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Economics of Education Review

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How much more does a disadvantaged student cost?

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Received 28 June 2004; accepted 28 July 2004

Abstract

This paper provides a guide to statistically based methods for estimating the extra costs of educating disadvantaged students, shows how these methods are related, and compares state aid programs that account for these costs in different ways. We show how pupil weights, which are included in many state aid programs, can be estimated from an education cost equation, which many scholars use to obtain an education cost index. We also devise a method to estimate pupil weights directly. Using data from New York State, we show that the distribution of state aid is similar with either statistically based pupil weights or an educational cost index. Finally, we show that large, urban school districts with a high concentration of disadvantaged students would receive far more aid (and rich suburban districts would receive far less aid) if statistically based pupil weights were used instead of the ad hoc weights in existing state aid programs.

JEL classification: H73; I22

Keywords: State aid to education; Educational costs; Disadvantaged students

1. Introduction

Both scholars and policy makers have recognized that it costs more to achieve any given level of student performance when the students are disadvantaged than when they are not. Nevertheless, scholars and policy makers tend to use different methods to account for these extra costs. This paper provides a guide to statistically based methods for estimating the extra costs of educating disadvantaged students, shows how these methods are related, and compares state aid programs that account for these costs in different ways.

Many scholars have addressed educational costs through the use of an education cost index, which operates much like a cost-of-living index. Specifically, an education cost index indicates the amount a district must spend relative to the average district to obtain the same performance target. Several scholars also have proposed that these cost indexes be used in state education aid formulas, and in particular, that higher-cost districts should receive more aid, all else equal.

Educational costs are also considered by many state aid programs, but cost indexes are rarely used.[1] Instead, state aid formulas give extra weight to students in high-cost categories, such as poor students or students with limited English proficiency (LEP). Because state aid is based on the number of weighted students in a district, this approach, like a cost index, results in higher aid for districts with more disadvantaged students. If the extra weight for a poor student is 20 percent, for example,

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[1]A state aid formula incorporating a regression-based cost index was implemented for towns (including overlapping school districts) in Massachusetts in the 1980s (Bradbury et al., 1984).

0272-7757/$ - see front matter
doi:10.1016/j.econedurev.2004.07.015

then a district in which half the students are poor will receive 10 percent more aid than a district with no poor students, all else equal.

This paper is organized as follows. Section 2 provides background on the scholarly literature and the use of pupil weights in existing state aid formulas. Section 3 provides a guide to calculating pupil weights. This section shows how cost indexes and pupil weights are related, devises a new method for estimating pupil weights, and shows how pupil weights can be incorporated into an aid formula. Section 4 uses data from New York State to illustrate the consequences of various approaches to estimating pupil weights. In particular, this section shows which types of districts gain, and which types lose, when measures of expenditure need or associated state aid payments are based on pupil weights instead of on a cost index. The final section presents conclusions and policy implications.

2. Background

The idea that educational costs depend on student characteristics can be traced back to the famous article by Bradford, Malt, and Oates (1969), which showed that the cost of providing public services depends on the environment in which the services are delivered. Scholars who have applied this notion to education include Bradbury, Ladd, Perrault, Reschovsky, and Yinger (1984), Ratcliffe, Riddle, and Yinger (1990), Downes and Pogue (1994), Ladd and Yinger (1994), Courant, Gramlich, and Loeb (1995), Duncombe, Ruggiero, and Yinger (1996), Duncombe and Yinger (1997, 1998, 2000), Reschovsky and Imazeki (1998, 2001, 2003), Duncombe and Johnston (2004), and Imazeki and Reschovsky (2004).

Existing scholarly work on pupil weights includes Reschovsky and Imazeki (1998), Duncombe (2002), and Duncombe, Lukemeyer, and Yinger (2003). Reschovsky and Imazeki start by estimating an education cost function. Then they use the estimated parameters to predict total spending in each district. One of the variables in their cost regression is the share of poor students (as measured by the share of students eligible for a free or reduced-price lunch). Next they set this variable at a low value (the value below which it has no impact on costs) and predict total spending again. Finally, they obtain a weight for each district by finding the difference between these two predictions, which is the impact of actual poverty in the district on total spending, and dividing this difference by the number of poor students in the district. They find that in both the mean and median district the extra weight for a poor student is 1.59.

