.8025***	-0.6239***	-0.8059***	-0.7976***
	(0.1138)	(0.1141)	(0.1152)	(0.1130)	(0.1115)
Campus Enrollment (Log) * Teacher Salary Index (Log)	0.1128*	0.1086*	0.0606	0.1297**	0.1286**
	(0.0625)	(0.0621)	(0.0609)	(0.0621)	(0.0610)
Campus Enrollment (Log) * Miles To Metro Center (Log)	0.0069*	0.0071*	-0.0016	0.0066*	0.0083**
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0036)
Campus Enrollment (Log) * % Economically Disadv.	0.0200	0.0186	0.0029	0.0306*	0.0116
	(0.0169)	(0.0169)	(0.0177)	(0.0167)	(0.0164)
Campus Enrollment (Log) * % Ever-LEP	0.0210	0.0225	0.0150	0.0094	0.0290*
	(0.0171)	(0.0173)	(0.0204)	(0.0169)	(0.0164)
Campus Enrollment (Log) * % High Needs Special Ed.	-0.2717**	-0.2743**	-0.5486***	-0.2456*	-0.2600**
	(0.1310)	(0.1309)	(0.1485)	(0.1273)	(0.1277)
Campus Enrollment (Log) * Elementary Campus	-0.0798***	-0.0795***	-0.0708***	-0.0635***	-0.0705***
	(0.0080)	(0.0080)	(0.0110)	(0.0081)	(0.0078)
Campus Enrollment (Log) * Middle School Campus	-0.0295***	-0.0294***	-0.0306***	-0.0161**	-0.0249***
	(0.0068)	(0.0067)	(0.0087)	(0.0065)	(0.0065)
Campus Enrollment (Log) * Multi-grade Campus	-0.1108***	-0.1112***	-0.1349***	-0.0947***	-0.1176***
	(0.0252)	(0.0252)	(0.0320)	(0.0236)	(0.0253)
Average NCE Score	0.8822**	1.3283**	0.5584	0.8429*	0.7945*
	(0.4341)	(0.6009)	(0.4938)	(0.4358)	(0.4239)
Average NCE Score, Squared	-0.5698***	-0.5608***	-0.5811**	-0.5228**	-0.5195**
	(0.2088)	(0.2077)	(0.2653)	(0.2050)	(0.2039)
Average NCE Score * % Other Special Ed.	-1.8314*	-1.8314*	-1.2233	-1.6347*	-1.7980*
	(0.9426)	(0.9414)	(1.0096)	(0.9393)	(0.9432)
Average NCE Score * Teacher Salary Index (Log)	-0.3229	-0.2957	-0.6851	-0.1454	-0.4894
	(0.4048)	(0.4021)	(0.4238)	(0.4039)	(0.4062)
Average NCE Score * Miles to Metro Center (Log)	-0.0416	-0.0409	-0.0581*	-0.0395	-0.0261
	(0.0305)	(0.0305)	(0.0330)	(0.0305)	(0.0298)
Average NCE Score * % Economically Disadv.	-0.1282	-0.1267	-0.1681	-0.1045	-0.1203
	(0.1266)	(0.1273)	(0.1382)	(0.1256)	(0.1277)

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
Average NCE Score * % Ever-LEP	-0.0668	-0.0636	-0.0703	-0.0928	-0.0498
	(0.1084)	(0.1084)	(0.1285)	(0.1061)	(0.1093)
Average NCE Score * % High Needs Special Ed.	1.4449	1.4816	1.1167	1.5429*	1.3269
	(0.9335)	(0.9317)	(1.0731)	(0.9169)	(0.9236)
Average NCE Score * Elementary Campus	0.2812***	0.2820***	0.4454***	0.2544***	0.2714***
	(0.0827)	(0.0827)	(0.0847)	(0.0818)	(0.0810)
Average NCE Score * Middle School Campus	0.3347***	0.3349***	0.4543***	0.2938***	0.3235***
	(0.0798)	(0.0798)	(0.0869)	(0.0778)	(0.0782)
Average NCE Score * Multi-grade Campus	0.4869**	0.4840**	0.4327*	0.5459***	0.4900**
	(0.2163)	(0.2168)	(0.2305)	(0.2026)	(0.2077)
% Other Special Ed.	3.2872***	3.0854***	2.5520***	3.4132***	3.0660***
	(0.8780)	(1.1218)	(0.9505)	(0.8739)	(0.8541)
% Other Special Ed., Squared	3.8988***	5.9311	4.1622***	4.2743***	4.2631***
	(1.4971)	(4.9558)	(1.5888)	(1.4734)	(1.4994)
