

The Literature on Education Cost Functions: An Overview

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The tables in this report are intended to be a resource to scholars who are interested in the literature concerning education cost differentials across school districts. These tables provide information on twenty-six cost function studies conducted in nine different states. These studies and their respective states are listed in Table 1. Any additions, changes, and corrections are welcome.

Introduction

Cost differentials of school districts have become a major focal point for education finance literature in the recent past. This is likely a consequence of the emergence and development of accountability systems and the attention they have brought to a school district's ability to produce academic performance given its financial position. Education cost functions are often used to measure the effect of certain school district characteristics on the cost of producing academic performance in a state. Many of the cost function studies discuss implications of their results for the way states distribute state aid. Many assert, for example, that to achieve educational equity standards, state aid formulas must include appropriate adjustments for environmental factors that make the production of academic performance more costly in certain districts (Downes and Pogue 1994, Reschovsky and Imazeki 2001, Duncombe and Yinger 2005a).

In most states, the district receives its funding from two main sources: property taxes and state aid. State aid is distributed among school districts, and one of its primary functions is to promote educational equity between districts in the state. Equity objectives vary by state and include adequacy, access equality, fiscal neutrality, and equality. For a more detailed explanation of these objectives, the reader is referred to Yinger (2004). With scholars' focus on the distribution of state aid, school districts are the primary units of analysis for cost function studies, and school district characteristics are considered in determining appropriate adjustments in aid formulas.

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Presently, state aid formulas vary widely across states. General-purpose aid is the primary source of state aid and supports the basic operation of school districts. Most states use general-purpose aid in lump-sum form, usually with a “foundation” formula, which is described below. A few states use a “power-equalizing” formula for their basic operating aid, which is a type of matching grant. In these states, the rate at which the state matches education spending varies across districts and often lowers the price of education in low-wealth districts (Yinger 2004). Most states supplement the general-purpose aid with categorical aid, which is designated for a specific purpose. That is, it comes with restrictions on its use.

The type of aid formula selected by a state is linked to the state’s educational equity objectives. Foundation aid is designed to achieve educational adequacy, which is defined as some minimal level of performance or minimal level of spending (determined by the state) that school districts are expected to achieve. Because educational adequacy has become the focus for states across the country, foundation aid is the most common type of state aid. As noted by Huang (2004), 30 states use only foundation aid, and 11 states use foundation aid in addition to some other type of aid, including categorical aid.

Foundation aid is distributed to a school district based on the difference between the level of spending associated with the adequacy standard and the district’s fiscal capacity. So,

$$A = E^* - t\bar{V},$$

where A is the amount of state aid, E^* is the “adequate” level of spending or the spending associated with the “adequate” level of performance, t is the tax rate, and \bar{V} is the tax base in a district. Cost function studies focus their attention on “adequate” spending because, as discussed below, the amount of spending required to reach a certain level of performance differs across districts by student and district characteristics; some of which are outside the control of the school district.

Scholars in the education cost function literature argue that aid formulas should include appropriate adjustments for district characteristics that affect a district’s cost but for which districts have no control. For example, if the adequacy standard is some minimal level of resources, scholars argue that foundation aid should vary with cost-of-living in the same way that

the cost of producing academic performance varies with cost-of-living. In other words, the same level of expenditure in two districts with different costs-of-living will not purchase the same quantity and quality of inputs. Similarly, if the adequacy standard is some minimal level of performance, foundation aid should vary with student needs and district size to the same degree that these characteristics affect cost (Duncombe and Yinger forthcoming).

Empirical Design

The term “cost” refers to the minimum level of expenditure required to produce a certain level of student performance. However, to measure cost in this context is problematic because we observe spending, not cost. Spending differs from cost by the level of efficiency with which districts operate. In other words, inefficient districts spend more than efficient districts to produce the same level of student performance, all else equal. Therefore, the cost function used in some of the studies can be written as:

$$E=C(S, W, N, P)/e,$$

where E is the expenditure in a district, e indicates district efficiency (scaled to 1.0 in the most efficient district), and C represents cost. Efficiency cannot be measured directly, but, as shown below, many studies control for it with an indirect method, generally including variables hypothesized to have an effect on district efficiency. Cost is a function of S (the performance measure or measures), W (teacher salaries), N (enrollment), and P (other district characteristics that affect cost).

Although measuring the output of the educational production is controversial, every study in this literature uses a variable associated with student performance on state exams. These measures vary across cost studies often because of differences in exams administered by the state. Table 2 presents the measures of student performance used in each study. Since mathematics and English are often at the center of state accountability programs, results for these exams are widely available across states. Many studies use the percentage of students passing these exams in elementary, middle, and high school (Duncombe and Johnston 2004, Duncombe and Yinger 2005a). Other studies, like Downes and Pogue (1994) and Hamadeh (1998), use the average exam scores. In addition, the graduation rate is often included to account for any attrition that may inflate the percent passing the state exams and the average exam scores.

Some studies use performance measures that are in value-added form; that is, they compare test score information on the same cohort in different grades in an effort to better isolate the knowledge gained in a particular year (Imazeki 2001, Reschovsky and Imazeki 2003, Gronberg et al. 2004). This type of data is usually difficult to obtain because comparisons are meaningless unless the data relates to the same cohort of students. However, scholars can more readily follow the same cohort over a number of grades in states (like Texas) that give exams at many grade levels. The studies using the value-added performance often include some additional measure of high school performance like the percent of students reaching some level on the SAT or ACT, presumably to supplement the value-added measure with a level measure.

Student performance is endogenous in the sense that the school district determines target performance and spending simultaneously. In other words, unobservable characteristics of the district are expected to affect both spending decisions and decisions about target performance. Table 3 describes the instruments for performance variables in the studies that treat the performance variables as endogenous. Most studies use variables that appear in the demand equation for student performance: median income, tax price, aid, percent college-educated adults and percent of household heads who are homeowners (Duncombe and Yinger 1997, Reschovsky and Imazeki 2001, Imazeki and Reschovsky 2004a). These demand variables, by definition, are correlated with the performance level, but may be uncorrelated with the district's expenditure. However, some scholars argue that they are correlated with spending through district efficiency.

Other studies, like Duncombe, Lukemeyer, and Yinger (2006), use performance measures for adjacent districts with the expectation that voters demand more of their districts if surrounding districts have high performance levels. The use of neighboring performance measures could be a problem if the causation runs in both directions. That is, by using the performance level of neighboring districts, one is merely creating a different endogeneity problem. One way to solve this problem, used by only a few studies (Duncombe and Yinger 2005a, Duncombe and Yinger 2007), is to use as instruments the exogenous characteristics of neighbors that influence performance. These exogenous characteristics are related to the

performance of neighbors but are not influenced by either district, so they are good candidates for instruments.

Teacher salaries are included in the analysis because teachers are the primary input in educational production. Accounting for teacher salaries is complicated in that they are influenced by a number of characteristics of both the teacher and the district. Recalling the desire to control for characteristics that are not influenced by the district, teacher salaries must be broken into their components to measure the effect of the components for which the district has no control over, namely cost-of-living and the additional price associated with environmental factors of the district. In other words, teachers must have greater compensation in districts that have a relatively high percentage of disadvantaged students. Table 4 describes the way the salary variable was constructed in each of the cost studies. The early studies use average salaries of teachers as the measure of input cost (Downes and Pogue 1994). However, many of the more recent studies use the average salaries of teachers with 5 years or less of experience to predict teacher salaries, controlling for experience, education, and tenure status (Duncombe, Ruggiero and Yinger 1996, Duncombe and Yinger 1998, Duncombe and Yinger 2000).

Salaries of teachers with 5 or less years of experience are thought to be less noisy than salaries of teachers with more experience. In other words, salaries of teachers with more than 5 years of experience are thought to have more unobservable characteristics influencing their salaries. Additionally, the influence of experience, education, and tenure are removed, generally through the use of a hedonic teacher wage model, because they reflect district choices, not input prices. The remaining studies use indices of teacher salaries developed by Taylor (2004) or Chambers (1995); each of which was designed to separate the variation in compensation caused by factors over which the district has control and the variation caused by factors that are beyond the control of the district (Reschovsky and Imazeki 2001, Imazeki and Reschovsky 2004a).

