Estimating the cost function of Connecticut public K–12 education: implications for inequity and inadequacy in school spending

Bo Zhao

New England Public Policy Center, Research Department, Federal Reserve Bank of Boston, Boston, MA, USA

ABSTRACT

This paper is the first to estimate the cost function of Connecticut public K–12 education and to evaluate the state’s school spending based on regression-estimated education costs. It finds large disparities across districts in education costs and cost-adjusted spending. A large percentage of the state’s public school students are enrolled in districts where spending is inadequate relative to the predicted cost of achieving a common student performance target. Thus, many school districts, especially the high-cost ones, need a large amount of additional spending to improve student performance.

ARTICLE HISTORY

Received 6 August 2021
Accepted 16 April 2022

KEYWORDS

Cost function; education costs; school spending; equity in education finance; adequacy in education finance

JEL CODES

H75; I21; I22; I28

1. Introduction

Since the early 1970s, almost every state in the USA has been sued for failing to provide equitable and adequate school funding mandated by their constitutions.¹ The inequity and inadequacy is mainly caused by an uneven distribution of property wealth and the disparities in education cost across school districts, given their varying student learning needs. This paper uses Connecticut as a case study to examine the issues on education cost.

A series of high-profile court rulings in recent years has put Connecticut’s education finance under the national spotlight. In 2016, a Connecticut Superior Court judge ruled in the case Connecticut Coalition for Justice in Education Funding (CCJEF) v. Rell that the distribution of state education aid is irrational and unconstitutional, requiring the state to make system-wide changes in its education policies. The judge particularly ‘told the General Assembly it first had to determine how much money schools actually need to educate children and then must allocate the funds in a way that met that goal.’ (Harris and Hussey 2016). However, in 2018, the Connecticut Supreme Court reversed the lower court ruling with a controversial 4–3 decision and deferred resolution of the issue to the state legislature.

The state legislature has struggled in fully addressing the concerns about equity and adequacy in education funding. In 2017, it adopted a new aid formula, which uses the foundation amount and the ‘need-student’ weights to determine the education costs for each school district. The foundation is the amount of money that the state deems is needed to educate a typical public school student who does not have any additional learning needs. However, each year’s foundation amount is simply ‘based on past foundation amounts and not derived using verifiable education spending data’ (Connecticut School Finance Project 2019, 60). Also, the foundation is not based directly on any student performance target (Connecticut School Finance Project 2019). While the formula contains three
student’ weights (low-income student, concentrated poverty, and English-learner) to account for higher costs for districts with greater student need, those weights are arbitrary and not derived from data analysis.\(^2\)

Therefore, there remains a need for an objective and rigorous study of Connecticut’s education costs that would be the basis of a more equitable and adequate state education aid formula. To fill this gap, this paper first estimates the cost function of Connecticut public K–12 education. Then, I use the cost function to estimate how much each district must spend to achieve a common student performance level, given student and district characteristics, if the district operates at the average efficiency level. Furthermore, I examine the distributions of education costs and school spending relative to costs. Finally, I investigate how much additional spending is needed for all districts to achieve some common student performance target levels.

To the best of my knowledge, this paper is the first cost function study of Connecticut public K–12 education. It is also the first paper to evaluate Connecticut’s school spending based on regression-estimated education costs for each district to achieve common target levels for student test performance. By filling the knowledge gap about Connecticut’s school finance, this paper helps the academic and policy communities to gain a more complete and deeper understanding of the US education equity and adequacy. While it is based on Connecticut, this paper can be relevant and useful for other states. Many other states have similar public education systems as Connecticut’s and face similar challenges in providing adequate and equitable education funding. Table 1 shows, for example, the percentage of minority students in the Connecticut system is close to the national average. Like Connecticut, almost all other northeastern states rely heavily on local revenues (mostly property taxes) to fund schools. Their student test performance is also comparable with Connecticut’s. Given the similarities and the generalizability of the research approach, other states can benefit from this research when conducting their cost studies and crafting appropriate policy solutions.

Compared with most of previous studies, this paper includes more controls for efficiency in the regression analysis. It adds fixed effects for labor market areas (LMAs) to control for time-invariant efficiency factors shared by school districts in each LMA.\(^3\) School districts in the same labor market area share the same labor pools (teachers and school managers) and compete for the same students whose families decide where to live in the area. Therefore, the differences between LMAs in the labor pools and the market competitiveness can result in efficiency differences between school districts in different LMAs. To the best of my knowledge, except for Downes and Pogue (1994) and Duncombe and Yinger (2007), previous studies do not include any geographic-level fixed effects in the regressions.\(^4\) Furthermore, this paper adds dummy variables for school districts bordering another state, which are not controlled in previous studies. A school district bordering another state competes with not only other school districts within the state for students, teachers, and school managers, but also school districts in the adjacent state, which could therefore affect its efficiency incentive. Compared with interior districts, a border district may also be exposed to different teaching and management technologies used in the neighboring state. I also expand the measures of educational outcomes beyond the common ones used in previous studies, such as test scores, the percentage of students who are at or above the proficiency level in the state’s standardized tests, and high school graduation rates. I use some alternative measures of educational outcomes including the percentage of high school graduates pursuing higher education and a growth measure of student test performance based on the matched student cohorts.

2. Connecticut’s school finance system

Connecticut’s school districts do not have taxing authority. They rely heavily on municipal governments for school funding. According to the US Census Bureau’s 2017 Annual Survey of School System Finances, the contribution from local revenues to Connecticut’s public school funding was 58
Table 1. Comparing Public K-12 Education Systems Between Connecticut and Other States, FY 2017.

|                      | Other New England States |          |          |          |          | Mid-Atlantic States |          |          |          |
|----------------------|--------------------------|----------|----------|----------|----------|---------------------|----------|----------|----------|
| Public School Student Population | CT | ME | MA | NH | RI | VT | NJ | NY | PA | USA |
| Enrollment (Thousands of Students) | 535.12 | 180.51 | 964.51 | 180.89 | 142.15 | 88.43 | 1410.42 | 2729.78 | 1727.50 | 991.92 |
| Percentage of Students Who Are Black | 12.84 | 3.46 | 8.91 | 1.98 | 8.45 | 2.01 | 15.85 | 17.38 | 14.79 | 15.31 |
| Percentage of Students Who Are Hispanic | 24.01 | 2.12 | 19.33 | 5.17 | 24.69 | 1.88 | 27.61 | 26.51 | 10.98 | 26.32 |
| Fiscal Indicators |          |          |          |          |          |          |          |          |          |          |
| Current Spending per Pupil (Thousands of Dollars) | 19.32 | 13.69 | 16.20 | 15.68 | 15.94 | 18.29 | 18.92 | 23.09 | 15.80 | 12.20 |
| Current Spending as Percentage of Personal Income | 39.61 | 42.28 | 36.05 | 37.01 | 41.89 | 53.31 | 48.59 | 52.36 | 40.96 | 37.46 |
| Percentage of Total Revenue from Federal Sources | 4.29 | 6.66 | 4.28 | 5.40 | 7.25 | 6.10 | 4.10 | 5.26 | 6.42 | 7.97 |
| Percentage of Total Revenue from State Sources | 38.01 | 38.34 | 38.73 | 32.13 | 40.52 | 90.31 | 40.95 | 40.84 | 38.67 | 47.12 |
| Percentage of Total Revenue from Local Sources | 57.70 | 55.00 | 56.98 | 62.47 | 52.23 | 3.59 | 54.95 | 53.90 | 54.90 | 44.91 |
| Student Performance in National Assessment of Educational Progress (NAEP) |          |          |          |          |          |          |          |          |          |          |
| Percentage of Grade-4 Students Reaching or Exceeding Proficiency in Math | 39.92 | 40.24 | 52.91 | 47.71 | 38.64 | 42.21 | 49.93 | 35.47 | 43.63 | 39.54 |
| Percentage of Grade-4 Students Reaching or Exceeding Proficiency in Reading | 42.73 | 36.37 | 50.82 | 43.03 | 38.73 | 42.93 | 48.63 | 35.96 | 40.18 | 35.44 |
| Percentage of Grade-8 Students Reaching or Exceeding Proficiency in Math | 36.22 | 35.99 | 49.69 | 45.41 | 30.23 | 39.37 | 43.76 | 33.85 | 38.13 | 33.43 |
| Percentage of Grade-8 Students Reaching or Exceeding Proficiency in Reading | 43.76 | 39.05 | 49.32 | 45.05 | 37.42 | 44.77 | 46.65 | 34.16 | 39.99 | 34.74 |

Sources: National Center for Educational Statistics and US Census Bureau’s Annual Survey of School System Finances
Note: Enrollment for the United States is a simple average of enrollments in 50 states and Washington, DC.
percent—the fourth highest percentage in the country. The second-largest revenue source for Connecticut public schools is state grants. Connecticut’s education aid system includes more than 10 different aid programs. Of these programs, the formula-based Education Cost Sharing (ECS) grants are the largest. Since the state legislature created the ECS program in 1988, the structure of the ECS formula has remained largely the same. The amount of ECS grant funding allocated to a school district is based on three components: the foundation amount, a weighted count of enrolled students, and the base aid ratio (Connecticut School Finance Project 2019). Connecticut set the foundation amount at $9,687 per pupil for the FY2008–2013 period and $11,525 per pupil for FY2014 and onward. The state recognizes that a school district with a greater share of at-risk students needs to spend more money than the foundation amount; therefore, it uses need-student weights to adjust the number of enrolled students and thus the amount of funding needed. For the FY2008–2013 period, the state gave additional weights of 0.33 to each Title I student and 0.15 to each student with limited English proficiency. After the total funding is calculated by multiplying the foundation amount by the weighted count of enrolled students, the base aid ratio determines the share of this amount that ECS grants will fund, subject to a state-designated minimum value of the ratio. It takes into account both the total equalized value of taxable property, called the Equalized Net Grand List (ENGL), and the median household income in a school district. In general, districts with lower ENGLs per capita and lower median household incomes are given higher base aid ratios.

Before 2015, Connecticut’s school accountability system focused on the level of student performance in state standardized tests and high school graduation rates. After 2015, the accountability system expanded to include additional indicators for student academic growth, chronic absenteeism, physical fitness, and arts access. Based on the school accountability system, the state identifies the lowest-performing school districts and provides them with school accountability grants to improve student outcomes (Connecticut School and State Finance Project 2021). As a condition for receiving school accountability grants, each of these lowest-performing school districts is required to submit and obtain the state’s approval of an improvement plan. The plan must explain how the district will use the school accountability grants, especially in the focus areas of spending such as foundational reading programs, additional learning time, and a talent strategy.

3. General framework

Researchers have used five approaches to estimate the cost for each school district to meet a given student performance target. They include three non-econometric approaches (professional judgement, evidence-based, and successful schools) and two econometric approaches (cost function and production function). For a detailed discussion of these approaches and their pros and cons, see Duncombe, Lukemeyer, and Yinger (2003), Taylor, Baker, and Vedlitz (2005), Imazeki and Reschovsky (2005), Duncombe (2006), Imazeki (2008), and Duncombe and Yinger (2011a).

The cost function approach has several advantages over the other approaches. First, it can provide a more rigorous measure of education cost than the non-econometric approaches. Based on a regression analysis of historical data, it can directly quantify the relationship among student performance, student characteristics, and costs for school districts. Second, the cost function approach avoids two problems that seriously undermine the validity of the production function approach: extreme assumptions about production technology and measurement error in a key explanatory variable (Duncombe and Yinger 2011a). Because it is difficult to observe a full list of inputs at the school district level, Costrell, Hanushek, and Loeb (2008) and Imazeki (2008) use per-pupil spending as a proxy for the input bundle and include it as a key explanatory variable to estimate the production function equation. In doing so, they implicitly assume that a dollar spent on one type of input is equally productive as a dollar spent on another type of input and that all input combinations produce the same efficiency. Furthermore, because per-pupil spending reflects not only inputs but also inefficiency, this creates a difficult errors-in-variables problem that biases the estimation results (Duncombe and Yinger 2011a; Baker et al. 2018). In contrast, the cost function
approach uses per-pupil spending as a dependent variable and includes a variety of control variables to account for inefficiency in the model. In addition, Duncombe (2006) and Duncombe and Yinger (2011a) show that the cost function approach can provide a reliable cost estimate with good forecasting accuracy.

The cost function approach is not perfect and does have several disadvantages compared with the other approaches. It is generally considered more complicated and more difficult for policymakers to understand than the non-econometric approaches. It is also less suitable to identify a specific set of resources and educational interventions for a school district to reach a given student performance target. In fact, it does not indicate how school districts should organize their resources to be more efficient. In addition, if a cost function study does not have adequate controls for inefficiency, the estimates could be biased and inaccurate (Costrell, Hanushek, and Loeb 2008; Imazeki 2008).