Duncombe et al. (2003) use a similar approach to calculate the cost of bringing a student with a given disadvantage up to the average performance in the state. This approach also results in a different weight in each school district. They estimate that the extra weight for a poor student is 1.10 in the upstate Big Three cities (Buffalo, Syracuse, and Rochester) and 0.98 in both New York City and the average suburban district. The LEP weight is 1.12 in the Big Three, 1.15 in New York City, and about 1.10 in the average suburb.

Some scholars (e.g., Guthrie & Rothstein, 1999) have criticized the cost-function approach and have proposed alternatives. One alternative that has appeared in consultants' report for several states is to ask professional educators to identify the programs necessary to reach a given performance standard in a school with many disadvantaged students and then to calculate the cost of these programs. This so-called ‘‘professional judgment'' approach was recently used in Maryland, for example (Maryland Commission on Education Finance, Equity, and Excellence, 2002). In our judgment, however, a cost function makes the best use of available information and is the preferred approach.[2] For discussions of the strengths and weaknesses of various methods, see Baker, Taylor, and Vedlitz (2004) and Duncombe, Lukemeyer, and Yinger (2004).

As shown in Tables 1 and 2, many state aid programs account for the higher costs of educating disadvantaged students.[3] Table 1 indicates that the weighted-pupil approach is used to adjust the main operating aid formula for poverty in 15 states, for students with LEP in nine states, and for students with handicaps in 14 states. The legislated extra weights for students with these disadvantages vary widely across states. Among the states that adjust for poverty, 11 use weights of 0.3 or below, whereas Maryland uses a weight of 1.0 and New Hampshire's weight reaches 1.0 under some circumstances. The LEP weights vary from 0.06 to 1.2. Virtually all of these weights fall well below the values estimated by scholars. The weights for handicaps vary widely, depending on the handicap to which they apply, and no attempt is made to summarize them. Overall, this table testifies both to the intuitive appeal of the weighted-pupil approach to aid and to the need for a systematic approach to determining the weights.

A legislated pupil weight may not be used in all state aid programs, and it may be subject to various restrictions. Thus, the effective weight may differ from

[2]This does not imply, of course, that the cost-function approach is without challenges. It may be difficult to find the necessary data, for example, and, as discussed below, difficult choices must be made about the best way to specify the cost equation and the best estimating technique.

[3]The information in this table is based on legislative language in various published sources and web sites, so it may not be complete or include all the latest aid revisions. We are grateful to Yao Huang for compiling this information.

Table 1
Legislated pupil weights in selected state aid programs

State	Pupil weight for		
	Poverty[a]	LEP[a]	Handicap[b]
Alaska			Yes
Arizona		0.06	Yes
Colorado	0.115–0.3		
Connecticut	0.25[c]	0.1	
Delaware			Yes[d]
Florida		0.201	Yes
Georgia			Yes
Idaho		[c,d]	Yes[d]
Iowa		0.19	Yes
Kansas	0.1	0.2	
Kentucky	0.15[c]		
Louisiana	0.17		
Massachusetts	0.343–0.464[c]		Yes
Maryland	1.0	1.2	
Minnesota	0.01–0.6[c]		
Mississippi	0.05		
Missouri	0.22		
New Hampshire	0.5–1.0		
New Mexico	0.0915		Yes
Oklahoma	0.25		Yes
Oregon	0.25	0.5	Yes
South Carolina			Yes
Texas	0.2[c]	0.1	Yes
West Virginia			Yes

Source: Compiled by Yao Huang based on the sources cited in Huang (2004).

[a]The weights in these two columns indicate the percentage by which aid for a student in the relevant category (poor or limited English proficiency (LEP)) exceeds aid for a student not in the category.

[b]Weights for students with handicaps vary widely depending on the nature of the handicap.

[c]These states also provide categorical grants for students in this category.

