# Estimating the Cost of Meeting Student Performance Standards in the St. Louis Public Schools

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## 1. Introduction

. Over the past decade, there has been a growing interest among state governments in estimating the required costs to provide education that both meet state standards and comply with NCLB. In Missouri, the state constitution requires adequate funding to assure that the school system will lead to “a general diffusion of knowledge…” (Mo. Const. art. IX, section 1(a) (2000). With regard to accountability standards, Missouri has established the Missouri School Improvement Program (MSIP) and is charged with monitoring and enforcing the federal No Child Left Behind Act (NCLB).

It is well established in education finance and education policy research that some districts face more challenges in educating their students than other districts, because of several important factors that are outside district control (Bradford, Malt and Oates, 1969; Downes and Pogue, 1994; Duncombe, Ruggiero, and Yinger, 1996). In estimating the costs for districts to provide an opportunity for their students to meet academic standards it is important to consider three external factors affecting costs: 1) the school district share of disadvantaged students; 2) school district size; and 3) geographic variation in resource prices.

Several methods for estimating the cost of education have emerged over the last several decades, and have been used in various states around the country (for descriptions see Downes, 2004; Duncombe, Lukemeyer, and Yinger, 2003; Guthrie and Rothstein, 1999; Baker, Taylor, and Vedlitz, 2004). The cost function approach, which is used in this report, uses a statistical methodology and actual historical data to estimate the relationship between per pupil spending and student performance, student needs, resource prices and enrollment size. The cost function results can be used to directly estimate the impact of all three cost factors on required spending.

The major objective of this report is to apply the cost function approach to estimate the cost of providing students in St. Louis the opportunity to reach proficiency on the key exams used in the state accountability system (MSIP) and to comply with NCLB requirements. The report is organized into three major sections. In the next section, I introduce the cost function methodology, and discuss the data sources and measures used in the empirical analysis. I will then discuss in the third section the statistical methodology used in the analysis and present the cost function estimates. In the fourth section, the cost function estimates are used to develop several cost measures, including estimates of the costs required for the St. Louis Public Schools (SLPS) to reach several student performance standards.

## 2. Methodology and Data

In this section I will discuss the application of the cost function methodology to estimating the cost of reaching student performance levels, and then turn to discussing data sources, and measures.

### 2a. Cost Function Method

The term cost in economics refers to the minimum spending required to produce a given level of output. Applied to education, costs represent the minimum spending required to provide students in a district with the opportunity to reach a particular student performance level. Minimum spending can also be interpreted as the spending associated with current best practices for supporting student performance. Spending can be higher than costs because some districts may not use resources efficiently, that is, they may not use current best practices. Because data is available on spending, not costs, to estimate costs of education requires controlling for differences in school district efficiency. The approach used in this analysis is discussed below.

Education policy and finance scholars have established that the cost of producing educational outcomes depends not only on the cost of inputs, such as teachers, but also on the environment in which education must be provided (Bradford, Malt and Oates, 1969; Downes and Pogue, 1994; Duncombe, Ruggiero, and Yinger, 1996). One of the central findings in education policy research in the last several decades is the important role that non-school inputs, such as student characteristics, family background, neighborhood environment, and peers can have on a child's success in school (Coleman, 1966; Cohn and Geske, 1990; Bridge, Judd, and Moock, 1979; Haveman and Wolfe, 1994). In addition, significant research has examined the impact of school district size on the per pupil costs of providing education (Andrews, Duncombe, and Yinger, 2001; Fox, 1981).

To model the relationship between costs, student performance, and other important characteristics of school districts, a number of education researchers have employed one of the tools of production theory in microeconomics, cost functions. A cost function for school districts relates five factors to spending per pupil: 1) student performance; 2) the prices districts pay for important resources, particularly teacher salaries; 3) the enrollment size of the district; 4) student characteristics that affect their educational performance, such as poverty; and 5) other school district characteristics, such as the level of inefficiency, that can affect spending and performance. In other words, a cost function measures how much a given change in teacher salaries, student characteristics, or district size affects the cost of providing students the opportunity to achieve a particular level of performance.

The cost function methodology has been refined over several decades of empirical application, and cost function studies have been undertaken for New York (Duncombe and Yinger, 1996, 1998, 2000, 2005a; Duncombe, Lukemeyer, and Yinger, 2003), Arizona (Downes and Pogue, 1994), Illinois (Imazeki, 2001), Kansas (Duncombe and Yinger, 2005b), Texas (Imazeki and Reschovsky, 2004a, 2004b; Gronberg, et al., 2004), and Wisconsin (Reschovsky and Imazeki, 1998). In estimating the education cost function in Missouri, I have relied on standard methods used in past research modified to reflect education production in Missouri.

## 2.b. Data Sources and Measures

The cost function estimates provided in this report are based on a number of databases. Most of the data is produced by the Missouri Department of Elementary and Secondary Education (DESE). This section is organized by major type of variable used in the cost model, and summary statistics for key variables in 2005 are reported in Table 1 for St. Louis Public Schools (SLPS) and all school districts in Missouri.[1] The sample size in 2005 was 516 school districts.

### *Per Pupil Spending*

The dependent variable used in the cost function is per pupil spending. To broadly reflect resources used in the production of education in Missouri school districts, the spending measure is based on "current operating cost (COC)" developed by DESE. COC includes total instructional and support spending minus total capital outlay and several

[1] The summary statistics presented in Table 1 are based on individual school districts and are not weighted by the number of students in each district. Unweighted averages for each variable are used in the calculation of several cost measures discussed later in the report.

revenue categories (food service sales, state food service aid, federal food service aid, and receipts from other districts). In addition, I removed transportation, since this is not directly related to student performance.[2] The major source of spending data is the *Annual Secretary of the Board Report* (ABSR) produced by districts for DESE. Using this spending measure, SLPS spent slightly over $10,000 per pupil ($10,056) in 2005, while the average district in the state spent approximately $6,700.

**Table 1. Descriptive Statistics for Variables Used in Cost Model, Missouri School Districts (2005)**

| | | All School Districts in Missouri | | | |
|---|---|---|---|---|---|
| Variables | St. Louis Public Schools | Average | Standard Deviation | Minimum | Maximum |
| Per pupil spending | $10,056 | $6,699 | $1,533 | $4,406 | $16,740 |
| Student Performance Measure | 16.7 | 25.6 | 7.2 | 4.8 | 53.5 |
| **Cost variables** | | | | | |
| Teacher salaries | $34,017 | $27,460 | $3,290 | $21,201 | $40,055 |
| Student poverty (percent subsidized lunch students) | 86.4 | 46.1 | 16.0 | 4.7 | 95.1 |
| Black-white achievement gap (Poverty variable multiplied by percent African American) | 7020.4 | 288.8 | 1005.7 | 0.0 | 9619.2 |
| Percent special education students | 28.5 | 17.0 | 4.5 | 4.1 | 42.1 |
| K12 distircts (1=yes; 0=no) | 1.00 | 0.86 | 0.34 | 0.00 | 1.00 |
| **Enrollment categories** | | | | | |
| Under 100 students | 0.000 | 0.050 | 0.219 | 0.000 | 1.000 |
| 100 to 150 students | 0.000 | 0.047 | 0.211 | 0.000 | 1.000 |
| 150 to 250 students | 0.000 | 0.132 | 0.339 | 0.000 | 1.000 |
| 250 to 500 students | 0.000 | 0.203 | 0.403 | 0.000 | 1.000 |
| 500 to 1,000 students | 0.000 | 0.238 | 0.427 | 0.000 | 1.000 |
| 1,000 to 1,500 students | 0.000 | 0.093 | 0.291 | 0.000 | 1.000 |
| 1,500 to 2,500 students | 0.000 | 0.089 | 0.285 | 0.000 | 1.000 |
| 2,500 to 5,000 students | 0.000 | 0.085 | 0.280 | 0.000 | 1.000 |
| 5,000 to 15,000 students | 0.000 | 0.041 | 0.198 | 0.000 | 1.000 |
| Over 15,000 students | 1.000 | 0.021 | 0.145 | 0.000 | 1.000 |
| **Efficiency-related variables** | | | | | |
| **Fiscal capacity** | | | | | |
| Per pupil property values | $33,809 | $61,631 | $41,074 | $20,399 | $410,166 |
| Per pupil income | $110,411 | $63,962 | $35,112 | $2,652 | $394,463 |
| Statel aid/income ratio | 0.03 | 0.06 | 0.06 | 0.00 | 1.14 |
| **Other monitoring variables** | | | | | |
| Percent of adults that are college educated (2000) | 19.07 | 13.11 | 8.05 | 3.22 | 67.43 |
| Percent of population 65 years or older (2000) | 13.71 | 15.19 | 4.25 | 4.02 | 32.38 |
| Percent of housing units that are owner occupied (2000) | 46.86 | 77.28 | 8.03 | 42.30 | 95.38 |
| Local tax share (median housing price/average property values) | 1.89 | 1.23 | 0.49 | 0.25 | 2.91 |
| Sample Size | | | 516 | | |

Sources: Missouri Department of Elementary and Secondary Education; U. S. Census Bureau.

