Twice as Nice:
An Analysis of School District Efficiency
with Two Measures of Student Performance

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Abstract: This study examines the components of efficiency measures used in studies of educational cost. We enrich the literature by developing a model that uses two indexes of student performance. This model is used to reveal how scholars' choice among student performance measures affects the measurement of efficiency. We show that the inefficiency measured in educational cost studies includes spending related to student performance measures not included in the analyses. Our simulation shows that more of the resulting increase in spending associated with a $1000 increase in state aid can be explained by spending on other included student performance measures than by an increase in inefficiency, which measures both wasteful spending and spending on other outputs not included in the study. These results suggest that efforts to minimize measures of inefficiency may incentivize districts to dissolve programs valued by voters because spending for these programs is implicitly considered inefficient. This finding has widespread implications for education policy, especially in the development of accountability systems.

Introduction

In common usage, the term "inefficiency" means wasteful spending. Policy makers often conceptualize inefficiency in a similar manner when designing accountability systems, such as the federal *No Child Left Behind Act* of 2001, intended to discourage "inefficient" behavior by schools and school districts. When applied to econometric measurement for a production process with multiple outputs, however, productive inefficiency is more complicated than this simple definition. In the setting of educational cost measurement, inefficiency can only be defined with respect to specific, measurable outputs, and wasteful spending cannot generally be separated from the provision of outputs other than the ones specified in the analysis. Schools characterized as inefficient in the production of student performance on Math and English tests, for example, might spend funds wastefully, but they might also spend a large amount of funding to boost performance on science and history exams. When we speak of inefficiency throughout this paper, we are referring to the understanding of inefficiency that includes both wasteful spending and spending on non-specified outputs. The misinterpretation of the term inefficiency has widespread implications for policy, in that incentives to become more efficient may undermine other valuable programs.

Existing studies of school district efficiency cannot distinguish between spending on outputs other than those included in the analysis and wasteful spending. This paper contributes to an understanding of school district efficiency by devising and estimating a two-output educational cost function, along with demand functions for the two outputs. Output A could be the average student performance on Math and English tests, for example, whereas output B could be student performance in science and history. This approach separates inefficiency in the delivery of output A into two parts: spending for output B and spending that does not contribute to either output A or output B. The latter category includes wasteful spending, but could also include spending on outputs other than A or B. This approach makes it possible to determine the extent to which state policies designed to boost output A, such as educational aid increases, also lead to changes in spending on output B and to changes in other types of spending, including wasteful spending.

To consider our argument regarding inefficiency in a less complicated framework, we can think of a private manufacturer that produces two outputs: widgets and gadgets. The manufacturing process is such that the inputs into production are shared by two outputs. Widgets are produced in the first step, and in the second step, the "wasted" inputs are used to produce gadgets. So, when considered independently, we conclude that the widget production process is inefficient since there is a substantial amount of "wasted" input. To increase the efficiency of the widget production process, though, we produce fewer gadgets. We can only draw conclusions regarding the efficiency of the production process as a whole when we include both outputs in the analysis.

Both the inputs and outputs of the educational production process are more complicated than this example. We cannot directly measure the waste of the educational production process. Instead, we must make inferences about inefficiency in the production of specified outputs by observing the way spending varies across school districts, controlling for the level of these outputs and other cost factors that affect this variation in spending. This set-up does not allow us to separate waste from spending on outputs that are not specified. For the difference between the cost estimated and actual spending to be solely composed of waste, all valuable outputs of the educational production process must be measured and included in the study. Because of the vast number of outputs of the educational production process and the difficulty in measuring the outputs, this is a nearly impossible task. In this paper, we take a step in this direction by identifying two sets of outputs, one of which could be thought of as the target of an accountability system, whereas the other could be thought of as additional outputs valued by voters.

Because we desire to separate increases in expenditure into its various components, namely, increases in core subject performance, in non-core subject performance and in inefficiency, we identify the district characteristics that have an impact on district efficiency and use a structural model to separately estimate the impact of these characteristics on efficiency and on the demand for student performance. We use two indexes of student performance to highlight the impact of choices made by researchers with respect to the performance measures they include and the resulting effect on the inefficiency measure. The paper begins by describing the theory behind the structural model. Then, we describe the estimation procedure and estimation results. The results of the simulation are presented in the following section, and finally, we interpret the findings. To preview the results, in the simulation, we use the estimates of the underlying parameters, identified with the structure of the model, to estimate the impact of an increase in state aid by $1000 per pupil. We find that more of the change in "inefficiency" is due to spending on the secondary performance measure than it is to other forms of spending, that is, to wasteful spending and spending on performance measures that have not been identified.

A Model of the Demand for and Costs of Two School-District Outputs

Our model consists of voter and community budget constraints, constant elasticity demand functions for school services, a cost function, and an efficiency equation. After presenting these elements, we derive expenditure and demand equations that we can estimate.

Cost functions, budget constraints and efficiency

Following previous studies (Duncombe and Yinger 2008), we assume that cost, C, is a multiplicative function of the two measures of student performance (S_1 and S_2) and we add cost factors, D, such as teachers' salaries, student enrollment, and the percentage of students receiving free or reduced price lunch. These steps yield

$$C\left\{S_1, S_2, D\right\} = kS_1^{\sigma_1} S_2^{\sigma_2} D^{\lambda} \tag{1}$$

In equation (1), σ_1 can be interpreted as the economies (or diseconomies) of scale associated with S_1, and σ_2 as the economies (or diseconomies) of scale associated with S_2. A value greater than 1.0 indicates diseconomies of scale.

We do not observe the cost to produce specific levels of student performance. Instead, we use the expenditure of the district to estimate costs. The difference between cost and expenditure is what we refer to as inefficiency. Spending per pupil, E, equals costs, $C\{S_1, S_2, D\}$ divided by school district efficiency, e, where e is an index with a minimum of zero (completely inefficient) and a maximum of 1 (completely efficient). The cost function describes the spending required to provide S_1 and S_2 using best practices; that is, with $e = 1$. As e decreases, E increases. In other words, inefficient districts spend more than efficient districts to obtain the same performance level of the specified outputs.

$$E \equiv \frac{C\{S_1, S_2, D\}}{e} \tag{2}$$

The community budget constraint requires spending per pupil to equal revenue per pupil. Revenue per pupil comes from local and state sources: property taxes (the tax rate, t, multiplied by assessed value per pupil, $\bar{V}$) and state aid (A).

$$E \equiv \frac{C\{S_1, S_2, D\}}{e} = t\bar{V} + A \tag{3}$$

Equation (3) can be solved for the budget-balancing value of t, namely,

$$t = \left(\frac{1}{\bar{V}}\right)\left(\frac{C\{S_1, S_2, D\}}{e} - A\right) \tag{4}$$

Because efficiency is a component of the expenditure equation, this analysis uses the expenditure equation results to produce a measure of school district efficiency. We, like previous studies (Downes and Pogue 1994, Reschovsky and Imazeki 1998, Duncombe and Yinger 2001), use total district spending per pupil[1], which includes spending on S_2 and other outputs, as the dependent variable. Previous studies treat spending beyond the minimum to produce S_1 as inefficiency even though this spending is not necessarily wasteful, as S_2 is also a product of education valued by some voters. We incorporate both S_1 and S_2 into the cost function so that the minimum spending needed to produce S_2 is not counted as inefficiency in our analysis[2]. However, we still cannot distinguish between waste and spending for S_3 (other educational outputs not included in the analysis). We leave that for future research.