Because salaries, even for starting teachers, reflect a district's generosity, they may be influenced by some of the same unobservable district characteristics as spending, and may therefore be endogenous. Table 5 identifies the instruments being used for salary variables in the studies that address this potential endogeneity. Important to note is that many of the studies do

not use an instrument for teacher salaries, presumably due to their assertion that the controls for education, experience, certification, etc. are sufficient to correct for the endogeneity. Other studies consider the district's generosity as a potential endogeneity problem and use instruments like cost-of-living indices and county manufacturing, service, and trade wages (Hamadeh 1998, Duncombe and Johnston 2004, Duncombe, Lukemeyer and Yinger 2006). These industries are thought to include many jobs that are substitutes for teaching positions and therefore are thought to have salaries that are correlated with teachers' salaries, while being uncorrelated with the expenditure decisions made by a district. Cost-of-living indices are used in other studies because teachers in high cost-of-living areas demand a higher salary, and cost-of-living affects spending only through this input price (Reschovsky and Imazeki 1998, Reschovsky and Imazeki 2001, Imazeki 2001).

With the desire to measure how environmental factors influence the cost a district faces in producing a certain level of academic performance, the cost function studies seek to include all relevant cost factors and measure their effects. Table 6 identifies the non-salary cost variables that are used in the education cost models. Nearly all of the studies use a measure of enrollment, a measure of students in poverty, a measure of students with limited English proficiency, and a measure of students in special education. The square and cube of enrollment are sometimes included to account for the possibility that the benefit of increasing enrollment may diminish and may even become a cost as the enrollment becomes too large. Some studies include dummies for whether the district is an elementary or a high school district (Alexander, et al. 2000, Reschovsky and Imazeki 2003, Duncombe and Yinger 2007). Many of these studies find that high school districts have a higher cost; this may be due to the high cost of science laboratories and other programs found exclusively in high schools.

The poverty measure is generally either the percent of children in poverty or the percent of students who are eligible to receive a free or reduced-price lunch. Eligibility for the federal free and reduced-price lunch program is linked to a family's income relative to the poverty line and is therefore considered an appropriate measure of the students in poverty. The percentage of students with limited English proficiency is included to capture cost associated with language barriers that may impede achievement. Resources must be spent to provide additional instruction

to these students. With respect to special education students, some studies include only severe handicaps to address the possibility that the district itself influences the number of students classified with disabilities (Duncombe and Yinger 1997, Imazeki and Reschovsky 2004c). A large proportion of students with these characteristics necessitates additional programs to supplement the existing classes provided by the school districts and, therefore, makes them more costly to educate.

The final component of the expenditure equation is the measure of school district efficiency, which is likely the most controversial component in cost function studies. This is because efficiency cannot be directly measured. The production of education is much too complicated to accurately estimate the production frontier with any certainty. However, as noted previously, without a control for efficiency, scholars obtain biased estimates of their coefficients due to the inability to observe cost. Table 7 presents controls for efficiency. These controls attempt to indirectly account for the efficiency with which districts and schools operate.

One common control is the non-parametric method known as Data Envelopment Analysis (DEA), which estimates a production frontier and an associated efficiency measure for each district. Districts that spend more than other districts with the same performance are deemed to be inefficient (Duncombe, Ruggiero and Yinger 1996). Although appealing, this approach is not an exact control for efficiency because it does not account for cost factors outside a district's control. That is, a district may produce less performance for a given level of spending either because the district is inefficient or because it has higher costs. Other studies use the Herfindahl index as a measure of private school competition (Imazeki and Reschovsky 2004a, Imazeki and Reschovsky 2004b, Imazeki 2006). Hoxby (2000) finds that competition from private schools is related to increases in performance within neighboring public schools, which can be interpreted as an efficiency argument. The more competition a public school district faces, the more likely the district will produce to its capacity.

Other studies, like Duncombe and Yinger (2001) and Duncombe, Lukemeyer, and Yinger (2006), use factors that have conceptual links to efficiency, such as fiscal capacity, tax share, percent of housing that is owner-occupied, and percent of population 65 or older. These factors

are linked to efficiency in that they may affect the decision voters make about monitoring school officials or about demanding school activities other than those promoting the specified performance measures (spending on these activities is a form of inefficiency). For example, fiscal capacity influences the amount of aid received by a district and as aid increases, the price to the median voter of an increase in performance decreases. As the price decreases, the voter is less likely to monitor their school officials. The factors may also have an impact on the practices of school officials directly.

The econometric technique used by the majority of the studies is two stage least squares. This is due to the endogeneity of student performance and teacher salaries previously discussed. Downes and Pogue (1994) used the panel data method of fixed effects to rid the model of any unobserved, time invariant characteristics of school districts. This study considered efficiency to be time invariant, so it did not need to include any indirect measures of efficiency. Other studies did not address the potential endogeneity problems and used ordinary least squares.

Note that the choice of performance measures is critical to the interpretation of the estimates of the cost function studies. As discussed below, the estimation of the cost function is relative to the performance measures included in the study. In general, the performance measures are fairly narrow and reflect the subjects that state accountability systems usually emphasize. This is especially important in any discussion of estimated district efficiency. Estimated efficiency is relative to the measures of output included in the study.

Results

The results of the cost function studies are summarized in tables 8-14. One would expect measured cost differentials to vary by the specification of the model, by the choice of variables and instruments, and by state due to certain state-specific conditions. The differences between the specifications and variables used in the cost function studies have been discussed, and the following section will describe the similarities/dissimilarities in results in more detail.

Table 8 shows the results for the coefficient on student performance. It is labeled “economies of quality scale” because the estimated coefficients are often elasticities of

expenditure with respect to academic performance. In many cases, the estimated coefficients indicate the returns to quality scale in the production of education. However, note the dissimilarity between the coefficients estimated for student performance in the expenditure equation. This is due to the wide variety of performance measures used by the various studies. Some use indices of performance. Others include a number of performance measures separately, which may introduce a significant amount of collinearity into the equation. The difference between instruments used to correct the endogeneity of performance and controls for efficiency will also affect the estimation of the coefficients for these variables. Most of the coefficients estimated indicate increasing returns to scale (with estimated coefficients less than one) and are statistically significant, but are difficult to compare between studies because of the difference between specifications and variables.

In terms of the effect of teacher salary on the expenditure of a district, there is a large degree of similarity between the estimated coefficients, as can be seen in table 9. All of the coefficients are positive, most are statistically significant, and many of the estimates are close to 1. This can be interpreted as follows: a 1% increase in teacher salaries leads to a 1% increase in expenditure. The estimates are slightly above 1 in Texas (Reschovsky and Imazeki 1998) and slightly below 1 in New York (Duncombe and Yinger 2000), which may be interpreted as differences across states, but may also be a result of the difference in treatment of the teacher salary variable. For example, in many of the Texas studies, the salary variable was not treated as endogenous. Those studies that have different estimates either used different teacher salary measures or did not take the natural log.

As shown in table 10, school district enrollment is negatively related to cost up to a certain point, but that relationship becomes positive after that point. In other words, each study that uses enrollment and enrollment squared as measures of district size has a negative coefficient on enrollment and a positive coefficient on enrollment squared, showing a U-shaped relationship between enrollment and costs. Very small and very large school districts have the highest costs. Those studies that use enrollment classes instead of enrollment and enrollment squared also find a similar shape of the relationship between district size and cost. Some studies

also find that the optimal district size is approximately 3000 students (Duncombe, Lukemeyer, and Yinger 2003, Duncombe and Yinger 2005a).