[2] In addition, the costs of providing transportation are affected by factors, such as sparsity of the population, weather conditions, and road conditions, which are not likely to affect instructional costs. State assistance for transportation is often provided through a separate aid formula.

Special education services in St. Louis County and Pemiscot County are provided by special school districts serving these counties.  Total spending, counts for special education students, and counts of students receiving subsidized lunch in these two special school districts are assigned to the regular school districts in each county using the share of county enrollment in each regular school district.  For example, if a regular school district had 10% of St. Louis County enrollment, then it would be assigned 10% of the spending, 10% of special education students, and 10% of the subsidized lunch students in the special district serving St. Louis County.

***Student Performance Measure***

The student performance measures used in the cost function are based on Missouri Assessment Program (MAP) exams in Math and Communication Arts administered by DESE. These are criterion-referenced exams in three grades for each subject area (grades 4, 8, 10 for math, and grades 3, 7, and 11 for communication arts). These exams are the principal academic measure used in the accreditation process for the Missouri School Improvement Program (MSIP).  They are also key measures used in calculating adequate yearly progress (AYP) for compliance with NCLB. Since the last year available for spending data is 2005, the last year of performance data used in the analysis is also 2005.

The information reported on these exams is the percent of students reaching certain thresholds in performance: (step 1, progressing, near proficient, proficient, and advanced).  The measure of student performance is based on the percent of students reaching proficiency or advanced on these exams (proficiency rate).  For the overall measure of performance I took a simple average of the proficiency rate on the six exams.

In 2005, 16.7 percent of students in SLPS reached a proficient or advanced level on these six exams, on average (Table 1). Statewide, the average proficiency rate for the six exams was 25.6% in 2005.

While the majority of districts in Missouri serve the full range of grades, there are 73 districts serving kindergarten to eighth grades. Students in K8 districts attending only one K12 district are assigned the high school proficiency rates for math and communication arts in this K12 district. In a few cases students in a K8 district attended two K12 districts for high school. To assign a high school performance measure to a K8 district, I constructed a weighted average of proficiency for high school math and communication arts exams, where the weight is based on relative enrollment. For example, assume students in the K8 district A attended K12 districts B and C, where the enrollment in district B is 6000, and enrollment in district C is 4000. Then the high school performance assigned to district A is based on a weighted average of high school performance in districts B and C, where the weights are 60% and 40%, respectively.

***Cost Variables***

***Teacher salaries:*** Costs of providing education services varies across districts, in part, because of differences in prices that districts have to pay for resources, such as teachers. Some districts may have to pay more to attract similar teachers than other districts, because of a higher cost of living, fewer amenities in the area, and more difficult working conditions. Since teachers are the principal resource used to produce education, I include a measure of teacher salaries in the cost model.[3] To assure that the teacher salary

[3] Other professional staff are another key resource used by districts. Because variations in other professional salaries across districts are typically highly related to variation in teacher salaries (correlation over 0.75), I include only teacher salaries in the cost model. Non-professional salaries and professional services used by the district are also likely to be strongly related to salary levels in the local labor market.

measure is comparable across districts, I control for differences in education and experience.

To measure salaries for comparable teachers, I use information on individual teachers with 0 to 5 years of experience collected from districts in October of each year as part of the Core Data Collection System (screen 18) maintained by DESE. Data on inexperienced teachers is used, because it is more apt to reflect variation in the underlying cost of hiring comparable teachers and not differences in teacher contract provisions.[4] Information is available on regular-term salary, years of experience, and educational attainment.[5] To control for variation in education and experience across districts, the natural logarithm of teacher salaries is regressed on the log of total experience, and an indicator variable for whether the teacher has a graduate degree. I use the regression to estimate average salaries for teachers in each district with the statewide average experience (between 0 and 5 years) and the statewide average percent of teachers with a graduate degree. The predicted salary in SLPS in 2005 is $34,017 compared to $27,460 in the average district.

**Student poverty (percent subsidized lunch students):** One of the key factors affecting the cost of reaching performance targets is the number of students requiring additional assistance to be successful in school. Poverty has consistently been found to be negatively correlated with student performance (Ferguson and Ladd, 1996; Cohn and Geske, 1990; and Haveman and Wolfe, 1994). Poverty measures should accurately

[4] The salary scale between senior and junior teachers can reflect the power of the union in negotiating favorable contracts for senior teachers, who are more apt to be union members (Landford and Wyckoff, 1997).

[5] To minimize measurement errors in the teacher data that could significantly affect the salary estimates, I dropped teacher salaries under $20,000 and over $100,000 and I dropped teachers with over 36 years of experience.

capture the percentage of a district's students living in low-income households. The most commonly used measure of poverty in education research is the share of students receiving free or reduced price lunch in a school,[6] because this measure is produced annually.[7] To reduce the potential instability in this measure, especially in small districts, I use a 2-year average of the subsidized lunch percent. The source of counts for subsidized lunch students rate is the core data collection system (screen 15) published by DESE. The share of subsidized lunch students in SLPS in 2004 and 2005 average 86% (2-year average), while in the average district the subsidized lunch rate is 46%.

***Black-white achievement gap (Poverty variable multiplied by percent African American):*** Significant research has documented the size and persistence of a gap between white and African American students in student performance (Jencks and Phillips, 1998). While a number of explanations have been offered for the achievement gap, empirical research has found that controlling for socio-economic differences (particularly poverty) do not fully account for the gap, and that differences in school resources, and racial segregation may also play a role (Cook and Evans, 2000; Card and Rothstein, 2006; Todd and Wolpin, 2004; Ellen, Schwartz and Stiefel, forthcoming; Hanushek and Rivkin, 2006; Krueger, 2001). To account for the possibility that districts

[6]The National School Lunch Program is administered by the U.S. Department of Agriculture, and individual school districts are reimbursed by the meal depending on the level of subsidy for which a child is eligible. Children with family incomes at or below 130 percent of the federal poverty line are eligible for free lunch, and students with family incomes between 130 and 185 percent of the poverty line are eligible for reduced price lunch. In addition, households receiving Food Stamps, Aid to Dependent Children (ADC), or Temporary Assistance to Needy Families (TANF), or the Food Distribution Program on Indian Reservations (FDPIR) are also eligible for free lunch. A description of the program and eligibility requirements is available on the Food and Nutrition Service website: http://www.fns.usda.gov/cnd/lunch/.

[7] Another measure of child poverty is the child poverty rate produced by the Census Bureau every ten years as part of the *Census of Population*. While this measure is updated on a biennial basis, the updates are based on the decennial Census estimates, which implies that they may be quite inaccurate by the end of every decade. I found that the subsidized lunch rate in 2000 had a correlation of over 0.7 with the Census child poverty rate. Therefore, the subsidized lunch rate should provide an accurate measure of child poverty in Missouri.

serving high concentrations of low-income African American students may face particular challenges in improving student performance, I have included a variable in the cost model that measures the interaction of the subsidized lunch rate with the percent of students that are African American.[8] The share of African American students in SLPS is 81% in 2005, compared to 5% in the average district in Missouri (not shown).

