Assessing the Costs of K-12 Education in California Public Schools

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December 1, 2006

* The author gratefully acknowledges the support of the Bill and Melinda Gates Foundation, the William and Flora Hewlett Foundation, the James Irvine Foundation and the Stuart Foundation. I am also grateful to Bruce Baker for providing the latest version of his tables and for helpful discussion. This report also benefited from discussions with Eric Brunner, Susanna Loeb and other researchers involved in the Getting Down to Facts project.

Executive Summary

The *cost* of education can be defined as the minimum amount of money that a school district must spend in order to achieve a given educational outcome, such as reading at a grade-appropriate level. Costs generally differ across school districts for reasons that are outside the control of local school boards or state governments, such as the number of children with “special needs”. All else equal, districts with higher costs will need to spend more than districts with lower costs in order to achieve any given outcome. While many states, including California, have some adjustments for cost factors in their school finance formulas (such as weights and categorical programs for special education, etc.), these adjustments are often ad hoc, and most state systems of school finance do not attempt to explicitly link district revenues with costs or student outcomes.

The objective of this study is to estimate the costs for California districts to meet the achievement goals set out for them by the state and examine how these costs vary across districts with different student characteristics. The primary methodology used is the econometric cost function approach. A cost function for K-12 education is estimated for California and used to provide estimates of base costs (i.e., per-pupil costs in a district with relatively low levels of student need) and marginal costs (i.e., the additional costs associated with specific student characteristics) for poverty, English Learners and special education. These results are compared with the findings from cost studies in other states, which have used a variety of methods, and then used to analyze whether the current system appropriately accounts for cost differentials across districts.

It is important to recognize that California’s current school finance environment imposes constraints on districts that may lead to statistical noise in the estimation of the cost function. As a result, the relationship between spending and outcomes is not estimated very precisely. This is apparent from the comparison analysis, as the base cost estimate generated by the California cost function is fairly low when compared to the range of estimates generated in other states and with other methodologies; for example, the California estimate of base costs (after being adjusted for time and regional variation), is lower than base costs in all but one of the twenty-one comparative studies that use alternative methodologies. Using the cost function results, it is estimated that overall, districts need an additional $1.7 to $5.7 billion in order to achieve current accountability standards but this is almost certainly biased downward.

One indication that the cost function under-states true costs comes from a parallel estimation of a production function. In theory, the cost function and production function are merely inverses of each other and should therefore produce similar predictions. However, this does not happen with the California data. For example, take a district that is spending $8000 and has an API of 750. Using the cost function estimates, a fifty-point increase in API (to 800) would appear to require an increase of only $181 per pupil. Using the production function estimates, the same fifty-point increase in API would require an increase of $11,600 per pupil, and total estimated costs from the California production function are $1.5 *trillion*. The difference in predictions from the two functions is consistent with the presence of unobservable inefficiency that is negatively correlated with test scores (more inefficient districts have lower performance) and positively correlated with spending (more inefficient districts spend more). The 'true' cost lies somewhere in between the two estimates but will depend on the correlations between the unobservable inefficiency and test scores or spending.

At the same time, the cost function estimates of *marginal* cost (i.e., the additional cost for specific factors such as poverty) are more consistent with other studies in California that use alternative methodologies, though they are somewhat lower than those found in studies from other states. It is also noteworthy that even the conservative cost function estimates imply that the current system of school finance appreciably under-funds districts with the highest needs. For example, among the districts with the highest levels of poverty, actual per-pupil expenditures are an average of sixteen percent lower than the estimates of cost-adjusted spending.

I. Introduction

For the last three decades, school finance reforms throughout the country have attempted to equalize property tax burdens and/or per-pupil expenditures across districts. In California, reforms in response to *Serrano v. Priest* focused almost entirely on equalizing school spending per pupil across districts, with much success. However, in more recent years, there has been a growing emphasis on accountability and the issue of whether districts have sufficient resources to achieve particular educational outcomes. Fueled by a number of court cases, this shift has been accompanied by a recognition that equal dollars will not necessarily result in equal educational outcomes as long as some districts face higher costs than other districts.

The *cost* of education can be defined as the minimum amount of money that a school district must spend in order to achieve a given educational outcome, such as reading at a grade-appropriate level. Costs generally differ across school districts for reasons that are outside the control of local school boards or state governments, such as the number of children with "special needs". Other factors may include cost-of-living differences that increase the amount of money needed to attract good teachers in some regions, or the diseconomies of scale associated with very small and very large districts. All else equal, districts with higher costs will need to spend more than districts with lower costs in order to achieve any given outcome. While many states, including California, have some adjustments for cost factors in their school finance formulas (such as weights and categorical programs for special education, etc.), these adjustments are often ad hoc, and most state systems of school finance do not attempt to explicitly link district revenues with costs or student outcomes.

The objective of this study is to estimate the costs for California districts to meet the achievement goals set out for them by the state and examine how these costs vary across districts with different student characteristics. The primary methodology used is the econometric cost function approach but I will also synthesize the findings from cost studies in other states, which have used a variety of methods. In the next section, I discuss the primary methodologies that are generally used to estimate educational costs, with a more detailed discussion of the econometric approach used in this study. Section III details the data that will be used in estimating the cost function for California, as well as a descriptive analysis of the distribution of spending and performance outcomes in California. Section IV presents the cost function results and Section V compares these results to cost function findings in Texas and New York. Section VI synthesizes the findings from cost studies using alternative methodologies and compares these to the results using cost functions. Finally, Section VII discusses how this information might be applied to California and discusses a problem with using the cost function methodology in California that leads to under-estimates of the total costs.

II. Background

An increasing number of studies have now been conducted in various states, all designed to provide information about the costs of providing a high-quality K-12 education. As mentioned, the cost of education is the minimum amount of money that a school district must spend in order to achieve a given educational outcome. Thus, costs are specifically linked to outcomes, and *costs* can differ from *spending* if districts choose to spend more than the minimum necessary to obtain a stated objective. It can also be helpful to consider the total cost for a given district as the sum of two components: base cost and marginal costs. Base cost refers to the cost for a low-need district to achieve the state standard; that is, a district with relatively low levels of poverty, few English Learners, etc. Base cost may vary across time or across states because of differences in standards (e.g., if states raise their performance standards, the base cost will increase) or differences in regional price levels (e.g., southern states may have lower base costs than northeastern states), but in a given year and state, the base cost represents the minimum bar for per-pupil spending within that state.

Marginal costs refer to the additional costs associated with specific student or district characteristics (such as poverty, English Learners and special education), above and beyond the base cost in a district with none of these special needs. For example, suppose that the marginal cost of a student in poverty is determined to be ten percent. If the base cost for a student with no special needs is $8000 per pupil, then the cost for a poor student is $8800, or ten percent more. Many state aid formulas try to account for marginal costs by assigning extra weight, and thus extra revenue, to students in certain categories. Following the same example, a poor student may be given an extra weight of 0.1 and this generates ten percent more revenue for that student, relative to the revenue allocated for a non-poor student.

A number of cost studies also discuss average costs which, as the term suggests, represent the costs associated with an 'average' district in a state, i.e., a district with the average number of students in poverty, the average number of English Learners, etc. Because these average costs already incorporate some of the marginal costs associated with student need factors, they are always higher than base costs in a given state. Average costs can be a useful benchmark because they roughly represent the middle of the distribution for a state. However, because the definition of 'average' can vary dramatically across states (for example, the average district in Nebraska looks very different from the average district in California), any attempt to compare average costs across states must contend with the additional complication of trying to account for these differences in the level of average student need. In this study, I report average costs for easier comparison with other California estimates, but will focus more on base costs and marginal costs, which are more easily compared across states.