Considering both its advantages and disadvantages, Duncombe and Yinger (2011a) conclude that the cost function approach is ‘the best currently available method for estimating the cost of reaching any given performance target.’ (35) In this paper, I apply the cost function approach to Connecticut, with adjustments made to improve the controls for inefficiency and incorporate Connecticut-specific institutional details.

Following previous studies, this paper is conceptually built on an expenditure function as follows:

\[ E = f(C, S, e), \]  

where \( E \) is per-pupil school spending, \( C \) is cost factors, \( S \) is educational outcomes, and \( e \) is school efficiency in delivering educational outcomes.

Cost factors often include ‘student-need’ measures, student enrollment, and labor input prices such as teacher salaries. Student-need measures are characteristics of the student body that are outside the direct control of local officials at any given point in time and that affect the school spending needed to achieve a given student performance level. For example, students from low-income families are likely to receive less time and resources from parents. Therefore, a district with a greater percentage of low-income students may have to spend more to achieve a given student performance level. In addition, per-pupil school spending may have a nonlinear relationship with the size of student enrollment because of economies of scale (Andrews, Duncombe, and Yinger 2002).

In theory, the measure of educational outcomes should be comprehensive, since each school is a multi-output producer. However, due to the constraints of data availability, educational outcomes are usually narrowly defined in the empirical work and do not reflect the quality of all school-provided education services. They are often measured in terms of student performance in state-administered standardized tests and/or high school graduation rates. States collect these student performance data in order to evaluate schools and enforce school accountability policies. Other outcomes of school-provided education services either are not measured (for example, foreign language skills) or cannot be measured (for example, artistic skills).

As efficiency must be determined relative to outcome, it is similarly defined narrowly in this empirical literature. When educational outcomes are measured in student test performance, the corresponding efficiency only means efficiency in delivering student test performance. Duncombe and Yinger (2011a) suggest that there are two main sources of such narrowly defined school inefficiency. First, schools may spend wastefully. They may not employ the most effective teachers and administrators or the best available technology for teaching and school management. Second, schools may spend on subjects – such as sports, art, and foreign languages – that are not covered by the state’s standardized testing. Such spending does not directly contribute to student test performance.

As district efficiency cannot be directly observed, Duncombe and Yinger (2011a) discuss the three empirical approaches that scholars have used to control for it. The first approach is to include district fixed effects (Downes and Pogue 1994). This can control for time-invariant district efficiency, but cannot control for time-variant district efficiency. This approach produces arguably a more conservative estimate than other approaches, since it does not use vast variation across districts to identify
the coefficients. But it requires a long panel of data, since many cost factors do not change much in a short period within a district. This approach cannot identify cost factors that do not change over time, since they will be absorbed into district fixed effects.

The second approach is to use data envelopment analysis (DEA) (see Duncombe, Ruggiero, and Yinger 1996; Duncombe and Yinger 1998, 1999; Reschovsky and Imakie 2003; Gronberg et al. 2004). While this approach estimates efficiency more directly than other approaches, it relies on the untenable strong assumptions about the functional form to identify the role of efficiency. It is also likely to underestimate the cost coefficients because the impact of cost factors on spending may be partly captured by the estimated inefficiency, given that the DEA index of inefficiency reflects both cost and efficiency.

The third approach is to include observable factors that can be conceptually linked to efficiency and therefore act as proxies for efficiency (see Duncombe and Yinger 1997, 1998, 1999, 2000, 2005a, 2005b, 2006, 2011a, 2011b; Duncombe 2002, 2006, 2007; Duncombe, Lukemeyer, and Yinger 2003; Imakie and Reschovsky 2004, 2006; Imakie 2008; Baker et al. 2018). One advantage of this approach is that it helps control for time-variant efficiency. It also does not require a long panel of data and is therefore particularly useful for studies facing significant data constraints. In addition, Baker et al. (2018) conclude that this approach is ‘more thorough and likely more accurate’ to correct for the omitted variable bias than the other approaches (43). Duncombe and Yinger (2011a) acknowledge that the conceptual links between efficiency and the observed proxy variables are assumed and cannot be directly tested. Also, existing studies may not include sufficient proxy variables to fully account for efficiency. While none of the three approaches can perfectly control for efficiency, I use the third approach because it strikes a good balance between conceptual plausibility and empirical feasibility, and it is used more commonly in the literature.

4. Empirical specification

Based on their experience with Texas policymakers, practitioners, and courts, Imakie and Reschovsky (2005) recommend that researchers conducting cost function studies choose a modeling strategy that is not overly complex. Duncombe and Yinger (2005a) discuss how they derive a relatively simple functional form of the education cost function. They first assume that the expenditure equation can be described in a constant elasticity function—one of the most common assumptions made in applied microeconomic research. Then, they take a natural logarithm of both sides of the equation, except for percentage and dummy variables. As a result, they obtain a log-linear function. Duncombe and Yinger (2011a) observe that the regression equations in most existing cost function studies take this functional form.

Following this tradition, this paper estimates a log-linear transformation of Equation (1):

\[
\log(E_{ijt}) = \alpha C_{ijt} + \beta S_{ijt} + \gamma F_{ijt} + L_j + T_t + \delta,
\]

where \( E \) is per-pupil school spending, \( C \) is cost factors, \( S \) is student performance, \( F \) is observable factors that can be conceptually linked to school efficiency, \( L \) is LMA fixed effects, \( T \) is year fixed effects, \( \delta \) is a constant term, \( i \) is an index for school districts, \( j \) is an index for LMAs, and \( t \) is an index for years. Student performance is treated as endogenous. Year fixed effects absorb all statewide common factors for each year, such as business cycles and federal and state policy changes. By controlling for LMA fixed effects, this paper uses variation within LMAs to identify the regression coefficients. In addition, standard errors are clustered at the school-district level to allow for correlations within districts over time. Appendix Table A1 lists all data sources.

At least 18 previous studies use an empirical specification similar to Equation (2), which includes observable variables as proxies for efficiency. To the best of my knowledge, this paper includes one of the longest, if not the longest, list of efficiency-related variables, which I discuss later.
4.1. Spending variable

The dependent variable in Equation (2) is the logarithm of inflation-adjusted current spending per pupil. Current spending excludes capital outlays and debt services, which are lumpy and not directly linked to student performance. Following a standard practice in the literature, I also remove payments to private schools and spending on transportation and food services from current spending.

4.2. Cost factors

Previous studies conducted for other states provide a list of potential cost factors to examine with the Connecticut data. However, it is not realistic and even ideal to include all of them in one regression. First, data on some variables are not available for Connecticut over the sample period. Second, there is a tradeoff between including more variables in the regression and obtaining a better estimation precision for each variable. Some potential cost factors are highly correlated with each other. If they are included in one regression, multi-collinearity could make it difficult to identify a statistically significant and precisely estimated coefficient on these factors. In addition, one ultimate goal of this research is to recommend cost factors to be used in the state aid formula. Simplicity and both conceptual and statistical defensibility are important considerations for policymakers when choosing cost factors.

Therefore, following Ladd, Reschovsky, and Yinger (1991), Bradbury and Zhao (2009), and Zhao (2018), I apply two criteria to narrow down the final cost factors. First, the reason the factors affect education spending should be intuitive and straightforward. Second, they should be statistically significant at the 10 percent level or lower in the regressions for Connecticut. Given the restrictions of the criteria, the interpretation on the final cost factors should be broadened. The coefficient on each cost factor mostly reflects the independent impact of this variable on school spending, but it also captures some (if not all) of the impact of excluded potential cost factors that are unobserved or statistically insignificant but are correlated with this final cost factor.

4.3. Educational outcomes

Because standardized test results are the most important and publicized metric in the school accountability system, I use the average percentage of students who are at or above the proficiency level in math, reading, and writing as the preferred measure of educational outcomes. I also test various alternative measures of student performance, including test scores, high school graduation rates, the percentage of high school graduates pursuing higher education, and a value-added measure of student test performance (also called growth measure) based on matched student cohorts.

Because student performance is likely to be endogenous, it needs to be instrumented to avoid endogeneity bias. This paper uses the most common approach to select instruments for the measure of student performance, which has been employed in at least 13 previous cost function studies. This approach utilizes exogenous characteristics of neighbor districts as the instrumental variables (IVs) for student performance in the home district (that is, the district in question). Previous studies often choose other school districts in the same labor market area as neighbor districts, because these districts are more likely to be part of the home district’s comparison group than distant districts.

The idea behind this IV approach is that the demand for student performance in the home district is influenced by student performance in neighbor districts. The home district and neighbor districts operate in the same labor market and compete for students and state aid dollars that follow students. In this competitive context, district officials could react strategically to neighbor districts’ student performance in setting their outcome targets. Voters may also determine their desired
level of student performance partly by observing what neighbor districts are able to accomplish. Then through monitoring activities, they could pressure school officials to keep up with neighbor districts’ student achievements. The demand for student performance in neighbor districts is in turn affected by neighbor districts’ own characteristics, which can therefore indirectly influence and correlate student performance in the home district.

On the other hand, Duncombe and Yinger (2011a, 2011b) argue that exogeneous characteristics of neighbor districts are unlikely to be correlated with the error term in the second-stage expenditure equation after controlling for the measure of student performance. Given resource constraints, competition or copycatting among school districts is likely to focus on the most publicized and valued measures of student performance. That is therefore the most plausible and likely channel for neighbor districts’ characteristics to indirectly affect the home district’s spending. See Duncombe and Yinger (2011a, 2011b) for more detailed discussions.

Another way to think about this IV approach is through more explicitly formulating the first-stage equation. This equation can be considered to estimate a function of demand for education quality in a district with the measure of student performance as the dependent variable. Because the competition or copycat behaviors result in a spatial interdependence in the measure of student performance among districts in the same area, the demand function can be modeled as a standard spatial lag model, in which the measure of student performance in the home district depends on not only its own characteristics but also the measure of student performance in neighbor districts. Because the measure of student performance in neighbor districts is likely to be endogenous, it is subsequently substituted by some characteristics of neighbor districts that affect neighbor districts’ student performance but are more likely to be exogenous. As a result, the first-stage equation estimates the demand for student performance in a district as a function of its own exogenous characteristics and a set of exogeneous characteristics of neighbor districts. For an example of such a demand function, see equation (5) in Duncombe and Yinger (2011b).

There is no theory to specify exactly which characteristics of neighbor districts are valid IVs. Therefore, the previous 13 studies using this IV approach rely on statistical tests to find which of many characteristics of neighbor districts satisfy the conditions of instrument relevance and instrument exogeneity. As Baker et al. (2018) put it, ‘Instrument selection is an iterative process involving consideration of both conceptual appropriateness of instruments and statistical tests of instruments’ (41). As a result, the previous studies select different neighbor-district characteristics as IVs for different states or different time periods.

Following these previous papers, I apply several criteria for selecting IVs from a variety of neighbor districts’ characteristics. First, the economic explanation for why they affect student performance should be intuitive. Second, they can be plausibly assumed to be outside the direct control of local officials at any given point in time. Third, they should pass the under-identification test with the p-value at or below 5 percent. Fourth, they should pass the over-identification test with the p-value at or above 10 percent. Lastly, each IV should be significant at or below the 10 percent level in the first-stage regression.

It should be noted that the theory gives an ambiguous prediction on the sign of the IVs in the first-stage regression. This is because the two mechanisms through which neighbor districts affect the home district – competition and copycat behaviors – generate opposite predictions. Therefore, the sign on the IVs must be determined empirically.