***Percent special education students:*** Students with special needs often require additional services and support, which can substantially increase school spending. Counts of special education students with individualized education programs (IEPs) are produced in December each year by districts and recorded in the Core Data Collection System (screen 11) maintained by DESE. To measure special education I calculated total special education students as a share of enrollment.[9] In SLPS, 28.5% of students are classified as special education compared to 17% in the average district.

***K12 districts:*** While most districts in Missouri are K12 districts, about 14% of districts are K8 districts. It is possible that costs may be higher in districts serving high schools than those serving only elementary and middle school students, because of the

[8] Ideally, a measure of the share of students in SLPS, who are low-income African Americans, would be included in the cost function. Because this data is not available, I multiply the share of subsidized lunch students by the share of African American students to provide a rough measure of the concentration of low-income African American students. Imazeki and Reschovsky (2004a) included the percent of students, who are African American, as well as a child poverty measure in their cost function study for Texas. They found that a higher concentration of African Americans students in a district raises the cost of reaching student performance standards.

[9] Another student characteristic that can affect the cost of bringing students up to a performance level is fluency with English, often called limited English proficiency (LEP). Unlike subsidized lunch, there are no federal standards on how LEP students are measured, and typically no auditing process to assure that the data is accurate. In Missouri, student language data is collected in the Limited English Proficient Student Census (or English Language Learners Census) in October of each year. The Census is an estimate of LEP students by language, where LEP students are defined as school age students, who are born in another country where the native language is not English and who have difficulty communicating in English. To evaluate the accuracy of the LEP data collected by Missouri, I compared this data to an alternative measure available in the *2000 Census of Population*--the percent of students, who live in a household where English is not spoken well at home. The LEP measure supplied by school districts in Missouri is not highly correlated (r=0.30) with the Census measure, suggesting that there are inconsistencies in how districts are classifying and reporting LEP students. When the LEP share is included in the cost function its coefficient is not statistically different from zero.

more specialized nature of the curriculum in high school. I have included an indicator variable for K12 districts (equals 1 if K12 district, equals 0 if K8 district), to account for possible cost differences across type of district.

***Enrollment categories:*** A key variable in a cost model is the number of students served by the district. Student counts are used both directly as a variable in the cost model, and to transform other variables into per pupil measures. The student count measure used in this report is an average of the enrollment estimates in September and in January. I use the average of these two enrollment counts to provide a measure of average enrollment for the year. Average enrollment provides a better estimate of the underlying enrollment of the district during the year and is less sensitive to unusual results associated with a single enrollment count. I did not use a measure of average daily attendance, because it is expected that for the major spending categories districts have to hire staff and budget other resources as if there were full attendance.

The relationship between enrollment and per pupil spending has often been found to have a nonlinear functional form. Per pupil spending drops quickly as enrollment increases from very small districts (under 100 students) to a district with 1,000 students as relatively fixed costs, such as administration, can be shared across more students. However, the decline in per pupil operating costs slows down significantly and most cost savings are exhausted by the time a district reaches 2,500 students. Per pupil costs may even go up in very large districts (Andrews, Duncombe, and Yinger, 2001). To capture this potential non-linear relationship I include several variables for different enrollment classes (variable equals 1 if district falls into a particular enrollment class, and 0 otherwise).[10] I use enrollment classes in the cost model to allow maximum flexibility in modeling the relationship between enrollment and spending.[11]

***Efficiency-Related Measures***

Costs are defined as the minimum spending of school resources required to provide students an opportunity to reach a given level of student performance. However, the dependent variable in the cost model is per pupil spending. Some school districts may have higher spending relative to their level of student achievement not because of higher costs, but because of inefficient use of resources. In addition, some districts may choose to focus on other subject areas (e.g., art, music, or athletics) that may not be directly related to improving test score performance in math and communication arts.

While controlling for efficiency differences across districts is an important step in estimating education cost functions, measuring efficiency is difficult, because it cannot be observed directly. The approach that I take is to include in the cost function variables that have been found to be related to efficiency in previous research. The literature on managerial efficiency in public bureaucracies suggests three broad factors that might be related to productive inefficiency: fiscal capacity, competition, and other factors affecting voter involvement in monitoring government (Leibenstein, 1966; Niskanen, 1971;

[10] If districts have enrollment over 15,000 students, then the indicator variable for "over 15,000" will be assigned a one, and for districts with 15,000 or fewer students the indicator variable "over 15,000" will be assigned a zero. I created 10 enrollment class variables (Table 1) and one of these variables (under 100 students) is dropped from the estimated cost function. Regression coefficients on other enrollment class variables in the cost model can be interpreted as the percent change in spending per pupil to be in this enrollment class compared to a district with fewer than 100 students, holding all other variables in the cost function constant.

[11] An alternative approach used in the literature has been to include instead the log of enrollment and the square of the log of enrollment in the cost function, which imposes a particular functional form (quadratic) on the relationship between spending and enrollment. Studies using quadratic functions for enrollment often find diseconomies of scale, which may be driven in part by this functional form.

Wyckoff, 1990). While I do not have a good measure of competition, I can get information on other factors, which may be related to differences in efficiency.

***Fiscal capacity:*** Research on New York school districts indicates that taxpayers in districts with high fiscal capacity, as measured by property wealth, income and state aid, may have less incentive to put pressure on district officials to be efficient, or may be more apt to spend money on non-tested subjects (Duncombe, Miner, and Ruggiero, 1997; Duncombe and Yinger, 2000). Property values are measured by assessed value for real property (residential, agricultural, and commercial and industrial), and personal property. The measure of income used in the analysis is adjusted gross income, which is provided by the Missouri Department of Revenue to DESE based on information from Missouri income tax returns.[12] Finally, I use a measure of state aid per pupil supporting basic operations. The state aid measure includes minimum guarantee aid (basic formula) and aid for free and reduced price lunch students.[13] State aid is reported in the ABSR on an annual basis.

***Other monitoring variables:*** In addition, voter's incentive and capacity to monitor operations in school districts may differ depending on several factors, such as the education level of residents, the share of senior citizens in the population, the share of owner occupied housing, and the share of school taxes paid by the typical voter (local tax

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[12] The income data lags several years, so that the income data from the 2002 calendar year is used for the 2004-05 school year.

[13] Although aid per pupil might appear to be an appropriate way to measure the amount of aid a district receives, the underlying theory behind the measurement of district fiscal capacity indicates that the appropriate measure of aid is actually per pupil aid divided by per pupil income (Ladd and Yinger, 1991). The measure used in the cost model is per pupil aid divided by per pupil adjusted gross income.

share).[14] Per pupil property values come from DESE, and the other monitoring variables come from the *2000 Census of Population* published by the U.S. Census Bureau.

## 3. Cost Function Estimates

In this section, I present the cost function estimates, and discuss the statistical methodology used in the analysis.

### 3.a. Statistical Methodology

The cost model is estimated with data on most school districts in Missouri over a five year period (2000-2005).[15] In specifying the functional form of the empirical cost function, I use one of the most common cost functions used in empirical research, a constant elasticity (or Cobb-Douglas) function.[16] To estimate a cost function, I use a multiple regression method, which has been commonly employed in economics and public policy research. Multiple regression estimates the relationship between an independent variable (e.g., student poverty rate) and the dependent variable (e.g., per pupil spending), controlling for the impact of other variables in the model on the dependent variable (e.g., efficiency-related factors).

I have taken several steps to assure that the statistical estimates from the multiple regression models are accurate. First, I have included in the cost model several

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[14] In communities with little commercial and industrial property, the typical homeowner bears a larger share of school taxes (higher tax share) than in communities with significant non-residential property. The local tax share is typically measured as median housing value divided by average property values in a district. See Ladd and Yinger (1991), and Rubinfeld (1985) for a discussion of the tax share measure used in median voter models of local public service demand.

[15] The cost function is estimated using 3,068 observations. Observations on five districts are not included in the sample because of missing data.