Prior to presenting the efficiency equation, we derive terms to be used in the efficiency and demand equations. We begin with the household budget constraint. The household budget constraint requires that income equal expenses, which consists of spending on the composite good and property taxes. The composite good, Q, includes housing, which plays no special role in the present analysis and is defined so that it has a price of unity. The STAR program in New York State exempts the first X dollars in house value from property taxes[3]. This leads to the following household budget constraint:

$$Y = Q + t(V - X) \tag{5}$$

Substituting equation (4) into (5) yields the combined household budget constraint.

[1] Though, we exclude spending designated for specific purposes not directly related to student performance, like transportation spending.
[2] Note that we are implicitly considering these outputs to be valuable.
[3] For a more detailed explanation of New York State's STAR exemption program, see Eom, Duncombe and Yinger (2007).

$$Y + A\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) = Q + \frac{C\{S_1, S_2, D\}}{e}\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) \quad (6)$$

The left side of equation (6) is full household income, which is composed of the household's own income and its share of state aid. The right side is the household's expenditure, including its share of expenditure on education.

Tax price, *TP*, is what an increment in school performance costs a voter, so it is derived by differentiating a voter's spending with respect to performance. In the case of S_1, this step yields

$$TP_1 \equiv \frac{\partial Spending}{\partial S_1} = \frac{dC}{dS_1} e^{-1}\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) = MC_1 e^{-1}\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) \quad (3)$$

The tax price of the second index of performance measures is found through an identical process. Tax price affects both the demand for educational outcomes and the efficiency of a district. We expect that a higher tax price leads to a lower demand for performance, as the relationship between price and quantity demanded is generally negative.

The wasteful spending component of *e* is determined by the level of monitoring per pupil, which we assume is a function of the median voter's income, the tax price of each of the performance measures, and other factors, such as the percentage of population that is elderly. The spending on other outputs component of *e* is determined by variables related to the demand for the other outputs, which include the median income and tax price. In theory, an increase in income has two effects on the level of monitoring chosen by the voter: an income effect and a substitution effect. Higher income individuals may spend less time monitoring because they have a high opportunity cost (income effect). However, the substitution effect leads the voter to spend more time monitoring and to spend less time working. Income also has an impact on voters' demand for S_3, the other component of inefficiency. For example, wealthier voters may value, and therefore demand, better music programs. If this is true, and performance in music programs show up as inefficiency, income has a negative impact on efficiency.

We expect the price effect in the efficiency equation to be positive: individuals spend more time monitoring because they do not want their tax dollars to be wasted. Tax price is also expected to have an effect on the demand for other outputs. Based on the price, voters decide which services they want the education system to provide. For example, at a high price, voters may choose to demand performance only in core subjects like English and Mathematics. If this is the case, tax price is positively related to measures of efficiency, as there is little spending on other programs. Finally, we expect other characteristics like percent elderly to matter because these voters may not have as vested an interest in the performance level achieved by the students in their district and therefore monitor less often, or they may have a lower opportunity cost and therefore monitor more often.

The efficiency equation takes the form:

$$e = \kappa M^{\rho}\left(Y + fA\left(\frac{\bar{V}}{V}\right)\left(1-\frac{X}{V}\right)\right)^{\gamma}\left(MC_1\left(\frac{\bar{V}}{V}\right)\left(1-\frac{X}{V}\right)\right)^{\delta}\left(MC_2\left(\frac{\bar{V}}{V}\right)\left(1-\frac{X}{V}\right)\right)^{\delta}, \qquad (4)$$

where γ is the elasticity of efficiency with respect to income, δ_1 is the elasticity of efficiency associated with the marginal cost and tax share components of tax price[4], and δ_2 is the elasticity of efficiency associated with the STAR component of tax price.

Expenditure Equation

Substituting equation (8) into the definition of E in equation (2) yields

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[4] In order to be able to solve for the underlying parameters of the efficiency equation, we assume that the elasticity of efficiency with respect to marginal cost is equal to the elasticity of efficiency with respect to the median voter's tax share. We do this empirically to be able to solve for λ. Theoretically, this makes sense because both of these variables are components of tax price. We chose the tax share over the STAR component because the results regarding tax share have been more consistent (add cites).

$$E = \frac{C\{S_1, S_2, D\}}{e} = \kappa^* S_1^{\sigma_1^*} S_2^{\sigma_2^*} D^{\lambda(1-2\delta_1)} M^{-\rho} \left(Y + fA\left(\frac{V}{\bar{\bar{V}}}\right)\left(1-\frac{X}{V}\right)\right)^{-\gamma} \left(\frac{V}{\bar{\bar{V}}}\right)^{-\delta_1} \left(1-\frac{X}{V}\right)^{-\delta_2} \quad (5)$$

where

$$\sigma_1^* = \sigma_1 - \left[\delta_1\left(2\sigma_1 - 1\right)\right]$$
$$\text{and } \sigma_2^* = \sigma_2 - \left[\delta_1\left(2\sigma_2 - 1\right)\right] \quad (6)$$

Taking logs of equation (8) yields the estimating equation

$$\ln E = \kappa^{**} + \sigma_1^* \ln S_1 + \sigma_2^* \ln S_2 + \lambda\left(1-2\delta_1\right)\ln D - \rho \ln M - \gamma \ln Y$$
$$-\gamma f \frac{A}{Y}\left(\frac{V}{\bar{\bar{V}}}\right)\left(1-\frac{X}{V}\right) - \delta_1 \ln\left(\frac{V}{\bar{\bar{V}}}\right) - \delta_2 \ln\left(1-\frac{X}{V}\right) \quad (7)$$

In estimating the expenditure equation, we must address the simultaneity that exists between the performance measures, teacher salary, and the expenditure level of the district. The district determines its level of expenditure at the same time as it determines its target performance level and teacher salaries. In this study, we choose instruments for a district's performance based on their influence on similar districts' performance. Our instruments are based on the theory that a district compares its performance to the performance of similar districts—and uses those other districts as a standard to shoot for.

We define groups of similar districts in terms of their tax base per pupil. The method begins by grouping districts by their total property value (as a proxy for potential to collect revenue locally) per pupil. The instruments are the difference between the group average of the median house value and the median house value of the district, the difference between the group average percentage of students receiving free or reduced price lunch and that of the individual district, and the maximum median household income of the group[5].