If policymakers wish to design a school finance system that reflects the costs of achieving state performance standards, they will need estimates of both base and marginal costs. Researchers in other states have used a number of different methodologies to estimate educational costs, but most studies involve one of four methodological approaches: professional judgment, evidence based, successful schools, or the cost function (or "econometric") approach.[1]

Researchers conducting a "professional judgment" study organize from one to several teams of educators within a state and ask them to design an educational program that will achieve the state's educational goals. Once team members have identified the required set of inputs, researchers determine how much money will be needed to fund those inputs; typically, the panels themselves are not required to consider how much their suggested program will cost.[2] The "evidence-based" approach is similar except that the source of expert opinion is not panels of professionals but research evidence on strategies that have been proven effective. Both professional judgment and evidence-based studies have the appeal of transparency; i.e., not only do they provide a total cost of education in dollars, but they specify *how* those dollars are to be spent. However, the simplicity of these methods also means that the estimated costs may be only weakly connected to specific outcomes. This could be considered a strength, as it allows for the consideration of performance outcomes that may be difficult (or impossible) to measure, but it could also be considered a weakness in a policy environment focused increasingly on specific

[1] See Duncombe, Lukemeyer and Yinger, 2004, and Baker, Taylor and Vedlitz, 2004, for a full discussion of the advantages and disadvantages of each of these methods. Note that in the following discussion, I highlight the most commonly-cited benefits and drawbacks of each approach; these may or may not apply to any individual study.

[2] See AIR (2006) for a description of a traditional professional judgment study conducted in California. Sonstelie (2006) describes a modification of the professional judgment approach, applied in California, in which surveys are used to reach a much larger sample of professionals and those professionals are given specific budgets.

accountability standards. Finally, although some professional judgment and evidence-based studies address the issue of extra resources that may be required for certain types of students, such as those from low-income families or with limited English proficiency (i.e., marginal costs), it may be problematic to estimate costs for actual districts that differ significantly from the 'typical' school or district for which the original program was designed.

Cost studies using the "successful schools" approach start by identifying a set of high-performing schools (with performance generally based on the state's educational goals). Estimates of the cost of providing a high-quality education are then based on the lowest level of per-pupil spending among this set of successful schools. This approach has the advantage of directly linking costs and outcomes, but generally says little about how resources ought to be allocated within the school or district. A few successful schools studies have addressed the issue of marginal costs for low-income students by identifying high-performing schools among schools with high proportions of students in poverty but, as with the professional judgment and evidence-based methods, it may be challenging to extrapolate to districts that are significantly different from the original set of successful schools.

The cost function, or "econometric", approach utilizes data on per-pupil school expenditures, student performance, and various characteristics of students and school districts, from all school districts within a state. Using regression techniques, the researcher estimates an equation that best fits the available data. Generically, a cost function can be represented by the following equation:

(1) $$S_{it} = h(T_{it}, P_{it}, Z_{it}, F_{it}, \varepsilon_{it}, u_{it}),$$

where per-pupil expenditures in district *i* in year *t* (S_{it}) are specified as a function of public school performance (T_{it}), a vector of input prices (P_{it}), the characteristics of the student body

(Z_{it}), other characteristics of the school district such as its size (F_{it}), a vector of unobserved characteristics of the school district (ε_{it}) and a random error term (u_{it}). Once a functional form is chosen for equation (1), it can be estimated with district-level data for a given state.[3] The resulting coefficients indicate the contribution of various district characteristics to the cost of education, holding constant the level of performance. The cost function can then be used to predict the cost of any given level of performance; this is done by multiplying the cost function coefficients by the actual values of the student and district characteristics while setting the performance variables equal to the desired level. Thus, for each district, we can predict the minimum amount of money necessary to achieve various educational performance goals, given the characteristics of the school district and its student body. Base costs are easily determined as the minimum costs predicted using the cost function. Marginal costs are also easily determined since the coefficients quantify the additional spending required for higher values of a specific cost factor, holding constant everything else.

Although generally considered more complex than other methods, the econometric approach is the only methodology that directly quantifies the relationship between outcomes and costs for districts with a variety of characteristics. This approach is particularly appealing for California, given the tremendous diversity in both student and school district characteristics. However, as with the successful schools method, cost functions are ‘black boxes’ that do not illuminate how districts should organize their resources. Furthermore, both the cost function and successful schools approaches derive their cost estimates from observed data under the pre-existing system; the resulting estimates thus implicitly assume no structural changes in the

[3] In theory, a cost function could be estimated with school-level data. However, in practice, budgets are developed and reported at the district level.

institutional structure of the system. That is, the cost estimates assume that districts will continue to operate under the same constraints they have operated under in the past.

Finally, cost functions are also limited by the same problems that can plague any statistical analysis, including errors in estimation and availability of high-quality data. In particular, it is assumed that districts organize their resources in order to maximize performance, given a set budget (or conversely, minimize spending, given a set performance target), and that the included variables capture all factors that may reasonably affect costs. For reasons discussed below, California poses particular challenges for an econometric analysis. Therefore, I also apply what we have learned from cost functions in other states to complement the cost function for California. In particular, cost functions have been estimated for Texas and New York, two states whose size and diversity are the most comparable to California's. The comparisons will be based on the cost function estimates in Imazeki and Reschovsky (2006) and Gronberg, et al (2004) for Texas, and Duncombe, Lukemeyer and Yinger (2003) for New York.

Furthermore, I will also attempt to synthesize information from cost studies in other states that have used alternative methodologies, and apply that knowledge to assessing costs in California. These issues will be discussed in greater detail in Section VI.

III. Data and methods

Following the approach found frequently in the literature, I assume that equation (1) above takes the specific log-linear form and fit a cost function using data for all K-12 districts in California. The dependent variable is general fund per-pupil expenditures for 2004-05, excluding spending on transportation and food services, as these categories are not directly related to student academic performance. The model is estimated using ordinary least-squares regression.[4] With the exception of the teacher salary index described below, all of the data used in the analysis is from the California Department of Education (CDE), with most variables downloaded from the CDE website.

Student Performance Measures

Although student performance can, in principle, be measured in various ways, most states rely on standardized exams to measure the effectiveness of school districts in improving the academic performance of their students. Furthermore, the federal No Child Left Behind Act of 2001 (NCLB) explicitly requires that all states develop accountability systems based on assessment tests. For several years now, California has tested students in several grades, using the Stanford-9, a nationally-normed test, as well as exams tailored specifically to California Standards (CST). Performance on these exams is summarized in the Academic Performance Index, a weighted average of exams in all subjects and for all grades.

For this study, I use the Academic Performance Index (API) as the primary measure of student achievement. I also estimate versions of the cost function where the API is replaced with the percent scoring at the proficient level or above on the California Standards Tests in English Language Arts and Mathematics.[5,6] In addition, it should be noted that both *No Child Left Behind* and the California accountability system explicitly require districts to meet student performance

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[4] In a number of previous studies, cost functions have been estimated with two-stage least squares where the outcome variables are treated as endogenous (i.e., simultaneously determined). Given the nature of California school finance, the endogeneity of performance and spending is much less clear than in other states. Using a variety of instruments (including median income, number of housing units, percent of students tested, and/or parental education) as instruments, standard specification tests could not reject the exogeneity of the California performance measures. I therefore proceed with OLS.

[5] Because the Academic Performance Index is based on a weighted average of the CSTs, including them both at the same time creates statistical noise that prevents valid interpretation of the results.

[6] I also estimated a specification that used the four-year dropout rate as the outcome measure. This variable is subject to a great deal of measurement error, and is obviously only available for high schools, and is therefore not part of the main analysis. Full results are reported in the Technical Appendix.

standards not only for all students, but separately for subgroups of White, African-American, Hispanic and economically disadvantaged students. Since performance among the African-American, Hispanic and economically disadvantaged subgroups is typically lower than the average, it will likely take additional resources to ensure that all of these sub-groups achieve their goals. However, including separate sub-group performance measures in the cost function regression can be problematic because they are quite highly correlated; this high correlation creates statistical noise that prevents precise estimation of the model. Thus, although I estimate a specification that includes the sub-group measures, those estimates should be taken as much more suggestive than definitive.