[16] In a constant elasticity function both the dependent and all the independent variables are expressed in natural logarithms. I modify this in several ways. For variables that are already in percentage terms (e.g., percentage of students receiving subsidized lunch), they are left in this form. Variables expressed as 0 or 1 (e.g., whether a district is a K12 district or not) are also left in this form because the natural log of 0 is not defined.

efficiency-related factors to account for relative efficiency differences across school districts. This allows me to control for efficiency, in estimating the impact of key cost factors, such as poverty, on the cost of reaching performance standards.

Second, standard multiple regression methods are based on the assumption that the direction of causation runs only from independent variables to the dependent variable. If causation could run the other direction or both directions, then the regression estimates can be biased (so called endogeneity bias). Student performance targets, and teacher salaries, are potentially set simultaneously with district spending, as part of the annual budgeting process. To account for the potential endogeneity of these variables, I employ a statistical procedure used frequently in economics research, two-stage least squares (2SLS) regression. This approach involves the selection of exogenous “instruments” to serve as proxies for the “endogenous” variables. To select instruments I use the average of exogenous variables related to student performance and salaries in other districts in the same labor market area or of the same Census district type.[17] A range of instruments were tested and the strongest set of instruments based on test results are used in estimating the cost function (see Appendix A).

Third, the standard errors in multiple regressions can also be biased when a panel data set is used because the errors are not statistically independent of each other. I use a method to correct standard errors for clustering at the district level (multiple observations

[17] Census district types include large cities, medium cities, urban fringe of large cities, urban fringe of medium cities, large town, small town, rural metro, and rural non-metro. Instruments examined include student demographics, enrollment, private wages, and fiscal capacity. The final set of instruments include enrollment, percent African American students, and percent Hispanic students in other districts in the same labor market area, and percent Hispanic students in other districts of the same Census district type. The final instrument is an estimate of comparable private sector wages in labor market areas developed for the National Center for Education Statistics (Taylor and Fowler, 2006). Two labor market areas in the Southwest corner of the state (27900 and 222220) are combined, because of a limited number of districts in each labor market area.

for the same district). In addition, to account for possible correlation of standard errors across time (e.g., due to inflation), dummy variables are included in the model for the year of the data (omitting the dummy variable for the first year, 2000).

## 3.b. Cost Function Results

Table 2 presents results of the cost function estimated for school districts in Missouri using data from 2000 to 2005. The dependent variable is per pupil spending measured by COC minus transportation spending. Most of the independent variables are expressed in relative terms (either per pupil or as a percent)[18] and their regression coefficient can be interpreted as an elasticity--the percent change in per pupil spending associated with a one percent change in an independent variable (holding the other variables in the model constant).

In general, per pupil spending has the expected relationship with the independent variables in the cost function (Table 2) and are statistically significant from zero. Hypothesis testing results are measured by “t-statistics” and “p-values” on Table 2. P-values measure the probability of error if it is concluded that there is a relationship between per pupil spending and a particular independent variable. Typically, 5% is considered to be an acceptable level of error. In other words, if the p-value is 5% or less, researchers are typically willing to conclude that there is a relationship between the dependent and independent variables.[19] The following is a brief discussion of the cost function results by type of variable.[20]

[18] Per pupil spending, the outcome measure, teacher salaries, per pupil income, local tax share and per pupil property values are measured as natural logarithms.

[19] t-statistics measure the distance (as measured in standard deviations) between the regression coefficient and zero. The higher the t-statistic the lower the p-value.

[20] The intercept measures the predicted level of per pupil spending when all the independent variables in the model are equal to zero. Since this is unlikely to be the case for any school district, the interpretation of

**Table 2. Cost Function Estimates for Missouri School Districts (2000-2005)**

| Variables | Coefficient | t-statistic | p-value |
|---|---|---|---|
| Intercept | -2.62715 | -0.82 | 0.41400 |
| Student Performance measure[a] | 0.38841 | 2.39 | 0.01700 |
| **Cost variables** | | | |
| Teacher salaries[a] | 0.77985 | 2.70 | 0.00700 |
| Student poverty (percent subsidized lunch students) | 0.00475 | 4.25 | 0 |
| Black-white achievement gap (Poverty variable multiplied by percent African American) | 0.0000443 | 2.77 | 0.006 |
| Percent special education students | 0.00469 | 3.28 | 0.00100 |
| K12 distircts (1=yes; 0=no) | 0.12925 | 4.52 | 0.00000 |
| **Enrollment categories** | | | |
| 100 to 150 students | -0.1664292 | -3.15 | 0.002 |
| 150 to 250 students | -0.31497 | -5.06 | 0.00000 |
| 250 to 500 students | -0.43991 | -6.52 | 0.00000 |
| 500 to 1,000 students | -0.53374 | -6.98 | 0.00000 |
| 1,000 to 1,500 students | -0.60150 | -7.19 | 0.00000 |
| 1,500 to 2,500 students | -0.64754 | -7.13 | 0.00000 |
| 2,500 to 5,000 students | -0.72289 | -7.17 | 0.00000 |
| 5,000 to 15,000 students | -0.70954 | -5.97 | 0.00000 |
| Over 15,000 students | -0.69510 | -6.76 | 0.00000 |
| **Efficiency-related variables** | | | |
| **Fiscal capacity** | | | |
| Per pupil property values[a] | 0.02213 | 0.65 | 0.51800 |
| Per pupil income[a] | 0.19162 | 5.10 | 0.00000 |
| Statel aid/income ratio | 1.22156 | 3.94 | 0.00000 |
| **Other monitoring variables** | | | |
| Percent of adults that are college educated (2000) | 0.15800 | 0.60 | 0.54600 |
| Percent of population 65 years or older (2000) | -0.40735 | -1.98 | 0.04800 |
| Percent of housing units that are owner occupied (2000) | -0.09709 | -0.95 | 0.34000 |
| Local tax share (median housing price/average property values)[a] | -0.06505 | -2.44 | 0.01500 |
| **Year indicator variables** | | | |
| 2001 | 0.00870 | 0.50 | 0.62100 |
| 2002 | 0.01373 | 0.48 | 0.63300 |
| 2003 | 0.00577 | 0.15 | 0.88100 |
| 2004 | -0.03173 | -0.69 | 0.49200 |
| 2005 | -0.02049 | -0.35 | 0.72500 |
| Sample Size | | 3068 | |

Note: Estimated with linear 2SLS regression with the log of per pupil current operating cost (minus transportation spending) as the dependent variables. The performance measure and teacher salaries are treated as endogenous variables with instruments based on exogenous variables for other districts in the same labor market area and census district type(see text). Robust standard errors are used for hypothesis testing (controlling for clustering at the district level).
[a] Expressed as a natural logarithm.

### *Student Performance Measure*

The accuracy of the regression coefficient on the student performance measure is important because it is used to calculate the required spending increases for SLPS to

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the intercept is not of practical significance. Instead, the intercept is necessary to estimate spending levels using the regression results.

reach MSIP and NCLB performance standards. The coefficient on the student performance measure, 0.388, indicates that a one percent increase in performance (as measured by a composite of proficiency rates for communication arts and math tests) is associated with a 0.388 percent increase in per pupil spending, controlling for the other variables in the cost function. The regression coefficient on the performance measure is statistically significant from zero with a 1.7 percent chance of error (p-value), providing strong evidence that there is a relationship between student performance and spending.

***Cost Variables***

***Teacher salaries:*** Teachers' salaries are positively related to per pupil spending and are statistically significant from zero with a 0.7% chance of error. A one percent increase in teacher's salaries is associated with a 0.78 percent increase in per pupil expenditures holding other factors constant. The salary coefficient fits expectations since professional salaries typically represent 70 to 80 percent of operating spending.

**Student poverty (percent subsidized lunch students)**: An important factor affecting the cost of providing educational opportunity is the share of students in the district living in poverty. As discussed above, I have included two measures of student poverty in the cost function: 1) percent of students receiving subsidized lunch; and 2) the share of students receiving subsidized lunch multiplied by the share of African American students. The latter measure is meant to capture any separate impact that high concentrations of low-income African American students may have on student performance. The coefficients on both of these variables have the expected positive sign and are both statistically significant from zero with little chance of error (low p-value). To evaluate the impact of poverty on spending it is necessary to consider both regression coefficients. The effect of poverty on spending will be discussed below in the section on pupil weights.