4.4. Efficiency variables

The literature on managerial efficiency in the public sector (Leibenstein 1966; Niskanen 1971; Wyckoff 1990) and at least 18 previous cost studies suggest that three groups of variables can be conceptually linked to school efficiency.22 They are (1) factors affecting voter involvement in monitoring school districts, (2) parents’ demand for students’ education in untested subjects, and (3) market competition.
Higher scrutiny from voters could put more pressure on district officials to be efficient and reduce wasteful spending. Voters’ incentives to monitor schools may depend on local revenue capacity, tax price, and voter characteristics. First, if the local government has a lower revenue capacity to support school spending, voters could have a stronger incentive to monitor their schools and make sure they spend money carefully. The empirical measure of local revenue capacity is often based on the property tax base and/or income. Therefore, I use per-pupil Equalized Net Grand List (ENGL) and median household income as proxy variables for local revenue capacity. Second, voters who pay a higher tax price for funding schools are likely to have a stronger incentive to monitor their school district and demand higher efficiency. Tax price is affected by local revenue structure. Voters face a lower tax price if a larger share of a school district’s total revenue is funded by non-local sources (that is, the federal and state governments), or if a higher share of local property taxes are paid by businesses and nonresidents. Therefore, I use the percentage of a school district’s total revenue from federal and state sources and the percentage of the property tax base that comes from businesses and nonresidents as proxy variables for tax price. In addition, voters’ incentive and capacity to monitor a school district’s activities might vary with their age, educational background, political ideology, and homeownership status (Duncombe 2006). Older voters presumably have more spare time and lower opportunity costs and therefore are more likely to engage in monitoring government activities. The relationship between people’s educational background and their incentive and capacity to monitor schools is ambiguous. On the one hand, people with higher educational attainment level are more likely to engage in local civic activities. On the other hand, they tend to earn higher hourly wages and therefore face higher opportunity costs to monitoring their school district. Fiscally conservative voters may be more likely to engage in monitoring the school district. Compared with renters, homeowners are more likely to participate in local civic activities and be aware of their property tax burdens. Therefore, they may have a stronger incentive to monitor their school district. Based on these considerations, I control for the percentage of the population that is aged 65 and older, the percentage of adults with a bachelor’s degree or higher, the percentage of registered Republican voters, and the percentage of owner-occupied housing units.

A higher demand from parents for their children’s education in athletics, art, and foreign languages could push school districts to spend more on these untested subjects. It may make school districts look less efficient in delivering student test performance. Parents’ demand for students’ education in untested subjects could be related to their income, age, and educational background, as well as tax price. Families with higher income or higher educational attainment level are likely to desire a more comprehensive education for their school-age children and therefore have a higher demand for untested subjects. The senior population are less likely to have children in schools and thus may have a lower demand for untested subjects. In addition, the demand for untested subjects decreases with tax price. Partly for these reasons, I control for median household income, the percentage of adults with a bachelor’s degree or higher, the percentage of the population that is aged 65 and older, the percentage of a school district’s total revenue from federal and state sources, and the percentage of the property tax base that comes from businesses and nonresidents.

If a school district is located in a more competitive education market, it is more likely to employ the most effective teachers and administrators and the best available technology for teaching and school management (Hoxby 2000; Imazeki and Reschovsky 2004; Imazeki 2008). I include LMA fixed effects to help control for the education market’s competitiveness. School districts in different LMAs face different level of competition in attracting students and therefore have different incentives to efficiently deliver student performance. LMA fixed effects also control for other time-invariant efficiency factors shared by school districts in each LMA, such as the labor pools (teachers and school managers). In addition, I include three dummy variables for school districts bordering another state (Massachusetts, New York, and Rhode Island). A border district competes for students, teachers, and school managers not only with other school districts within the state, but also school districts in the adjacent state. A border district is also more likely to be exposed to different teaching and management technologies used in the neighboring state than an interior district.
5. Data

This paper conducts the analysis at the district level because Connecticut does not require financial information to be reported at the school level. Following a standard practice in the literature, I remove charter schools and other non-regular local education agencies from the data, since they are rather different from traditional school districts. I make further adjustments to ensure that all districts in the final sample have complete K–12 grades and are thus more comparable and more suitable for regression analysis. As a result, this paper has 117 districts in the regression sample, including 103 local unified K–12 districts, nine regional unified K-12 districts, and five pseudo regional K–12 districts. This sample covers about 94 percent of the state’s total enrollment in public schools during the 2009–2013 period.

The sample period was determined by the availability of consistent data on student test results and the American Community Survey (ACS) five-year estimates. Connecticut has changed standardized tests several times since the mid-1980s. The state’s Department of Education deems that data from different test periods are not directly comparable and advises against combining them. In order to have a sufficiently long panel from one test period that is as recent as possible, I use data from 2009 through 2013. This is a period in which students in grades 3 through 8 took the 4th generation of the Connecticut Mastery Test (CMT) and students in grade 10 took the 3rd generation of the Connecticut Academic Performance Test (CAPT); it is also a period for which the ACS five-year estimates are available. There is no obvious trend for student test performance in this period. The sample mean for the percentage of students reaching or exceeding proficiency in math, reading, and writing increased gradually from 86.1 percent in 2009 to 87.8 percent in 2012 and then decreased to 87.2 percent in 2013. The difference in the sample mean between any two years in this period is not significantly different from zero at the 10 percent level.

While this paper does not use the latest test results, its findings are generalizable to the more recent period. Previous studies show that the cost function is relatively stable over time. Using data from Kansas and Missouri, Duncombe (2006) and Duncombe and Yinger (2011a), respectively, show that the cost function estimates are not sensitive to the data periods used and are reliable for forecasting purposes. Furthermore, I find there is a tight 1:1 relationship between student performance under the CMT 4th Generation and CAPT 3rd Generation and student performance under the Smarter Balanced Test that Connecticut has used since 2015. Therefore, student performance under the old test regime can be re-interpreted in terms of student performance under the new test regime.

6. Regression results

Table 2 shows regression results from the preferred specification. In the first stage, neighbor districts’ percentage of the property tax base from businesses and neighbor districts’ percentage of adults without a high school degree are the two variables satisfying the pre-set IV selection criteria, including the statistical tests. See Section 4 for a discussion of the economic rationale for using characteristics of neighbor districts as valid IVs to instrument the measure of student performance in the home district. In the second-stage regression, the student test performance measure is positive and significant, supporting that higher student achievement requires more school spending. In addition, most of the efficiency variables are significant and have the expected sign.

Four variables meet the pre-set criteria for selecting the cost factors. First, a higher percentage of school-age children from families living in poverty and a higher percentage of students living in single-parent or non-family households tend to drive up school spending. This is because these students face more challenges in achieving a given performance level. Their parents are less able to dedicate time and financial resources to helping with their education. They are more likely to be English learners and to have disabilities. They are also more likely to experience an unstable and even unsafe living situation and to relocate frequently.
### Table 2. Regression results from the Preferred Specification, 2009–2013.

| Dependent Variables                                                                 | Percentage of Students Reaching or Exceeding Proficiency in Math, Reading, and Writing (First Stage) | Log of Current Spending per Pupil (Second Stage) |
|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------|
| **Instrumental Variables:**                                                          |                                                                                                     |                                                  |
| Neighbor Districts’ Percentage of Property Tax Base from Businesses                  | −1.093***                                                                                             |                                                  |
|                                                                                      | (0.353)                                                                                                |                                                  |
| Neighbor Districts’ Percentage of Adults without a High School Degree                | 0.888*                                                                                               |                                                  |
|                                                                                      | (0.520)                                                                                                |                                                  |
| **Educational Outcome:**                                                              |                                                                                                     |                                                  |
| Percentage of Students Reaching or Exceeding Proficiency in Math, Reading, and Writing |                                                                                                     | 0.010*                                           |
|                                                                                      |                                                                                                     | (0.005)                                          |
| **Cost Factors:**                                                                     |                                                                                                     |                                                  |
| Percentage of School-age Children (Aged 5–17) from Families Living in Poverty        | −0.734***                                                                                             | 0.012**                                          |
|                                                                                      | (0.156)                                                                                                | (0.005)                                          |
| Percentage of Children Enrolled in Public Schools Living in Single-parent or Non-family Households | −0.122***                                                                                             | 0.003*                                           |
|                                                                                      | (0.038)                                                                                                | (0.002)                                          |
| Dummy for Enrollment < 2000                                                          | −0.962                                                                                               | 0.072***                                          |
|                                                                                      | (0.694)                                                                                                | (0.022)                                          |
| Dummy for Regional School District                                                   | −0.480                                                                                               | 0.077***                                          |
|                                                                                      | (0.466)                                                                                                | (0.019)                                          |
| **Efficiency Variables:**                                                             |                                                                                                     |                                                  |
| Log of Real ENGL per Pupil                                                           | −0.136                                                                                               | 0.221***                                          |
|                                                                                      | (1.021)                                                                                                | (0.025)                                          |
| Log of Real Median Household Income                                                  | −2.705                                                                                               | −0.027                                           |
|                                                                                      | (2.792)                                                                                                | (0.109)                                          |
| Percentage of Total Revenue from Federal and State Sources                           | −0.065*                                                                                               | 0.003***                                          |
|                                                                                      | (0.035)                                                                                                | (0.001)                                          |
| Percentage of Property Tax Base from Businesses                                      | −0.047                                                                                               | 0.004***                                          |
|                                                                                      | (0.075)                                                                                                | (0.001)                                          |
| Percentage of Registered Republican Voters                                           | 0.198***                                                                                              | −0.006***                                         |
|                                                                                      | (0.053)                                                                                                | (0.002)                                          |
| Percentage of Population Aged 65 and Older                                           | −0.028                                                                                               | −0.003                                           |
|                                                                                      | (0.098)                                                                                                | (0.003)                                          |
| Percentage of Adults with a Bachelor’s Degree or Higher                               | 0.068                                                                                                 | 0.004***                                          |
|                                                                                      | (0.046)                                                                                                | (0.001)                                          |
| Percentage of Owner-occupied Housing Units                                           | 0.057                                                                                                 | 0.003                                            |
|                                                                                      | (0.055)                                                                                                | (0.002)                                          |
| Dummy for Bordering Massachusetts                                                    | 1.740                                                                                                 | −0.017                                           |
|                                                                                      | (1.362)                                                                                                | (0.022)                                          |
| Dummy for Bordering New York                                                        | −2.214***                                                                                             | 0.021                                            |
|                                                                                      | (0.761)                                                                                                | (0.039)                                          |
| Dummy for Bordering Rhode Island                                                    | −0.240                                                                                               | −0.078*                                           |
|                                                                                      | (1.624)                                                                                                | (0.042)                                          |
| Constant                                                                             | 109.796***                                                                                             | −0.123                                           |
|                                                                                      | (13.016)                                                                                                | (0.730)                                          |
| **Observations**                                                                     | 585                                                                                                   | 585                                              |
| **Endogeneity Test P-value**                                                         | 0.052                                                                                                 |                                                  |
| **Kleibergen-Paap Underidentification Test P-value**                                 | 0.017                                                                                                 |                                                  |
| **Hansen J Overidentification Test P-value**                                         | 0.218                                                                                                 |                                                  |
| **Adjusted R-squared**                                                               | 0.908                                                                                                 | 0.574                                            |

Source: Author’s calculations

Note: All regressions include year and labor market area (LMA) fixed effects. Standard errors are clustered at the school district level.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$
Second, a district with fewer than 2000 enrolled students has to spend more to achieve a given student performance level. Such small districts are not able to enjoy the economies of scale that benefit larger districts.36 I choose an enrollment of 2000 as the size cutoff, following previous studies (Andrews, Duncombe, and Yinger 2002 and Baker et al. 2018).

Last, the cost of achieving a given student performance level is higher for regional school districts than for local school districts, perhaps due to costs associated with coordination among the member towns. Connecticut’s regional school districts were all established before the late 1970s and therefore can be taken as a given during this sample period.

I experiment with many other potential cost factors, but find them to be statistically insignificant. They include the percentage of students who are black; the percentage of students who are Hispanic; the square of the percentage of school-age children from families living in poverty; the interactions of the school-age-child-poverty rate with population density, log of population density, the percentage of students who are black, and the percentage of students who are Hispanic; the percentage of English-learner students; the percentage of students enrolled in public schools who are foreign-born; the percentage of students in grades 9 through 12; and the percentage of students who are homeless.37 For almost all of these variables, they are not statistically significant likely because they are highly correlated with the percentage of school-age children from families living in poverty and with the percentage of public school students living in single-parent or non-family households. These two cost factors should therefore capture part of the effects of these other potential cost factors, if not all.

Table 3 examines the robustness of the cost estimates. In Column 2, I replace the percentage of school-age children from families living in poverty with the percentage of students eligible for free or reduced-price lunch (commonly abbreviated as FRPL).38 The latter has been used extensively in previous studies and states’ education aid formulas, including Connecticut’s current formula, to account for low-income students. In this regression, the percentage of students eligible for FRPL is positive and significant. But its coefficient is smaller than the coefficient on the percentage of school-age children from families living in poverty, likely because for each district, the percentage of students eligible for FRPL is greater than the percentage of school-age children from families living in poverty. The income thresholds for FRPL are 130 percent and 185 percent, respectively, of the federal poverty guideline.