% Other Special Ed. * Teacher Salary Index (Log)	-3.5204***	-3.2948**	-2.9000**	-2.9932***	-4.5341***
	(1.1379)	(1.5850)	(1.1996)	(1.1188)	(1.1251)
% Other Special Ed. * Miles to Metro Center (Log)	0.2599***	0.2450***	0.1713*	0.2293***	0.2939***
	(0.0835)	(0.0838)	(0.0882)	(0.0819)	(0.0802)
% Other Special Ed. * % Economically Disadv.	-0.5301*	-0.7672**	-0.5067*	-0.4910*	-0.5405**
	(0.2730)	(0.3662)	(0.3045)	(0.2711)	(0.2726)
% Other Special Ed. * % Ever-LEP	0.9212***	1.1662***	0.8632**	0.8704***	0.8441***
	(0.3178)	(0.3771)	(0.3602)	(0.3146)	(0.3220)
% Other Special Ed. * % High Needs Special Ed.	-1.5449	-0.4300	-6.6272***	-1.4745	-1.6349
	(2.2461)	(4.6820)	(2.4219)	(2.2172)	(2.2041)
% Other Special Ed. * Elementary Campus	-0.9199***	-0.8662**	-0.8243***	-0.8457***	-0.9368***
	(0.1441)	(0.3671)	(0.1656)	(0.1385)	(0.1432)
% Other Special Ed. * Middle School Campus	-0.6980***	-0.6802***	-0.5909***	-0.5991***	-0.6951***
	(0.1368)	(0.2375)	(0.1614)	(0.1285)	(0.1335)
% Other Special Ed. * Multi-grade Campus	-0.6442*	-0.5226	-0.4522	-0.4962	-0.6061*
	(0.3306)	(0.3856)	(0.3468)	(0.3211)	(0.3286)
Teacher Salary Index (Log)	0.8269*	0.6951	0.9237*	0.6199	0.6453
	(0.4717)	(0.5484)	(0.4749)	(0.4648)	(0.4663)
Teacher Salary Index (Log), Squared	-4.0045***	-4.3515***	-3.9806***	-3.7211***	-4.3626***
	(0.8619)	(0.9677)	(0.8562)	(0.8616)	(0.8453)
Teacher Salary Index (Log) * Miles to Metro Center (Log)	0.0132	0.0271	0.0267	0.0060	0.0522

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
	(0.0513)	(0.0594)	(0.0534)	(0.0515)	(0.0503)
Teacher Salary Index (Log) * % Economically Disadv.	-0.5305***	-0.5086**	-0.4691**	-0.4898***	-0.4393**
	(0.1821)	(0.2331)	(0.1881)	(0.1814)	(0.1815)
Teacher Salary Index (Log) * % Ever-LEP	0.2262	0.2383	0.2385	0.2590	0.1216
	(0.1615)	(0.1845)	(0.1751)	(0.1605)	(0.1640)
Teacher Salary Index (Log) * % High Needs Special Ed.	2.3202**	3.1780*	4.1826***	2.5548**	1.8716*
	(1.0882)	(1.7891)	(1.1322)	(1.0678)	(1.0860)
Teacher Salary Index (Log) * Elementary Campus	0.4107***	0.3980***	0.4286***	0.3272***	0.3883***
	(0.0642)	(0.0893)	(0.0662)	(0.0610)	(0.0625)
Teacher Salary Index (Log) * Middle School Campus	0.1573***	0.1483	0.1701***	0.0872	0.1718***
	(0.0560)	(0.0969)	(0.0576)	(0.0533)	(0.0548)
Teacher Salary Index (Log) * Multi-grade Campus	0.1896	0.1968	0.1601	0.1665	0.1903
	(0.1674)	(0.1982)	(0.1782)	(0.1647)	(0.1646)
Miles To Metro Center (Log)	0.0033	0.0023	0.0468	0.0062	-0.0054
	(0.0348)	(0.0346)	(0.0345)	(0.0348)	(0.0337)
Miles To Metro Center (Log), Squared	-0.0007	-0.0002	-0.0004	-0.0008	-0.0001
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Miles To Metro Center (Log) * % Economically Disadv.	0.0267**	0.0256*	0.0318**	0.0312**	0.0308**
	(0.0130)	(0.0132)	(0.0140)	(0.0133)	(0.0129)
Miles To Metro Center (Log) * % Ever-LEP	0.0248**	0.0243**	0.0103	0.0162	0.0165
	(0.0121)	(0.0121)	(0.0136)	(0.0123)	(0.0120)