***Percent special education students:*** The positive regression coefficient on the variable for the percent special education students confirms that students with special needs require additional services and support, which raises school district costs. An increase in one percentage point in special needs students is associated with a .47% increase in spending and this result is statistically significant from zero with little chance of error. The effect of special education on spending will be discussed in more depth below in the section on pupil weights.

***Enrollment categories:*** To capture possible economies of scale (and diseconomies of scale) I have included a series of variables measuring whether districts fall into different enrollment categories. The enrollment category used as a base for comparison is enrollment below 100 students. The regression coefficient on an enrollment category variable can be interpreted as the percent change in costs for a district to be in this enrollment category compared to a district with under 100 students. For example, the coefficient of -0.166 on the enrollment category, 100 to 150 students, indicates that districts with 100 to 150 students are 16.6% less costly to operate than districts with under 100 students, holding other variables in the cost function constant. As expected, the cost of operating a school district declines with an increase in enrollment. School districts with 150 to 250 students are 32% less expensive to operate than a district with 100 students, districts between 500 and 1000 students are 53% less expensive, and districts with 2,500 to 5,000 students are 72% less expensive to operate. Beyond an enrollment of 5,000, costs go up slightly, although the potential diseconomies of scale in large districts appear to be minimal.[21] All of the regression coefficients on the enrollment category variables are statistically significant from zero with little chance of error.

***Efficiency-Related Measures***

As indicated previously, the cost model includes several variables found to be associated to relative efficiency differences across districts. The coefficients on the efficiency variables have the anticipated direction of effect, although not all coefficients are statistically significant from zero at conventional levels.[22]

***Fiscal capacity:*** As expected an increase in fiscal capacity, as measured by income, property values and state aid, is associated with higher spending, which may indicate greater inefficiency or more demand for a broader array of educational services. The coefficients for state aid and per pupil income are statistically significant from zero at conventional levels.

***Other monitoring variables:*** A higher share of college educated adults is associated with higher spending, which probably reflects their higher demand for education services.  A higher share of senior citizens in the population, a higher share of owner-occupied housing in the district, and a higher local tax share are associated with lower spending, which may be due to greater monitoring of district operations (higher efficiency).

***Year Indicator Variables***

Year indicator variables are included in the model to control for the effects of inflation or state-level policy changes, which have not been accounted for by the other

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[21] There is no statistically significant difference between the regression coefficients for the enrollment category variables for 2,500 to 5,000 students, 5,000 to 15,000 students, and over 15,000 students.
[22] Since the efficiency-related variables are included only as control variables, the lack of statistical significance of some coefficients doesn't affect the accuracy of the relative cost measures, presented in the next section, because they are based primarily on factors outside of district control.

variables in the model. The fact that none of the coefficients on the year variables are statistically significant from zero at conventional levels, suggests that the cost model has captured the key factors affecting cost differences, which can vary across time.

## 4. Cost Measures

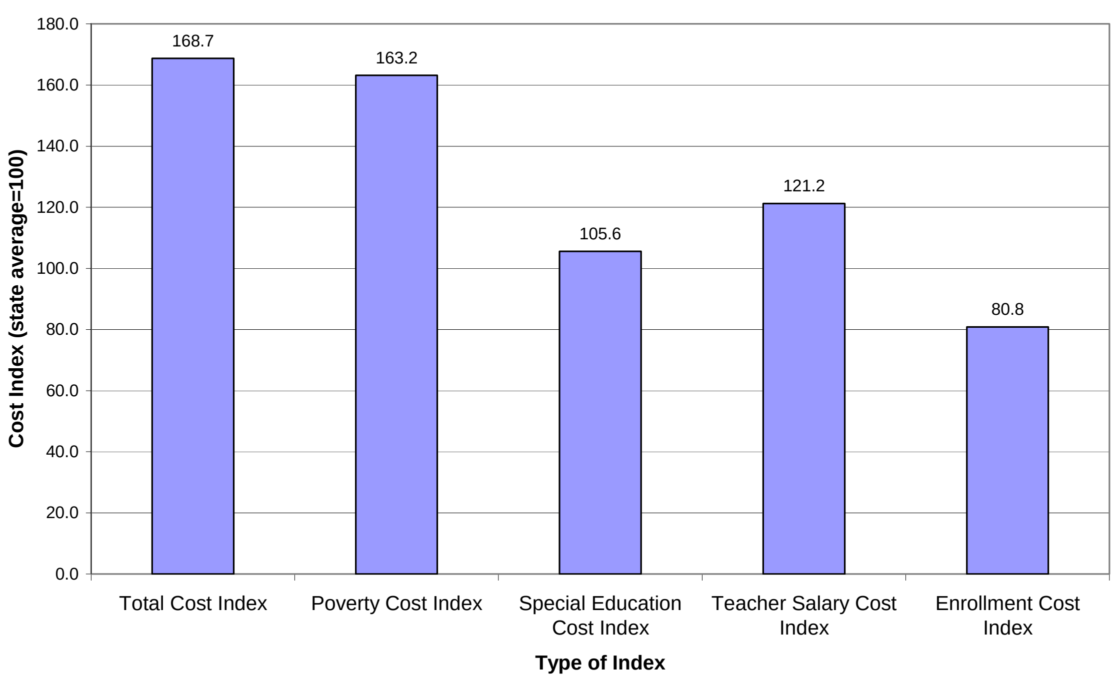
Cost function results can be used to develop several cost measures, which capture relative cost differences across school districts, due to factors outside district control. In this section, I will present three types of cost measures: 1) cost indices; 2) pupil weights; and 3) estimates of the cost of providing students the opportunity to reach student performance standards. All three cost measures can be used directly in school aid formulas (Duncombe and Yinger, 1998; Duncombe and Yinger, 2000).

### 4.a. Cost Indices

One measure of relative cost differences is a cost index. A cost index measures the percent difference in spending in a particular district, due to factors outside of district control, to reach a given student performance level compared to a district with average characteristics. For example, a cost index of 120 indicates that it is 20% more expensive in this district than the average district due to cost variables outside of district control. The key cost variables included in the cost function are: teacher salaries, student poverty, special education, and enrollment size.

Cost indices can be calculated using the cost function results in a few simple steps. For each cost variable outside of district control, the regression coefficient is multiplied by the actual value in each district.[23] For each variable a district can influence (student performance measure, and efficiency), the estimated coefficient of the cost model is multiplied by the state average for that variable. The sum of each of these terms and the intercept is the predicted spending in each district to reach average student performance with average efficiency.[24] The predicted spending in each district is divided by the predicted spending in a district with average characteristics for all variables (and multiplied by 100) to get the cost index for each district. Figure 1 presents cost index results for SLPS.

**Figure 1: Cost Indices for St. Louis Public Schools**




The total cost index for SLPS is 169, which indicates that SLPS will require 69% more spending per pupil than the average district in Missouri to provide its students the

[23] Because teacher salaries are treated as endogenous, to calculate the cost index I use the predicted salaries from a first stage regression of the log of teacher salaries regressed on all exogenous variables in the cost function and the instruments.
[24] Since the dependent variable in the cost model is expressed as a natural logarithm, the antilog of the sum of the products is taken to get the predicted spending per pupil.

opportunity to reach any given student performance level due to factors outside of district control. The overall cost index for SLPS can be decomposed into the cost indices for each cost factor.[25] The principal factor causing higher costs in St. Louis is a high poverty rate in combination with a high share of African American students. The poverty cost index indicates that SLPS will need to spend 63% more than the average district because of its high share of low-income African American students.[26] Higher teacher salaries also lead to 21% higher costs in SLPS than in the average district, and and special education costs are 6% higher. Because costs tend to go down with higher enrollment, the higher enrollment in SLPS compared to the average district reduces costs by over 19%.