The estimates for the coefficients of the poverty variable seem to vary by state, but are likely to be affected by other variables included in the model, as well. For example, if there is some measure of female-headed households or of student race in the model, it is likely to be correlated with the measure of students in poverty and will affect the estimates. Like each of the estimates, it also depends on the performance measure used. Table 11 shows the results for the baseline estimates of the coefficient of the percentage of students in poverty. For many of the studies in New York, the estimated coefficient is close to 1 (Duncombe and Yinger 1997, Duncombe and Yinger 2000, Duncombe and Yinger 2005a), which can be interpreted as follows: a 1 percentage point increase in students in poverty leads to a 1 percent increase in expenditure. In other words, a poor child costs twice as much. For the studies in Texas, the estimated coefficient is often close to 0.4 (Imazeki and Reschovsky 2004a, Imazeki and Reschovsky 2004b, Imazeki and Reschovsky 2006). In other states, the estimate is much lower, but still positive and statistically significant (Downes and Pogue 1994, Imazeki 2001).

The results with respect to the percentage of students with limited English proficiency can be found in table 12. Here the results also seem to vary by state, but again, may just be sensitive to the use of other variables that are correlated with this measure. In addition, the studies that use the percentage of students with limited English proficiency in addition to that variable squared seem to find a U-shaped relationship between this variable and school district expenditure (Imazeki and Reschovsky 2004a, Imazeki and Reschovsky 2004b, Imazeki and Reschovsky 2006). In other words, these studies find that very small and very large percentages of students with limited English proficiency lead to higher costs of producing academic performance. However, the majority of studies find a positive, statistically significant relationship between the percentage of students with limited English proficiency and the districts' expenditure.

Table 13 summarizes the results for students with disabilities. This variable is defined in a number of different ways, depending on how the state collects and publishes this information.

In addition, as aforementioned, scholars choose to include different classifications of disabilities to avoid including a classification that the district can influence. Some studies use the percentage of deaf, blind, or autistic students as a measure of students with severe disabilities. Other studies use the percent of students in special education. Still others use the percentage of students who are out of classrooms for a given portion of the day. As can be deduced from this summary, the results associated with students with disabilities vary by study. For those studies that include this measure, though, scholars often find a positive, statistically significant coefficient (Alexander et al. 2000, Gronberg et al. 2004, Duncombe and Yinger 2005a).

With respect to the efficiency measure included in the study, comparing the magnitudes of the coefficients is a complicated task. This is because efficiency measures vary widely by study, and there is no clear way to determine if efficiency is being measured correctly. In addition, in many of the studies, there are a number of different variables included to control for efficiency. The coefficient on each of the variables has to be discussed independently since each is included for a different purpose. For example, in those studies that use income, tax price, and other factors that affect monitoring, the coefficients are expected to be different signs based on how they are thought to affect the decisions made by voters and school officials.

Table 14 summarizes the results with respect to efficiency measures. For the studies that include one control for efficiency, they consistently find a negative, statistically significant relationship (Duncombe and Yinger 1997, Hamadeh 1998, Reschovsky and Imazeki 2001). This is the expected result: as districts get more efficient, all else equal, their spending decreases. For the studies using a number of efficiency controls, they find a positive impact of income on expenditure (Duncombe and Yinger 2001, Duncombe and Yinger 2005b, Duncombe, Lukemeyer and Yinger 2006), which can be interpreted in the following way: higher income individuals do not spend much time monitoring school officials. There is also a negative impact of tax price on expenditure. In other words, individuals with a high tax price monitor school officials, which may lead to a more efficient district, or demand a smaller range of outputs. Studies commonly find support for their variables as indirect controls for efficiency.

Cost function studies face difficult challenges because of the nature of the data and production process being examined. Efficiency appears in cost function studies because spending is observed, not cost. Efficiency cannot be directly measured, so variables thought to be correlated with efficiency are included. There is no clear way to determine whether efficiency is being measured correctly, though. In addition, measures of inefficiency include both waste and spending on other objectives not included in the study. For example, if math and English scores are used in conjunction with a graduation rate, spending on music programs is considered inefficiency. To the extent that music programs are valued, one may want to consider its effect on the measure of inefficiency. In other words, interpretations of efficiency estimates must reflect the performance measures included in the study.

Conclusion

The scholars who perform cost function studies note the weaknesses with foundation aid programs, as they exist presently. Most importantly, the expenditure associated with the minimum level of education (used in foundation aid formulas) does not appropriately account for educational cost differences. Many states do not include any cost factors in their foundation aid formula, and the states using cost variables in their formula use ad hoc weights. That is, school district and student characteristics that are not influenced by the district, such as the percentage of students in poverty, are used by a few states to distribute basic operating aid among their school districts. However, the weights used in the state aid formulas generally fall short of what scholars measure as the cost factors' observed effects.

The states that do not use cost variables in their foundation aid formulas generally have some supplemental categorical aid program to provide extra resources to the districts with more costly environments. However, in determining that educational adequacy is the equity target, basic operating resources must reflect the additional costs faced by some school districts (Duncombe and Yinger forthcoming). Categorical aid programs are less successful at providing resources to achieve a certain level of performance because their use is determined at a more centralized level. Foundation aid programs, by design, are more flexible in terms of what is purchased and decentralizes the decision-making process. They are better designed to allow the

district to achieve a certain minimal level of performance, even if the district has a high proportion of more costly students.

Cost function studies seek to measure the impact of various environmental factors on the cost of producing academic performance. The goal is to develop aid formulas that appropriately handle the additional costs associated with certain types of students and districts. The district cannot influence these characteristics, so to achieve adequacy, the foundation aid formula should include appropriate weights for more costly students. By including these measures, the state offers districts with higher costs equal opportunity to achieve the same level of student performance as do low-cost districts. As evidenced in this review of the cost function literature, to obtain appropriate weights, studies must be performed in each state and weights should be empirically measured. The method is shown to work well in many states, but does not always produce the same results. More research is needed to determine whether differences in estimates are a product of differences across states or differences across studies. At present, there are too few studies to do a careful meta-analysis of the education cost function results.

For a more detailed review of the cost-function literature, see W. Duncombe and J. Yinger "The Measurement of Cost Differentials," in the Handbook of Research on Education Finance and Policy, edited by E. Fisk and H.F. Ladd (Laurence Erlbaum, Forthcoming).

Table 1. Education Cost Function Studies

Article	State
Alexander, et al. (2000)	Texas
Downes and Pogue (1994)	Arizona
Duncombe and Johnston (2004)	Kansas
Duncombe and Yinger (1997)	New York
Duncombe and Yinger (1998)	New York
Duncombe and Yinger (2000)	New York
Duncombe and Yinger (2001)	New York
Duncombe and Yinger (2005a)	New York
Duncombe and Yinger (2005b)	Kansas
Duncombe and Yinger (2007)	California
Duncombe, Lukemeyer, and Yinger (2003)	New York
Duncombe, Lukemeyer, and Yinger (2006)	Kansas
Duncombe, Lukemeyer, and Yinger (2006) part 2	Missouri
Duncombe, Ruggiero, and Yinger (1996)	New York
Gronberg, et al. (2004)	Texas
Hamadeh (1998)	Georgia
Imazeki (2001)	Illinois
Imazeki (2006)	California
Imazeki and Reschovsky (2004a)	Texas
Imazeki and Reschovsky (2004b)	Texas
Imazeki and Reschovsky (2004c)	Texas
Imazeki and Reschovsky (2006)	Texas
Reschovsky and Imazeki (1998)	Wisconsin
Reschovsky and Imazeki (2001)	Texas
Reschovsky and Imazeki (2001) part 2	Wisconsin
Reschovsky and Imazeki (2003)	Texas