Considering the first instrument (the difference between the average of the median house value for the group and the median house value of the district), if the average of the other median house values in the group is greater than the district's median house value, a district may choose a higher performance level based on the other districts' greater demand (higher median house value), and therefore, higher level of performance. Similar arguments can be made for each of the other instruments. Note that we cannot use the performance measures themselves because these are also endogenous, so we choose exogenous variables that are correlated with performance. We also include the instruments in the demand equations because we expect these variables to have an effect on the demand for student performance. In addition, similar to many previous studies (Duncombe and Yinger 1997, Duncombe and Yinger 2001), we use the district's average manufacturing wage to instrument for teacher salaries as a proxy for the opportunity cost involved associated with the teaching profession.

Demand Equations

We assume that the demand functions for S_1 and S_2 take the widely used constant-elasticity form. This assumption allows us to introduce the full income, equation (6), and tax price, equation (7), terms derived earlier into a multiplicative demand function. The resulting equation for S_1:

$$S_1 = K(Y^*)^{\theta}(TP_1)^{\mu} = K(Y^*)^{\theta}\left(MC_1 e^{-1}\left(\frac{V}{\overline{\overline{V}}}\right)\left(1-\frac{X}{V}\right)\right)^{\mu} \tag{8}$$

[5] We create groups of eight by the total property value in the district per pupil and calculate the minimum, maximum, average, and difference for a variety of exogenous variables included in the estimation. We choose instruments based on the results of the F-test for weak instruments, and also use the Fuller estimator to avoid the bias associated with instrument weakness (Fuller 1977). These choices are examined in Appendix A. We show results in the appendix using the Fuller(4) estimator and groups of six, and results using two stage least squares and groups of eight.

Using the expenditure equation results, we create cost and efficiency indexes (D^* and e^*, respectively). The variation in the cost index comes from the variation in the variables of the expenditure equation related to the cost a district faces in producing an additional unit of student performance. The variation in the efficiency index comes from the variation in the variables of the expenditure equation that affects the level of monitoring chosen by voters in the district. The variables in each of the indexes are weighted by the estimated coefficients in the expenditure equation[6]. Neither index derives variation from the measures of student performance, so we rely on structural assumptions to identify the demand equations. Solving equation (12) for S_1 yields:

$$S_1 = \left(K_1^*\right)^{1/\mu_1^*} \left(Y^*\right)^{\theta/\mu_1^*} \left(S_2\right)^{\phi_2/\mu_1^*} D^{*\mu_1/\mu_1^*} e^{*-\mu_1/\mu_1^*} \left(\frac{V}{\bar{\bar{V}}}\right)^{\mu_2/\mu_1^*} \left(1-\frac{X}{V}\right)^{\mu_3/\mu_1^*} Z^{\mu_4/\mu_1^*} \qquad (9)$$

where

$$\begin{aligned} &K_1^* = K\left(\sigma_1 k\right)^{\mu_1} \kappa^{-\mu_2},\ \ \mu_1^* = 1-\left(\mu_1\left(\sigma_1 - 1\right) - \mu_1\delta_1\left(2\sigma_1 - 1\right)\right), \\ &\phi_2 = \mu_1\sigma_2 - \mu_1\delta_1\left(2\sigma_2 - 1\right) \end{aligned} \qquad (10)$$

and Z is a vector of other characteristics expected to have an effect on demand, including those variables used as instruments in the expenditure equation.

Using the parameter estimates recovered in the expenditure equation, we can estimate the demand parameters: θ is the income elasticity of demand for S_1, μ_1 is the price elasticity of demand for S_1 associated with marginal cost and - μ_1 with efficiency[7], μ_2 is the price elasticity of

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[6] The estimation of the coefficients in the expenditure equation is logically prior to the estimation of the demand coefficients, so these equations cannot be estimated simultaneously.

[7] We assume that the coefficients of marginal cost and efficiency in the demand equations are equal in magnitude but opposite in sign. We do this to be able to recover the underlying parameters of the demand equations. We consider this reasonable based on the results of previous studies that have shown this to be reasonably accurate (add cites).

demand associated with tax share, and μ_3 is the price elasticity of demand associated with the STAR component of tax price[8].

Taking logs of each side yields the estimating equation,

$$\ln S_1 = \left(K_1^{**}\right) + \frac{\theta}{\mu_1^*}\ln Y^* + \frac{\phi_2}{\mu_1^*}\ln\left(S_2\right) + \frac{\mu_1}{\mu_1^*}\ln D^* - \frac{\mu_1}{\mu_1^*}\ln e^* + \frac{\mu_2}{\mu_1^*}\ln\left(\frac{V}{\bar{\bar{V}}}\right) + \frac{\mu_3}{\mu_1^*}\ln\left(1-\frac{X}{V}\right) + \frac{\mu_4}{\mu_1^*}\ln Z \qquad (11)$$

Equation (15) can be estimated, so long as S_2 is treated as an endogenous variable. In addition, a similar demand equation can be derived for S_2, with S_1 treated as endogenous. The problem with this approach is that it is very difficult to find a variable that influences one S without also influencing the other, which is, of course, a requirement for a valid instrument.

However, these two demand equations constitute a system of two equations with two unknowns. An alternative estimating procedure, therefore, is to solve these two equations for S_1 and S_2, thereby eliminating the need for an instrumental variables procedure.

By simplifying (15) and adding the comparable equation for S_2 we have

$$S_1 = B_1\left(S_2\right)^{\eta_1} \text{ and } S_2 = B_2\left(S_1\right)^{\eta_2} \qquad (12)$$

Solving these two equations yields

$$\begin{aligned} S_1 &= \left(B_1\right)^{1/(1-\eta_1\eta_2)}\left(B_2\right)^{\eta_1/(1-\eta_1\eta_2)} \\ S_2 &= \left(B_2\right)^{1/(1-\eta_1\eta_2)}\left(B_1\right)^{\eta_2/(1-\eta_1\eta_2)} \end{aligned} \qquad (13)$$

where

$$B_1 = \left(K_1^*\right)^{1/\mu_1^*}\left(Y^*\right)^{\theta/\mu_1^*} D^{*\mu_1/\mu_1^*} e^{*-\mu_1/\mu_1^*}\left(\frac{V}{\bar{\bar{V}}}\right)^{\mu_2/\mu_1^*}\left(1-\frac{X}{V}\right)^{\mu_3/\mu_1^*} Z^{\mu_4/\mu_1^*}$$

[8] This approach could be extended to consider cross-price elasticities in principle but we would not be able to solve for the underlying parameters.

$$B_2 = \left(K_2^*\right)^{1/\varphi_1^*} \left(Y^*\right)^{\varphi_1/\varphi_1^*} D^{*\varphi_1/\varphi_1^*} e^{*-\varphi_1/\varphi_1^*} \left(\frac{V}{\bar{\bar{V}}}\right)^{\varphi_2/\varphi_1^*} \left(1-\frac{X}{V}\right)^{\varphi_3/\varphi_1^*} Z^{\varphi_4/\varphi_1^*} \tag{14}$$

$$\eta_1 = \frac{\mu_1\sigma_2 - \mu_2\left[\delta_1\left(2\sigma_2 - 1\right)\right]}{\mu_1^*}$$

$$\eta_2 = \frac{\varphi_1\sigma_1 - \varphi_2\left[\delta_1\left(2\sigma_1 - 1\right)\right]}{\varphi_1^*}$$

These two equations do not require instruments for the performance variables. Moreover, when combined with estimates of the expenditure equation, the estimated coefficients from these two equations can be used to recover all the structural parameters of the model.