Concerns have increasingly been raised about the validity of FRPL, especially since the Community Eligibility Provision (CEP) in the federal Healthy, Hunger-Free Kids Act of 2010 took effect.39 Therefore, many states have been seeking alternative, more reliable measures of low-income students to replace FRPL in the education aid formulas. I prefer the percentage of school-age children from families living in poverty, because it is not affected by the CEP and it is consistently produced on the annual basis by the Census Bureau, not by school districts, and therefore are not subject to local manipulations.

In Column 3, I replace the dummy variable for enrollment of fewer than 2,000 students with the log of total enrollment and the square of the log of total enrollment. Both of the new variables are significant. They indicate a U-shaped relationship between enrollment size and current spending per pupil and the most spending-efficient enrollment size for a district is about 8,350 students. Whether to use the enrollment dummy variable or the log of total enrollment and its square does not significantly affect the analysis results. Nonetheless, I prefer the enrollment dummy variable, because it is simpler and easier for policymakers to understand and accept. Therefore, it better serves a goal of this research that is to recommend which cost factors the state should consider in the education aid formula.

To check the influence of potential outliers, I drop all pseudo regional K–12 districts in Column 4 and exclude data from 2009 and 2010 in Column 5. One may be concerned that 2009 and 2010 are during or right after the Great Recession, a period that is significantly different from other parts of the sample period. Both sample changes have little impact on the cost coefficients.

I use alternative measures of student test performance in Columns 6 through 14 in Table 4. Instead of using the percentage of students who are at or above the proficiency level averaged
over math, reading, and writing, I replace it with the percentage of students who are at or above the proficiency level in each individual test subject in Columns 6 through 8.40 Next, in Columns 9 through 12, I use the average scale score in each test subject or scale score averaged over the three subjects to exploit the differences in education quality within districts with the same percentage of students reaching or exceeding the proficiency level.41 Then, in Columns 13 and 14, I separate the high school students’ test performance from the elementary and middle school students’ test performance, because they take different tests−CMT for elementary and middle school students and CAPT for high school students—and also averaging across all grades may hide heterogeneity across districts in high school education quality.

These alternative measures of student test performance are positive and almost all significant. Their coefficients are similar to that on the performance variable in the preferred specification. More important, using these alternative measures of student test performance has almost no impact on the cost coefficients.

I use non-test measures of educational outcomes in the two next columns. In Column 15, I include the four-year high school graduation rate.42 This variable is positive but not significant, likely because it contains large measurement errors.43 The state gives districts and schools flexibility and multiple pathways to graduate high school students. Subject to the minimum requirements, districts have discretion in determining the number of required credits and the eligibility of credits counted toward high school graduation. Districts are also allowed to award credits based on a demonstration of mastery. Therefore, the high school graduation rate partly reflects a district’s and school’s choices and is a noisy measure of education quality.44 In Column 16, I use the percentage of high school graduates pursuing higher education, although the sample size is smaller due to data limitations.45 This variable is positive and significant.

Table 3. Regression results from Robustness Checks (Part A), 2009–2013 (Unless Otherwise Noted).

| Dependent Variable: Log of Current Spending per Pupil | Preferred (1) | Alternative Measures of Low-income Students (2) | Excluding Economies of Scale of K–12 Districts (3) | Excluding Pseudo Regional 2009 and 2010 Data (4) | Excluding 2009 and 2010 Data (5) |
|-----------------------------------------------------|---------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------|
| Cost Factors:                                       |               |                                               |                                               |                                               |                                 |
| Percentage of School-age Children (Aged 5–17) from Families Living in Poverty | 0.012**       | 0.011*                                        | 0.013**                                       | 0.012**                                       |                                 |
|                                                     | (0.005)       | (0.006)                                       | (0.005)                                       | (0.006)                                       |                                 |
| Percentage of Students Eligible for Free or Reduced-price Lunch |               |                                               |                                               |                                               |                                 |
|                                                     | 0.003*        | 0.003*                                        | 0.003**                                       | 0.003**                                       | 0.003**                         |
|                                                     | (0.003)       | (0.003)                                       | (0.002)                                       | (0.002)                                       | (0.002)                         |
| Percentage of Children Enrolled in Public Schools Living in Single-parent or Non-family Households |               |                                               |                                               |                                               |                                 |
|                                                     | 0.072***      | 0.080***                                      | 0.072***                                      | 0.072***                                      | 0.071***                        |
|                                                     | (0.022)       | (0.022)                                       | (0.022)                                       | (0.022)                                       | (0.021)                         |
| Dummy for Enrollment < 2000                         |               |                                               |                                               |                                               |                                 |
|                                                     | −0.560***     |                                               |                                               |                                               |                                 |
|                                                     | (0.176)       |                                               |                                               |                                               |                                 |
| Log of Total Enrollment                             |               |                                               |                                               |                                               |                                 |
|                                                     | 0.031***      |                                               |                                               |                                               |                                 |
|                                                     | (0.011)       |                                               |                                               |                                               |                                 |
| Dummy for Regional School District                  |               |                                               |                                               |                                               |                                 |
|                                                     | 0.077***      | 0.085***                                      | 0.072***                                      | 0.082***                                      | 0.065***                        |
|                                                     | (0.019)       | (0.020)                                       | (0.018)                                       | (0.028)                                       | (0.019)                         |
| Observations                                        | 585           | 585                                           | 585                                           | 560                                           | 351                             |
| Adjusted R-squared                                 | 0.574         | 0.552                                         | 0.614                                         | 0.559                                         | 0.596                           |

Source: Author’s calculations
Note: All regressions include year and labor market area (LMA) fixed effects and the same educational outcome and efficiency factors as in the preferred specification. Standard errors are clustered at the school district level. The instrumental variables used in Columns (1) through (5) are neighbor districts’ percentage of property tax base from businesses and neighbor districts’ percentage of adults without a high school degree. The sample period for Column (5) is 2011 through 2013.

* p<0.10, ** p<0.05, *** p<0.01
Table 4. Regression Results From Robustness Checks (Part B), 2009–2013 (Unless Otherwise Noted).

| Dependent Variable | Educational Outcomes: | Alternative Measures of Educational Outcomes |
|--------------------|-----------------------|-----------------------------------------------|
| Log of Current Spending per Pupil | | |
| Preferred Specification | Math Proficiency Only | Reading Proficiency Only | Writing Proficiency Only | Average Score | Math Score Only | Reading Score Only | Writing Score Only | Average Growth | Elementary and Middle School Students' Performance Only | High School Students' Performance Only | High School Graduation Rate | Higher Education Entry Rate | Average Growth Only | Average Growth and Proficiency Average Score |
| (1) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
| Log of Current Spending per Pupil | | | | | | | | | | | | | | | |
| Preferred Specification | Math Proficiency Only | Reading Proficiency Only | Writing Proficiency Only | Average Score | Math Score Only | Reading Score Only | Writing Score Only | Average Growth | Elementary and Middle School Students' Performance Only | High School Students' Performance Only | High School Graduation Rate | Higher Education Entry Rate | Average Growth Only | Average Growth and Proficiency Average Score |
| (1) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) |
| Educational Outcomes: Percentage of Students Reaching or Exceeding Proficiency in Math, Reading, and Writing | 0.010* | 0.011** |
| Percentage of Students Reaching or Exceeding Proficiency in Math | 0.009* |
| Percentage of Students Reaching or Exceeding Proficiency in Reading | 0.008 |
| Percentage of Students Reaching or Exceeding Proficiency in Writing | 0.007** |
| Average Scale Score in Math, Reading, and Writing | 0.008** |
| Average Scale Score in Math | 0.009** |
| Average Scale Score in Reading | 0.009** |
| Average Scale Score in Writing | 0.009** |
| Percentage of Elementary and Middle School Students Reaching or Exceeding Proficiency in Math, Reading, or Writing | 0.010* |
| Percentage of High School Students Reaching or Exceeding Proficiency in Math, Reading and Writing | 0.009** |
| Four-year High School Graduation Rate | 0.013 |
| Percentage of High School Graduates Pursuing Higher Education | 0.006*** |
| Average Growth in Math and Reading | −0.015 |
| Cost Factors: Percentage of School-age Children (Aged 5–17) from Families Living in Poverty | 0.012** |
| | 0.013** |
| | 0.010** |
| | 0.012** |
| | 0.012** |
| | 0.012** |
| | 0.012** |
| | 0.012** |
| | 0.012** |
| | 0.010** |
| | 0.011 |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| | 0.010** |
| Dummy for Enrollment < 2,000 | 0.072*** (0.022) | 0.069*** (0.020) | 0.075*** (0.023) | 0.071*** (0.022) | 0.068*** (0.022) | 0.070*** (0.020) | 0.072*** (0.023) | 0.069*** (0.022) | 0.062*** (0.021) | 0.071*** (0.022) | 0.064*** (0.023) | 0.073*** (0.022) | 0.068*** (0.022) |
|----------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Dummy for Regional School District | 0.077*** (0.019) | 0.075*** (0.018) | 0.074*** (0.019) | 0.076*** (0.020) | 0.080*** (0.020) | 0.076*** (0.021) | 0.081*** (0.020) | 0.073*** (0.021) | 0.071*** (0.019) | 0.078*** (0.022) | 0.102*** (0.023) | 0.096*** (0.023) | 0.087*** (0.021) | 0.091*** (0.023) | 0.096*** (0.023) |
| Observations | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 456 | 565 | 565 | 565 |
| Adjusted R-squared | 0.574 | 0.580 | 0.541 | 0.593 | 0.524 | 0.528 | 0.501 | 0.485 | 0.570 | 0.576 | 0.462 | 0.632 | 0.619 | 0.551 | 0.520 |

Source: Author's calculations

Note: All regressions include year and labor market area (LMA) fixed effects and the same efficiency factors as in the preferred specification. Standard errors are clustered at the school district level. The instrumental variables used in Columns (1) and (6) through (13) are neighbor districts' percentage of property tax base from businesses and neighbor districts' percentage of adults without a high school degree. The instrumental variables used in Column (14) are neighbor districts' percentage of property tax base from businesses and neighbor districts' percentage of the population aged 5 to 17. The instrumental variables used in Columns (15) and (16) are neighbor districts' log of median household income and neighbor districts' percentage of adults with a bachelor's degree or higher. The instrumental variables used in Columns (17) are neighbor districts' log of median household income and neighbor districts' percentage of adults without a high school degree. The instrumental variables used in Columns (18) and (19) are neighbor districts' percentage of property tax base from businesses, neighbor districts' percentage of total revenues from federal and state sources, and neighbor districts' percentage of adults without a high school degree. The sample period for Column (16) is 2009 through 2012.

* p<0.10, ** p<0.05, *** p<0.01
Using these non-test performance measures has no or only small impact on the cost coefficients. Furthermore, these non-test performance measures are highly correlated with the test performance measures. Using them as the outcome measure thus does not significantly affect the analysis results, especially considering that the outcome measure is held constant across school districts in calculating each district’s education cost. Because data quality of these non-test performance measures is less robust, I prefer to use the percentage of students reaching or exceeding the proficiency level.

Finally, I use a value-added measure of student performance (also called growth measure) in Column 17 and then include it in conjunction with the percentage of students reaching or exceeding the proficiency level in Column 18 and with average scale score in Column 19. To measure student growth, the state developed the ‘vertical scales’ for CMT math and reading that are comparable across grades and years. The difference in the vertical scale between two grades for the same student indicates this student’s growth over the corresponding period. Similarly, the difference in the mean vertical scales between two grades for a school district, based only on matched students who took the CMT in both grades, indicates this district’s growth over the corresponding period. To simplify, I use the average of the growth measures across grades and subjects as a summary measure of student growth in each year for each district.46

Columns 17 through 19 show that taking into account the growth measure has little impact on the cost coefficients, relative to those in the preferred specification. The growth measure is not significant, possibly due to measurement errors. Kane and Staiger (2002) show that value-added measures often contain a considerable amount of data noise, especially for small school districts. Due to the limitations of the growth measure, the Connecticut State Department of Education (2009) advises that it should only be considered complementary to the proficiency-level measure and not as its replacement.47

7. Cost index

The effects of various cost factors on school spending can be aggregated into a cost index. It compares a district’s predicted spending per pupil to that of a hypothetical average district while all other variables in the estimation equation, except the cost factors, are held constant. The hypothetical average district is often defined as a district with the enrollment-weighted statewide average values of the cost factors and all other variables. Because all other variables are held constant across districts, they are cancelled out from the numerator and denominator of the index. As a result, the cost index depends on only the cost factors. In mathematical terms,

\[
CI_{it} = \frac{\hat{E}_{it}}{E_{at}} = e^{\alpha(C_i - C_a)},
\]

where \(CI\) is the cost index, \(\hat{E}\) is the predicted spending per pupil, \(C\) is the cost factors, \(\alpha\) is the estimated coefficients on the cost factors, and \(a\) is an indicator for the hypothetical average district. By construction, the cost index for the hypothetical average district is 1. If a district’s cost index is greater than 1, it means that the district has higher costs per pupil than the average district does. During the 2009–2013 period, about 38 percent of the state’s public school students were enrolled in districts where the cost index is greater than 1.