Miles To Metro Center (Log) * % High Needs Special Ed.	-0.1733**	-0.1569*	-0.2800***	-0.2001**	-0.1618**
	(0.0795)	(0.0837)	(0.0809)	(0.0779)	(0.0783)
Miles To Metro Center (Log) * Elementary Campus	0.0159***	0.0168***	0.0079	0.0123**	0.0174***
	(0.0060)	(0.0062)	(0.0060)	(0.0056)	(0.0057)
Miles To Metro Center (Log) * Middle School Campus	0.0117***	0.0116**	0.0062	0.0091**	0.0128***
	(0.0041)	(0.0047)	(0.0042)	(0.0038)	(0.0039)
Miles To Metro Center (Log) * Multi-grade Campus	-0.0086	-0.0070	-0.0131	-0.0056	-0.0110
	(0.0116)	(0.0121)	(0.0121)	(0.0113)	(0.0113)
% Economically Disadv.	-0.0923	-0.0362	-0.1170	-0.1328	-0.0355
	(0.1432)	(0.1526)	(0.1568)	(0.1414)	(0.1416)
% Economically Disadv., Squared	0.2109***	0.2124***	0.2511***	0.2159***	0.1913***
	(0.0345)	(0.0343)	(0.0359)	(0.0346)	(0.0338)
% Economically Disadv. * % Ever-LEP	-0.2720***	-0.3026***	-0.3210***	-0.2962***	-0.2441***
	(0.0488)	(0.0555)	(0.0555)	(0.0485)	(0.0481)

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
% Economically Disadv. * % High Needs Special Ed.	-0.7292***	-0.7169***	-0.5689**	-0.7611***	-0.5996**
	(0.2506)	(0.2572)	(0.2821)	(0.2497)	(0.2506)
% Economically Disadv. * Elementary Campus	-0.0598***	-0.0865	-0.0605**	-0.0833***	-0.0656***
	(0.0229)	(0.0575)	(0.0250)	(0.0215)	(0.0223)
% Economically Disadv. * Middle School Campus	0.0232	0.0148	0.0292	0.0058	0.0189
	(0.0215)	(0.0417)	(0.0230)	(0.0201)	(0.0209)
% Economically Disadv. * Multi-grade Campus	-0.1813***	-0.2120***	-0.1376**	-0.1923***	-0.2048***
	(0.0621)	(0.0717)	(0.0678)	(0.0592)	(0.0611)
% Ever-LEP	0.1521	0.1251	0.2853	0.2948*	0.1043
	(0.1580)	(0.1607)	(0.1776)	(0.1555)	(0.1563)
% Ever-LEP, Squared	0.0018	0.0478	0.0237	0.0001	0.0013
	(0.0275)	(0.0481)	(0.0329)	(0.0274)	(0.0278)
% Ever-LEP * % High Needs Special Ed.	0.0463	0.0866	-0.1825	0.1092	0.0111
	(0.2988)	(0.3147)	(0.3417)	(0.2969)	(0.2992)
% Ever-LEP * Elementary Campus	0.0293	0.0534	0.0018	0.0228	0.0344
	(0.0224)	(0.0478)	(0.0259)	(0.0209)	(0.0220)
% Ever-LEP * Middle School Campus	0.0318	0.0458	0.0078	0.0259	0.0360*
	(0.0219)	(0.0387)	(0.0233)	(0.0204)	(0.0211)
% Ever-LEP * Multi-grade Campus	0.2518***	0.2539***	0.2458***	0.2449***	0.2879***
	(0.0671)	(0.0676)	(0.0817)	(0.0648)	(0.0667)
% High Needs Special Ed.	2.4554**	2.1033	3.5965***	2.4908**	2.2765**
	(1.1216)	(1.3041)	(1.1779)	(1.1005)	(1.0897)
% High Needs Special Ed., Squared	-8.9990***	-7.4527*	-12.1778***	-8.6276***	-8.7607***
	(1.3832)	(4.1325)	(1.2906)	(1.4037)	(1.3960)
% High Needs Special Ed. * Elementary Campus	-0.3139	-0.1358	-0.7911***	-0.1623	-0.3435*
	(0.1945)	(0.5592)	(0.2096)	(0.1876)	(0.1935)
% High Needs Special Ed. * Middle School Campus	-0.5543***	-0.4103	-1.0701***	-0.4231**	-0.5842***
	(0.2007)	(0.4236)	(0.1851)	(0.1924)	(0.1986)
% High Needs Special Ed. * Multi-grade Campus	1.1299***	1.1547**	0.8883*	1.0583***	1.1490***
	(0.3404)	(0.4799)	(0.5013)	(0.3571)	(0.3332)