Table 2. Student Performance Measures in Education Cost Models

Article	Performance Measures
Alexander, et al. (2000)	Average value-added on TAAS performance (administered to all students in grades 3 through 8 and in grade 10), percent of students who perform above criterion on the SAT or ACT tests and the percent of students who complete an advanced course
Downes and Pogue (1994)	Mean standardized test scores for sixth and twelfth graders and scores for eleventh graders from previous year
Duncombe and Johnston (2004)	Average percentage of students passing exams - math given in fourth, seventh and tenth and reading given in third, seventh and tenth grades, and dropout rates
Duncombe and Yinger (1997)	Average share above reference point on third and sixth grade math and English tests; the average share of students who pass several state-run standardized tests in high school; and the share of students who stay in school
Duncombe and Yinger (1998)	Percent of students performing above a standard reference point on Pupil Evaluation Program tests (reading and math), given in third and sixth grades, percent of students receiving a Regents diploma upon graduation from high school, and the inverse of the dropout rate
Duncombe and Yinger (2000)	Average share above reference point on third and sixth grade math and reading tests; the share of students who receive a more demanding Regents diploma (which requires passing a series of exams), and the graduation rate
Duncombe and Yinger (2001)	Percent of students graduating with a Regents diploma and percent dropouts
Duncombe and Yinger (2005a)	Passing rates on fourth and eight grade math and reading and passing rates on Regents exams
Duncombe and Yinger (2005b)	Percent of students reaching certain thresholds in performance on the Quality Performance and Accreditation exams in math (grades 4, 7, 10) and reading (grades 5, 8, 11) and the graduation rate
Duncombe and Yinger (2007)	Academic Performance Index – weighted average of test results in several subjects from grades 2-11
Duncombe, Lukemeyer, and Yinger (2003)	Weighted average of fourth- and eighth-grade exam scores, and high school Regents exam scores
Duncombe, Lukemeyer, and Yinger (2006)	Share reaching proficiency on criterion-referenced exams in math and reading in three grades (grades 4, 7 and 10 for math, and grades 5, 8 and 11 for reading)
Duncombe, Lukemeyer, and Yinger (2006) part 2	Proficiency rates for three math and three reading exams (grades 3, 7 and 11 for communication arts, and grades 4, 8 and 10 for math)
Duncombe, Ruggiero, and Yinger (1996)	Average share above reference point on third and sixth grade

math and reading tests; the share of students who receive a more demanding Regents diploma (which requires passing a series of exams), and the inverse of the drop-out rate

- Gronberg, et al. (2004) Percentage of students in each district who passed the TAAS in math and reading in grades 5-8 and 10 and the percentage of students in each district who passed in grades 3-6 and 8 two years earlier, the percent of students who perform above 1100 on the SAT or 24 on the ACT, and the percent of students who complete an advanced course
- Hamadeh (1998) Average reading, math and science scores for third grade pupils in Curriculum Based Assessment test and the percentage of 11th grade students who passed spring English and math graduation tests the first time
- Imazeki (2001) Composite scores on the EGAP exams in math and reading (grades 3, 6, 8, and 10), and science and social studies (grades 4, 7, and 11) and scores of the same cohort of students in earlier years and grades
- Imazeki (2006) Academic Performance Index and average California standards tests passing rates
- Imazeki and Reschovsky (2004a) Average passing rate on the TAAS reading and mathematics exams administered to students in grades 5 through 8 and in grade 10 and average passing rates in grades 4 through 8 and 10 from the year before, the annual retention rate, and the percentage of graduating seniors who achieve at least a 1100 on the SAT or a 24 on the ACT
- Imazeki and Reschovsky (2004b) Average passing rate on the TAAS reading and mathematics exams administered to students in grades 4 through 8 and in grade 10 and average passing rate in grades 3 through 8 and 10 from the year before, passing rate on State-Developed Alternative Assessment, annual retention rate, interaction of retention rate with the percent of students enrolled in high school, percentage of graduating seniors who achieve at least a 1100 on the SAT or a 24 on the ACT
- Imazeki and Reschovsky (2004c) Scores on the Texas Assessment of Academic Skills and the scores from the previous year, the percent of students taking either the SAT I or the ACT exams and who achieve either a 1110 on the SAT I and a 24 on the ACT
- Imazeki and Reschovsky (2006) Passing rate on the TAAS exam administered in grades 5-8 and in grade 10 and the passing rate in grades 3 through 8 and 10 from the year before, the passing rate on the SDAA exams (for special education students), the percent of graduating seniors who achieve a score of at least 1100 on the SAT and a 24 on the ACT, and the retention rate
- Reschovsky and Imazeki (1998) Tenth grade standardized test results and eighth grade from two years earlier and number of advanced courses offered
- Reschovsky and Imazeki (2001) Composite TAAS score for all students in the fourth through

eighth grades and in the tenth grade and score in grades 3-7 from the year before and grade 8 from two years before, and student performance on the ACT exams

Reschovsky and Imazeki (2001) part 2

Tenth grade standardized test results and eighth grade results from two years earlier and number of advanced courses offered

Reschovsky and Imazeki (2003)

Composite TAAS score for all students in the fourth through eighth grades and in the tenth grade and score in grades 3-7 from the year before and grade 8 from two years before, and student performance on the ACT exams

Table 3. Instruments for Performance Variables in Education Cost Models

Article	Instruments for Performance
Alexander, et al. (2000)	None
Downes and Pogue (1994)*	Fraction of population Hispanic, fraction of the population black, fraction of the population Native American, fraction of the families below the poverty line, fraction of the families with children
Duncombe and Johnston (2004)*	Averages of other school districts in the county and adjacent counties of enrollment, child poverty, bilingual student share, dropout rate, average math score, median house value, federal aid per pupil, population density, and tax share
Duncombe and Yinger (1997)*	Median income, tax price of the median voter, percent owner-occupied housing, relative percent of adults with college education, and aid
Duncombe and Yinger (1998)*	District population, population density, percent employees managers/professionals, dummy for city district
Duncombe and Yinger (2000)*	Instruments from the demand equation (median income and tax price faced by the median voter)
Duncombe and Yinger (2001)*	Median income, tax price of median voter, efficiency index, percent of population that is elderly, percent of population in central city, percent of employees that are managers, percent owner-occupied housing, percent of housing stock built before 1940, ratio of high-to low-income households, percent of adults with college education, percent of households with telephones, log of households per child
Duncombe and Yinger (2005a)*	Instruments from adjacent districts that measure fiscal capacity, student need, physical conditions, and student performance
Duncombe and Yinger (2005b)*	For districts in adjacent counties, average proficiency on math and reading exams, maximum graduation rate, maximum per pupil total property values, and maximum per pupil personal property values
Duncombe and Yinger (2007)	Average values for other districts in the same Census district type or in the same county for several socio-economic variables
Duncombe, Lukemeyer, and Yinger (2003)*	Average of LEP students in adjacent districts, maximum for income and performance on the grade 8 exams, and minimum of performance on grade 8 exams for adjacent districts
Duncombe, Lukemeyer, and Yinger (2006)*	Values for performance, salaries and other socio-economic characteristics in districts in neighboring counties
Duncombe, Lukemeyer, and Yinger (2006) part 2*	Values for performance, salaries and other socio-economic characteristics in other districts in the same county or census region
Duncombe, Ruggiero, and Yinger (1996)*	Instruments from the demand equation (median income, basic operating aid and tax share of the median voter)
Gronberg, et al. (2004)	None

Hamadeh (1998)*	Percent of adults in the district with college education, median income, tax share of median voter, ratio of federal aid to median income, ratio of state aid to median income, percent of owner-occupied houses, the percentage of school age children
Imazeki (2001)*	District median income, each district's aid from the state equalization formula, aid from the federal government, categorical aid received from the state, ratio of residential property to the total tax base, the percent of adults with a 4-year degree, and the percent of household heads that are homeowners
Imazeki (2006)	None
Imazeki and Reschovsky (2004a)	Median income and tax price faced by the median voter, percentage of households with children, percentage of household heads who are homeowners, percentage of adults who have a 4 year college degree
Imazeki and Reschovsky (2004b)	Median income and tax price faced by the median voter, Tier 1 Foundation School Program aid, percentage of households with children, percentage of household heads who are homeowners, and the percentage of adults who have earned a 4 year college degree
Imazeki and Reschovsky (2004c)	None
Imazeki and Reschovsky (2006)	Median income and tax price faced by the median voter, the percent of households with children, the percent of household heads who are homeowners, the percent of adults who have a 4-year degree
Reschovsky and Imazeki (1998)*	Median income and tax price faced by the median voter, categorical aid, percentage of households with children, percentage of household heads who are homeowners, percentage of population age 65 and older, percentage of adults who have a 4 year college degree
Reschovsky and Imazeki (2001)*	Median income and tax price faced by the median voter, aid from the foundation tier of the Texas aid system, percentage of households with children, percentage of household heads who are homeowners, percentage of adults who have a 4 year college degree
Reschovsky and Imazeki (2001) part 2*	Median income and tax price faced by the median voter, categorical aid, percentage of households with children, percentage of household heads who are homeowners, percentage of adults who have a 4 year college degree
Reschovsky and Imazeki (2003)	Percentage of students who take a college entrance exam, median income and tax price faced by the median voter, percentage of households with children and percentage of household heads who are homeowners