There are large disparities in the five-year average of the cost index across Connecticut districts. It ranges from 0.82 to 1.47. The maximum-to-minimum ratio is almost 1.8, which lies within the range of the estimated ratios for other states (Appendix Table A3). The ratio of the 90th percentile to the 10th percentile and the ratio of the 80th percentile to the 20th percentile are about 1.6 and 1.3, respectively.

Table 5 shows that districts with the largest enrollments, the highest school-age-child-poverty rates, or the least amount of property wealth per pupil tend to have the highest average cost
index. This is because such districts, on average, have the highest percentage of school-age children from families living in poverty and the highest percentage of students living in single-parent or non-family households. The smallest districts have the second-highest average cost index, partly because each has an enrollment of fewer than 2000 students.

The cost index value is not geographically evenly distributed (Figure 1). The highest cost indices are concentrated among the largest school districts that are also poor and urban. The wealthy suburbs tend to have the lowest cost indices. In particular, the southwestern corner of the state has a large cluster of the lowest-cost school districts.

8. Cost-adjusted spending

Without taking cost differentials into account, a direct comparison of spending among districts provides only a partial, and sometimes misleading, picture of funding equity. Therefore, following Baker et al. (2018), I calculate cost-adjusted spending (CE):

$$CE_{it} = \frac{E_{it}}{CI_{it}}.$$  (4)

Because two districts with the same current spending per pupil can have different cost indices, using cost-adjusted spending can reveal more disparities across districts, compared with using unadjusted spending. Indeed, Table 6 shows that cost-adjusted spending has a higher value in each of the six inequality measures than unadjusted spending.

| Table 5. Cost Index by District Characteristics, Five-year Average (2009–2013). |
|---------------------------------|-----------------|
|                                | Cost Factors    |
|                                | Cost Index      | Percentage of School-age Children from Families Living in Poverty | Percentage of Children Enrolled in Public Schools Living in Single-parent or Non-family Households | Dummy for Enrollment < 2000 | Dummy for Regional District | Share of Statewide Enrollment |
| Enrollment Quintiles           |                 |                                                              |                                            |                             |                             |                                |
| 1                               | 1.00            | 7.23                                                         | 27.82                                      | 1.00                        | 0.13                        | 6.12                            |
| 2                               | 0.93            | 6.58                                                         | 25.20                                      | 0.09                        | 0.24                        | 10.83                           |
| 3                               | 0.94            | 8.23                                                         | 26.62                                      | 0.00                        | 0.13                        | 14.70                           |
| 4                               | 0.90            | 5.95                                                         | 21.56                                      | 0.00                        | 0.12                        | 21.75                           |
| 5                               | 1.12            | 18.29                                                        | 43.29                                      | 0.00                        | 0.00                        | 46.59                           |
| Poverty Quintiles               |                 |                                                              |                                            |                             |                             |                                |
| 1                               | 0.86            | 3.49                                                         | 15.29                                      | 0.05                        | 0.21                        | 17.24                           |
| 2                               | 0.88            | 4.67                                                         | 19.34                                      | 0.11                        | 0.13                        | 15.29                           |
| 3                               | 0.92            | 5.99                                                         | 23.28                                      | 0.17                        | 0.17                        | 12.71                           |
| 4                               | 0.96            | 9.06                                                         | 31.46                                      | 0.10                        | 0.00                        | 17.32                           |
| 5                               | 1.20            | 22.79                                                        | 51.29                                      | 0.01                        | 0.00                        | 37.44                           |
| Property Wealth Quintiles       |                 |                                                              |                                            |                             |                             |                                |
| 1                               | 1.23            | 23.88                                                        | 53.40                                      | 0.05                        | 0.02                        | 29.86                           |
| 2                               | 0.95            | 8.11                                                         | 28.05                                      | 0.14                        | 0.17                        | 13.31                           |
| 3                               | 0.90            | 6.30                                                         | 23.72                                      | 0.06                        | 0.05                        | 20.18                           |
| 4                               | 0.93            | 7.70                                                         | 25.26                                      | 0.07                        | 0.13                        | 17.28                           |
| 5                               | 0.91            | 7.07                                                         | 22.58                                      | 0.07                        | 0.09                        | 19.36                           |
| Cost Index Quintiles            |                 |                                                              |                                            |                             |                             |                                |
| 1                               | 0.85            | 3.90                                                         | 15.26                                      | 0.00                        | 0.00                        | 19.96                           |
| 2                               | 0.89            | 5.33                                                         | 21.20                                      | 0.06                        | 0.10                        | 16.42                           |
| 3                               | 0.93            | 6.65                                                         | 25.61                                      | 0.11                        | 0.27                        | 15.47                           |
| 4                               | 0.99            | 11.08                                                        | 33.19                                      | 0.13                        | 0.07                        | 18.39                           |
| 5                               | 1.25            | 25.07                                                        | 55.82                                      | 0.07                        | 0.02                        | 29.76                           |

Source: Author’s calculations
Notes: The five-year average enrollment of each district is used as the weight to calculate the weighted average values for each quintile. Property wealth per pupil is measured as Equalized Net Grand List (ENGL) per pupil. Quintiles are ranked from low to high.
Districts with the largest enrollments, the highest school-age-child-poverty rates, the least amount of property wealth, or the highest cost index, on average, have the lowest cost-adjusted spending (Table 7). This is not because their unadjusted spending is low. In fact, their unadjusted spending, on average, is either the highest or second-highest among the five quintiles. But their cost index, on average, is the highest. In other words, these districts' high spending is not enough to compensate for their high costs.

9. Spending-to-cost ratio

While cost-adjusted spending is useful for describing spending equity, on its own it is insufficient for examining spending adequacy. This is because the cost index, and therefore cost-adjusted spending, is not defined according to any specific student performance level. To assess whether a district's spending is adequate for achieving a common target level of student performance, I calculate the

| Table 6. Comparing Disparities in Cost-adjusted Spending with Disparities in Unadjusted Current Spending, Five-year Average (2009–2013). |
|---------------------------------------------------------------|
| **Current Spending per Pupil** | **Cost-adjusted Current Spending per Pupil** |
| Range | 10.62 | 13.30 |
| Maximum | 1.90 | 2.33 |
| Minimum | 1.32 | 1.66 |
| 100th Percentile | 1.24 | 1.38 |
| 20th Percentile | 0.07 | 0.10 |
| Gini Coefficient | 0.12 | 0.19 |

Source: Author's calculations
Notes: The five-year average enrollment of each district is used as the weight to calculate the disparity measures. Both cost-adjusted current spending per pupil and unadjusted current spending per pupil are in thousands of 2013 dollars.
spending-to-cost ratio (SC):

\[ SC_{it} = \frac{E_{it}}{E_{it}(S_t)} = \frac{E_{it}}{e^{(aC_i + \beta S_t + \gamma O_i)}}, \]  

(5)

where \( \hat{E}(S) \) is the predicted cost to achieve a common student performance level \( S \). When other variables \( O \) are set at the enrollment-weighted statewide average values, the predicted cost measures how much each district must spend to achieve the common student performance target, given its cost factors, if it operates at an average efficiency level.\(^{49}\) If a district’s spending-to-cost ratio is less than 1, it means that the district’s spending is not adequate for paying the education costs required to reach the selected performance target. For illustration purpose, I use 90 percent of students reaching or exceeding the proficiency level as the target, which is higher than the statewide average percentage of students reaching or exceeding the proficiency level in the 2009–2013 period (about 83 percent).\(^{50}\)

According to this spending-to-cost ratio, the education spending for a large share of Connecticut’s public school students is inadequate. More than 74 percent of students were enrolled in districts where the spending-to-cost ratio was less than 1. There are also large disparities in the spending-to-cost ratio across districts, with the five-year average ratio ranging from 0.61 to 1.46. In addition, districts with the largest enrollments, the highest school-age-child-poverty rates, or the least amount of property wealth, on average, have the lowest spending-to-cost ratios (Table 8). In contrast, districts with the lowest school-age-child-poverty rates or the greatest amount of property wealth, on average, have the highest spending-to-cost ratios that are all greater than 1.
Figure 2 shows the spatial distribution of the spending-to-cost ratio. Spending exceeded predicted costs in the southwestern corner of the state, several coastal districts, and some inland suburban districts. However, in the majority of Connecticut districts, spending was lower than the predicted costs.

### 10. Needed additional spending

There are negative consequences for student performance when a district’s spending is inadequate relative to the predicted cost. Figure 3 compares the student performance gap with the spending gap per pupil across school districts. The student performance gap is defined as the difference between the state’s student performance target and a district’s actual student performance level. The spending gap is defined as the difference between a district’s predicted cost for achieving this performance target level and its actual current spending per pupil. This figure shows that there is a significant positive relationship between the spending gap and the student performance gap. Even though it does not prove a causal relationship, it suggests that a district’s student performance level tends to fall further below the common target when its spending is more severely inadequate relative to the predicted cost.

Therefore, many districts need additional spending to achieve the common student performance target level. The needed additional spending is defined as the amount of money that a district needs to close its spending gap when the spending gap is positive. Under the target of 90 percent of students to have reached or exceeded the proficiency level, Connecticut as a whole would have needed to spend an additional $1.34 billion in 2013, which represents a 17.6 percent increase from the actual statewide school spending that year. Districts with the largest enrollments, the highest school-age-child-poverty rates, the least amount of property wealth, or the highest cost

| Enrollment Quintiles | Spending-to-cost Ratio | Current Spending per Pupil (Thousands of 2013 Dollars) | Predicted Cost per Pupil (Thousands of 2013 Dollars) |
|----------------------|------------------------|------------------------------------------------------|------------------------------------------------------|
| 1                    | 0.92                   | 15.07                                                | 16.46                                                |
| 2                    | 0.95                   | 14.42                                                | 15.30                                                |
| 3                    | 0.93                   | 14.30                                                | 15.50                                                |
| 4                    | 1.01                   | 14.87                                                | 14.78                                                |
| 5                    | 0.85                   | 15.20                                                | 18.40                                                |
| Poverty Quintiles    |                        |                                                      |                                                      |
| 1                    | 1.05                   | 14.94                                                | 14.22                                                |
| 2                    | 0.98                   | 14.24                                                | 14.57                                                |
| 3                    | 1.01                   | 15.18                                                | 15.09                                                |
| 4                    | 0.94                   | 14.76                                                | 15.75                                                |
| 5                    | 0.78                   | 15.13                                                | 19.78                                                |
| Property Wealth Quintiles |                |                                                      |                                                      |
| 1                    | 0.73                   | 14.69                                                | 20.30                                                |
| 2                    | 0.88                   | 13.81                                                | 15.70                                                |
| 3                    | 0.95                   | 14.11                                                | 14.91                                                |
| 4                    | 0.95                   | 14.58                                                | 15.35                                                |
| 5                    | 1.14                   | 17.09                                                | 15.08                                                |
| Cost Index Quintiles |                        |                                                      |                                                      |
| 1                    | 1.07                   | 14.90                                                | 13.99                                                |
| 2                    | 0.98                   | 14.43                                                | 14.67                                                |
| 3                    | 0.96                   | 14.71                                                | 15.36                                                |
| 4                    | 0.93                   | 15.12                                                | 16.34                                                |
| 5                    | 0.74                   | 15.13                                                | 20.66                                                |

Source: Author’s calculations
Notes: The predicted cost per pupil is calculated under the assumption that the student test performance target is 90 percent of students reaching or exceeding the proficiency level. The five-year average enrollment of each district is used as the weight to calculate the weighted average values for each quintile. Property wealth per pupil is measured as Equalized Net Grand List (ENGL) per pupil. Quintiles are ranked from low to high.
Figure 2. Spending-to-Cost Ratio by Connecticut School District, Five-year Average (2009–2013).

Source: Author’s calculations.

Notes: School districts are excluded due to missing data. The predicted cost per pupil is calculated under the assumption that the student test performance target is 90 percent of students reaching or exceeding the proficiency level.

Figure 3. Student Performance Gap versus Spending Gap per Pupil, 117 K–12 School Districts in Connecticut, 2009–2013.

Source: Author’s calculations.