[d]These states adjust aid per teacher unit for weighted pupils, which is similar to standard pupil weights.

the legislated weight. Table 2 provides information on effective or implicit poverty weights calculated in several different ways. This table reveals wide variation in effective poverty weights across states. Alaska, Connecticut, and New Jersey, for example, provide more than twice as much aid for high-poverty districts as for low-poverty districts, whereas New Hampshire provides less aid to high-poverty districts despite a relatively high extra weight (42.6 percent) for poor pupils. Moreover, no state has an effective poverty weight as high as the estimated weight in the scholarly literature.[4]

[4]The figures in Table 2 predate the new aid program in Maryland; this new program may be an exception to this claim.

The principle of aid adjustments for student disadvantage has been endorsed by several state supreme courts (Lukemeyer, 2004). In a 1990 decision that called for a more equitable educational finance system, for example, the New Jersey State Supreme Court first required the state "to assure that poorer urban districts' educational funding is substantially equal to that of property-rich districts" and then declared that "[t]he level of funding must also be adequate to provide for the special educational needs of these poorer urban districts and address their extreme disadvantages" (Abbott v. Burke, 1990, p. 385). A similar argument appeared in a recent decision by the highest court in New York State (Campaign for Fiscal Equity v. New York, 2003).

3. How to calculate pupil weights

Pupil weights are designed to indicate the extra expense associated with students in particular categories, holding student performance constant. In principle, these weights should be related to actual experience, that is, to the extra expenses that districts must actually pay to bring disadvantaged students up to a given standard. The existing literature brings in actual experience by deriving pupil weights from the estimated parameters of a standard education cost function. This section begins by exploring various ways to use standard education cost functions to determine the added cost per disadvantaged student in a state, expressed as a share of the cost for a student with no disadvantages. An alternative approach is to specify an education cost function so that the pupil weights can be estimated directly. The second part of this section explores this approach. The third part shows how to incorporate pupil weights into a state aid formula.

3.1. Pupil weights based on a standard education cost function

Consider the following cost function, which is similar to the formulation in most of the papers cited earlier:

$$S_j = \alpha_0 T_j^{\alpha_T} Z_j^{\alpha_Z} P_j^{\alpha_P} \exp\left\{\sum_i \beta_i C_j^i\right\}, \quad (1)$$

where S_j equals spending per pupil in district j; T equals a vector of student test scores and perhaps other performance measures; Z equals other control variables, such as those designed to control for district efficiency; P equals the price of the key input, namely teachers; C_j^i equals the share of students in cost category i in district j; and α and β indicate coefficients to be estimated. In particular, β_i indicates the percentage change in spending associated with a one percentage point increase in C_j^i. By taking logarithms and adding an error term, this

Table 2
Implicit poverty weights in state aid programs, 2001–2002

State	Implicit poverty weights			Per pupil state aid: Ratio of high poverty districts to average district[c]
	Estimate 1 (%)[a]	Estimate 2 (%)[b]	Per pupil spending: Ratio of high poverty district to average district[c]	
Alabama	3.1	2.7	0.90	1.00
Alaska				1.97
Arizona	2.0	0.0	0.79	1.10
Arkansas	2.0	10.6	1.23	1.03
California	5.5	6.5	0.69	1.12
Colorado	25.8			1.02
Connecticut	37.1	3.6	1.01	2.04
Delaware				1.22
Florida				1.10
Georgia	1.9			1.06
Idaho				1.10
Illinois	22.3	1.9	0.34	1.20
Indiana	20.1	1.2	0.83	1.34
Iowa	2.6	2.5	1.13	0.99
Kansas	15.8			1.16
Kentucky	25.5			1.16
Louisiana	19.7			1.03
Maine				1.04
Maryland	23.5	16.9	1.16	1.69
Massachusetts	52.5			1.60
Michigan	20.3	13.0	0.98	1.13
Minnesota	35.8	27.2	1.63	1.35
Mississippi	4.9	17.2	0.80	1.01
Missouri	36.0			1.26
Montana				1.15
Nebraska	15.0			1.19
Nevada		0.1	0.00	1.52
New Hampshire	42.6			0.98
New Jersey	31.9	46.3	1.48	2.17
New Mexico	13.8	0.6	1.25	1.01
New York	19.6			1.07
North Carolina	14.6			1.09
North Dakota				1.13
Ohio	17.2	9.1	1.38	1.39
Oklahoma	32.1			1.06
Oregon	17.1			1.23
Pennsylvania		1.2	0.44	1.33
Rhode Island	25.4			1.55
South Carolina	16.3	11.2	0.93	1.01
South Dakota				1.26
Tennessee	2.7			1.05
Texas	27.7			1.16
Utah	4.6	7.5	1.39	1.00
Vermont	3.7			1.56
Virginia	15.1	12.1	0.99	1.27
Washington	7.7	12.6	0.77	1.12
West Virginia				1.04
Wisconsin	10.0			1.30
Wyoming	3.0			1.55