* denotes that the study also includes instruments for the salary variables – see Table 5

Table 4. Salary Variable in Education Cost Models

Article	Salary Variable
Alexander, et al. (2000)	Average wage for teachers with 5 or fewer years of experience
Downes and Pogue (1994)	Average teacher salaries, average salary per classified employee
Duncombe and Johnston (2004)	Average teacher salaries (including fringe benefits)
Duncombe and Yinger (1997)	Average salary for teachers with 5 or fewer years of experience, adjusted for experience, education, type or certification, and tenure
Duncombe and Yinger (1998)	Teacher salaries of those with 5 years or less of experience controlling for experience, education, type of certification and tenure
Duncombe and Yinger (2000)	Teachers with 5 years or less of experience used to predict teacher salary for each district for a teacher with same gender, tenure status and education
Duncombe and Yinger (2001)	School wages determined as a function of local labor market conditions – population of county where school is located and the county wage rate for manufacturing production workers
Duncombe and Yinger (2005a)	Teachers with 5 years or less of experience used to predict teacher salary for each district for a teacher with statewide average experience and average probability of having a graduate degree
Duncombe and Yinger (2005b)	Teacher salaries estimated with state average percent with a graduate degree and state average total experience
Duncombe and Yinger (2007)	District's minimum salary
Duncombe, Lukemeyer, and Yinger (2003)	Teacher wage model (teacher experience, education, enrollment, class size, efficiency variables, average student performance, average unemployment rate, pupil density, professional wage, share of county's teachers, percent LEP students, free lunch rate, juvenile violent crime rate) used to predict wages, and the teacher wage index is then defined as the ratio of the predicted wage for each district divided by the state average wage and multiplied by 100
Duncombe, Lukemeyer and Yinger (2006)	Individual teacher data is used to predict what teacher salaries would be in each district if teachers had average experience and education (for teacher with average experience)
Duncombe, Lukemeyer and Yinger (2006) part 2	Individual teacher data is used to predict what teacher salaries would be in each district if teachers had average experience and education (for teacher with five or less years of experience)
Duncombe, Ruggiero, and Yinger (1996)	Teachers with 5 years or less of experience used to predict teacher salary for each district controlling for experience, level of education, type of certification, and tenure
Gronberg, et al. (2004)	Average salary of teachers with less than three years of experience (also include average salary of auxiliaries and teacher aides)
Hamadeh (1998)	Error term of the regression of teacher's salary on experience, education and certification

Imazeki (2001)	Teacher's background characteristics (including years of teaching experience and highest degree earned) and district dummies are used to explain teacher salaries – the coefficients on district dummies are used as values for the teacher salary index
Imazeki (2006)	Index of teacher costs created using predicted salary developed by Rose (2006)
Imazeki and Reschovsky (2004a)	Index of teacher costs developed by Taylor (2004) - separates variations in compensation arising from uncontrollable district characteristics from variation arising from factors that districts can influence
Imazeki and Reschovsky (2004b)	Index of teacher costs developed by Taylor (2004) - separates variations in compensation arising from uncontrollable district characteristics from variation arising from factors that districts can influence
Imazeki and Reschovsky (2004c)	Teacher salary index
Imazeki and Reschovsky (2006)	Index of teacher costs developed by Taylor (2004) - separates variations in compensation arising from uncontrollable district characteristics from variation arising from factors that districts can influence
Reschovsky and Imazeki (1998)	Teacher wage model (teacher experience, education, dummy for each district) - coefficients on district dummies used as the values of teacher salary index
Reschovsky and Imazeki (2001)	Chambers' index
Reschovsky and Imazeki (2001) part 2	Teacher salary index, which reflects differences in salaries that are due to factors outside local control
Reschovsky and Imazeki (2003)	Chambers' index

Table 5. Instruments for Salary Variables in Education Cost Models

Article	Instruments for Salary Variables
Alexander, et al. (2000)	None
Downes and Pogue (1994)*	Index of teacher experience, payroll per employee in the service sector in the county
Duncombe and Johnston (2004)*	Average private wages in wholesale trade, retail trade, management services, and public services
Duncombe and Yinger (1997)*	County population and the county wage rate for manufacturing production workers
Duncombe and Yinger (1998)*	Hourly wages for production workers in manufacturing at the county level and the county population
Duncombe and Yinger (2000)*	County manufacturing wage and the county population
Duncombe and Yinger (2001)*	County population and county manufacturing wage
Duncombe and Yinger (2005a)*	Pupil density, private wages in professional occupations, unemployment rate, concentration of area teachers in the district, and the average salaries of adjacent districts
Duncombe and Yinger (2005b)*	Average salaries of districts in adjacent counties
Duncombe and Yinger (2007)*	Predicted value from a regression of minimum teacher salary on private sector wages in the local labor market, county population and the percent of the district's population in an urban area
Duncombe, Lukemeyer, and Yinger (2003)*	Pupil density
Duncombe, Lukemeyer, and Yinger (2006)*	Index of private wages in the district's labor market
Duncombe, Lukemeyer, and Yinger (2006) part 2*	Index of private wages in the district's labor market
Duncombe, Ruggiero, and Yinger (1996)*	County population
Gronberg, et al. (2004)	None
Hamadeh (1998)*	Manufacturing wage, district's population and population density
Imazeki (2001)*	Cost-of-living index developed by McMahon (1991, 1994)
Imazeki (2006)	None
Imazeki and Reschovsky (2004a)*	None
Imazeki and Reschovsky (2004b)*	None
Imazeki and Reschovsky (2004c)	None
Imazeki and Reschovsky (2006)*	None
Reschovsky and Imazeki (1998)*	Dummy variables reflecting the assignment of each school district to its appropriate cost-of-living group

Reschovsky and Imazeki (2001)*	Cost-of-living index
Reschovsky and Imazeki (2001) part 2*	Variable that reflects differences in the cost of living in various parts of the state based on Deller, Green and Voss (1996)
Reschovsky and Imazeki (2003)*	None

* denotes that the study also includes instruments for the performance measures – see Table 3