Teacher Cost Index

Teachers are the single most important factor in the production of education[7] and not surprisingly, teacher salaries account for the largest share of school expenditures. It is important to recognize that teacher payrolls are determined both by factors under the control of local school boards, and factors that are largely outside of their control.[8] In setting hiring policies, districts make decisions about the quality of teachers that they recruit and these decisions have obvious fiscal implications. For example, a district can limit its search for new teachers to those with advanced degrees, to those with high grade-point averages or to those with a certain number of courses in their teaching specialty. Teacher salary levels are generally determined through a process of negotiation with teacher unions, and school boards have a substantial impact on the outcome of these negotiations. At the same time, the composition of the student body, working conditions within schools, and area cost-of-living play a potentially large role in determining the

[7] See, for example, Rivkin, Hanushek and Kain (2005).
[8] See Rose (2006) for a fuller discussion of the determinants of teacher salaries in California.

salary a school district must offer in order to attract teachers of any given quality. Some of these factors will be reflected in the other student and district cost variables.

The goal of the cost function analysis is to isolate factors that contribute to higher levels of education spending, but that are outside the control of local school districts. To accomplish this with respect to salaries, I use a predicted salary developed by Heather Rose (2006) to create an index of teacher costs in California. Her index isolates variations in compensation arising from uncontrollable district characteristics (such as area cost of living) from variations arising from factors that districts can influence (such as teacher experience and educational background).[9]

Student Characteristics

There exists a large literature that has demonstrated that it costs more to educate students from economically disadvantaged families, students with various mental and physical disabilities, and students with limited proficiency in English, relative to students without these disadvantages.[10] In fact, these higher costs are recognized in many of California's categorical aid programs. To measure the number of children from economically disadvantaged families, I use the percentage of students who qualify for the federal government-financed Free and Reduced Price Lunch program, provided by the California Department of Education. To minimize problems of random errors in the data, I use a two-year average for this variable (from 2003-04 and 2004-05).[11]

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[9] I refer the reader to Rose's paper for a full discussion of the estimation, construction and analysis of this salary index.

[10] Cost function studies that have found that school districts with high concentrations of students with these characteristics face higher than average costs include Downes and Pogue (1994), Duncombe, Ruggiero, and Yinger (1996), Duncombe, Lukemeyer and Yinger (2003), and Imazeki and Reschovsky (2004).

[11] To further reduce measurement error, I also drop eighteen districts in which the standard deviation of this variable across the two years is greater than 40.

I include two measures of disabilities. The first is the percentage of students who are classified as having any kind of disability; the second is the percentage of students who have a disability that may be particularly high-cost, such as autism, deaf, deaf-blind, orthopedic impairment, traumatic brain injury, visual impairment, or multiple disabilities. I also include two measures of the percentage of students in each district who have been identified as English Learners (ELs). The vast majority of ELs in California are Spanish speakers but there are also over fifty other languages represented in California schools. In order to capture the economies of scale that likely accompany the significantly higher proportion of Spanish speakers, I include separate two-year average measures for the percentage of students who are classified as English Learners with a primary language of Spanish, and the percentage who speak some other language.

District Characteristics

To account for the possibility that different levels of resources may be needed to provide a high school education as compared to an elementary school education, I include the proportion of each school district's student body that is enrolled in high school. Previous research on the question of whether higher proportions of students enrolled in high school leads to higher average costs has been inconclusive, with some studies finding higher costs and other studies finding lower than average costs.[12]

There exists a long history of research on economies of scale in public education. In a recent review of this literature, Andrews, Duncombe, and Yinger (2002) present strong evidence that small school districts have higher costs per student than other districts. They also provide

[12] An alternative specification that included separate indicator variables for high school districts and elementary districts was also estimated; these variables were never statistically significant and their inclusion or exclusion had no impact on the coefficients of the other variables. These were therefore dropped from the final specification.

some evidence that per-student costs are higher in extremely large districts, although the results are less conclusive. Following standard practice, to reflect potential diseconomies of scale associated with both small and large school districts, each district's enrollment and enrollment-squared are included in the cost function.[13]

Efficiency

Some school districts may have higher per-pupil expenditures, not because of higher costs, but because they are not using their resources efficiently. Although on a conceptual level, it is easy to discuss enhancing efficiency by minimizing costs, the actual measurement of efficiency in the context of elementary and secondary education is exceedingly complex. In order to accurately measure school district efficiency, it is necessary to accurately identify and quantify both the educational goals of each school district and the factors that contribute to the achievement of these goals and to school district expenditures. A number of authors have used complex statistical techniques to attempt to identify spending that is high, relative to spending in districts with similar performance and costs.[14] The measurement of school district efficiency using these statistical methods is, however, highly sensitive to the way that school district goals are measured. For example, in school districts that emphasize vocational education, or arts and music – subjects not directly measured by standardized tests – money spent on these alternative educational objectives will be counted as inefficient spending.

[13] An alternative specification that included a cubic term for enrollment was also estimated (allowing for higher costs in small, but not large, districts). This term was never statistically significant and its inclusion had little impact on the coefficients of the other variables. It was therefore dropped from the final specification. Also, including indicator variables for enrollment categories, rather than enrollment and enrollment-sqaured, mirrored the results with the continuous enrollment measures.
[14] See, for example, Duncombe, Ruggiero and Yinger (1996), McCarty and Yaisawarng (1993), and Deller and Rudnicki (1993).

Rather than attempting to measure efficiency directly, I address the issue of efficiency by assuming that school districts will operate more efficiently if they face a competitive local educational market. Lori Taylor (2000), after reviewing the literature on government competition, concludes that, "Almost across the board, researchers have found that school spending is lower, academic outcomes are better, and school-district efficiency is higher where parents have more choice in their children's education provider." (p. 7) To measure public school competition, I use a Herfindahl index. This index, which is fairly standard in the literature on school choice (e.g., see Hoxby, 2000), is constructed on the assumption that metropolitan statistical areas can be used to define local "markets" for education.[15] The index increases with the amount of competition so if district efficiency is correlated with the amount of competition that the district faces, then we would expect spending to be lower in districts with higher values of the Herfindahl index. While the use of the Herfindahl index may provide an underestimate of school district inefficiency, more complex methods almost certainly provide overestimates.[16]

Descriptive Statistics

[15] A Herfindahl index for school districts in market k can be calculated using the following formula:

$$\text{Herfindahl Index} = 1 - \sum_i \left(\frac{enrollment_i}{enrollment_k} \right)^2$$

For a market with just one district and no competition, the index will equal zero. For a market with *n* equally-sized districts, the index will equal 1 – 1/n. Thus, the index approaches 1 as the number of districts, and presumably competition, increases.

[16] That is, the aforementioned statistical methods for directly measuring inefficiency assume that any spending on alternative objectives is 'inefficient' and thus should be completely removed from the analysis. The more indirect method of including a Herfindahl index does not specifically remove spending on alternative objectives; instead such spending is considered statistical noise and, if large, may decrease the precision of the resulting cost estimates.

Table 1 shows summary statistics for each of the variables included in the cost function.[17] The final estimation sample includes the 937 districts with complete data.[18] To see the current distribution of spending and performance more clearly, Table 2 shows a breakdown across districts with varying characteristics. The first four panels show average spending and average performance across quintiles of percent of students in poverty, percent ELs, percent in special education, and district size. The quintiles are based on student enrollment so each quintile contains twenty percent of the students in the state (the third column shows the number of districts in each quintile) and the averages are pupil-weighted; thus, these numbers can be considered the spending and performance experienced by the average student. The bottom panel shows the distribution across urban categories.