[a] *Source*: Carey (2002). Poverty, funding per low-income student divided by state and local funding per student.
[b] *Source:* Baker and Duncombe (2004). Compensatory aid per child (5–17 years old) in poverty divided by total spending per pupil.
[c] *Source*: Baker and Duncombe (2004).

equation can be estimated with standard linear regression techniques. Because they are directly influenced by district actions, T and P should be treated as endogenous (see Duncombe & Yinger, 1997, 1998, 2000; Reschovsky & Imazeki, 1998).

Once Eq. (1) has been estimated, a standard cost index is found in two steps. The first step is to calculate the spending required in each district to reach a given performance target, called expenditure need, assuming that districts differ only in their cost characteristics. This step is accomplished by setting the variables in T at the same performance level for all districts ($\tilde{T}$); setting the variables in Z at the state average for all districts ($\bar{Z}$); setting P at the required wage level for each district ($\hat{P}$), based on exogenous factors, such as the regional wage level; and setting student characteristics in C at their actual value in each district.[5] Then with the estimated values of the coefficients, a and b, substituted for the parameters in Eq. (1), α and β, one obtains this expenditure need in each district, $\hat{S}_j$. In symbols,

$$\hat{S}_j = a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \exp\left\{ \sum_i b_i C_j^i \right\}. \tag{2}$$

The second step is to divide $\hat{S}_j$ by its value in a district with average required wages and average student characteristics, say $\hat{S}_{j*}$, which is defined as[6]

$$\hat{S}_{j*} = a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \bar{\hat{P}}^{a_P} \exp\left\{ \sum_i b_i \bar{C}^i \right\}. \tag{3}$$

Eqs. (2) and (3) lead to a cost index for each district, I_j. This index equals 1.0 in a district with average characteristics, is above 1.0 in relatively high-cost districts, and is below 1.0 in relatively low-cost districts. A district with a value of 1.5, for example, has educational costs that are 50 percent above those in a district with average characteristics. The formula for a cost index is

$$I_j = \frac{\hat{S}_j}{\hat{S}_{j*}} = \frac{(\hat{P}_j)^{a_P} \exp\left\{ \sum_i b_i C_j^i \right\}}{\left(\bar{\hat{P}}\right)^{a_P} \exp\left\{ \sum_i b_i \bar{C}^i \right\}}. \tag{4}$$

Note that the T and Z terms are the same in every district, so they cancel when the expression for I_j is written out.

One complicating factor is that educational cost indexes sometimes account for economies and diseconomies of enrollment scale, as well as for teacher costs and student disadvantages. These types of adjustments are somewhat more controversial than others. There is extensive evidence, for example, that small districts have higher costs per pupil than middle-sized districts (see Andrews, Duncombe, & Yinger, 2002). This can be interpreted as a cost difference, but it can also be interpreted as a sign that the small districts have refused to consolidate with their neighbors and thereby to lower their costs.[7] Similarly, there is evidence that large districts have higher costs than middle-sized districts. This difference may reflect diseconomies of district scale, but it might also reflect mismanagement that arises in some large districts but not in others. Because these issues are not our primary concern in this paper, we calculate pupil weights without considering enrollment. We include enrollment variables in our cost regressions, but we treat them as Z variables. As a result, they are simply set at the average value for all districts and have no impact on the cost indexes or pupil weights.