Model Estimation

Data

The sample is composed of school district data in New York State for the years 2000-2002. Because we are composing two performance indexes using elementary, middle school, and high school data, we use only unified districts having at least one school teaching at each of these grade levels. Additionally, we lose some districts from the sample due to missing data, usually the performance indicator[9].

To calculate a value of median house value, *V*, the ORPS's equalization rate is used to update the Census measure of property value by annual percentage change in residential property value. This is done for the reason that the Census measure is only available every ten years. The ORPS calculates this equalization rate (used to correct STAR exemptions when assessed values are not equivalent to the full values) through the use of a survey that is conducted every two

[9] We have no reason to believe these districts are different than those in the sample. Districts that do not have certain programs that we are interested in have a value of 0 and are not "missing".

years[10]. The equalization rate is also multiplied by the total assessed value minus all property tax exemptions, except STAR, and then divided by number of pupils to yield $\overline{V}$, total property value per pupil.

Our objective is to use a range of different measures for student performance. The data for our measures originates in the Chapter 655 reports for school districts compiled by the New York State Education Department[11]. These data indicate the percentage of students reaching a state-determined reference point, like passing for the Regents examinations or gaining the highest level of achievement on the 4th and 8th grade examinations in Mathematics and English[12]. We also use the percent of students going to college and the inverse of the dropout rate as additional outcome measures. The index will give equal weights across the performances in various subjects[13].

Our baseline version uses the 4th and 8th grade test results in English and Mathematics, the percentage of "average grade enrollment" passing English and Mathematics Regents examinations, and the high school graduation rate in the first performance index. The baseline version of the second performance index is composed of the "average grade enrollment" passing Regents examinations in Global History, French, Physics, and Chemistry. We also include the percent of graduating high school students who continue their education at the university level in S_2. We call this measure the college-bound rate. We also create two other versions of performance indexes to examine how the results change based on the choice of what

[10] The survey is designed to better reveal the relationship between assessed and market value. However, it should be noted that the surveys are only given to a small sample of houses, so their power in correcting the assessments may be limited.

[11] We use pooled cross-section data for years 2000-2002 in our estimation.

[12] In some cases, changes in the tests introduce inconsistency in the measurement of high school educational outcomes across years. We control for these changes by including year dummies in the equation.

[13] As mentioned in the introduction, we can differentially weight the various performance measures to define the relative importance of each school output, but since we are simply using the performance measures to explore their effect on the efficiency measure, we choose equal weights and change how we define S1 and S2 in the different versions we estimate.

performance indicators to include in the estimation. We use the 4^{th} and 8^{th} grade English and Mathematics results and the graduation rate in version 2 of the first performance index, and the passing rate of the high school English, Mathematics, Physics, Chemistry, French, and Global Studies Regents examinations and the college-bound rate in the second performance index. In version 3, we use the passing rate of the English and Mathematics Regents examinations in S_1, and in S_2, we use the 4^{th} and 8^{th} grade English and Mathematics results, the graduation rate, the passing rate of the high school Physics, Chemistry, French, and Global Studies Regents examinations, and the college-bound rate.

For each of the versions of the first and second performance indexes, we selected the first index based on the prevalence of Math and English scores in the majority of previous cost studies and their position at the center of accountability efforts. We chose test results to include in the second performance index to highlight some of the important outputs that are often overlooked in accountability programs, but for which standardized test results are available (and are therefore interpreted as valued by the voters and administrators). The examinations for these programs are also relatively consistent over the period being considered[14].

Many of the socioeconomic variables included in the study are extracted from the Chapter 655 reports. They contain measures of students receiving free or reduced price lunch, students with limited English proficiency, measures of students with disabilities, enrollment in the district, and data on spending in the district. We add data from the U.S. Census including the median household income, the percent elderly in the district, the percent of residents with college degrees, and the classification of land in the district as rural, suburban or urban.

[14] Spanish exam outcomes are not included because of their theoretical relationship to students with limited English proficiency.

Teacher salaries are considered endogenous in the expenditure equation in that districts decide how to compensate teachers and which teachers to hire. Like Duncombe and Yinger (2005a), we measure teacher salaries using salaries of teachers with between one and five years of experience (from the Personnel Master Files of the New York State Education Department). This group was chosen because we wish to minimize the diversity in salaries due to tenure and other distinctions that come with greater experience. We use the unexplained part of the salary of teachers with between one and five years of experience after regressing salary on experience and education. In other words, we use salary of beginning teachers, holding experience and education constant, because districts can choose teachers with certain credentials, and we do not want to include factors that the district has control over in our estimation of cost.

Estimation

To estimate the expenditure equation with our instruments, we use the Fuller-k estimator with k=4. This estimator has been shown to be less subject to the bias associated with weak instruments[15], as compared to two stage least squares (2SLS) and limited information maximum likelihood (Andrews and Stock 2005, Hahn, Hausman and Kuersteiner 2003). Because we are instrumenting for three potentially endogenous variables in the expenditure equation and each of the instruments is not highly correlated with all three of the endogenous variables, this estimator is the best candidate.

Table 2 presents the results for the expenditure equation[16]. Recall that we must solve for the parameter components to be able to interpret the numbers in relation to the cost and efficiency equations. Each of the cost variables has the expected sign. The underlying parameters and their standard errors are found in Tables 3 and 4. Note that our baseline results

[15] The partial-F statistic associated with S1 is 9.37, with S2 is 1.92, and with teacher salaries is 13.12.
[16] Each of the regressions is estimated using Fuller-k with k=4 and instruments in groups of eight.

are in the version 1 column of each of the tables, and these are the results that will be highlighted in the discussion. The estimated coefficients of the performance indexes indicate economies of scale in the production of educational performance. The coefficient on teacher salary is in line with previous measures: a one percent increase in teacher salaries increases expenditure by 0.82 percent. The cost factors, like the percent of students in poverty and percent of students with limited English proficiency, all have positive coefficients and are significant[17]. As in many previous studies, we find a U-shaped relationship between cost and enrollment in a district (Duncombe and Johnston 2004, Duncombe and Yinger 2001, Imazeki and Reschovsky 2006). In the efficiency equation, all of the parameter estimates have the expected sign. A one percent increase in median income leads to a 0.05% percent decrease in efficiency, which is consistent with the story that higher income households have a high opportunity cost for monitoring and higher income households demand a wider variety of services. However, this result is insignificant. Also, an increase in tax share and a decrease in the size of the STAR exemption increases district efficiency, which is consistent with our expectation that an increase in tax price increases efficiency. The sizes of the responding increase in efficiency are on the order of 0.064% and 0.031%, respectively. Also, results indicate that residents in rural districts demand greater efficiency: a one percentage point increase in the percent rural leads to a 0.038% increase in efficiency.