## 4.b. Pupil Weights

Most states adjust for disadvantaged students either through categorical aid programs, or by providing extra weights for high need students in the basic operating aid program (Baker and Duncombe, 2004; Carey, 2002). Pupil weights measure how much more expensive are students with a certain characteristic (e.g., living in poverty) compared to a student without this characteristics. For example, a poverty weight of 0.5 indicates that a child living in poverty is typically 50% more expensive to bring up to any performance level than students not living in poverty.

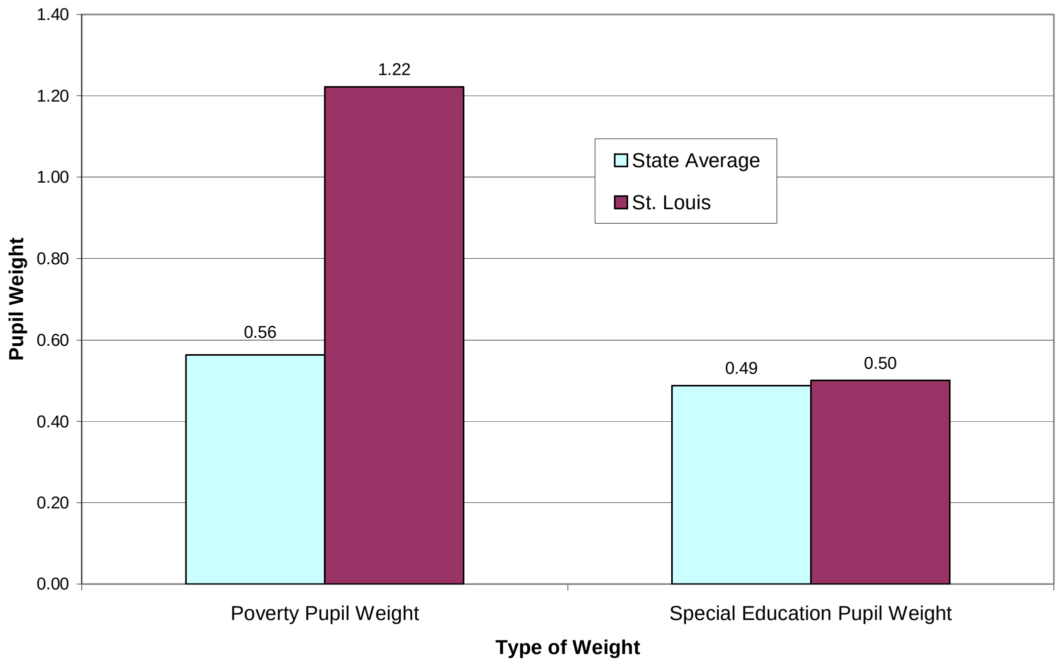
Using cost function results it is possible to develop pupil weights for both poverty (percent of students receiving subsidized lunch) and special education (percent of special education students). The regression coefficients on the poverty and special education

[25] Because the dependent variable is expressed as a natural logarithm, the cost index values for individual cost factors are multiplied by each other to get the overall cost index (after each index is divided by 100). For example for SLPS the overall index (divided by 100) is 1.687, which equals 1.632 x 1.056 x 1.212 x 0.808.

[26] The poverty cost index combines the effects of the percent subsidized lunch student variable alone, and the impacts of the interaction of poverty with the concentration of African American students.

variables and the share of students in a district with these characteristics are used to estimate pupil weights.[27] Figure 2 reports the estimated pupil weights for SLPS compared to the state average.

**Figure 2: Pupil Weights Based on Cost Function Estimates**




The poverty pupil weight in the average district is 0.56, which indicates that a student receiving a subsidized lunch is 56% more expensive than a student not receiving subsidized lunch to bring up to the same student performance level. In SLPS, a student receiving subsidized lunch is 122% more expensive than a non-poverty student. The poverty pupil weight is significantly higher in St. Louis compared to the average district, because of the high concentration of low-income African American students in the district. Turning to the weight for special education students, the pupil weight is

[27] Duncombe and Yinger (2005a) show that student need weights are equal to $(\exp(b_iC_i) - 1)/ C_i$, where $b_i$ is the regression coefficient on student characteristic i, and $C_i$ is the share of students with characteristic i. The coefficients on both the subsidized lunch variable, and the interaction of subsidized lunch with the share African American are used in calculating the poverty pupil weight.

approximately 0.50 in both St. Louis and for the average district in the state. Special education students are 50% more expensive, on average, than non-special education students.

## 4.c. Estimated Spending Necessary To Reach Performance Standards

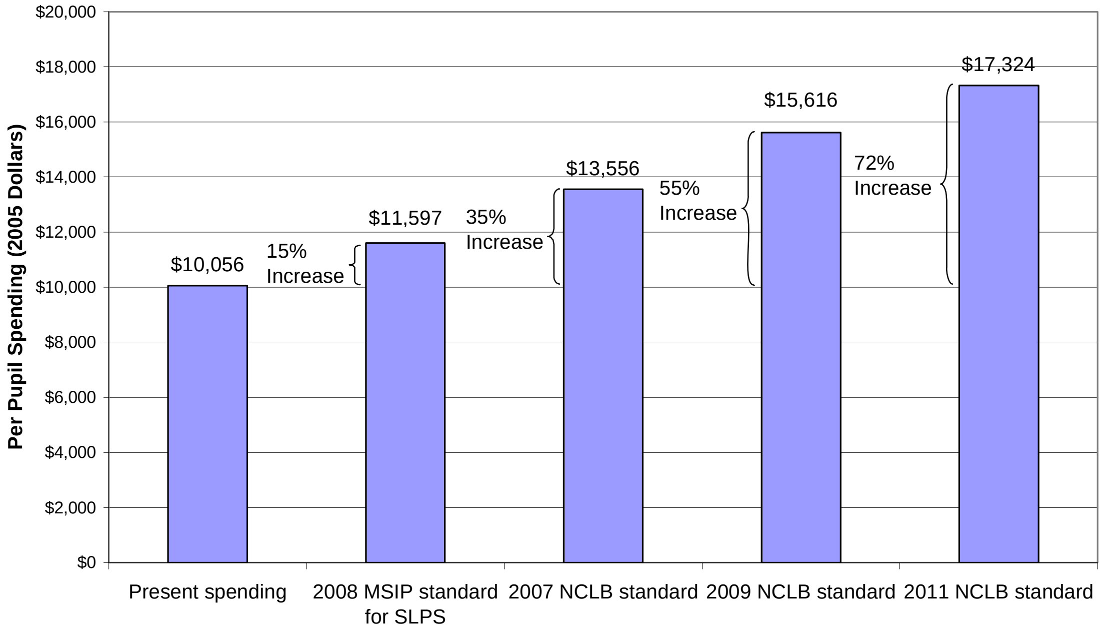
The bottom line in developing a school finance system to support student achievement standards is to assure that each school district has the resources necessary to reach these standards (Duncombe, Lukemeyer, and Yinger, 2003). A key part of determining whether a district has adequate resources is an estimate of the minimum spending required by a district to provide its students the opportunity to reach a performance standard (so called cost of adequacy). While there are several approaches to estimating the cost of adequacy, the cost function method is particularly well suited for developing these cost estimates, because it can account for all the key factors outside of district control, which can affect costs (teacher salaries, student needs, and enrollment).

The cost function results are used to estimate the required spending in school districts in Missouri to reach a given student performance standard. The process is similar to constructing a cost index except that the performance standard (instead of average performance) is multiplied by the coefficient for the student performance measure. The predicted spending can be interpreted as the spending necessary to provide students in a particular district the opportunity to reach a particular performance standard. I estimate the cost of adequacy for several standards: MSIP standards for test performance in 2008 and NCLB proficiency targets in 2007, 2009, and 2011.[28] Figure 3

[28] The proficiency standard for communication arts and math exams in elementary, middle, and high schools are averaged to produce an overall standard. This approach is likely to produce a conservative estimate of required spending, because it allows a low proficiency score in one subject or grade to be

compares current operating spending per pupil in 2005 with estimated spending necessary to reach NCLB standards.