Table 6. Non-Salary Cost Variables in Education Cost Models

Article	Cost Variables
Alexander, et al. (2000)	Average daily attendance, percent disadvantaged, percent at-risk, percent with limited English proficiency, percent of students in special education, percent of students in high school, miles to major metropolitan area
Downes and Pogue (1994)	Ratio of median house value to assessed value per pupil, average daily membership, percent black, Hispanic, or Native American, percent receiving subsidized lunch, percent limited English proficient, square root of percent LEP, interaction of district size indicator with percent Native American
Duncombe and Johnston (2004)	Pupils (FTE), pupils squared, percent of children in poverty, child poverty rate in large districts, bilingual hours per FTE
Duncombe and Yinger (1997)	Enrollment, square of enrollment, percent of children in poverty, percent female-headed households, percent of students with severe handicaps, percent of students with limited English proficiency
Duncombe and Yinger (1998)	Enrollment, percent children in poverty, percent female-headed households, percent handicapped students, percent severely handicapped students, percent of persons with limited English proficiency
Duncombe and Yinger (2000)	Enrollment, percent of children in poverty, percent female-headed households, percent of students with severe handicaps, percent of students with limited English proficiency, and population density
Duncombe and Yinger (2001)	Enrollment, square of enrollment, cube of enrollment, percent of children in poverty, percent female-headed households, percent of students with severe handicap, percent of students with limited English proficiency
Duncombe and Yinger (2005a)	Percent child poverty, 2-year average LEP students, K-6 subsidized lunch rate, percent special education students, and 6 categories of enrollment
Duncombe and Yinger (2005b)	Percent free lunch students, free lunch multiplied by pupil density, adjusted percent bilingual headcount, 10 groups of enrollment categories
Duncombe and Yinger (2007)	Share of students eligible for free lunch, share of students with limited English proficiency, share of disabled students out of classrooms 80% of the time, percent 3-year enrollment change if positive, percent 3-year enrollment change if negative, dummies for elementary and high school districts
Duncombe, Lukemeyer, and Yinger (2003)	Percent child poverty, 2-year average LEP students, 6 categories of enrollment classes
Duncombe, Lukemeyer, and Yinger (2006)	Percent free lunch students, poverty variable multiplied by pupil density, adjusted percent bilingual headcount, and 10 categories of enrollment

Duncombe, Lukemeyer, and Yinger (2006) part 2	Percent subsidized lunch students, poverty variable multiplied by pupil density, and 10 categories of enrollment
Duncombe, Ruggiero, and Yinger (1996)	Enrollment, square of enrollment, percent of children in poverty, percent female-headed households, percent of students with handicaps, percent of students with severe handicaps, percent of students with limited English proficiency, percent of students enrolled in high school
Gronberg, et al. (2004)	Enrollment, percent free lunch, percent limited English proficient, percent special education (learning and speech disabled), percent special education (all other special education students), percent of students in high school, miles to major metropolitan area
Hamadeh (1998)	Enrollment, percent of students living in poverty, percent of students who are intellectually disabled
Imazeki (2001)	Percent of students eligible for free and reduced price lunch, enrollment, percent of students with disabilities, percent of students with severe disabilities, percent of students with limited English proficiency, percent of students enrolled in high school
Imazeki (2006)	Percent of students eligible for free and reduced price lunch, percent of students who are Spanish-speaking English learners, percent of students who are non-Spanish-speaking English learners, percent of students in special education, percent of students with high-cost disabilities, percent of students enrolled in high school
Imazeki and Reschovsky (2004a)	Percent of students eligible for free and reduced price lunch, percent of students with learning or speech disabilities, percent of students with other disabilities, percent of students who are black, percent of students who are Hispanic, percent of students with limited English proficiency, percent of students enrolled in high school, enrollment
Imazeki and Reschovsky (2004b)	Percent of students eligible for free and reduced price lunch, percent of students who are black, percent of students who are Hispanic, percent of students with learning or speech disabilities, percent of students with other disabilities, percent of students with other disabilities squared, percent of students with limited English proficiency, percent of students with limited English proficiency squared, percent of student enrolled in high school, enrollment, enrollment squared
Imazeki and Reschovsky (2004c)	Percent of students eligible for free and reduced price lunch, percent of students with severe disabilities, percent of students with limited English proficiency, enrollment, enrollment squared, percent of students enrolled in high school, indicator for Dallas or Houston
Imazeki and Reschovsky (2006)	Percent of students eligible for free and reduced price lunch, percent of students who are black, percent of students who are Hispanic, percent of students with learning or speech disabilities, percent of students with other disabilities, percent of students with other disabilities squared, percent of students with limited English proficiency, percent of students with limited English proficiency squared, percent of students enrolled in high school, enrollment, square of enrollment
Reschovsky and Imazeki (1998)	Percent of students eligible for free and reduced price lunch, percent of students with disabilities, percent of students with severe disabilities,

percent of students enrolled in high school, enrollment

Reschovsky and Imazeki (2001)

Percent of students eligible for free and reduced price lunch, percent of students with disabilities and the percentage of those who are autistic, blind, or deaf/blind, percent of students with limited English proficiency, enrollment, enrollment squared, proportion of students enrolled in high school

Reschovsky and Imazeki (2001) part 2

Percent of students eligible for free and reduced price lunch, percent of students with disabilities and the percentage of those who are autistic, blind, deaf/blind, percent of students with limited English proficiency, enrollment, enrollment squared, proportion of students enrolled in high school

Reschovsky and Imazeki (2003)

Percent of students eligible for free and reduced price lunch, percent of students with disabilities, percent of students with severe disabilities, percent of students with limited English proficiency, percent of students enrolled in high school, enrollment, enrollment squared

Table 7. Efficiency Controls in Education Cost Models

Article	Controls for Efficiency
Alexander, et al. (2000)	Stochastic cost frontier
Downes and Pogue (1994)	Fixed effects
Duncombe and Johnston (2004)	Per-pupil property values, per-pupil state aid, median household income
Duncombe and Yinger (1997)	Data Envelopment Analysis (DEA)
Duncombe and Yinger (1998)	DEA
Duncombe and Yinger (2000)	DEA
Duncombe and Yinger (2001)	Augmented district income, tax price, percent of elderly households, number of households per child, dummy variables for upstate suburbs and upstate rural
Duncombe and Yinger (2005a)	Budget constraints measured by property value, income, and state aid
Duncombe and Yinger (2005b)	Fiscal capacity (property wealth, income, state aid), college-educated adults, age 65-and over residents, homeowners, tax share of typical voter, consolidation
Duncombe and Yinger (2007)	Log of median earnings; additions to voters' effective income from unrestricted aid, categorical aid, federal aid, and education foundation contributions; number of parcels per pupil, share of migrants, change in revenue limit, share of intergovernmental support in form of categorical grants
Duncombe, Lukemeyer, and Yinger (2003)	Difference between a district and the average in its peer group for per pupil income, per pupil property values, and state aid as a percentage of district income
Duncombe, Lukemeyer, and Yinger (2006)	Per pupil income, per pupil property values, state aid ratio (includes federal aid), local tax share, college education variable, percent of population 65 or older, percent of housing units that are owner occupied
Duncombe, Lukemeyer, and Yinger (2006) part 2	Per pupil income, per pupil property values, state aid ratio, local tax share, college education variable, percent of population 65 or older, percent of housing units that are owner occupied
Duncombe, Ruggiero, and Yinger (1996)	DEA
Gronberg, et al. (2004)	Stochastic cost frontier
Hamadeh (1998)	DEA
Imazeki (2001)	None
Imazeki (2006)	Herfindahl index to measure public school competition

Imazeki and Reschovsky (2004a)	Herfindahl index to measure public school competition
Imazeki and Reschovsky (2004b)	Herfindahl index to measure public school competition
Imazeki and Reschovsky (2004c)	None
Imazeki and Reschovsky (2006)	Herfindahl index to measure public school competition
Reschovsky and Imazeki (1998)	None
Reschovsky and Imazeki (2001)	DEA
Reschovsky and Imazeki (2001) part 2	DEA
Reschovsky and Imazeki (2003)	DEA