The demand estimates are presented in tables 5 and 6. The demand equations include cost and efficiency indexes created using coefficients estimated in the expenditure equation[18]. An increase of one percent in median household income increases our first student performance

[17] The standard errors were calculated using a bootstrap. Each of the 999 bootstrap estimates were used to calculate the underlying parameters, and the standard deviation of these estimates are used as the standard errors that appear in Tables 3.
[18] We bootstrap to obtain the standard errors in tables 5 and 6 due to the nature of the cost and efficiency indexes being predicted regressors.

measure by 0.09%, whereas a one percentage point increase in adjusted aid leads to an increase of 1.2% in the first student performance measure. The coefficients associated with tax price components are negative as expected: -0.0737 for the log of tax share and -0.0137 for the STAR component. The cost index term in the baseline version of the first demand equation has a negative sign: a one percent increase in the cost index leads to a 0.63% decrease in demand. The efficiency index has a positive sign: a one percent increase in the efficiency index increases demand by 2.7%. Also, the instruments used in the expenditure equation are all significant in the baseline version of the first demand equation.

The results for the second demand equation are very similar to those for the first demand equation, though they are measured with less precision. A one percent increase in median household income increases demand for the second measure of student performance by 0.06%, whereas a one percent increase in the adjusted aid term increases student performance by 0.397%. The coefficients estimated for each of the components of tax price are negative: -0.0315 for tax share and -0.0134 for the STAR component. The cost index has the expected negative sign and the efficiency index has the expected positive sign. The results also indicate that a one percentage point increase in the percent college graduate increases demand by 0.477%. Finally, just one of the instruments, the maximum median household income for the group is significant[19].

Tables 7 and 8 present the underlying parameters of the two demand equations. Each of these structural parameters has the expected sign, and their magnitudes are generally in line with previous estimates. The parameters appear without standard errors because when estimated, these standard errors are inflated by the procedure used to calculate the parameters. It is

[19] This is the main reason we use the Fuller estimator in the expenditure equation – the instruments are weakest for the second performance index, possibly because this variable is estimated with less precision.

expected that standard errors of structural parameters computed using a number of random variables will be large, and therefore do not hold much information with regard to the significance of the estimates. In addition, we use the estimated coefficients that appear in tables 5 and 6 to create the predictions of student performance in the simulation.

Simulation

The estimates of the underlying parameters are used in the simulation to show the effects of a $1000 increase in state aid. Shocks to the system like an increase in state aid affect the various levels of performance, the efficiency of the district, and the level of spending. Table 9 shows the results of the simulation. The first column contains the results using the baseline version of the performance indexes, and the following 2 columns hold the results using the other versions of S_1 and S_2.

In Table 9, the first column of each version represents the makeup of the increase in expenditure associated with a $1000 increase in state aid. So, in the baseline version, a $1000 increase in aid causes a 3.77% increase in expenditure. Of this 3.77%, 0.62 percentage points are attributable to a decrease in efficiency, 1.65 percentage points are attributable to an increase in S_1 and 1.50 percentage points are attributable to an increase in S_2. The second column represents the makeup of the increase in expenditure in percentage terms. With the baseline version of S_1 and S_2 (version 1), the $1000 increase in aid results in approximately the same percentage increase in S_2 and S_1. The increase in S_2 is more than twice as large as the drop in efficiency. Figure 1 shows the composition in a bar graph.

In each of the three simulations, the shock to aid leads to an increase in expenditure of approximately 3 or 4%. Between 11 and 22% of this increase is explained by a decrease in efficiency, which may still contain spending on valuable outputs other than those included in S1 and S2. Depending on how S1 and S2 are specified, the increase in the second performance index in response to the increase in aid explains at least twice as much of the increase in expenditure as inefficiency. So, the potential to overstate an increase in inefficiency (if inefficiency is to be interpreted as waste) is relatively large. That is, by ignoring the performance measures in the second index (assuming that these outputs are considered valuable), the contribution of inefficiency to the increase in expenditure may be estimated to be at least three and as large as eight times as large as we estimate including these measures of performance. In the third version of the simulation, using just English and Mathematics high school passing rates in S1, we would have attributed almost all of the increase in expenditure to an increase in inefficiency[20].

Conclusion

With full information, we would have a comprehensive list of all valuable outputs (and an agreement about how to measure them), so that we could estimate a comprehensive education cost function and measures of inefficiency would consist solely of wasteful spending. Lacking this information (and agreement), we have estimated a cost function with two output measures and explored the consequences for the way efficiency is defined and estimates of efficiency are interpreted. With this approach, the results obviously depend on the outputs that are selected. In other words, the results could be quite different if we had access to information on outputs not considered here, such as music education, computer education, and extracurricular activities. Our analysis is not intended as a way to determine which educational outputs are most valuable. Instead, we sought to highlight the importance of defining valuable outputs and making the discussion and concern about school district efficiency one that begins by forming this definition.

[20] Though when interpreting the simulation, we must recognize that if the two performance indexes are highly correlated, the estimation with just the first performance index may pick up some of the impact of the second performance index.

Often, in its paternal role, the policymakers of the government define valuable outputs, even if the value placed on various outputs is not consistent with the value placed on the outputs by voters. Labeling school districts inefficient because the voters in the district and state or federal policymakers place different values on outputs is not a proper characterization, nor does the disagreement make the district wasteful. It simply means that the district is responding to the demands of the voters. Existing educational accountability programs have not recognized this issue and are based on the view that any spending not devoted to a few specified objectives is inevitably wasteful. Our analysis shows that this view is not correct; spending on non-specified outputs is not necessarily wasteful. Further research is needed to help guide policy makers in the selection of performance targets for their school accountability systems and in the design of provisions that discourage wasteful spending by schools.

Table 1. Means

	Mean	Standard Deviation
Log of Expenditure Per Pupil	9.311636	0.2008469
Measure of Teacher Salary	10.50265	0.1440655
Log of Performance Index 1	-0.9507766	0.1648513
Log of Performance Index 2	-0.8144943	0.2129891
Log of Median Household Income	10.73942	0.3437584
Adjusted Aid	0.026194	0.0243207
Percent Students Receiving Free/Reduced Price Lunch	0.2978476	0.1891106
Percent Students with Limited English Proficiency	0.0152904	0.0298877
Percent Students with Disabilities	0.1328698	0.0280552
Percent of Disabled Students in Separated Classrooms	0.0463983	0.0478577
Log of Enrollment	7.561126	0.8786913
Log of Enrollment Squared	57.94225	13.43995
Log of Tax Share	-1.221963	0.6034598
Log of STAR Component of Tax Price	-0.3496883	0.466395
Percent Elderly	0.140013	0.0344133
Percent Rural	0.2804878	0.4493746
Percent Urban	0.0902439	0.2866183
Year 2001	0.34	0.4726858
Year 2002	0.33	0.4709701
Cost Index	0.9999	0.0509758
Efficiency Index	0.9754013	0.0081061
Percent College Graduate	0.2444469	0.1380003
Difference between Students Receiving Free/Reduced Price Lunch and Group Average	0.00000000121	0.1783912
Difference between Median House Value and Group Average	-0.0004859	67047.44
Maximum Median Household Income for the Group	70097.64	29015.33