Elementary Campus	-0.2227***	-0.2718**	-0.3189***	-0.0803	-0.2486***
	(0.0766)	(0.1152)	(0.0771)	(0.0755)	(0.0747)
Middle School Campus	-0.5098***	-0.5304***	-0.5724***	-0.3922***	-0.5143***
	(0.0596)	(0.0654)	(0.0632)	(0.0571)	(0.0575)
Multi-grade Campus	0.2444	0.1829	0.2595	0.2403	0.3086

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
	(0.2048)	(0.2448)	(0.2217)	(0.1915)	(0.2002)
Major Urban Area	-0.0158*	-0.0068	-0.0182**	-0.0106	-0.0119
	(0.0084)	(0.0259)	(0.0083)	(0.0084)	(0.0083)
Micropolitan Area	-0.0279***	-0.0283***	-0.0263***	-0.0260***	-0.0281***
	(0.0073)	(0.0072)	(0.0074)	(0.0072)	(0.0073)
Military	0.3295***	0.3214***	0.3203***	0.3495***	0.3272***
	(0.0282)	(0.0330)	(0.0282)	(0.0318)	(0.0288)
Houston ISD	-0.0742***	-0.0747***	0.0000	-0.0675***	-0.0769***
	(0.0243)	(0.0252)	(0.0000)	(0.0239)	(0.0243)
Dallas ISD	0.0008	0.0004	0.0000	-0.0019	-0.0051
	(0.0222)	(0.0229)	(0.0000)	(0.0219)	(0.0230)
Cypress Fairbanks ISD	-0.0778***	-0.0924***	0.0000	-0.0749***	-0.0718***
	(0.0160)	(0.0262)	(0.0000)	(0.0160)	(0.0159)
Northside ISD	-0.0472***	-0.0645**	0.0000	-0.0530***	-0.0415***
	(0.0133)	(0.0277)	(0.0000)	(0.0132)	(0.0135)
2012–13 School Year	0.0039	0.0026	0.0075	0.0030	0.0045
	(0.0058)	(0.0060)	(0.0060)	(0.0058)	(0.0058)
2013–14 School Year	0.0515***	0.0496***	0.0542***	0.0505***	0.0522***
	(0.0058)	(0.0064)	(0.0058)	(0.0058)	(0.0058)
2014–15 School Year	0.0944***	0.0940***	0.0955***	0.0928***	0.0942***
	(0.0057)	(0.0062)	(0.0057)	(0.0056)	(0.0057)
2015–16 School Year	0.1281***	0.1272***	0.1270***	0.1259***	0.1279***
	(0.0058)	(0.0062)	(0.0058)	(0.0057)	(0.0059)
School Size Residual		-0.0307			
		(0.0551)			
School Quality Residual		-0.4392			
		(0.3889)			
Constant	9.8215***	9.6399***	9.9609***	9.9732***	9.7520***
	(0.3653)	(0.4789)	(0.3675)	(0.3647)	(0.3678)
One-Sided Error					
Herfindahl Index (Log)	0.3921***	0.3977***	0.4075***	0.3690***	0.4029***
	(0.0540)	(0.0542)	(0.0605)	(0.0533)	(0.0548)
K-8 District Indicator	0.7389***	0.7363***	0.7113***	0.7193***	0.9076***
	(0.2330)	(0.2343)	(0.2496)	(0.2305)	(0.2232)
Constant	-4.5332***	-4.5217***	-4.5838***	-4.5667***	-4.5501***

Variables	Model 1	Model 1a	Model 2	Model 3	Model 4
	(0.1177)	(0.1182)	(0.1221)	(0.1161)	(0.1190)
Two-Sided Error					
Unallocated Share	2.9707***	2.9578***	3.0162***	3.1095***	2.7115***
	(0.6467)	(0.6479)	(0.6539)	(0.6348)	(0.6472)
Number of Student Tested (Log)	-0.1569***	-0.1579***	-0.1355***	-0.1877***	-0.1843***
	(0.0264)	(0.0266)	(0.0275)	(0.0259)	(0.0265)
Constant	-4.8014***	-4.7941***	-4.8462***	-4.7124***	-4.6305***
	(0.2202)	(0.2210)	(0.2325)	(0.2143)	(0.2202)
Number of Observations	30,542	30,542	27,306	30,542	30,542

Note: Robust standard errors clustered by district-year in parentheses. The asterisks indicate a coefficient estimate that is statistically significant at the 1% (***), 5%(**) or 10%(*) levels.
Source: Authors' calculations.