Notes: Student performance gap is calculated by subtracting the percentage of students reaching or exceeding the proficiency level from 90. Spending gap per pupil is calculated by subtracting current spending per pupil from the predicted cost per pupil of achieving the target of having 90 percent of students reach or exceed the proficiency level. The red straight line is generated from a univariate regression that describes a simple linear relationship between the two variables in question.
indices, on average, need the highest additional spending per pupil and the largest increases from the actual current spending (Table 9).

11. Conclusion and policy discussions

This paper contributes to the knowledge about the US education equity and adequacy by conducting the first regression analysis of the cost function of Connecticut public K–12 education. It finds that when student performance and district efficiency are held constant, school districts have to spend more if they have a higher school-age-child-poverty rate, a higher percentage of students living in single-parent or non-family households, or an enrollment smaller than 2000 students, or if they are a regional school district. There are large disparities across districts in the cost index and in cost-adjusted spending. Districts with the largest enrollments, the highest school-age-child-poverty rates, or the least amount of property wealth, on average, have the highest cost indices and the lowest cost-adjusted spending.

The analysis shows that a large share of Connecticut’s public school students are enrolled in districts where spending is inadequate relative to the predicted cost for achieving the target of 90 percent of students reaching or exceeding the proficiency level. Inadequate school spending may contribute to student underperformance, as the performance gap is positively associated with the spending gap. Therefore, many districts need to increase their spending to meet the predicted costs. Districts with the highest cost indices, on average, require the most additional spending.

Meeting these needs for additional spending would demand more state aid. More importantly, to better address inequity and inadequacy, the state may consider adopting the predicted-cost measure that this paper develops as the basis of a new aid formula. Because the predicted cost is

### Table 9. Additional Spending Needed by District Characteristics, Five-year Average (2009–2013).

| Enrollment Quintiles | Additional Spending Needed as Percentage of Current Spending (%) | Additional Spending Needed per Pupil (Thousands of 2013 Dollars) | Current Spending per Pupil (Thousands of 2013 Dollars) |
|----------------------|---------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------|
| 1                    | 12.83                                                         | 1.75                                                          | 15.07                                                 |
| 2                    | 10.07                                                         | 1.32                                                          | 14.42                                                 |
| 3                    | 10.76                                                         | 1.48                                                          | 14.30                                                 |
| 4                    | 5.93                                                          | 0.81                                                          | 14.87                                                 |
| 5                    | 24.64                                                         | 3.60                                                          | 15.20                                                 |
| Poverty Quintiles    |                                                               |                                                               |                                                      |
| 1                    | 3.54                                                          | 0.45                                                          | 14.94                                                 |
| 2                    | 6.52                                                          | 0.85                                                          | 14.24                                                 |
| 3                    | 6.40                                                          | 0.84                                                          | 15.18                                                 |
| 4                    | 8.80                                                          | 1.22                                                          | 14.76                                                 |
| 5                    | 32.81                                                         | 4.80                                                          | 15.13                                                 |
| Property Wealth Quintiles |                                                               |                                                               |                                                      |
| 1                    | 38.09                                                         | 5.60                                                          | 14.69                                                 |
| 2                    | 15.08                                                         | 1.99                                                          | 13.81                                                 |
| 3                    | 6.40                                                          | 0.88                                                          | 14.11                                                 |
| 4                    | 8.02                                                          | 1.06                                                          | 14.58                                                 |
| 5                    | 0.94                                                          | 0.13                                                          | 17.09                                                 |
| Cost Index Quintiles |                                                               |                                                               |                                                      |
| 1                    | 2.79                                                          | 0.35                                                          | 14.90                                                 |
| 2                    | 7.02                                                          | 0.91                                                          | 14.43                                                 |
| 3                    | 6.84                                                          | 0.94                                                          | 14.71                                                 |
| 4                    | 11.34                                                         | 1.52                                                          | 15.12                                                 |
| 5                    | 38.26                                                         | 5.64                                                          | 15.13                                                 |

Source: Author’s calculations
Notes: The additional spending needed per pupil is calculated under the assumption that the student test performance target is 90 percent of students reaching or exceeding the proficiency level. The five-year average enrollment of each district is used as the weight to calculate the weighted average values for each quintile. Property wealth per pupil is measured as Equalized Net Grand List (ENGL) per pupil. Quintiles are ranked from low to high.
derived from rigorous data analysis, it is more rational and defensible than the foundation amount and the ‘need-student’ weights that are arbitrarily determined and used in Connecticut’s current formula.

This paper can be relevant and useful beyond Connecticut. Many other states’ education finance systems are similar to Connecticut’s. They have similar issues in funding equity and adequacy as those of Connecticut. They can benefit from this work by using this research approach that is sufficiently general and easily adaptable to conduct their own cost studies and make appropriate policies.

Notes

1. See http://schoolfunding.info/.
2. Whereas a typical student without additional learning needs receives a weight of 1 in the formula, a low-income student receives a weight of 1.3, and an English-learner student receives a weight of 1.15. Furthermore, the state gives an additional weight of 0.05 to each low-income student who pushes their school districts above the concentrated-poverty threshold, which is defined as low-income students making up 75 or higher percent of the enrolled students.
3. The U.S. Bureau of Labor Statistics defines an LMA as ‘an economically integrated area within which individuals can reside and find employment within a reasonable distance or can readily change jobs without changing their place of residence.’ (See https://www.bls.gov/lau/laualfaq.htm#)
4. Downes and Pogue (1994) and Duncombe and Yinger (2007) include fixed effects for school districts. Other studies without geographic-level fixed effects include Duncombe, Ruggiero, and Yinger (1996); Duncombe and Yinger (1997, 1998, 1999, 2000, 2005a, 2005b, 2006, 2011a, 2011b); Imazeki (2001, 2008); Duncombe (2002, 2006, 2007); Duncombe, Lukemeyer, and Yinger (2003, 2004); Imazeki and Reschovsky (2003, 2004, 2006); Reschovsky and Imazeki (2003); Gronberg et al. (2004); Gronberg, Jansen, and Taylor (2011).
5. See https://portal.ct.gov/-/media/SDE/Digest/2016_17/nextgenFAQ.pdf
6. See Duncombe and Yinger (2011a) for the mathematical proof. Even Imazeki (2008) cautions that ‘estimating the production function … is an approach that must be explored a great deal more before one would want to use the results to draw any conclusion about actual costs.’ (103)
7. However, based on their Texas experience, Imazeki and Reschovsky (2005) point out that ‘the courts are capable of understanding and using the results of complex statistical analysis.’ (123)
8. One potential area of inefficiency is that school districts may pay teachers higher wages if they have stronger teachers’ unions with greater bargaining power. Winkler, Scull, and Zeehandelaar (2012) show that 98.8 percent of public-school teachers in Connecticut were union members, according to the National Center for Education Statistics’ Schools and Staffing Survey for academic year 2007–2008. This is the highest percentage among all states in that year. There is no publicly available data on district-level teachers’ union membership. But given that nearly all public-school teachers in the state are unionized, variation in union density across Connecticut school districts is likely to be small. In addition, Winkler, Scull, and Zeehandelaar (2012) indicate that collective bargaining is mandatory for public schools in Connecticut and state law permits teachers’ unions to automatically collect agency fees from non-members. As such, there is no variation in the legal scope of bargaining among school districts in the state. To the extent that the strength of teachers’ unions is affected by the business cycle, this is controlled for by year fixed effects in the regressions. If the strength of teachers’ unions is related to the labor market competitiveness, LMA fixed effects help to account for it. If there is remaining variation in the strength of teachers’ unions within an LMA, it is likely to be correlated with resources available to the school district, political leaning and socioeconomic and demographic characteristics of the population in the school district. These are accounted for through such control variables as property tax base per pupil, median household income, the percentage of registered Republican voters, the percentage of population aged 65 or older, and the percentage of adults with a bachelor’s degree or higher.
9. I tried using district fixed effects. But there is not enough variation within districts in the sample period to identify the regression coefficients.
10. An alternative functional form of the cost function is a translog model (for example, Gronberg et al. 2004). While this is a more flexible specification, it adds a large number of interaction variables and quadratic terms, which makes it much more difficult to identify the coefficients with precision and interpret the results (Imazeki and Reschovsky 2005; Duncombe and Yinger 2011a).
11. I omit teacher salaries in the regression because LMA fixed effects help control for differences in teacher salaries across LMAs. Reschovsky and Imazeki (2003), Imazeki and Reschovsky (2003, 2004, 2005), and Baker et al. (2018) include the Education Comparable Wage Index (ECWI) as a proxy measure of teacher salaries, without including LMA or other geographic-level fixed effects. The National Center for Education Statistics develops this index
using the salaries of college graduates in the school district’s LMA who are not teachers. Because the ECWI is defined at the LMA level and does not change substantially in a short time, LMA fixed effects should already capture most (if not all) of the effects of the ECWI. Therefore, I do not concurrently include the ECWI and LMA fixed effects in the regression equation. In fact, when I include the ECWI without LMA fixed effects, the ECWI is positive but not statistically significant, which suggests that wage differences do not play an important role in cost disparities across Connecticut school districts.

12. There are six federally designated LMAs in Connecticut. I also tried using county fixed effects instead of LMA fixed effects. (There are eight counties in Connecticut, which mostly overlap with LMAs.) The regression results are similar to those using LMA fixed effects.

13. School districts in the same labor market area share the same labor pools (teachers and school managers) and compete for the same students whose families decide where to live in the area. For this reason, school districts in the same LMA are more comparable than those in different LMAs for the regression purpose.

14. See Duncombe and Yinger (1997, 2000, 2005a, 2005b, 2006, 2007, 2011a, 2011b), Duncombe (2002, 2006, 2007), Duncombe, Lukemeyer, and Yinger (2003), Imazeki and Reschovsky (2003, 2004, 2006), Imazeki (2008) and Baker et al. (2018).

15. Martorell, Stange, and McFarlin (2016) find that school facility investments have no effect on student achievement.

16. Transportation and food services expenditures are relatively small. On average, they were less than 8 percent of total current spending in Connecticut in 2013. I find that including spending on transportation and food services has virtually no impact on the cost coefficients, except to somewhat raise the coefficient on the dummy variable for regional school district. This likely reflects that regional districts tend to be rural and encompass a large area. Therefore, it costs them more to provide school transportation on a per-pupil basis.

17. Imazeki (2001) and Duncombe (2002, 2006, 2007) also use a lack of statistical significance as a reason to reject some potential cost factors.

18. The cost measure that is later calculated based on the final cost factors is an empirical, composite measure. It does not require each cost coefficient to reflect only the pure, independent impact of the factor on school spending. In fact, accounting for the correlated impact helps the cost measure to be more comprehensive, given an unavoidable omission of some potential cost factors due to data constraints.

19. First, for each test subject, I calculate a weighted average of the percentage of students who are at or above the proficiency level across grades in each district, using the number of tested students in each grade as a weight. Then, I take the simple mean of the three weighted average percentages of students who are at or above the proficiency level in math, reading, and writing.

20. Numerous studies show that school expenditures have a positive effect on students’ achievement. See, for example, Elliot (1998), Guryan (2001), Card and Payne (2002), Deke (2003), Kinnucan, Zheng, and Brehmer (2006), Chaudhary (2009), Roy (2011), Nguyen-Hoang and Yinger (2014), Jackson, Johnson, and Persico (2016), Han (2017), Lafortune, Rothstein, and Schanzenbach (2018), and Gigliotti and Sorensen (2018).

21. See Duncombe and Yinger (2005a, 2005b, 2006, 2007, 2011a, 2011b), Duncombe, Lukemeyer, and Yinger (2003), Gronberg et al. (2004), Duncombe (2002, 2006, 2007), Gronberg, Jansen, and Taylor (2011), and Baker et al. (2018).

22. See Duncombe and Yinger (1997, 2000, 2005a, 2005b, 2006, 2007, 2011a, 2011b), Duncombe (2002, 2006, 2007, 2011a, 2011b), Duncombe, Lukemeyer, and Yinger (2003), Imazeki and Reschovsky (2003, 2004, 2006), Imazeki (2008) and Baker et al. (2018).

23. Downes and Pogue (1994), Duncombe and Yinger (1997, 2000, 2005a, 2005b, 2006, 2007, 2011a, 2011b), Duncombe (2002, 2006, 2007), Duncombe, Lukemeyer, and Yinger (2003), and Imazeki and Reschovsky (2003) control for per-pupil property values, per-pupil income, or median household/family income in their cost regressions.