Table 2. Expenditure Results

Variable	Estimate Version 1^ (Standard Error)	Estimate Version 2^^ (Standard Error)	Estimate Version 3^^^ (Standard Error)
Teacher Salary	0.716955 (0.5063442)	0.7591064 (0.576173)	0.5990373 (0.4091004)
Log of Performance Index 1	0.7980323* (0.4780743)	0.4586569 (0.4304734)	0.2223063 (0.6540997)
Log of Performance Index 2	0.8316811** (0.3581061)	1.171101** (0.4435628)	1.486039*** (0.4627208)
Log of Median Household Income	0.0481004 (0.0947957)	0.065821 (0.0886651)	0.0447923 (0.1170554)
Adjusted Aid	1.428627*** (0.5091662)	1.310624*** (0.4804832)	1.595305*** (0.6063968)
Percent Receiving Free or Reduced Price Lunch	0.5705409*** (0.2060102)	0.5598046** (0.2329134)	0.6282023*** (0.1898618)
Percent with Limited English Proficiency	2.026026*** (0.6953876)	2.020316*** (0.7206803)	1.996184*** (0.6284926)
Percent with Disability	2.211753*** (0.4411977)	2.159888*** (0.536739)	2.39283*** (0.4455249)
Percent of Disabled Students in Separated Classrooms	0.7366207** (0.3692222)	0.6843951* (0.4032268)	0.8061085** (0.3276178)
Log of Enrollment	-0.7449745*** (0.1379052)	-0.7197678*** (0.1214624)	-0.728199*** (0.101966)
Log of Enrollment Squared	0.0427974*** (0.0086919)	0.0410439*** (0.0075347)	0.0419894*** (0.006779)
Log of Tax Share	-0.0643025*** (0.0197034)	-0.059584*** (0.0211375)	-0.0702823*** (0.0261926)
Log of STAR Component of Tax Price	-0.0310652** (0.0150915)	-0.0320761** (0.0160901)	-0.0324752* (0.0173351)
Percent Elderly	-0.3072569 (0.3209616)	-0.2680077 (0.3914768)	-0.3590827 (0.39742)
Percent Rural	-0.0384773** (0.0175836)	-0.0368405** (0.0173705)	-0.0403963** (0.0176723)
Percent Urban	0.0196323 (0.02519)	0.0262638 (0.0284741)	0.012627 (0.0317391)
Year 2001	0.0413983* (0.0237662)	0.0489131 (0.0324209)	0.0379558* (0.01897)
Year 2002	-0.0521393 (0.0489229)	-0.0628 (0.0448765)	-0.0350662 (0.0739617)
Constant	5.25393 (4.881433)	4.510996 (5.886038)	6.515823 (4.25135)
Number of Observations	1640	1640	1639

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 3. Underlying Parameters in Cost Equation

	Estimate Version 1^ (Standard Error)	Estimate Version 2^^ (Standard Error)	Estimate Version 3^^^ (Standard Error)
Log of Performance Index 1	0.8420177	0.4530636	0.1768882
	(0.5421389)	(0.483953)	(0.3990657)
Log of Performance Index 2	0.8806348**	1.261894***	1.64731***
	(0.4074042)	(0.5086682)	(0.5520642)
Teacher Salary	0.8227669*	0.861806	0.6970127*
	(0.4693349)	(0.5422705)	(0.3908981)
Percent Receiving Free/Red. Lunch	0.6547452***	0.6355407***	0.7309477***
	(0.177748)	(0.197818)	(0.1599609)
Percent with Limited English Prof.	2.32504***	2.293645***	2.322669***
	(0.5862587)	(0.6001679)	(0.5364094)
Percent Disabled	2.538177***	2.4521***	2.784189***
	(0.3691582)	(0.437677)	(0.3465869)
Percent in Separated Classroom	0.8453361***	0.7769871**	0.9379514***
	(0.3207653)	(0.3472784)	(0.2751434)
Log of Enrollment	-0.8549226***	-0.8171454***	-0.8472993***
	(0.1220284)	(0.1179828)	(0.0921095)
Log of Enrollment Squared	0.0491137***	0.0465968***	0.0488569***
	(0.0075726)	(0.0070636)	(0.0058439)

^ Version 1 – S_1 includes the percentage of 4^{th} and 8^{th} graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4^{th} and 8^{th} graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4^{th} and 8^{th} graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 4. Underlying Parameters in the Efficiency Equation

	Estimate Version 1^ (Standard Error)	Estimate Version 2^^ (Standard Error)	Estimate Version 3^^^ (Standard Error)
Log of Median Household Income	-0.0481001 (0.0947957)	-0.065821 (0.0886651)	-0.0447923 (0.1170554)
Flypaper Effect	29.70116 (3105.246)	19.91194 (812.727)	35.61561 (9904.687)
Log of Tax Share	0.0643025*** (0.0197034)	0.059584*** (0.0211375)	0.0702823*** (0.0261926)
Log of STAR Comp. of Tax Price	0.0310652** (0.0150915)	0.0320761** (0.0160901)	0.0324752* (0.0173351)
Percent Elderly	0.3072582 (0.3209616)	0.2680077 (0.389751)	0.3590827 (0.39742)
Percent Rural	0.0384773** (0.0175836)	0.0368405** (0.0173667)	0.0403963** (0.0176723)
Percent Urban	-0.0196322 (0.02519)	-0.0262638 (0.0284351)	-0.012627 (0.0317391)

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 5. Demand for S1 Estimates

	Estimate Version 1^ (Standard Error)	Estimate Version 2^^ (Standard Error)	Estimate Version 3^^^ (Standard Error)
Log of Median Household Income	0.0903539* (0.047749)	0.168401*** (0.065116)	-0.05788 (0.04975)
Adjusted Aid Term	1.199269** (0.524913)	1.022782 (0.760307)	0.493414 (0.658378)
Cost Index	-0.62959 (0.396013)	-0.8257 (0.560897)	-0.42432 (0.458979)
Log of Tax Share	-0.07373*** (0.020739)	-0.06373** (0.031073)	-0.0465 (0.029893)
Log of STAR Component of Tax Price	-0.0137 (0.012722)	-0.02828 (0.020149)	0.033435* (0.018524)
Year 2001	0.04518*** (0.005832)	0.081942*** (0.007111)	-0.02686** (0.011922)
Year 2002	0.148319*** (0.008544)	0.086141*** (0.008362)	0.24115*** (0.01595)
Efficiency Index	2.708676 (2.570367)	4.167307 (3.821845)	-0.21661 (2.461075)
Percent College Graduate	0.40404*** (0.043245)	0.722459*** (0.045258)	-0.24693*** (0.09073)
Difference Between Percent Receiving Free/Red. Price Lunch and Group Average	-0.10218* (0.06013)	-0.08547 (0.063588)	-0.12278 (0.081975)
Difference Between Median House Value and Group Average	0.000000213** (0.0000000903)	0.000000232** (0.0000000936)	0.0000000908 (0.000000204)
Maximum Median Household Income of the Group	0.000000567*** (0.000000168)	0.000000756*** (0.000000167)	0.00000034 (0.000000404)
Constant	-4.26278* (2.31782)	-6.5932* (3.797339)	0.499378 (2.553076)

Standard errors were calculated using a bootstrap method that was designed to correct for the use of the cost and efficiency indexes (essentially predicted variables) in the demand equation.