**Figure 3: Estimated Spending Required for Students in St. Louis Public Schools to Meet NCLB Standards (2005 Dollars)**




For all three years, SLPS is estimated to require a substantial increase in spending ranging from 15% to meet the 2008 MSIP standards, to 35% to meet 2007 NCLB standard,and 72% to meet the 2011 NCLB standard.  The required spending increases are not surprising given that average performance in SLPS would need to more than double over 2005 levels to reach the 2007 NCLB standard, and go up over 4 times to reach the 2011 standard.

It should be noted that these spending estimates are in 2005 dollars. Assuming that inflation for public education in Missouri grows at the same rate as the national inflation rate for government consumption expenditures in education from 2000 to 2005,

averaged with higher proficiency scores in other grades or subjects.  NCLB, on the other hand, requires that proficiency standards be achieved in each exam for all subgroups in a school.

spending  will increase by over 4% per year (4.3%).[29] Required spending per pupil in nominal dollars to meet the 2008 MSIP standards would be approximately $13,200, and to meet 2007, 2009, and 2011 NCLB standards would be $14,700,  $18,500, and $22,300, respectively.

## 4.d. Examining the Accuracy of the Cost Function Results

Estimating the cost of adequacy involves forecasting the spending required to bring students up to a particular performance standard.  What makes developing forecasts for spending over the next five years particularly challenging is that states are in the process of implementing accountability systems to comply with NCLB.  NCLB itself will undergo reauthorization during this time period and funding and accountability changes are certainly possible.

I have taken two approaches to examining the accuracy of the spending estimates: 1) estimating forecasting accuracy; and 2) developing confidence intervals for forecasts. The principal criteria used to evaluate forecasts are accuracy and bias (Makridakis, Wheelwright and McGee, 1983). The process for estimating forecasting accuracy involves three steps: 1) build the forecasting model using data for one period of time; 2) use the model results to forecast spending in a second period of time (not in the sample used to estimate the model); and 3) compare forecasted and actual values for the second period of time.  In this analysis I estimate a cost function with data from 2000 to 2002 and then use the cost function coefficients to forecast spending in 2005.[30] Percent error is

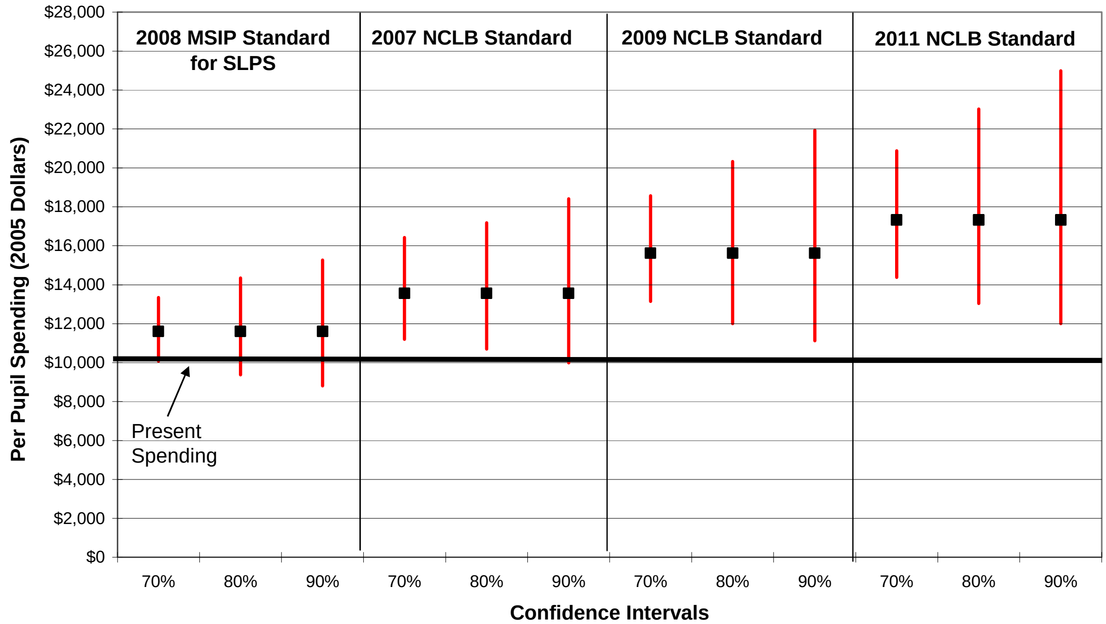
[29] I used price index for government consumption expenditures for elementary and secondary education. The source is the U.S. Bureau of Economic Analysis, *National Income and Product Accounts*, Table 3.15.4.

[30] To match the forecasting approach used in this report to estimate spending to meet MSIP and NCLB standards, the efficiency-related variables are set at the state average.  The results of the cost model for 2000-2002 are reported in appendix Table B-1.

the difference between forecasted and actual values, divided by actual values. For SLPS, the percent error for 2005 using the 2000-2002 cost model is 4.4%. This indicates that per pupil spending for SLPS was forecast to be 4.4% higher in 2005 to reach 2005 performance levels than actual spending. For all districts in the state, the median forecasting bias (average percent error) is 3.2%. Thus, the cost function developed using 2000-2002 data appears to slightly over-estimate actual spending in SLPS (and statewide) in 2005. If the required spending in SLPS to meet performance standards is adjusted down by 4.4%, the predicted spending would be $11,091 (10% increase over 2005 actual spending) to meet the 2008 MSIP standard, $12,964 (29% increase) to meet the 2007 NCLB standard, $14, 935 (49% increase) to meet 2009 NCLB standard, and $16,568 (65% increase) to meet 2011 NCLB standard.

The second approach for examining forecasting accuracy is to develop confidence intervals that should encompass the true estimate of spending with a certain chance of error. I calculate confidence intervals around the predicted spending level, which account for two possible sources of variation: 1) variation in the underlying data; and 2) possible error in the estimated coefficients in the cost function (Pindyck and Rubinfeld, 1991). For example, a 90% confidence interval should contain the true spending level with a 10% chance of being wrong. I estimate three different confidence intervals (90%, 80% and 70%), which are presented in Figure 4. The dark box in each confidence interval is the predicted spending level from the cost function, which represents the most likely spending estimate.

**Figure 4: Confidence Intervals for Estimated Spending Required for Students in St. Louis Public Schools to Meet Performance Standards (2005 Dollars)**




Looking first at the 2008 MSIP standard for SLPS using a 90% confidence interval, the estimated spending ranges from $8,810 (12% below 2005 spending) to $15,265 (52% above). By contrast, with a 70% confidence interval the spending estimates range from slightly above present spending to 33% above (Table 3). With the 2007 NCLB standard, the estimated spending in SLPS with a 90% confidence interval ranges from slightly lower than 2005 spending (0.7% below) to significantly higher $18,400 (83% increase); with a 70% confidence interval the spending estimate varies from $11,200 to $16,400, increases of 11% to 63%. With a 2011 NCLB standard, spending increases are estimated to range from 19% to 149% with a 90% confidence interval, and between 43% and 108% with a 70% confidence interval.

**Table 3. Percent Increase in Spending in St. Louis Public Schools to Meet NCLB Standards Compared to 2005 Actual Spending, Range of Estimates (2005 Dollars)**

| | Lower Bound | Most Likely | Upper Bound | Probability That Required Spending Will Be Above 2005 Spending Level |
|---|---|---|---|---|
| **2008 MSIP Standard for SLPS:** | | | | 80.50% |
| 70% Confidence Interval | 0.3 | 15.3 | 32.6 | |
| 80% Confidence Interval | -6.8 | 15.3 | 42.7 | |
| 90% Confidence Interval | -12.4 | 15.3 | 51.8 | |
| **2007 NCLB Standard:** | | | | 94.63% |
| 70% Confidence Interval | 11.3 | 34.8 | 63.3 | |
| 80% Confidence Interval | 6.3 | 34.8 | 70.9 | |
| 90% Confidence Interval | -0.7 | 34.8 | 83.0 | |
| **2009 NCLB Standard:** | | | | 98.38% |
| 70% Confidence Interval | 30.6 | 55.3 | 84.6 | |
| 80% Confidence Interval | 19.3 | 55.3 | 102.1 | |
| 90% Confidence Interval | 10.6 | 55.3 | 118.1 | |
| **2011 NCLB Standard:** | | | | 99.29% |
| 70% Confidence Interval | 43.0 | 72.3 | 107.6 | |
| 80% Confidence Interval | 29.7 | 72.3 | 128.9 | |
| 90% Confidence Interval | 19.4 | 72.3 | 148.5 | |

While there could be significant variation in the predicted spending levels to meet MSIP and NCLB standards, in most cases spending in SLPS would have to increase over 2005 spending. Stated more formally, there is close to a 81% chance that spending will have to increase over 2005 spending levels to meet the 2008 MSIP standard (Table 3). To meet the 2007 NCLB standard, there is close to a 95% chance of a spending increase in SLPS over 2005 spending, and to meet the 2011 standard, there is over a 99% chance. In other words, I can state with a high degree of confidence that spending in SLPS will need to increase to meet MSIP and NCLB standards in the near future.