Table 8. Education Cost Function Study Results – Economies of Quality Scale

Article	Estimated Coefficient
Alexander, et al. (2000)	TAAS: -0.0228 Percent scoring above criterion on ACT/SAT: 0.359** Percent completing advanced course: 0.582**
Downes and Pogue (1994)	Grade 6 test scores: 0.3919 Grade 12 test scores: 0.4655 Lagged Grade 11 test scores: -0.4010
Duncombe and Johnston (2004)	Math grades 4,7, and 10: 0.0134** Reading grade 3: -0.0055 Dropout rates: -0.0340
Duncombe and Yinger (1997)	Grades 3 and 6: 5.1106** Percent nondropouts: 4.4757 Percent receiving Regents diploma: 1.3449**
Duncombe and Yinger (1998)	Grades 3 and 6: 5.1106** Percent nondropouts: 4.4757 Percent receiving Regents diploma: 1.3449**
Duncombe and Yinger (2000)	Grades 3 and 6: 3.7637 Percent nondropouts: 9.0461** Percent receiving Regents diploma: 0.8793**
Duncombe and Yinger (2001)	Percent dropouts: -0.0728** Percent receiving Regents diploma: 0.0102**
Duncombe and Yinger (2005a)	0.0073**
Duncombe and Yinger (2005b)	0.83013**
Duncombe and Yinger (2007)	2.7223**
Duncombe, Lukemeyer, and Yinger (2003)	0.00752**
Duncombe, Lukemeyer, and Yinger (2006)	0.50124*
Duncombe, Lukemeyer, and Yinger (2006) part 2	0.34902**
Duncombe, Ruggiero, and Yinger (1996)	Grades 3 and 6: 2.3472 Percent nondropouts: 7.1626** Percent receiving Regents diploma: 1.2432**
Gronberg, et al. (2004)	Change in ave. TAAS pass rate: 0.3354** Percent completing advanced course: 0.1646** Percent above criterion on ACT/SAT: 0.0716* Prior TAAS passing rate: 0.0353
Hamadeh (1998)	Grade 3 scores: 1.889** Grade 5 scores: -0.877* % Grade 11 passing: 0.00215**

Imazeki (2001)	IGAP score: 5.411** Lagged IGAP score: -4.512**
Imazeki (2006)	0.339**
Imazeki and Reschovsky (2004a)	TAAS passing rate: 2.28** Lagged TAAS pass rate: -0.03** Percent graduates who performed above criteria on SAT: 0.059 Passing rate on alt. assessment: 0.006 Annual retention rate: 0.104
Imazeki and Reschovsky (2004b)	TAAS passing rate: 0.914* Lagged TAAS pass rate: -2.69** Percent graduates who performed above criteria on SAT: 0.38 Passing rate on alt. assessment: 0.35 Annual retention rate times percent enrolled in high school: 104.5**
Imazeki and Reschovsky (2004c)	Composite exam score: 9.19** Lagged exam score: -6.6** Percent passing college boards: 0.98**
Imazeki and Reschovsky (2006)	TAAS passing rate: 2.39** Lagged TAAS pass rate: -0.043** Percent graduates who performed above criteria on SAT: 0.005 Passing rate on alt. assessment: 0.107 Annual retention rate: 0.017
Reschovsky and Imazeki (1998)	Grade 10 score: 2.796** Lagged score: -1.650 Number of advanced courses: -0.002**
Reschovsky and Imazeki (2001)	Composite exam score: 2.078** Lagged exam score: -1.535* Ave. ACT score: 1.104**
Reschovsky and Imazeki (2001) part 2	Grade 10 score: 1.079** Lagged score: -0.346 Number of advanced courses: -0.002
Reschovsky and Imazeki (2003)	Composite exam score: 3.34** Lagged exam score: -2.53* Ave. ACT score: 1.03**

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 9. Education Cost Function Study Results – Teacher Salaries

Article	Estimated Coefficient
Alexander, et al. (2000)	1.179**
Downes and Pogue (1994)	0.1509
Duncombe and Johnston (2004)	0.6678**
Duncombe and Yinger (1997)	0.6487
Duncombe and Yinger (1998)	0.6487
Duncombe and Yinger (2000)	0.7451*
Duncombe and Yinger (2001)	0.6811*
Duncombe and Yinger (2005a)	1.0006**
Duncombe and Yinger (2005b)	1.01765**
Duncombe and Yinger (2007)	0.8030**
Duncombe, Lukemeyer, and Yinger (2003)	0.99296**
Duncombe, Lukemeyer, and Yinger (2006)	0.67969*
Duncombe, Lukemeyer, and Yinger (2006) part 2	0.86275**
Duncombe, Ruggiero, and Yinger (1996)	0.8913**
Gronberg, et al. (2004)	0.4201**
Hamadeh (1998)	0.359**
Imazeki (2001)	1.076**
Imazeki (2006)	0.321**
Imazeki and Reschovsky (2004a)	0.859**
Imazeki and Reschovsky (2004b)	1.44**
Imazeki and Reschovsky (2004c)	0.004**
Imazeki and Reschovsky (2006)	0.829**
Reschovsky and Imazeki (1998)	1.583**
Reschovsky and Imazeki (2001)	0.002**
Reschovsky and Imazeki (2001) part 2	1.142**
Reschovsky and Imazeki (2003)	0.0015*

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 10. Education Cost Function Study Results – Enrollment

Article	Estimated Coefficient
Alexander, et al. (2000)	-0.0932**
Downes and Pogue (1994)	-0.0863**
Duncombe and Johnston (2004)	-0.6715** Pupils squared: 0.0368**
Duncombe and Yinger (1997)	-0.5680** Enrollment squared: 0.0345**
Duncombe and Yinger (1998)	-0.5680**
Duncombe and Yinger (2000)	-1.0744** Enrollment squared: 0.1099**
Duncombe and Yinger (2001)	-1.8553** Enrollment squared: 0.1985**
Duncombe and Yinger (2005a)	1000-2000: -0.0823** 2000-3000: -0.0896** 3000-5000: -0.1067** 5000-7000: -0.0915** 7000-15000: -0.1019** Over 15000: 0.0236
Duncombe and Yinger (2005b)	100-150: -0.12987** 150-300: -0.29443** 300-500: -0.38580** 500-750: -0.44523** 750-1000: -0.45612** 1000-1700: -0.52671** 1700-2500: -0.57252** 2500-5000: -0.56802** 5000 and above: -0.5537**
Duncombe and Yinger (2007)	-0.2287** Enrollment squared: 0.0112**
Duncombe, Lukemeyer, and Yinger (2003)	1000-2000: -0.09342** 2000-3000: -0.7956** 3000-5000: -0.09500** 5000-7000: -0.07944** 7000-15000: -0.09579** Over 15000: 0.05404
Duncombe, Lukemeyer, and Yinger (2006)	100-150: -0.12166** 150-250: -0.22828** 250-500: -0.36138** 500-1000: -0.42874** 1000-1500: -0.50830** 1500-2500: -0.56852** 2500-5000: -0.56608** 5000-15000: -0.51823** Over 15000: -0.62161**

Duncombe, Lukemeyer, and Yinger (2006) part 2	100-150: -0.16098** 150-250: -0.30392** 250-500: -0.42965** 500-1000: -0.51954** 1000-1500: -0.59337** 1500-2500: -0.64389** 2500-5000: -0.70801** 5000-15000: -0.69755** Over 15000: -0.68095**
Duncombe, Ruggiero, and Yinger (1996)	-0.5331** Enrollment squared: 0.0329**
Gronberg, et al. (2004)	-0.0809**
Hamadeh (1998)	-0.00607*
Imazeki (2001)	-0.052
Imazeki (2006)	-0.286** Enrollment squared: 0.014**
Imazeki and Reschovsky (2004a)	-0.286** Enrollment squared: 0.013**
Imazeki and Reschovsky (2004b)	-0.284** Enrollment squared: 0.013**
Imazeki and Reschovsky (2004c)	-0.28** Enrollment squared: 0.015**
Imazeki and Reschovsky (2006)	-0.28** Enrollment squared: 0.013**
Reschovsky and Imazeki (1998)	-0.593** Enrollment squared: 0.034**
Reschovsky and Imazeki (2001)	-0.182** Enrollment squared: 0.009**
Reschovsky and Imazeki (2001) part 2	-0.495** Enrollment squared: 0.028**
Reschovsky and Imazeki (2003)	-0.20** Enrollment squared: 0.01**

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 11. Education Cost Function Study Results – Students in Poverty