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 6. Demand for S2 Estimates

	Estimate Version 1^ (Standard Error)	Estimate Version 2^^ (Standard Error)	Estimate Version 3^^^ (Standard Error)
Log of Median Household Income	0.060092 (0.046868)	0.039937 (0.037931)	0.097115** (0.044129)
Adjusted Aid Term	0.396733 (0.595844)	0.590483 (0.414373)	0.913296 (0.638583)
Cost Index	-1.21901 (0.853677)	-1.12899 (0.781542)	-0.7069 (0.644706)
Log of Tax Share	-0.03153 (0.025353)	-0.04454** (0.017924)	-0.05455** (0.025652)
Log of STAR Component of Tax Price	-0.0134 (0.013135)	-0.00618 (0.010012)	-0.02138* (0.012417)
Year 2001	-0.028** (0.01097)	-0.02877*** (0.00826)	0.016702** (0.006902)
Year 2002	0.061082*** (0.012207)	0.117891*** (0.010261)	0.068822*** (0.008026)
Efficiency Index	3.107885 (3.168774)	2.960774 (2.439527)	2.400091 (2.422462)
Percent College Graduate	0.477196*** (0.057865)	0.29092*** (0.055094)	0.570659*** (0.045926)
Difference Between Percent Receiving Free/Red. Price Lunch and Group Average	-0.13228 (0.093461)	-0.1424* (0.0781)	-0.09572 (0.067975)
Difference Between Median House Value and Group Average	0.0000000453 (0.000000124)	-0.0000000191 (0.000000108)	0.0000000834 (0.0000000831)
Maximum Median Household Income of the Group	0.00000048** (0.000000226)	0.000000445** (0.000000221)	0.000000539*** (0.000000162)
Constant	-3.487 (2.73173)	-3.17182 (2.06274)	-3.89191* (2.266501)

Standard errors were calculated using a bootstrap method that was designed to correct for the use of the cost and efficiency indexes (essentially predicted variables) in the demand equation.

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 7. Underlying Parameters in the Demand for S1 Equation

	Estimate Version 1^	Estimate Version 2^^	Estimate Version 3^^^
Log of Median Household Income	0.266634	-0.125236	0.229519
Flypaper Effect	13.272978	6.073521	-7.499706
Cost Index (Eff. Index)	-5.555823	-6.614606	-1.517983
Log of Tax Share	-0.1366784	-0.1805918	-0.1146633
Log of STAR Component of Tax Price	-0.0602433	0.0251242	-0.0542692

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.
^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.
^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

Table 8. Underlying Parameters in the Demand for S2 Equation

	Estimate Version 1^	Estimate Version 2^^	Estimate Version 3^^^
Log of Median Household Income	0.167624	0.2616423	0.1402925
Flypaper Effect	6.602077	14.785433	9.404332
Cost Index (Efficiency Index)	-1.734644	-2.6371	-1.25759
Log of Tax Share	-0.1243869	-0.1417206	-0.100895
Log of STAR Component of Tax Price	-0.028455	-0.0431768	-0.0251041

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.
^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.
^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

Table 9. Simulation

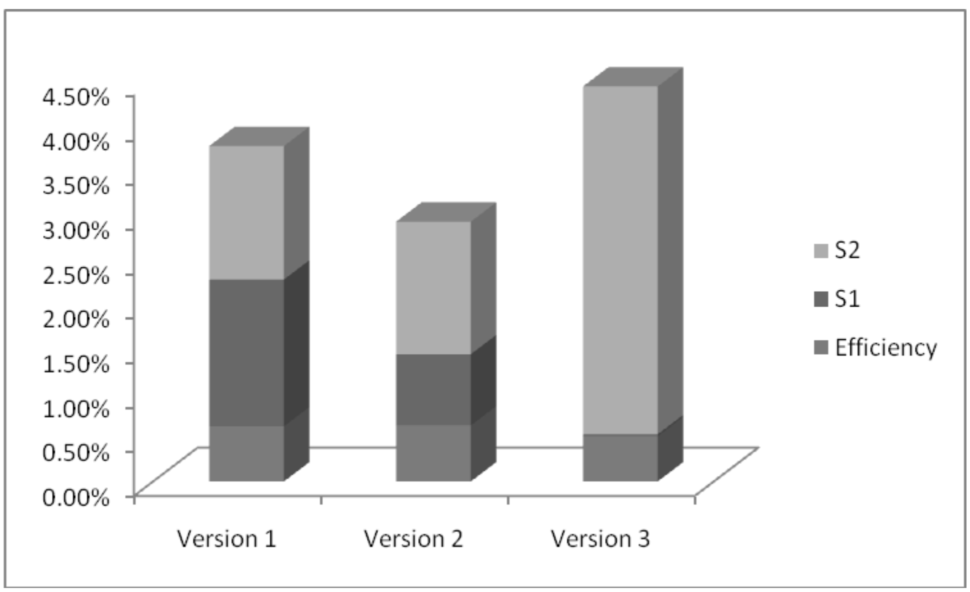
	Version 1		Version 2		Version 3	
Expenditure	3.77%	100%	2.92%	100%	4.44%	100%
Efficiency	0.62pps.	16.45%	0.63pps.	21.58%	0.51pps.	11.49%
S1	1.65pps.	43.77%	0.80pps.	27.40%	0.02pps.	0.45%
S2	1.50pps.	39.79%	1.49pps.	51.03%	3.91pps.	88.06%

^ Version 1 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Mathematics and English, and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^ Version 2 – S_1 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams and the high school graduation rate. S_2 includes the percentage of high school students passing the Regents exams in Mathematics, English, Global Studies, French, Physics and Chemistry, in addition to the college-bound rate.

^^^Version 3 - S_1 includes the percentage of high school students passing the Regents exams in Mathematics and English. S_2 includes the percentage of 4th and 8th graders in the highest level of performance on Mathematics and English standardized exams, the percentage of high school students passing the Regents exams in Global Studies, French, Physics and Chemistry, in addition to the high school graduation rate and the college-bound rate.

Figure 1. Simulation



Appendix A. Estimation – Robustness Checks

We chose the Fuller(4) estimator in response to a problem with weak instruments. As is evident in Tables 10, 11 and 12, 2SLS produces dramatically different estimates than those using Fuller(4), which is expected in the presence of weak instruments, and we expect the 2SLS estimates to be biased. Column 2 of Table 10 presents the results for the regression run using 2SLS, which are in many ways different than the results in column 1. The results are different from both expectations, given economic theory, and results from previous studies. For example, we find using 2SLS that an increase in teacher salaries actually decreases expenditure, which is counter to both theory and previous results. Additionally, estimates indicate very large diseconomies of scale associated with both measures of student performance, which runs counter to the results of many previous studies.