## 5. Conclusions

The objective of this report is to apply the cost function approach to estimate per pupil spending necessary for the St. Louis Public Schools to provide their students the opportunity to meet MSIP and NCLB standards. The cost function was estimated with data from 2000 to 2005 for Missouri school districts. The coefficients for the independent variables in the cost function have the expected relationship with spending per pupil and most are statistically significant from zero at conventional levels.

Cost function results can be used to examine factors outside of district control affecting the cost of providing educational services in SLPS. I estimate that SLPS will require 69% higher spending per pupil than the average district in Missouri to reach the same level of student performance. The higher cost in SLPS is driven primarily by a high concentration of low-income African American students, and above average salaries required to attract qualified teachers. Students receiving subsidized lunch are over twice as expensive in SLPS to bring up to a given performance level than non-poverty students, and special education students are 50% more expensive to educate on average.

Finally, I have used the cost function results to predict the required spending in SLPS to meet MSIP and NCLB standards. Spending is predicted to need to increase in SLPS by 15% to meet the 2008 MSIP standard, by 35% to meet the 2007 NCLB standard, by 55% to meet the 2009 standard, and by 72% to meet the 2011 standard. After examining the accuracy of these forecasts, I can state with a high degree of confidence that SLPS will require a significant spending increase to reach MSIP and NCLB standards in the next five years.

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## Appendix A. Instrument Selection Process

Because expenditure, teacher salaries, and performance targets are set as part of the district planning and budgeting processes, salaries and performance measure need to be treated as endogenous variables in the cost model. I use an instrumental variable regression method (two-stage least squares) to control for the endogeneity of performance, which requires the selection of instruments. To remove the endogeneity problem, instruments should be strongly related to the endogenous variables but not independently related to the error term of cost function regression. The process for selecting a set of instruments involved three stages: 1) determine on theoretical grounds potential instruments; 2) use statistical tests to screen out unacceptable sets of instruments; and 3) use forecasting accuracy analysis to select the final set of instruments.

The first step of the process was to use theory and past research to identify potential instruments for teacher salaries and student performance. Research on teacher labor markets has determined that the cost-of-living and amenities (such as urban location) of an area and student characteristics in a district are likely to affect teacher mobility decisions and the salaries required to attract teachers to work in a district (Duncombe, Lukemeyer, and Yinger, 2003). Discussed previously, the socio-economic characteristics of students are strongly related to student performance. I would expect that comparable private sector salaries, urbanization, and student socio-economic characteristics, should be related to teacher salaries and student performance. To assure that these factors are exogenous, I have used the average of these characteristics for other school districts in the same labor market area or of the same Census district type. The

Census district types are large cities, medium cities, urban fringe of large cities, urban fringe of medium cities, large towns, small towns, rural metro, and rural non-metro.

The set of instruments tested included a measure of comparable private sector wages for labor market areas developed for the NCES (Taylor and Fowler, 2006), enrollment size as a measure of urbanization, and at least one measure of student socio-economic status. I included in each set of instruments tested either a measure of the student subsidized lunch rate, the share of African American students, the share of minority students, or some combination of them. I also included in some sets of instruments the percent Hispanic students, percent Hispanic and Native American students, percent LEP students, and percent special education students. I also examined as possible instruments several measures of fiscal capacity (income, property values, or state aid) for other districts in the same labor market area, or of the same Census district type. To screen out inappropriate sets of instruments, I used several statistical tests commonly used to evaluate instruments. First, a weak instrument test was used to identify instruments that are strongly correlated with salaries and the performance measure (Bound, Jaeger, and Baker, 1995). Second, an overidentification test (Woolridge, 2003) was used to test whether the instruments are exogenous.

Once several sets of acceptable instruments were identified, the final set of instruments was selected based on a forecasting accuracy analysis. The process for estimating forecasting accuracy involves estimating a cost function for 2000 to 2002, using the cost function to estimate spending at actual performance levels in 2005, [31] and comparing forecasted and actual spending levels in 2005. Percent error is the difference

[31] To match the forecasting approach used in this report to estimate spending to meet MSIP and NCLB standards, the efficiency-related variables are set at the state average.

between forecasted and actual values, divided by actual values. The set of acceptable instruments with the highest forecasting accuracy (lowest percent error) for SLPS was selected as the final set of instruments to use in estimating the cost function used in this report.

**Table B-1. Cost Function Estimates for Missouri School Districts (2000-2002)**

| Variables | Coefficient | t-statistic | p-value |
|---|---|---|---|
| Intercept | -3.03572 | -0.84 | 0.40200 |
| Performance measure[a] | 0.40103 | 2.44 | 0.01500 |
| **Cost variables** | | | |
| Teacher salaries[a] | 0.75221 | 2.33 | 0.02000 |
| Student poverty (percent subsidized lunch students) | 0.00453 | 3.82 | 0 |
| Black-white achievement gap (Poverty variable multiplied by percent African American) | 0.0000481 | 2.64 | 0.009 |
| Percent special education students | 0.00517 | 2.73 | 0.00700 |
| K12 distircts (1=yes) | 0.11977 | 4.50 | 0.00000 |
| **Enrollment categories** | | | |
| 100 to 150 students | -0.1762472 | -2.52 | 0.012 |
| 150 to 250 students | -0.28481 | -4.45 | 0.00000 |
| 250 to 500 students | -0.39922 | -5.86 | 0.00000 |
| 500 to 1,000 students | -0.48484 | -6.42 | 0.00000 |
| 1,000 to 1,500 students | -0.55235 | -6.57 | 0.00000 |
| 1,500 to 2,500 students | -0.60377 | -6.38 | 0.00000 |
| 2,500 to 5,000 students | -0.66850 | -6.49 | 0.00000 |
| 5,000 to 15,000 students | -0.65245 | -5.41 | 0.00000 |
| Over 15,000 students | -0.63718 | -6.02 | 0.00000 |
| **Efficiency-related variables** | | | |
| **Fiscal capacity** | | | |
| Per pupil property values[a] | 0.03704 | 0.97 | 0.33100 |
| Per pupil income[a] | 0.23030 | 5.61 | 0.00000 |
| Statel aid/income ratio | 1.87763 | 6.50 | 0.00000 |
| **Other monitoring variables** | | | |
| Percent of adults that are college educated (2000) | 0.03154 | 0.11 | 0.91200 |
| Percent of population 65 or older (2000) | -0.38857 | -1.69 | 0.09100 |
| Percent of housing units that are owner occupied (2000) | -0.08099 | -0.75 | 0.45400 |
| Local tax share (median housing price/average property values)[a] | -0.06044 | -2.04 | 0.04200 |
| **Year indicator variables** | | | |
| 2001 | 0.00638 | 0.33 | 0.74000 |
| 2002 | 0.00973 | 0.30 | 0.76200 |
| Sample Size | | 1520 | |

Note: Estimated with linear 2SLS regression with the log of per pupil current operating cost (minus transportation spending) as the dependent variables. The performance measure and teacher salaries are treated as endogenous variables with instruments based on exogenous variables for other districts in the same labor market area and census region (see text). Robust standard errors are used for hypothesis testing (controlling for clustering at the district level).