Although Table 1 shows that there is significant variation in spending per pupil across the state as a whole, Table 2 reveals few consistent patterns in the distribution by student characteristics. Spending is highest in the smallest and largest districts, which is also reflected by the higher spending in districts located in large cities and non-metro rural areas. Although per-pupil spending is slightly higher in districts with higher proportions of students in poverty, English Learners or special education, in each case, the top quintile does not have the highest average spending.

In contrast, the pattern in performance is highly consistent: as the percent in poverty, percent ELs, and district size all rise, average API and CST scores consistently fall, as does the

[17] The measure of spending shown in Table 1 (that used in the cost function regression) is 2004-05 district general fund expenditures, minus expenditures for food, transportation and juvenile court schools. Because of the way that the variable is defined, the numbers are slightly different from other per-pupil spending numbers reported elsewhere by the CDE. Per-pupil spending elsewhere in the paper has food and transportation added back in for easier comparison with other estimates of total spending.

[18] The CDE only reports test results for sub-groups if there are more than five students in the group. Several schools and districts are therefore missing results for one or more of the sub-groups. In order to include these in the regressions, missing data were re-coded to zero and missing data flags for each of the sub-groups were also included, equal to one if the scores for that sub-group were missing, equal to zero otherwise.

graduation rate. The combined effect of these variables is also seen in districts in large cities; these tend to have higher values of all these cost factors, and they have the worst performance. The pattern is not as strong for special education; however, many disabled students take an alternative assessment and their performance is not necessarily included in the test score measures shown here.

IV. Results

The patterns highlighted in Table 2 are consistent with the intuition behind cost function estimation: equal spending will not result in equal outcomes if some districts face higher costs. Although there is a significant amount of variation in per-pupil spending across districts in California, that variation does not appear strongly connected to costs and it is therefore not surprising that larger districts, and/or districts with more high-need students will see lower achievement. I now turn to the results from the cost function estimation to quantify these relationships more explicitly.

Table 3 contains the cost function regression coefficients.[19] Note that the log-linear specification means that the coefficient on a particular variable can generally be interpreted as representing the percentage change in the dependent variable associated with a one percent change in that independent variable (or one percentage point for variables that are already in percentages). The specifications in columns 1 and 3 use the growth rates of the overall API and CST percent proficient as the measure of performance; the specifications in columns 2 and 4 also include outcomes for the economically disadvantaged, African-American and Hispanic sub-groups. When the sub-groups are included, the coefficients on those variables are generally

[19] The OLS regression is pupil-weighted and robust standard errors are clustered at the level of the Metropolitan Statistical Area.

estimated imprecisely; this is not surprising, given that the correlations among all the outcome variables is quite high (ranging from a correlation of 0.68 between the African-American API and the overall API to a correlation of 0.9 between the API for economically disadvantaged and Hispanic students). Focusing on the overall measures, the coefficients on average performance indicates that it generally costs more to achieve a given amount of progress on the state exams; however the magnitude of the effects are quite small. Using just average API, the coefficient in column 1 suggests that a 10 percent increase in API is associated with only a 3.4 percent increase in spending per pupil. To use a more concrete example, a district that has an API of 750 and is currently spending $8000 per pupil would need only $181 more per pupil to get up to an API of 800, all else equal.

Most of the student and district cost factors show statistically significant effects. In particular, costs rise with the percentage of students eligible for free and reduced-price lunch, the percentage of students in special education (with much larger effects for students with severe disabilities), and the percentage enrolled in high school, as well as regional teacher wage costs. The magnitude of all these effects is quite similar across the four specifications, which is perhaps not surprising, given that the API is largely a weighted average of the CST scores. Also not surprising is that the marginal effect of poverty is somewhat higher when the sub-group scores are included, reflecting the additional resources necessary to ensure that those students specifically are able meet performance targets.

Consistent with previous studies, there are economies and diseconomies of scale with respect to district size; these estimates suggest that average costs are lowest in a district with 28,992 students but costs begin to rise again above that point. The proportion of English Learners is also positively related to spending, although neither of the EL variables is statistically significant at conventional levels. These coefficients suggest that non-Spanish ELs are more costly than Spanish-speaking ELs; this may reflect the economies of scale associated with the much larger population of Spanish speakers.

Finally, the Herfindahl index is intended to provide a measure of school district efficiency. The negative coefficent indicates that, as expected, school districts located in areas of the state where there is more competition among schools, tend to operate more efficiently (i.e., spend less to achieve the same outcome). However, this variable is not statistically significant.

Cost Estimates

The cost function coefficients can be used to predict the cost of various outcome goals for each district. This is accomplished by setting the performance measure equal to the desired target, setting the cost factors equal to their actual values for each district, and multiplying by the estimated coefficients. In order to ensure that the predicted cost is for a district operating relatively efficiently, the Herfindahl index is set equal to the value at the ninetieth percentile (0.966) for all districts. Table 4 shows the resulting cost estimates for a performance target of at least 800 on the API. That is, for districts that are below 800, the API variable is set equal to 800 while for districts that are already at or above this standard, the estimated cost is simply the cost to maintain their level of performance (e.g., if a district's 2004-05 API is, say, 850, then the API variable is set equal to 850).

Recall that the measure of spending used in the cost function estimation excluded spending for food and transportation, as these expenditures that are not likely to vary with performance. In order to generate a measure of spending that is comparable to other estimates of total spending, I add back in the food and transportation expenditures that were originally excluded. The resulting estimates range from a low of $5,832 to a high of $23,818, with an average of $8,268. However, ninety percent of districts fall within the tighter range between $6,678 and $11,011. The total cost for all districts, summed together, is $45.1 billion.

For the 707 districts that are currently achieving API scores below 800, part of their costs can be attributed to the improvement they must make in performance. However, the estimated cost function can also be used to generate a prediction of the cost for districts to simply maintain their current level of performance; the calculation is the same as the preceding estimate but the growth rate is held equal to zero for all districts. The total cost for all districts to sustain their current API scores sums to just over $43.4 billion. Thus, relative to simply maintaining current performance, districts need an *additional* $1.7 billion. It is important to note that this $1.7 billion estimate is driven entirely by the coefficient on the performance variable. That is, all other characteristics of the districts are being held constant and the only thing changing is the API score so these additional costs are simply the costs for districts to increase performance up to 800.

V. Cross-study comparisons: Cost function studies

As discussed in Section II, the cost function approach is one of four methodologies that have been used to evaluate the costs of adequacy, the alternatives being professional judgment, successful schools and evidenced-based studies. Cost function analysis is the only methodology that explicitly quantifies the relationship between outcomes and costs for districts with a variety of characteristics and is therefore particularly well-suited to a state as diverse as California. However, the unique nature of school finance in California also raises potential problems for cost function estimation. The theoretical model that underlies cost functions assumes that districts spend their resources in order to maximize student performance on the specified outcomes. To the extent that districts do not, or can not, spend revenues efficiently, the cost function will not be estimated with much precision.[20] In addition, in California, district revenue that is subject to revenue limits is fairly uniform across districts; much of the variation in district revenues comes from categorical aid programs (see Loeb, Grissom and Strunk, 2006). Many of these programs carry specific requirements about how the money is spent so that in practice, districts may have relatively little discretion over how to use funds, even if the prescribed use is not the least-cost way to achieve the performance goals. Finally, some districts have substantial revenue from charitable contributions that are not reported in the official budget data maintained by the California Department of Education (see Brunner and Imazeki, 2004), and thus not included in the expenditures used to estimate the cost function. All of these issues create statistical noise and imprecision in estimating the cost function for California.