There may be concern regarding the choice of group size for the instruments. Comparing columns 1 and 3 of Tables 10, 11 and 12, which correspond to instruments derived from groups of 8 and 6, respectively, the estimates are remarkably similar. So, we are confident that our results are not highly reliant on the size of the group chosen for the instruments. We use the groups of 8 to avoid speculation regarding a small group size, as one may argue the instruments are endogenous with a small group size.

Table 10. Expenditure Results - Robustness

Variable	Estimate Vers. 1 - Fuller(4) groups of 8 (Standard Error)	Estimate 2SLS – groups of 8 (Standard Error)	Estimate Fuller(4) – groups of 6 (Standard Error)
Teacher Salary	0.716955 (0.5051685)	-1.170047 (2.641046)	0.917096 (0.682212)
Log of Performance Index 1	0.7980323* (0.4760803)	2.454507 (2.46966)	0.49763 (0.654335)
Log of Performance Index 2	0.8316811** (0.3581398)	1.824742 (1.397733)	0.78853** (0.316107)
Log of Median Household Income	0.0481004 (0.0948477)	0.1329272 (0.2717898)	0.053907 (0.108496)
Adjusted Aid	1.428627*** (0.5089515)	2.798577 (1.908349)	1.361526*** (0.471373)
Percent Receiving Free or Reduced Price Lunch	0.5705409*** (0.2057069)	1.517287 (1.17418)	0.457316* (0.236346)
Percent with Limited English Proficiency	2.026026*** (0.6943133)	4.875958 (3.591769)	1.758176** (0.766911)
Percent with Disability	2.211753*** (0.4400733)	4.067245* (2.336141)	2.002759*** (0.5879607)
Percent of Disabled Students in Separated Classrooms	0.7366207** (0.3685187)	2.345384 (2.075851)	0.54381 (0.461265)
Log of Enrollment	-0.7449745*** (0.1377696)	-0.9244295** (0.3945829)	-0.73927*** (0.125129)
Log of Enrollment Squared	0.0427974*** (0.0086845)	0.058457** (0.0268355)	0.041983*** (0.007614)
Log of Tax Share	-0.0643025*** (0.0197009)	-0.1143122 (0.0715189)	-0.06257*** (0.019175)
Log of STAR Component of Tax Price	-0.0310652** (0.0150433)	-0.0522578 (0.0404631)	-0.02891** (0.013226)
Percent Elderly	-0.3072569 (0.3207299)	-1.524045 (1.532925)	-0.1404 (0.323128)
Percent Rural	-0.0384773** (0.0175694)	-0.0372821 (0.0383992)	-0.03764** (0.015366)
Percent Urban	0.0196323 (0.0251732)	-0.0337136 (0.834596)	0.027033 (0.024167)
Year 2001	0.0413983* (0.0237489)	0.0667933 (0.069821)	0.045791* (0.023951)
Year 2002	-0.0521393 (0.048692)	-0.2234812 (0.2358701)	-0.01974 (0.058524)
Constant	5.25393 (4.867774)	26.46676 (27.88804)	2.815538 (6.459769)
Number of Observations	1640	1640	1642

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 11. Demand for S1 Estimates - Robustness

	Estimate Vers. 1 - Fuller(4) groups of 8 (Standard Error)	Estimate 2SLS – groups of 8 (Standard Error)	Estimate Fuller(4) – groups of 6 (Standard Error)
Log of Median Household Income	0.0903539* (0.047749)	0.058542 (0.070609)	0.093493* (0.048366)
Adjusted Aid Term	1.199269** (0.524913)	1.008058 (0.619687)	1.00955** (0.506377)
Cost Index	-0.62959 (0.396013)	1.605374* (0.93185)	-0.88437** (0.374711)
Log of Tax Share	-0.07373*** (0.020739)	-0.05328** (0.025762)	-0.0678*** (0.021564)
Log of STAR Component of Tax Price	-0.0137 (0.012722)	-0.00974 (0.013114)	-0.00896 (0.013598)
Year 2001	0.04518*** (0.005832)	0.038909*** (0.006278)	0.046248*** (0.005862)
Year 2002	0.148319*** (0.008544)	0.135758*** (0.0096)	0.149029*** (0.008057)
Efficiency Index	2.708676 (2.570367)	-3.94554 (4.120209)	3.737364 (2.688778)
Percent College Graduate	0.40404*** (0.043245)	0.39349*** (0.044339)	0.436693*** (0.042421)
Difference Between Percent Receiving Free/Red. Price Lunch and Group Average	-0.10218* (0.06013)	-0.08076 (0.071891)	-0.12515** (0.053999)
Difference Between Median House Value and Group Average	0.000000213** (0.0000000903)	0.000000122 (0.000000103)	0.000000133 (0.0000000964)
Maximum Median Household Income of the Group	0.000000567*** (0.000000168)	0.000000288 (0.000000189)	0.000000536*** (0.000000171)
Constant	-4.26278* (2.31782)	0.553901 (3.107852)	-5.07414** (2.541497)

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Table 12. Demand for S2 Estimates - Robustness

	Estimate Vers. 1 - Fuller(4) groups of 8 (Standard Error)	Estimate 2SLS – groups of 8 (Standard Error)	Estimate Fuller(4) – groups of 6 (Standard Error)
Log of Median Household Income	0.060092 (0.046868)	-0.01362 (0.067676)	0.05829 (0.051344)
Adjusted Aid Term	0.396733 (0.595844)	-0.10802 (0.650287)	0.262089 (0.562646)
Cost Index	-1.21901 (0.853677)	2.347519 (1.573347)	-1.88033** (0.830486)
Log of Tax Share	-0.03153 (0.025353)	0.0044159 (0.0186609)	-0.0288 (0.025528)
Log of STAR Component of Tax Price	-0.0134 (0.013135)	0.004416 (0.027419)	-0.00962 (0.013474)
Year 2001	-0.028** (0.01097)	-0.03856*** (0.012108)	-0.02597** (0.011092)
Year 2002	0.061082*** (0.012207)	0.40356*** (0.014384)	0.063055*** (0.012282)
Efficiency Index	3.107885 (3.168774)	-3.5098 (4.262294)	4.656656 (3.075602)
Percent College Graduate	0.477196*** (0.057865)	0.502103*** (0.065022)	0.489694*** (0.060308)
Difference Between Percent Receiving Free/Red. Price Lunch and Group Average	-0.13228 (0.093461)	-0.16651 (0.119494)	-0.16528* (0.085319)
Difference Between Median House Value and Group Average	0.0000000453 (0.000000124)	-0.00000024 (0.000000163)	0.0000000289 (0.000000118)
Maximum Median Household Income of the Group	0.00000048** (0.000000226)	0.0000000602 (0.000000245)	0.000000762*** (0.000000233)
Constant	-3.487 (2.73173)	0.428603 (2.995997)	-4.37818 (2.797266)

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

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