24. Downes and Pogue (1994), Duncombe and Yinger (1997, 2000, 2005a, 2005b, 2006, 2007, 2011a, 2011b), Duncombe (2002, 2006, 2007), Duncombe, Lukemeyer, and Yinger (2003), Imazeki and Reschovsky (2003) and Baker et al. (2018) include proxy variables for tax price.

25. However, some previous studies find that the impact of the elderly on school spending can be positive if the elderly are long-term residents and loyal to their communities and schools (Fletcher 2006) or if the capitalization of school spending in house prices benefits the elderly homeowners (Hilber and Mayer 2009).

26. Duncombe and Yinger (2005a, 2006, 2011a) and Duncombe (2006, 2007) control for the percentage of the population that is aged 65 and older. Duncombe and Yinger (1997, 2000, 2005a, 2011a), Imazeki and Reschovsky (2003), and Duncombe (2006, 2007) control for the percentage of adults with a bachelor’s degree or higher. Duncombe and Yinger (2000, 2005a, 2011a), Imazeki and Reschovsky (2003), and Duncombe (2006, 2007) control for the percentage of owner-occupied housing units.

27. To measure market competitiveness, Hoxby (2000) develops a Herfindahl index based on enrollment distribution across school districts within the education markets. Imazeki and Reschovsky (2004, 2006), Imazeki (2008), and Baker et al. (2018) include this Herfindahl index in their regressions. However, because this index is often defined at the LMA level and does not change substantially in a short time, I do not include it and
LMA fixed effects in the same regression. When I include the Herfindahl index without LMA fixed effects, it is not statistically significant.

28. During the sample period (2009–2013), the number of charter schools did not change in five out of six Connecticut LMAs, ranging from zero to eight. The remaining LMA saw the number of charter schools drop from five in 2009–2011 to four in 2012. Furthermore, the enrollment in charter schools was small and equivalent to between 0.3 and 1.8 percent of the total enrollment in traditional public schools in the same LMA. Given that charter schools play a relatively stable and small role in Connecticut public K–12 education, the LMA fixed effects should help to control for the competition pressure from charter schools (if any) on traditional school districts in each LMA. Estimating the education costs for charter schools and other non-regular local education agencies is beyond the scope of this paper and deserves a separate study.

29. I remove 19 districts that do not have their own high school and do not belong to a regional high school district. These districts instead send their high school students to designated schools in neighbor districts or to private high schools. They pay these students’ tuition based on agreements with the recipient districts or private schools. Next, for districts that do not operate their own high school but belong to a regional high school district, I aggregate them to the regional district level. In doing so, I create eight pseudo regional K–12 districts. However, three of them have to be dropped from the regression analysis, because of missing data on student performance.

30. The earliest ACS 5-year estimates were collected over the 2005–2009 period. This paper treats the 2005–2009 ACS data as the 2009 data. Doing so makes the endogeneity of the ACS variables less likely, since the 2009 current spending is unlikely to affect the ACS data collected in the 2005–2008 period. I also tried treating the 2005–2009 ACS data as the 2007 data. This change has little impact on the regression results. However, the 2007 current spending could potentially affect the ACS variables collected in 2008 and 2009 if families moved across school districts in response to changes in school spending. For this reason, treating the 2005–2009 ACS data as the 2007 data are less desirable.

31. If student performance improved due to teachers’ and students’ increased familiarity with the test over time, year fixed effects should help to control for that. In addition, in a robustness check (Column 5 in Table 3), I drop the observations from the first two years of implementing the new test when teachers and students were presumably the least familiar with the test. The results from this robustness check are essentially the same as those using the entire sample period.

32. I run a regression of the average percentage of students meeting or exceeding the achievement standard under the Smarter Balanced Test for each district in year $t$ on a constant term and the average percentage of students reaching or exceeding the proficiency level under the CMT and the CAPT for the same district in year $t-6$, with $t = 2015$ to 2019. This regression produces an adjusted $R$-squared of 0.88, a slope of 1.40, and an intercept of $-64.41$.

33. The percentage of the property tax base from businesses (which affects the tax price) and the percentage of adults without a high school degree influence the demand for student performance (Duncombe and Yinger 2011b). Baker et al. (2018) suggest that ‘one could use indicators of the education level of the adult population in surrounding districts…, which might indicate competitive pressures to improve educational outcomes at any given spending level,’ as valid IVs to instrument the measure of student performance in the home district (41).

34. When I use the percentage of total revenue from federal sources and the percentage of total revenue from state sources separately in a regression, instead of grouping them together, it has virtually no impact on the cost coefficients.

35. I do not directly include the percentage of special-education students because it is likely to be endogenous. School districts have a financial motive and discretion in determining students’ special-education status, given that special education is expensive but the state does not consider the number of special-education students in distributing the Education Cost Sharing grants to school districts. Local news publications report that some Connecticut districts have been accused of intentionally and systematically denying special education to students with disabilities (Thomas 2011, 2014; McCready 2018). In addition, the percentage of special-education students is highly correlated with the percentage of school-age children from families living in poverty and with the percentage of public school students living in single-parent or non-family households. Therefore, these two cost factors should capture most (if not all) of the effect of special-education students. Furthermore, I explore using disability data that were collected from the ACS. However, the ACS changed the disability questions in 2008, resulting in new questions that are incomparable to the previous years’ disability questions. Since I use the 2008–2012 ACS 5-year estimates (the first 5-year data with the new disability questions) as the 2012 data, it means that I have only two years of new ACS disability data (2012 and 2013) within this paper’s sample period, which is insufficient for regression analysis.

36. In theory, the state could mandate small districts to consolidate. However, until such state-level policy occurs, the size of district enrollment remains outside the direct control of local officials at any given point in time.

37. The quality of the homeless data is poor. Federal and state laws require schools to provide transportation and other costly services to homeless students; therefore, districts may have a financial incentive to under-identify homeless students. Many districts simply rely on self-identifying by homeless families and students, who may be
reluctant to do so for fear of stigma. In my data, nearly 56 percent of district-year observations reported zero homeless students. The highest percentage of students who were identified as homeless was 3.9 percent. Housing advocates believe that student homelessness is more widespread and severe than the official data suggest.

38. I tried replacing the percentage of school-age children from families living in poverty with the percentage of the population receiving Temporary Assistance for Needy Families (TANF). In that regression, the TANF variable is positive and significant. However, the TANF variable significantly underestimates the number of low-income students, since only about 1 percent of Connecticut’s population received TANF in the 2009–2013 period. In addition, I also tried using the number of children under age 19 and enrolled in Husky A (Connecticut’s Medicaid for children) per pupil as an alternative measure of low-income students. This variable is positive but not significant, likely because it reflects not only poverty, but also policy changes. The state significantly expanded the Medicaid program during this period, which resulted in a continuous increase in the Husky A enrollment, despite economic fluctuations.

39. The CEP allows all students, not just low-income students, to receive free meals in the qualified participating districts or schools. To qualify for the CEP, districts and schools must have at least 40 percent of their students directly certified by the state for free meals, without the use of a household application. The state can use administrative data to directly certify (1) students whose households participate in public benefits programs, such as the Supplemental Nutritional Assistance Program (SNAP), TANF, and Medicaid for children, and (2) students in other categorically eligible programs, such as homeless, runaway, migrant, foster care, and Head Start programs. In districts and schools that qualify for and participate in the CEP, parents of students no longer need to submit an application for FRPL. However, the Connecticut State Department of Education requires the CEP districts and schools to continue reporting each student’s hypothetical eligibility for FRPL by using the following protocol (see https://portal.ct.gov/-/media/SED/Digest/cepl_memo_and_alt_inc_survey_08092014_2.pdf?la=en). These districts and schools should report (1) the FRPL status of directly certified students as eligible for FRPL, (2) the FRPL status of returning students who are not directly certified the same as they were in the previous year, and (3) the FRPL status of new students who are not directly certified based on the ‘alternative income survey’ that their parents are supposed to complete and return to schools. However, parents of new students have no personal incentive to complete the survey, since their children are already guaranteed to receive free meals in these CEP districts and schools. The resulting student-level hypothetical FRPL data are likely to be inaccurate, drawing serious concerns from state officials. When testifying before the Connecticut General Assembly’s Appropriations Committee on 6 March 2019, the Connecticut State Department of Education officials highlighted ‘data integrity’ issues in the student-level FRPL data (Connecticut School Finance Project 2019).

40. I do not include all three measures for the individual subjects in one regression because they are highly correlated with each other; the correlations among them are greater than 0.9. As a result, I am unable to find three or more IVs that would separately identify each of the three performance measures if they were included in one regression.

41. I also tried using log of average scale score, either in individual test subjects or averaged over three test subjects. These log variables are positive and significant. Using them does not affect the cost coefficients.

42. I also tried five-year and six-year high school graduation rates, which are available only from 2011 onward. The results using five-year and six-year rates are similar to those using the four-year rates.

43. Imazeki (2001) also finds the graduation rate for high school students never statistically significant in her regressions for Illinois, likely due to a high amount of measurement error.

44. In the CCJEF v. Reil case, the superintendent of the Bridgeport School District acknowledged that the district could award a high school degree to a functionally illiterate student; the presiding state superior court judge called Connecticut’s high school graduation requirements and rising graduation rates meaningless (Harris 2016).

45. Its sample period is 2009 through 2012. Year 2013 is dropped because as of that year, the state stopped counting participation in non-degree postsecondary programs as pursuing higher education.

46. In each year and for each subject, there are five measures of growth: (1) growth from grade 3 in the previous year to grade 4 in the current year, (2) growth from grade 4 in the previous year to grade 5 in the current year, (3) growth from grade 5 in the previous year to grade 6 in the current year, (4) growth from grade 6 in the previous year to grade 7 in the current year, and (5) growth from grade 7 in the previous year to grade 8 in the current year. I first calculate a weighted average of these growth measures for each subject, using the number of matched students in the comparison grades as the weight. Then, I take a simple average of the weighted averages between math and reading.

47. This growth measure has several disadvantages over the level measure of student performance. First, Connecticut did not develop vertical scales for the writing tests and therefore does not measure student growth in writing. Second, growth in high school students’ performance was not measured. Third, policymakers find it harder to interpret the change in vertical scales between grades than to make year-over-year comparisons in the percentage of students reaching or exceeding the proficiency level. Therefore, the state published the growth measures mainly for informational purposes and did not use them for school accountability. In contrast,
it heavily relied on the percentage of students reaching or exceeding the proficiency level to identify low-performing schools and districts.

48. Appendix Table A2 shows that districts with the largest enrollments, the highest school-age-child-poverty rates, or the least amount of property wealth, on average, have the highest or second-highest dollar amounts of current spending on instruction. They spend similar dollar amounts per pupil on support services and other non-instruction programs as districts in other quintiles do.

49. The state could potentially use efficiency-related variables as a policy level to influence the predicted cost measure and then ultimately affect state funding responsibility for schools. Instead of setting \( O_{it} \) at the statewide average values in Equation (5), the state could first calculate each district's actual \( rO_{it} \), rank them from low to high, choose a value from this distribution, and then assign this chosen value to every district in calculating its predicted costs. For example, if policymakers choose the value at the 25th percentile of the distribution of \( rO_{it} \), it means that the state assumes that every district should operate at the top 25th percentile efficiency level, which will result in a lower predicted cost measure than that calculated at the average efficiency level. The value of \( r \) multiplying the statewide average values of \( O_{it} \) in FY 2013 is close to both the mean and the median of the statewide distribution of \( rO_{it} \) that year.

50. I also tried three other performance target levels: the statewide average for students reaching or exceeding the proficiency level, 95 percent, and 100 percent of students reaching or exceeding the proficiency level. The results using these other performance target levels are available upon request.

51. When a district has a negative spending gap, which means that it spends more money than the predicted cost, its needed additional spending is equal to zero. This paper does not allow the needed additional spending to be negative, because it is unlikely that the state will want to force districts to reduce spending. Some districts have legitimate reasons for spending above the predicted cost. For example, they may aim at a performance level that is higher than the common target, or they may spend more on untested subjects in response to parents' demands.

Acknowledgments

The author thanks Jeff Thompson, Rubén Hernández-Murillo, and participants at the Federal Reserve Bank of Boston Research Department’s Brown Bag Seminar and the annual meeting of the Federal Reserve System Committee on Regional Analysis for helpful comments. Lan Ha and Eli Inkelas provided excellent research assistance.

Disclaimer

The views expressed herein are those of the author and do not indicate concurrence by the Federal Reserve Bank of Boston, the principals of the Board of Governors, or the Federal Reserve System.

Disclosure statement

No potential conflict of interest was reported by the author.