Given these concerns, it would be helpful to examine how the cost function results in California compare to the results in other states and using other methodologies. In this section, I compare the California cost function estimates with results from cost function studies in Texas and New York; in the next section, I turn to the results using alternative methodologies. It is important to keep in mind that in any comparison of results across states and methodologies there are many factors that make direct comparisons difficult; as Baker puts it, the numbers produced by various studies "should be viewed cautiously as an eclectic fruit bowl, including apples, oranges, kiwis, mangoes and a variety of other incomparable produce" (Baker, 2006,

[20] Recall that in this context, any spending on objectives other than the specified outcomes (in this case, performance on standardized exams) would be deemed 'inefficient,' even if those outcomes are considered perfectly valid by the community. For example, spending on music, art, athletics or vocational education all may be considered reasonable uses of resources but they also may have very little impact on the test scores included in the API. Although this spending may be justified, it creates statistical noise in the estimation of the cost function.

page 15).[21] As one example, base costs from different states may legitimately differ because they are based on different outcome measures and standards. Comparisons across methodologies are further complicated by the myriad differences in the basic assumptions underlying the various approaches.

Even when comparing estimates derived using the same methodology, there are many reasons why the results may differ across studies. Because the econometric method relies on statistical analysis of pre-existing data, rather than the expert opinion of professionals or consultants, it is sometimes considered more 'objective' than other approaches. However, as discussed in Imazeki and Reschovsky (2005), in any empirical analysis, there are still a number of choices that the researcher must make. For example, before estimating a cost function, one must first specify a functional form (e.g. linear, log-linear, etc.), and choices must be made about which student performance, and school district and student characteristics to include, as well as how to define those variables. Although these choices are guided by an underlying model of public decision-making, and assumptions about cost-minimization, researchers still have considerable latitude in choosing specific variables, functional forms and estimation methods. When combined with the issues of statistical precision raised previously, one should not expect the results of different cost function studies to generate identical estimates of base and marginal costs. That said, we certainly would hope to find similar patterns, and for estimates of marginal effects to fall at least in the same ballpark. And to the extent that there are differences, we should be able to explain those differences in a rational way.

With these caveats in mind, Table 5 shows the distribution of predicted costs from the cost function for California as well as two studies in Texas and one in New York, from Imazeki and Reschovsky (2006), Gronberg, et al (2005), and Duncombe, Lukemeyer and Yinger (2003),

[21] See Baker (2006) for a full discussion of the difficulties inherent in cost study comparisons.

respectively. In each state, predicted costs have been used to generate a cost index where an index value of 100 corresponds to the district with median costs (i.e., half of the districts in the state have higher predicted costs and half have lower predicted costs). This median cost is shown in the bottom row of the table. Note that in order to compare dollars across states and time, all cost estimates in Tables 5 have been adjusted using the National Center for Education Statistics' Comparable Wage Index, in which 1999 is the base year (see Taylor and Fowler, 2006). Table 5 also reports the minimum, or base, cost for each state.[22]

The California estimate of base costs is significantly higher than one of the Texas estimates but falls between the other Texas estimate and the New York estimate. As noted, there are many reasons why the dollar value of cost estimates for different states may vary; it is therefore more useful to focus on the distribution, which is captured by the cost index. And as Table 5 shows, the distribution of the California estimates is relatively consistent with the distribution of costs found in the other states, particularly both Texas studies.

Student Weights

Since the coefficients of the cost function specifically isolate the effect of each variable on spending, holding constant other factors, cost functions are particularly useful for determining marginal costs, i.e., the additional cost of factors such as poverty, English Learners and special education, above and beyond the base cost. One advantage of cost indices, such as those shown in Table 5, is that they capture all of the marginal costs in one number. As discussed in Ladd and

[22] It is also possible to use a cost function to estimate a base cost for a hypothetical base district by setting all the cost factors equal to zero (or the minimum value possible). This will generally predict a cost that is lower than any observed district. However, as we try to predict using values that are farther and farther away from the estimation sample, we have less and less confidence in their accuracy. A simpler approach is to take the district in the sample that has the minimum predicted costs and use that as the 'base' cost.

Yinger (1994), this sort of cost adjustment could be incorporated into a basic foundation aid formula in a relatively straight-forward way.

Another way to think about marginal costs is in terms of pupil weights for specific cost variables. As mentioned in Section II, many states' school aid formulas assign extra weight to students in certain categories; however, the values assigned to those weights are often ad hoc, determined in a political environment, with little relation to actual costs. Alternatively, cost functions can be used to generate pupil weights that are directly linked to the marginal cost of a particular variable, controlling for other costs and the performance objectives. For example, if the marginal cost of poverty is determined to be $1000 and the base cost is $5000, then the poverty weight is 0.2 (=1000/5000), implying that poor students require twenty percent more resources. Such a weight can also be generated for ELs, special education, or any other variable in the cost function. See the Technical Appendix for a detailed discussion of calculating weights using the cost function.

The pupil weights generated from the California cost function are shown in the bottom panel of Table 5. Pupil weights from the Texas and New York cost function studies are also reported, when available.[23] It was mentioned earlier that cross-study comparisons can be complicated by the different choices that researchers make; that becomes apparent here, since differences in the cost functions estimated in each state have large implications for the resulting pupil weights. For example, the 2004-05 Texas study and the New York study do not include separate measures of students with severe disabilities; it is thus not possible to calculate a

[23] Weights for Texas, 2004-05, are based on this author's calculations, following the same procedure as in California. Weights for Texas, 2002-03, are from Gronberg, et al, 2005, and are based on those authors' calculations of the marginal cost for each variable, for an average district. Weights for New York are taken from Duncombe and Yinger (2005) using a somewhat different method but that gives results comparable to the procedure used to calculate the California weights.

separate weight for these students.[24] Similarly, because I separated Spanish-speaking and non-Spanish-speaking English Learners, the weights for those students are not quite comparable to the weight for all English Learners.

Nevertheless, the general pattern that emerges is that the marginal costs generated from the California cost function for poverty and ELs are generally smaller than the marginal costs found in other states. For example, the variable that is most comparable across the states is poverty, and the California cost function implies a pupil weight for poverty that is much smaller than in Texas and New York. Indeed, the weight in New York is over three times as large. This could be explained in a few different ways. One possibility is to take the numbers at face value, suggesting that the marginal cost of poverty is simply lower in California. However, as there is no reason to believe that California educators know something about teaching poor children that educators in Texas and New York do not, this seems unlikely. Another explanation lies in the algebra of cost functions. The magnitude of the coefficient on poverty (which is what ultimately determines the pupil weight) is a function of the variation in the dependent variable (per-pupil spending) and how that variation is correlated with variation in the percent of students in poverty. Although there is a large amount of variation in both spending and poverty rates within California, we saw in Table 2 that there is little relation between the two. If this relationship is stronger in Texas and New York, we would expect larger coefficients and bigger pupil weights. This is perhaps the largest weakness of the cost function approach overall: because the estimates are based on observed data, there is a certain extent to which the results are constrained by the current observed relationship between spending and student characteristics.[25]

[24] In the New York study, the special education variable does not include minor disabilities and thus captures something in between the two variables used in California.
[25] It is important to point out that the cost function does *not* simply repeat the state aid formula. The inclusion of test scores in the equation means that we are controlling for performance. The coefficient on poverty is based on the

VI. Cross-study comparison: Alternative methodologies

Given the drawbacks of the cost function methodology in general, it would be useful to compare the California cost function estimates to the estimates generated with other methodologies. Studies of the costs of K-12 education have now been conducted in at least nineteen other states and the majority of these have used methodologies other than the cost function approach. The most common alternative is to rely on professional judgment panels. Successful schools studies are also fairly common while there have been only a few evidence-based studies. Bruce Baker summarized almost all available district-level cost studies for *Education Week* and much of the analysis in this section is based on the resulting table in *Quality Counts* (Education Week, 2005).[26]

As with the comparison across cost function studies, we can consider two different aspects of costs: base costs and marginal costs. All cost studies report a measure of either base or average costs in a state. Recall that base costs capture the cost of meeting state performance goals for a low-need district while average costs reflect the cost for a school with 'average' student needs; thus, average costs will always be higher than base costs in a given state. Successful schools studies typically report base costs; many professional judgment studies also report base costs but a few report average costs (or costs for a 'typical' district). Evidence-based studies have largely focused on average costs. Cost function studies typically focus on average costs but in most cases, a base cost can also be backed out from the estimates presented.[27] I

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covariance of spending and poverty, after removing the covariance between poverty and test scores. If test scores are removed from the model, the coefficient on poverty is even smaller (the magnitude drops in half).