Article	Estimated Coefficient
Alexander, et al. (2000)	0.461**
Downes and Pogue (1994)	0.0329
Duncombe and Johnston (2004)	0.2433*
Duncombe and Yinger (1997)	1.0109**
Duncombe and Yinger (1998)	1.0109**
Duncombe and Yinger (2000)	0.8165**
Duncombe and Yinger (2001)	0.7468**
Duncombe and Yinger (2005a)	1.3071**
Duncombe and Yinger (2005b)	0.00636**
Duncombe and Yinger (2007)	0.0067**
Duncombe, Lukemeyer, and Yinger (2003)	0.97819**
Duncombe, Lukemeyer, and Yinger (2006)	0.00435**
Duncombe, Lukemeyer, and Yinger (2006) part 2	0.005688**
Duncombe, Ruggiero, and Yinger (1996)	0.8306**
Gronberg, et al. (2004)	0.2816**
Hamadeh (1998)	0.00023
Imazeki (2001)	0.026**
Imazeki (2006)	0.283**
Imazeki and Reschovsky (2004a)	0.424**
Imazeki and Reschovsky (2004b)	0.477**
Imazeki and Reschovsky (2004c)	0.57**
Imazeki and Reschovsky (2006)	0.431**
Reschovsky and Imazeki (1998)	0.004**
Reschovsky and Imazeki (2001)	0.159*
Reschovsky and Imazeki (2001) part 2	0.002**
Reschovsky and Imazeki (2003)	0.12

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 12. Education Cost Function Study Results – LEP

Article	Estimated Coefficient
Alexander, et al. (2000)	0.186
Downes and Pogue (1994)	-0.3853** Square root of LEP: 0.4241**
Duncombe and Johnston (2004)	0.4445*
Duncombe and Yinger (1997)	4.0525**
Duncombe and Yinger (1998)	4.0525**
Duncombe and Yinger (2000)	3.4684**
Duncombe and Yinger (2001)	3.2895**
Duncombe and Yinger (2005a)	0.9883**
Duncombe and Yinger (2005b)	0.00139**
Duncombe and Yinger (2007)	0.0039**
Duncombe, Lukemeyer, and Yinger (2003)	1.07514**
Duncombe, Lukemeyer, and Yinger (2006)	0.00158*
Duncombe, Lukemeyer, and Yinger (2006) part 2	None
Duncombe, Ruggiero, and Yinger (1996)	2.5236**
Gronberg, et al. (2004)	0.1915**
Hamadeh (1998)	None
Imazeki (2001)	0.629
Imazeki (2006)	Spanish speakers: 0.081 Non-Spanish speakers: 0.237
Imazeki and Reschovsky (2004a)	-0.645** Percent LEP squared: 0.499
Imazeki and Reschovsky (2004b)	-0.836** Percent LEP squared: 0.766*
Imazeki and Reschovsky (2004c)	-0.17*
Imazeki and Reschovsky (2006)	-0.634** Percent LEP squared: 0.469
Reschovsky and Imazeki (1998)	None
Reschovsky and Imazeki (2001)	0.339**

Reschovsky and Imazeki (2001) part 2

None

Reschovsky and Imazeki (2003)

0.41**

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 13. Education Cost Function Study Results – Students with Disabilities

Article	Estimated Coefficient
Alexander, et al. (2000)	0.601**
Downes and Pogue (1994)	None
Duncombe and Johnston (2004)	None
Duncombe and Yinger (1997)	0.8584
Duncombe and Yinger (1998)	0.8584
Duncombe and Yinger (2000)	1.1254*
Duncombe and Yinger (2001)	1.0947*
Duncombe and Yinger (2005a)	1.9547**
Duncombe and Yinger (2005b)	None
Duncombe and Yinger (2007)	0.0237
Duncombe, Lukemeyer, and Yinger (2003)	None
Duncombe, Lukemeyer, and Yinger (2006)	None
Duncombe, Lukemeyer, and Yinger (2006) part 2	None
Duncombe, Ruggiero, and Yinger (1996)	0.3903
Gronberg, et al. (2004)	Severe disabilities: 0.8253** Disabilities: 0.5490**
Hamadeh (1998)	0.0023
Imazeki (2001)	Severe Disabilities: 16.824* Disabilities: 1.135*
Imazeki (2006)	Percent special education students: 1.07** Percent with high-cost disabilities: 6.506**
Imazeki and Reschovsky (2004a)	Learning and speech: 1.20** Other disabilities: -0.43 Other disabilities squared: 2.71
Imazeki and Reschovsky (2004b)	Learning and speech: 0.688 Other disabilities: -3.03* Other disabilities squared: 19.1
Imazeki and Reschovsky (2004c)	Severe disabilities: -10.75** Disabilities: -0.08

Imazeki and Reschovsky (2006)	Learning and speech: 1.25** Other disabilities: -0.35 Other disabilities squared: 2.06
Reschovsky and Imazeki (1998)	Severe disabilities: 0.131* Disabilities: 0.004
Reschovsky and Imazeki (2001)	Severe disabilities: 2.106 Disabilities: -0.019
Reschovsky and Imazeki (2001) part 2	Severe disabilities: 0.076** Disabilities: 0.0003
Reschovsky and Imazeki (2003)	Severe disabilities: 3.58 Disabilities: 0.02

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

Table 14. Education Cost Function Study Results – Efficiency

Article	Estimated Coefficient
Alexander, et al. (2000)	Mean CEI: 1.41*
Downes and Pogue (1994)	None – fixed effects
Duncombe and Johnston (2004)	Per-pupil property values: 0.0000001* Per-pupil state aid: -0.00233 Median household income: 0.0000046
Duncombe and Yinger (1997)	-1.1670**
Duncombe and Yinger (1998)	-1.1670**
Duncombe and Yinger (2000)	-1.0664**
Duncombe and Yinger (2001)	Median income: 0.4231** Flypaper effect: 8.2834* Tax share: -0.2313** Percent elderly: -0.5196 Upstate suburbs: -0.0806** Upstate rural: -0.0969** Households per child: -0.1761
Duncombe and Yinger (2005a)	Full value: 0.0000** Aid: 0.8583** Income: 0.0000
Duncombe and Yinger (2005b)	Consolidated districts: 0.1478** Per pupil income: 0.13097** Per pupil property values: 0.05341** Total aid/income ratio: 0.80593** Local tax share: -0.02102 Percent of adults college educated: -0.00666** Percent elderly: -0.00347** Percent owner occupied: -0.00218*
Duncombe and Yinger (2007)	Median earnings: -.0519 Parcels per pupil: 0.1618** Population migration rate: 0.0019** Percent change in revenue limit: 0.0554* Percent categorical aid: 0.5605** Revenue limit component of adjusted income: 1.734** Categorical aid component of adj. income: -0.047 Federal aid component of adj. income: 0.43 Contributing component of adj. income: 19.47
Duncombe, Lukemeyer, and Yinger (2003)	Full value: 0.0000** Aid: 1.12073** Income: 0.0000

Duncombe, Lukemeyer, and Yinger (2006)	Per pupil income: 0.13505** Per pupil property values: 0.05599** Total aid/income ratio: 0.78701** Local tax share: -0.02146 Percent college educated: -0.00423** Percent elderly: -0.00209 Percent owner occupied: -0.00145
Duncombe, Lukemeyer, and Yinger (2006) part 2	Per pupil income: 0.16824** Per pupil property values: 0.03582 Total aid/income ratio: 1.12644** Local tax share: -0.06610** Percent college educated: 0.20811 Percent elderly: -0.42237** Percent owner occupied: -0.15041
Duncombe, Ruggiero, and Yinger (1996)	-0.993**
Gronberg, et al. (2004)	Mean ECI: 1.11*
Hamadeh (1998)	-0.0134**
Imazeki (2001)	None
Imazeki (2006)	-0.02
Imazeki and Reschovsky (2004a)	-0.008
Imazeki and Reschovsky (2004b)	-0.102*
Imazeki and Reschovsky (2004c)	None
Imazeki and Reschovsky (2006)	-0.006
Reschovsky and Imazeki (1998)	None
Reschovsky and Imazeki (2001)	-1.054**
Reschovsky and Imazeki (2001) part 2	-0.759**
Reschovsky and Imazeki (2003)	-1.08**

* indicates the variable is significant at the 10% level

** indicates the variable is significant at the 5% level

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