References

Andrews, M., W. Duncombe, and J. Yinger. 2002. “Revisiting Economies of Size in American Education: Are We Any Closer to a Consensus?” Economics of Education Review 21 (3): 245–262. doi:10.1016/S0272-7757(01)00006-1

Baker, B., M. Weber, A. Srikanth, R. Kim, and M. Atzbi. 2018. “The Real Shame of the Nation: The Causes and Consequences of Interstate Inequity in Public School Investments.” Policy Report. Newark, NJ: Education Law Center of New Jersey & Rutgers Graduate School of Education.

Bradbury, K., and B. Zhao. 2009. “Measuring Non-School Fiscal Disparities Among Municipalities.” National Tax Journal 62 (1): 25–56. doi:10.17310/ntj.2009.1.02

Card, D., and A. A. Payne. 2002. “School Finance Reform, the Distribution of School Spending, and the Distribution of Student Test Scores.” Journal of Public Economics 83 (1): 49–82. doi:10.1016/S0047-2727(00)00177-8

Chaudhary, L. 2009. “Education Inputs, Student Performance and School Finance Reform in Michigan.” Economics of Education Review 28 (1): 90–98. doi:10.1016/j.econedurev.2007.11.004

Connecticut School and State Finance Project. 2021. “School Accountability in Connecticut.” New Haven, CT: Connecticut School and State Finance Project.

Connecticut School Finance Project. 2019. “School Finance 101: An Introduction to How Public Schools are Funded in Connecticut.” Presentation Updated March 21, 2019. New Haven, CT: Connecticut School Finance Project.
Connecticut State Department of Education. 2009. “Connecticut Mastery Test Fourth Generation Data Analysis Guide.” New Haven, CT: Connecticut State Department of Education.

Costrell, R., E. Hanushek, and S. Loeb. 2008. “What Do Cost Functions Tell Us About the Cost of An Adequate Education?” Peabody Journal of Education 83 (2): 198–223. doi:10.1086/0161956X0801996988

Deke, J. 2003. “A Study of the Impact of Public School Spending on Postsecondary Educational Attainment Using Statewide School District Refinancing in Kansas.” Economics of Education Review 22 (3): 275–284. doi:10.1016/S0272-7757(02)00025-0

Downes, T., and T. Pogue. 1994. “Adjusting School Aid Formulas for the Higher Cost of Educating Disadvantaged Students.” National Tax Journal 47 (1): 89–110. doi:10.1086/NTJ41789054

Duncombe, W. 2002. “Estimating the Cost of an Adequate Education in New York.” Working Paper 44. Syracuse, NY: Syracuse University, Center for Policy Research.

Duncombe, W. 2006. “Responding to the Charge of Alchemy: Strategies for Evaluating the Reliability and Validity of Costing-out Research.” Journal of Education Finance 32 (2): 137–169. doi:10.1111/j.1468-0120.2006.00025.x

Duncombe, W. 2007. “Estimating the Cost of Meeting Student Performance Standards in the St. Louis Public Schools.” Report Prepared for the St. Louis Board of Education. Syracuse, NY: Syracuse University, Center for Policy Research.

Duncombe, W., A. Lukemeyer, and J. Yinger. 2003. “Financing an Adequate Education: A Case Study of New York.” In Developments in School Finance 2001–2002, 129–153. Washington, DC: U.S. Department of Education.

Duncombe, W., A. Lukemeyer, and J. Yinger. 2004. “Education Finance Reform in New York: Calculating the Cost of A ‘Sound Basic Education’ in New York City”. Policy Brief No. 28, the Maxwell School, Syracuse University.

Duncombe, W., J. Ruggiero, and J. Yinger. 1996. “Alternative Approaches to Measuring the Cost of Education.” In Holding Schools Accountable: Performance-Based Reform in Education, edited by H.F. Ladd, 327–356, Washington, DC: Brookings Institution.

Duncombe, W., and J. Yinger. 1997. “Why Is It So Hard to Help Central City Schools?” Journal of Policy Analysis and Management 16 (1): 85–113. doi:10.1002/(ISSN)1520-6688

Duncombe, W., and J. Yinger. 1998. “School Finance Reform: Aid Formulas and Equity Objectives.” National Tax Journal 51 (2): 239–262. doi:10.1086/NTJ41789325

Duncombe, W., and J. Yinger. 1999. “Performance Standards and Education Cost Indexes: You Can't Have One without the Other.” In Equity and Adequacy in Education Finance: Issues and Perspectives, edited by Helen F. Ladd, Rosemary Chalk, and Janet S. Hansen, 260–297, Washington, DC: National Academies Press.

Duncombe, W., and J. Yinger. 2000. “Financing Higher Student Performance Standards: The Case of New York State.” Economics of Education Review 19 (4): 363–386. doi:10.1016/S0272-7757(00)00004-2

Duncombe, W., and J. Yinger. 2005a. “Estimating the Costs of Meeting Student Performance Outcomes Adopted by the Kansas State Board of Education.” Report Prepared for the Kansas Legislative Division of Post Audit. Syracuse, NY: Syracuse University, Center for Policy Research.

Duncombe, W., and J. Yinger. 2005b. “How Much More Does a Disadvantaged Student Cost?” Economics of Education Review 24 (5): 513–532. doi:10.1016/j.econedurev.2004.07.015

Duncombe, W., and J. Yinger. 2006. “Understanding the Incentives in California's Education Finance System.” Report Prepared for the Getting Down to Facts Project. Syracuse, NY: Syracuse University, Center for Policy Research.

Duncombe, W., and J. Yinger. 2007. “Does School District Consolidation Cut Costs?” Education Finance and Policy 2 (4): 341–375. doi:10.1162/edfp.2007.2.4.341

Duncombe, W., and J. Yinger. 2011a. “Are Education Cost Functions Ready for Prime Time? An Examination of Their Validity and Reliability.” Peabody Journal of Education 86 (1): 28–57. doi:10.1080/0161956X.2011.539954

Duncombe, W., and J. Yinger. 2011b. “Making Do: State Constraints and Local Responses in California’s Education Finance System. International Tax and Public Finance 18 (3): 337–368. doi:10.1007/s10797-010-9159-3

Elliot, M. 1998. “School Finance and Opportunities to Learn: Does Money Well Spent Enhance Students’ Achievement?” Sociology of Education 71 (3): 223–245. doi:10.2307/2673203

Fletcher, D. 2006. “It Takes a Village? Intergenerational Conflict and Cooperation in Education Expenditures.” Unpublished Paper. Oxford, OH: Miami University.

Gigliotti, P., and L. C. Sorensen. 2018. “Education Resources and Student Achievement: Evidence From the Save Harmless Provision in New York State.” Economics of Education Review 66: 167–182. doi:10.1016/j.econedurev.2018.08.004

Gronberg, T. J., D. W. Jansen, and L. L. Taylor. 2011. “The Adequacy of Educational Cost Functions: Lessons From Texas.” Peabody Journal of Education 86 (1): 3–27. doi:10.1080/0161956X.2011.539953

Gronberg, T. J., D. W. Jansen, L. L. Taylor, and K. Booker. 2004. “School Outcomes and School Costs: The Cost Function Approach.” Draft Paper. College Station, TX: Texas A&M University.

Guryan, J. 2001. “Does Money Matter? Regression-Discontinuity Estimates from Education Finance Reform in Massachusetts.” NBER Working Paper 8269. Cambridge, MA: National Bureau of Economic Research.

Harris, EA. 2016. “Judge, Citing Inequality, Orders Connecticut to Overhaul Its School System,” New York Times, September 7, 2016.

Harris, E. A., and K. Hussey. 2016. “In Connecticut, A Wealth Gap Divides Neighboring Schools,” New York Times, September 11, 2016.
## Appendix

### Table A1. Data Sources.

| Variable                                                                 | Source                                                                 |
|-------------------------------------------------------------------------|------------------------------------------------------------------------|
| **Dependent Variable:**                                                 |                                                                        |
| Log of Current Spending per Pupil                                       | National Center for Education Statistics, Common Core of Data, Local Education Agency Finance Survey (F-33) |
| **Educational Outcomes:**                                               |                                                                        |
| Percentage of Students Reaching or Exceeding Proficiency in Math, Reading, and Writing | Connecticut Department of Education                                   |
| Average Scale Score in Math, Reading, and Writing                       | Connecticut Department of Education                                   |
| Average Growth in Math and Reading                                      | Connecticut Department of Education                                   |
| High School Graduation Rates                                            | Connecticut Department of Education                                   |
| Percentage of High School Graduates Pursuing Higher Education           | Connecticut Department of Education                                   |
| **Cost Factors:**                                                       |                                                                        |
| Percentage of School-age Children (Aged 5–17) from Families Living in Poverty | US Census Bureau, Small Area Income and Poverty Estimates            |
| Percentage of Children Enrolled in Public Schools Living in Single-parent or Non-family Households | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Dummy for Enrollment < 2,000                                             | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Dummy for Regional School District                                      | Connecticut Department of Education                                   |
| Percentage of Students Eligible for Free or Reduced-price Lunch         | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Log of Student Enrollment                                               | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| **Efficiency Variables:**                                               |                                                                        |
| Log of Real Equalized Net Grand List (ENGL) per Pupil                   | Connecticut Office of Policy and Management, Municipal Fiscal Indicator Report |
| Log of Median Household Income                                           | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Total Revenue from Federal and State Sources              | National Center for Education Statistics, Common Core of Data, Local Education Agency Finance Survey (F-33) |
| Percentage of Property Tax Base from Businesses                         | Connecticut Office of Policy and Management, Municipal Fiscal Indicator Report |
| Percentage of Registered Republican Voters                               | Connecticut Office of the Secretary of State                           |
| Percentage of Population Aged 65 and Older                               | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Adults with a Bachelor’s Degree or Higher                 | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Owner-occupied Housing Units                               | American Community Survey: Special Tabulation for National Center for Education Statistics |
| **Other Variables:**                                                    |                                                                        |
| Percentage of Students Who Are Black                                    | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Percentage of Students Who Are Hispanic                                 | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Percentage of English-learner Students                                  | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Percentage of Students with Special Needs                               | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Percentage of Students in Grades 9–12                                   | National Center for Education Statistics, Common Core of Data, Universe Surveys |
| Population Density                                                      | Connecticut Office of Policy and Management, Municipal Fiscal Indicator Report |
| Percentage of Population Receiving Temporary Assistance for Needy Families (TANF) | Connecticut Office of Policy and Management, Municipal Fiscal Indicator Report |
| Percentage of Students Who Were Identified as Homeless                  | Connecticut Department of Education                                   |
| Number of Children under Age 19 Enrolled in HUSKY A per Pupil           | Connecticut Department of Social Services                              |

(Continued)
| Variable                                                                 | Source                                                                 |
|-------------------------------------------------------------------------|------------------------------------------------------------------------|
| Percentage of Children Enrolled in Public Schools Who Are Foreign-born  | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Population Aged 5–17                                      | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Parents of Children Enrolled in Public Schools without a High School Degree | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Percentage of Adults without a High School Degree                       | American Community Survey: Special Tabulation for National Center for Education Statistics |
| Consumer Price Index for All Urban Consumers (CPI-U), Northeast Region  | US Bureau of Labor Statistics                                           |
| Education Comparable Wage Index (ECWI)                                  | Professor Lori Taylor, Texas A&M University                             |
### Table A3. Review of the Maximum-to-minimum Ratio for the Education Cost Index in Previous Studies.

| Study                              | State     | Data Period | Maximum of the Cost Index/Minimum of the Cost Index |
|------------------------------------|-----------|-------------|----------------------------------------------------|
| Imazeki and Reschovsky (2006)      | Texas     | 2002        | 8.05                                               |
| Imazeki and Reschovsky (2004)      | Texas     | 2002        | 6.85                                               |
| Duncombe and Yinger (1999)         | New York  | 1991        | 5.12                                               |
| Imazeki (2001)                     | Illinois  | 1998        | 3.96                                               |
| Duncombe and Yinger (2000)         | New York  | 1991        | 3.34                                               |
| Duncombe, Ruggiero, and Yinger (1996) | New York  | 1991        | 3.09                                               |
| Gronberg et al. (2004)             | Texas     | 1999–2002   | 2.79                                               |
| Duncombe (2002)                    | New York  | 2000        | 2.27                                               |
| Duncombe and Yinger (2005a)        | Kansas    | 2000–2004   | 2.01                                               |
| Duncombe and Yinger (2005b)        | New York  | 2001        | 1.81                                               |
| Reschovsky and Imazeki (2003)      | Texas     | 1996        | 1.57                                               |