[26] Table 6 in this section also includes a few additional studies from an updated table that Bruce Baker was kind enough to provide.

[27] Most cost function studies report cost indices rather than the cost estimates themselves. However, the cost estimate for any district can be generated by multiplying the average cost by the cost index. For example, if average costs are reported as $8000, then a district with a cost index of 0.70 has predicted costs of 8000*0.7 or $5600. As

focus here on base, rather than average, costs as these are the most comparable across states. However, keep in mind that the dollar values of even base costs from different states are based on different outcome measures and standards and thus may still vary widely, regardless of methodology.

Table 6 summarizes base costs for the twenty-one professional judgment and successful schools studies that report base costs.[28] Base costs tend to be highest in professional judgment studies, and both professional judgment and successful schools estimates appear generally higher than the cost function estimates of base cost seen in Table 5. However, there is certainly overlap among all the methods. In general, the California estimate of base costs appears to fall on the low end of the spectrum.

Studies that only report average costs are not included in Table 6 (thus excluding two evidence-based, four professional judgment, and two successful schools studies). However, cost function studies, which all report costs for a wide range of districts, generally find minimum costs that are thirty to fifty percent lower than average costs. Using this guideline, the costs estimated in the excluded professional judgment and successful schools studies fall well within the ranges of the other studies of the same type. The two evidence-based studies find costs that are on the low side, closer to the costs predicted with cost functions.

The bottom panel of Table 6 summarizes the findings on marginal costs from a sub-set of the professional judgment studies. These are based on Table 1 in Baker (2006), which reports the base cost and additional cost for poverty and LEP/EL in ten studies.[29] It should be noted that

discussed in footnote 19, it is simpler to define base costs in these studies as the predicted costs for the district with the minimum value of the cost index in each state.

[28] The data in Table 6 is based on the list of adequacy studies provided by Baker, the majority of which are listed in Education Week, 2005. All dollar values have been adjusted for inflation and regional variation in wage costs using the National Center for Education Statistics' Comparable Wage Index. The base year is 1999.

[29] Baker reports base cost and the additional dollar amount suggested in each study for poverty and/or LEP/EL. The weight here is calculated as this additional amount divided by the base cost.

a few of the studies appear to be outliers; for example, one of the studies in that table (Verstegen, 2003) finds unusually low weights in Kentucky for both poverty and LEP, while another study (Augenblick and Myers, 2001) finds an unusually high weight for poverty. When these outliers are excluded, the mean poverty weight drops from 0.52 to 0.44 and the mean LEP weight increases from 0.74 to 0.8.

Baker also makes the point that professional judgment studies tend to report higher base costs and lower marginal costs, relative to cost function studies that tend to report lower base costs and higher marginal costs. Using two studies in New York, he shows that although the base is considerably lower in the cost function study, the predicted cost for the highest-need district (putting together base and marginal costs) is quite similar under the two approaches. He notes that this “elevate the base, deflate the weight” pattern in professional judgment studies may be more politically palatable to individual districts (who would lose funding under the pattern suggested by the cost function approach) but also carries a much higher price tag that may be politically unpalatable to state legislators who must approve the funding. Interestingly, while the California cost function produces a relatively low estimate of base costs, similar to other cost function studies, it also produces relatively low estimates of marginal costs, more in line with (and even lower than) those found in professional judgment studies.

VII. Discussion

The proliferation of cost studies across the country has led to often-heated debates over the strengths and weaknesses and, ultimately, the usefulness of various approaches. These debates can be confusing for courts and policymakers, and self-defeating for researchers. However, regardless of the state studied or the methodology employed, one theme that is consistent across all of these studies is that the cost of achieving state performance standards is not the same for all districts; rather, adjustments are needed for districts with certain characteristics. Unfortunately, Table 2 makes it clear that under California's current system, district spending does not accurately reflect these differences in costs, and the proof is in the performance. The lower performance observed in high-cost districts is exactly what we would expect in a state where spending is only weakly related to costs.

Although researchers tend to agree on the need for cost adjustments, the difficulty, and debate, lies in determining the 'right' adjustments. Table 6 suggests that both the base cost and the marginal costs (at least for poverty and ELs) generated with the California cost function are fairly conservative estimates, though not completely out of the ballpark when compared to cost studies in other states. However, even these conservative estimates generate a distribution of cost-adjusted dollars that is appreciably different from California's current distribution. To get an idea of this difference, Table 7 again reports spending per-pupil across quintiles of poverty, ELs, special education, size and urban category. The table also shows Pupil-Weighted Spending per Pupil, which reports costs generated from pupil weights, applied to the base cost. That is, in a district with no costs (zero values of all cost factors) the predicted per-pupil cost is simply the base cost. For a district with non-zero costs, the marginal cost of each poor, EL and special education student is calculated using the pupil weights reported in Table 5.[30] All of these costs are summed together with the base cost for each student and those total costs are divided by the

[30] One variable that poses conceptual problems in the application of pupil weights is district size. In a review of the literature on economies of scale, Andrews, Duncombe and Yinger (2003) find strong evidence of higher costs in small districts, and somewhat weaker evidence that costs also increase for very large districts. However, there is no discussion of the marginal costs associated with size. One possibility is to assign extra weight for districts in varying size classes (e.g., districts below 200 pupils get one weight, districts with 200 to 500 pupils get a different weight, etc.). For Table 7, I simply calculate a weight for each pupil above and below the scale-efficient point (which I find to be 28,818), in the same way as for other cost factors. This weight has the value 0.002.

total number of students to arrive at a cost per pupil in each district. Finally, this cost is adjusted for differences in teacher salary costs using the teacher salary index.[31]

Not surprisingly, pupil-weighted spending generally increases with each of the cost factors and actual spending falls far short of covering costs in the highest-need districts. Even in the districts with the fewest students in poverty and the fewest ELs, pupil-weighted spending is slightly above actual spending, although the gap is much smaller. Summed up across all districts, the total cost to appropriately compensate all districts for their needs would be just over $49 billion, or roughly thirteen percent more than the cost of maintaining the status quo.

Furthermore, given that the true marginal costs of poverty and ELs are likely higher than the estimates used here, it is probable that the gap between current spending and the real cost of meeting California performance standards is significantly larger than suggested here. For example, if the weight for poverty is increased by ten percentage points, from 0.3 to 0.45 (i.e., a conservative estimate of the average weight across professional judgment studies), average pupil-weighted spending in the highest poverty quintile would increase by an additional $774 per pupil and total costs for the state would increase to $51.8 billion.

Alternative methodologies in California

All of the professional judgment and successful schools studies used to generate Table 6 were conducted in other states. As part of the Getting Down to Facts research project, at least two other estimates of costs were also generated for California using alternative methodologies. Sontelie (2006), in a modification of the professional judgment approach, uses data from a survey of 567 teachers, principals and superintendents to predict the cost for all districts to reach

[31] The cost function estimates suggest that a one percentage point change in the teacher salary index will increase total costs by 0.3 percent. Therefore, the pupil-weighted cost estimates are increased by 0.3 percent for each one percentage point increase in the teacher salary index for a given district.

an API of 800; these costs are estimated to be around $60 billion, although there is a large confidence interval around this number. Chambers, et al (2006) use a traditional professional judgment approach and find costs of $67.8 billion to $75.6 billion. As these estimates far exceed the estimates generated from the cost function, it is worth some discussion of why the difference arises.

As mentioned earlier, the cost function estimate of the additional costs for districts to reach a higher API target is driven entirely by the coefficient on the performance variable, which is relatively small. Recall the example that for a district with an API of 750, currently spending $8000 per pupil, the cost function predicts that only $181 more per pupil would be needed to get up to an API of 800, all else equal. One interpretation of this might be that dollars are extremely influential: a very small influx of revenue can lead to large increases in performance. Although many believe there is certainly a relationship between dollars and outcomes, it seems doubtful that money alone could be this powerful. A more likely explanation is that the cost function coefficient is artificially small. In the language of econometrics, it is probable that the coefficient on performance is *biased* due to some omitted characteristic of the district that is correlated with both spending and student outcomes. If there are factors that are correlated with spending and student outcomes but that are not explicitly included in the estimated model, this can create systematic error in the coefficients.[32] For example, some districts receive extra money from the state for the California School Age Families Education program (Cal-SAFE), a program for expectant and parenting students and their children. This aid increases district spending but likely has a very small impact on average district student performance; in fact, because teen-age pregnancy is more likely in lower-income districts, districts who receive the aid are likely to be

[32] See the technical appendix for a full discussion of omitted variables bias.

lower performing. Thus, this program is positively correlated with spending but negatively correlated with performance.[33]

Another way to put it is that this state program is creating inefficiency – the extra money increases spending without increasing test scores. Typically, 'inefficiency' implies that the district is somehow mis-managing resources, that administrators are not maximizing performance or minimizing costs, although they could if they chose to allocate resources differently. But in this case, the district could still be described as maximizing performance with a given budget, *within the constraints of the system*. This 'inefficiency' would not be captured very well by the Herfindahl index that is used as a control for efficiency in the cost function. The Herfindahl index, by focusing on competition, assumes that any inefficiency is at the discretion of administrators, that administrators who face stronger competitive forces will act more efficiently. However, competitive forces would have no effect on 'inefficiency' created by state regulations. This inefficiency is especially likely to be a problem in California because of the high proportion of funding, particularly for more disadvantaged districts, that comes from categorical aid with restrictions on how the money can be used.

As shown in the Technical Appendix, if this omitted variable is positively correlated with spending but negatively correlated with performance, the cost function coefficient on performance will be biased toward zero; that is, it will be smaller than the 'true' value. One way to check whether the cost function estimates are indeed subject to bias, is to turn the model around and estimate a production function. Recall equation (1), in which the cost function models spending (S_{it}) as a function of outcomes (T_{it}), input prices (P_{it}), student characteristics

[33] Note that correlation need not imply causation. Programs such as Cal-SAFE presumably exist in order to improve the outcomes of at least a few students, although perhaps indirectly, but they can still be negatively correlated with average district performance if the effect on test scores is small and the programs are more likely to be found in low-performing districts.

(Z_{it}), other characteristics of the school district (F_{it}), unobserved characteristics of the school district (ε_{it}) and a random error term (u_{it}) :

$$(1) \qquad S_{it} = f(T_{it}, P_{it}, Z_{it}, F_{it}, \varepsilon_{it}, u_{it})$$

In contrast, the production function models outcomes as a function of spending and the other variables:

$$(2) \qquad T_{it} = f(S_{it}, P_{it}, Z_{it}, F_{it}, \varepsilon_{it}, u_{it})$$

In theory, the cost function coefficient on student performance, and the production function coefficient on spending would be inverses of each other. If the data and model were perfect (i.e., correctly specified with no unobservable variables), estimates from the cost function and production function should be similar. However, if spending and test scores are both correlated with unobservable inefficiency, then the estimates in both cases will be biased. [34] In particular, if inefficiency is negatively correlated with test scores (more inefficient districts have lower performance) and positively correlated with spending (more inefficient districts spend more), then the estimate of total costs that comes out of the cost function will be lower than the 'true' value, and the estimate from the production function will be higher than the 'true' value. This is consistent with the California results: total estimated cost from the production function is $1.5 *trillion*, driven largely by a tiny coefficient on spending. Going back to the example of a district that is spending $8000 and has an API of 750, using the cost function estimates, a fifty-point increase in API (to 800) would require an increase of $181 per pupil. Using the production function estimates, the same fifty-point increase in API would require an increase of $11,600 per pupil. Where the 'true' value lies will depend on the correlations between the unobservable inefficiency and test scores or spending.

[34] See the technical appendix for a full explanation.

Thus, the cost function estimate of total additional costs for the state is almost certainly an under-estimate of the true costs. However, although the cost function produces an estimate of total costs that is significantly smaller than the other California cost studies, it is also important to point out that the different methodologies *are* fairly consistent in their estimates of the marginal costs associated with student needs. In particular, Sonstelie and Chambers, et al, both find poverty increases per-pupil costs by roughly 40 percent.

This study has attempted to provide an overview of the methods currently used to estimate the costs of attaining state performance standards. A review of the results for other states, using both cost functions and alternative methodologies, suggests that even if the cost function methodology is relatively imprecise in the California context, it provides an estimate of costs that is not entirely inconsistent with other studies, though certainly on the low end of the spectrum. Most importantly, even this fairly conservative estimate of costs suggests that much could be done in California to better align district spending with the true costs of education.

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Table 1

Descriptive Statistics
937 California K-12 School Districts
2004-05

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Spending per Pupil	$8,142	$3,099	$3,060	$36,653
2004-05 Academic Performance Index, Overall	745.2	78.8	510.6	958.6
2004-05 API, Economically Disadvantaged	674.7	50.1	505.6	883.0
2004-05 API, African-American	645.5	53.2	522.0	783.4
2004-05 API, Hispanic	669.0	48.7	491.1	825.0
2004-05 California Standards Tests, percent proficient, math and ELA average	46.4%	16.2%	8.6%	91.0%
2004-05 CST, Economically Disadvantaged	32.6%	9.2%	7.8%	69.5%
2004-05 CST, African-American	31.2%	10.7%	11.5%	68.3%
2004-05 CST, Hispanic	32.2%	10.1%	7.3%	86.5%
Teacher salary index	0.92	0.10	0.74	1.15
Enrollment	6,210	24,572	15	691,726
Percent of students in poverty*	45.9%	26.2%	0.0%	100.0%
Percent of students Spanish-speaking English Learners*	16.0%	17.6%	0.0%	94.0%
Percent of students non-Spanish-speaking English Learners*	2.0%	3.7%	0.0%	30.4%
Percent of students in special education	8.1%	4.5%	0.0%	32.9%
Percent of students with severe disabilities	0.5%	0.5%	0.0%	4.5%
Percent of students enrolled in high school	19.0%	28.2%	0.0%	100.0%
Herfindahl (efficiency) index	0.882	0.071	0.472	0.968

* Two-year average, 2003-04 and 2004-05

Table 2

Distribution by Pupil-Weighted Quintiles
Spending and Performance

California K-12 School Distircts, 2004-05

	Quintile Statistics						CST	
Quintiles	Mean	Number of Districts	Minimum Value	Maximum Value	**Spending per Pupil**	**API**	**Percent Proficient**	**Graduation Rate**
Percent of Students from Poor Families								
1	13.9%	252	0%	26.8%	$7,203	819.0	66.2%	97.7%
2	35.5	207	26.8	43.9	7,095	754.7	50.2	94.5
3	51.8	173	44.0	59.8	7,488	715.5	41.2	92.1
4	70.6	166	59.8	76.5	8,016	673.5	33.4	86.6
5	83.2	139	76.6	100.0	7,505	652.7	28.0	86.0
Percent of Students English Learners								
1	5.9%	431	0%	10.2%	$7,338	799.8	61.7%	96.8%
2	14.8	152	10.3	19.4	6,952	758.4	50.7	95.5
3	24.7	123	19.5	28.3	7,518	717.3	41.4	91.5
4	37.2	132	28.3	44.1	7,997	677.6	34.3	86.4
5	53.7	99	44.3	94.2	7,454	669.4	31.2	89.5
Percent of Students in Special Education								
1	6.8%	395	0.0%	8.3%	$7,128	734.7	45.4%	94.3%
2	8.8	123	8.3	9.2	7,202	731.7	44.1	91.7
3	9.8	137	9.2	10.3	7,133	742.1	46.8	94.5
4	10.4	72	10.3	10.8	8,300	686.8	36.6	85.4
5	11.9	210	10.8	32.9	7,770	733.2	44.5	93.5
District Size (Number of Students)								
1	3,579	722	15	6,842	$7,602	748.5	46.8%	95.8%
2	10,443	117	6,846	14,840	7,205	747.8	47.9	95.3
3	20,536	58	14,966	25,171	7,045	727.8	43.5	92.3
4	37,024	33	25,272	54,527	7,314	729.2	45.4	93.1
5	448,162	7	56,807	691,726	8,379	674.1	34.0	84.7
Urban Category								
Large City		42			$8,285	691.6	37.3%	87.0%
Mid-Size City		107			7,224	736.0	46.3	92.9
Urban Fringe, Large City		231			7,163	744.6	47.6	93.4
Urban Fringe, Mid-Size City		150			7,215	716.8	41.2	94.6
Town		48			7,698	735.9	43.8	96.5
Rural, outside metro area		120			8,813	744.7	45.5	96.8
Rural, inside metro area		239			7,478	723.1	39.9	94.9

Table 3

Education Cost Function, 2004-05
California K-12 School Districts

Dependent variable: Log of expenditures per pupil

Independent variables	**API**	**API sub-groups[a]**	**CST**	**CST sub-groups[a]**
2004-05 Performance[b]	0.339*	0.545**	0.308*	0.624**
	[2.29]	[3.65]	[2.63]	[4.72]
Teacher Salary Index	0.321**	0.234**	0.296*	0.226*
	[2.95]	[3.29]	[2.61]	[2.60]
Log of student enrollment	-0.286**	-0.218**	-0.266**	-0.236**
	[11.24]	[12.31]	[10.84]	[9.75]
Square of log of student enrollment [c]	0.014**	0.011**	0.013**	0.011**
	[12.31]	[13.39]	[11.88]	[11.12]
Percent of students eligible for free and reduced price lunch	0.283**	0.320**	0.344**	0.400**
	[3.78]	[4.71]	[3.60]	[3.96]
Percent of students Spanish-speaking English Learners	0.081	0.076	0.078	0.09
	[1.09]	[1.09]	[1.06]	[1.20]
Percent of students non-Spanish-speaking English Learners	0.237	0.236	0.204	0.17
	[1.27]	[1.46]	[1.08]	[1.14]
Percent of students in special education	1.070**	1.011**	1.351**	1.266**
	[4.40]	[4.58]	[5.30]	[5.04]
Percent of students with high-cost disabilities	6.506**	6.065**	5.685*	5.157*
	[2.98]	[3.31]	[2.47]	[2.55]
Percent of students enrolled in high school	0.247**	0.225**	0.232**	0.226**
	[7.89]	[7.43]	[5.03]	[4.81]
Herfindahl (efficiency) index	-0.02	-0.02	-0.06	-0.09
	[0.20]	[0.17]	[0.45]	[0.81]
2004-05 Performance, Economically Disadvantaged		-0.07		-0.236*
		[0.40]		[2.29]
2004-05 Performance, African-American		0.03		-0.11
		[0.28]		[1.96]
2004-05 Performance, Hispanic		-0.436		-0.217**
		[1.90]		[3.01]
Intercept	7.423**	8.912**	9.434**	9.403**
	[7.07]	[13.40]	[41.66]	[49.61]
Observations	937	937	808	808

* indicates statistically significant at the 5% level

[a] Also includes flags for missing sub-group test scores

[b] Log of API or Average CST passing rates

c Scale-efficient enrollment = 28,992

Table 4

Distribution of Predicted Costs
API Target = 800

	Cost Estimates 2004-05
Mean	$8,268
Standard Deviation	$1,513
Minimum	$5,832
Maximum	$23,818
At 5th Percentile	$6,678
At 95th Percentile	$11,011

Table 5

Distribution of Cost Indices

	Cost Index, 2004-05 California	Cost Index, 2004-05 Texas[b]	Cost Index, 2002-03 Texas[c]	Cost Index, 2000 New York[d,e]
Number of Districts	937	829	968	678
Mean	103.86	104.07	104.39	109.77
Standard Deviation	17.77	29.81	17.77	32.11
Minimum	72.97	45.61	75.57	70.46
Maximum	284.98	260.94	209.35	399.09
At 5th Percentile	85.06	63.70	83.82	81.89
At 95th Percentile	136.32	158.95	139.03	163.23
Predicted Spending:[a]				
Median Costs	$7,076	$7,736	$8,170	$9,215
Minimum (base) Costs	$5,163	$3,528	$6,174	$4,779
Marginal Costs: Pupil Weights				
Poverty	0.30	0.51	0.38	1.22
English Learners			0.24	1.01
- Spanish-speakers	0.08			
- non-Spanish-speakers	0.24			
Special Education				
- All Disabilities	1.13	0.71	0.72	2.05
- High-Cost Disabilities	6.68		1.03	

a) All costs are in 1999 dollars and adjusted for regional variation in wage costs using the National Center for Education Statistics' Comparable Wage Index; base year = 1999
b) 2004-05 Texas cost index and pupil weights from author's calculations, based on cost function in Imazeki and Reschovsky, 2006
c) 2002-03 Texas cost index from Gronberg, et al, 2005; pupil weights based on Gronberg, et al, Table 5
d) New York cost index from Duncombe, based on cost function in Duncombe, Lukemeyer and Yinger, 2003
e) New York pupil weights from Duncombe and Yinger, 2003, Table 6

Table 6

Comparison of Base and Marginal Costs[a]

	California Cost Function	Professional Judgment Studies[b]	Successful Schools Studies[b]
Base Costs:			
Number of Studies	1	12	9
Mean	$5,163	$7,890	$6,210
Minimum		$5,636	$5,124
Maximum		$9,757	$7,093
Marginal Costs: Pupil Weights			
Poverty	0.30	0.52	
		(range: 0.12 - 1.39)	
English Learners		0.74	
- Spanish-speakers	0.08		
- non-Spanish-speakers	0.24		
Special Education		1.47	
- All Disabilities	1.13		
- High-Cost Disabilities	6.68		

a) All costs are in 1999 dollars and adjusted for regional variation in wage costs using the National Center for Education Statistics' Comparable Wage Index; base year = 1999
b) Summarized from table in *Education Week* , 2005, and Baker, 2006

Table 7

Distribution by Pupil-Weighted Quintiles for Selected District Characteristics

934 California School Distrcts, 2004-05

Quintiles	Actual Spending per Pupil	Pupil-Weighted Spending per Pupil
Percent of Students from Poor Families		
1	$7,203	$7,760
2	7,095	8,203
3	7,487	8,472
4	8,017	8,878
5	7,505	8,885
Percent of Students English Learners		
1	$7,338	$7,816
2	6,955	8,120
3	7,518	8,502
4	7,997	8,863
5	7,454	8,909
Percent of Students in Special Education		
1	$7,128	$8,127
2	7,202	8,323
3	7,133	8,314
4	8,300	8,865
5	7,772	8,547
District Size (Number of Students)		
1	$7,604	$8,290
2	7,205	8,254
3	7,045	8,299
4	7,314	8,377
5	8,379	8,961
Urban Category		
Large City	$8,285	$8,909
Mid-Size City	7,224	8,276
Urban Fringe, Large City	7,163	8,258
Urban Fringe, Mid-Size City	7,215	8,215
Town	7,698	7,861
Rural, outside metro area	8,860	8,514
Rural, inside metro area	7,475	8,515