As shown by Reschovsky and Imazeki (1998) and Duncombe (2002), district-specific pupil weights can be calculated using reasoning similar to that behind a cost index. The first step is to calculate required spending in each district, assuming now that a district has no disadvantaged students at all, that is, that every variable in C has a value of zero. In this calculation, as in a cost-index calculation, T and Z are held constant and P is allowed to vary across districts. If district j had no disadvantaged students, in other words, its expenditure need would be

$$\hat{S}_j^0 = a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P}. \tag{5}$$

The second step is to find the extra spending in the district because of the presence of students with disadvantage i. This can be found by comparing required spending once disadvantage i is considered with required spending when, as above, one assumes that no students have this disadvantage, or

$$\Delta\hat{S}_j^i = a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \exp\{b_i C_j^i\} - a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} = \hat{S}_j^0(\exp\{b_i C_j^i\} - 1). \tag{6}$$

The district-specific weight, W_j^i, is the extra cost per student with disadvantage i in district j expressed as a share of spending on students with no disadvantages.[8] To find this weight, Eq. (6) must be divided by the share

[5] A note on notation: A "^" indicates a spending level "required" to reach a performance target under some specified set of conditions (or a wage level required to attract teachers), a "~" indicates a policy parameter, and a "–" indicates a mean value. In a few cases, the first and last symbols both appear, indicating the mean of a predicted value.

[6] An alternative base in this type of calculation is the value of $\hat{S}_j$ in the average district. This alternative base leads to similar results, but we find it less appealing because it shifts the focus away from the average values of the student characteristics on which the weights are based.

[7] In spite of these problems, about one-third of the states give more aid to small or sparsely settled districts. See Huang (2004).

[8] If the data made it possible to identify students with multiple disadvantages (which ours do not), then each combination of disadvantages could be treated as a separate cost category.

of students with this disadvantage and by $\hat{S}_j^0$, or

$$W_j^i = \frac{\Delta \hat{S}_j^i}{\hat{S}_j^0 C_j^i} = \frac{(\exp\{b_i C_j^i\} - 1)}{C_j^i}. \quad (7)$$

District-specific weights do not appear in any state aid formula. Instead, states use state-level weights for each category of student disadvantage. The district-specific weight in Eq. (7) can be translated into a statewide rate by averaging it across districts. The simulations in the next section examine statewide weights that are both simple averages and enrollment-weighted averages.

A key question for us to address is: How do measures of a district's expenditure need based on a cost index differ from those based on pupil weights? As discussed earlier, expenditure need equals the amount a district must spend to meet a given performance target, as defined by a set of values for the T variables. Using Eq. (2), we know that expenditure need in district j equals the amount a district with average costs must spend to reach these performance targets multiplied by district j's cost index, or

$$\hat{S}_j = \hat{S}_{j*} I_j = \hat{S}_{j*} \frac{(\hat{P}_j)^{a_P} \exp\left\{\sum_i b_i C_j^i\right\}}{\left(\bar{\hat{P}}\right)^{a_P} \exp\left\{\sum_i b_i \bar{C}^i\right\}}$$
$$= a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} (\hat{P}_j)^{a_P} \exp\left\{\sum_i b_i C_j^i\right\}. \quad (8)$$

Because $\exp\{a\} \approx (1 + a)$ when a is small, we can also write

$$\hat{S}_j \approx a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} (\hat{P}_j)^{a_P} \left(1 + \sum_i b_i C_j^i\right). \quad (9)$$

In the case of pupil weights, the base spending concept refers to spending required to meet a given performance standard assuming no disadvantaged students but actual wages, namely, $\hat{S}_j^0$ as defined by Eq. (5). Total expenditure need in district j equals $\hat{S}_j^0$ multiplied by the weighted number of students, and student need per pupil (written with a W superscript to emphasize the role of weighting, or $\hat{S}_j^W$) equals $\hat{S}_j^0$ multiplied by weighted pupils relative to actual pupils, or, using Eq. (7),

$$\hat{S}_j^W = \hat{S}_j^0 \frac{N_j\left(1 + \sum_i W_j^i C_j^i\right)}{N_j}$$
$$= a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \left(1 + \sum_i W_j^i C_j^i\right)$$
$$= a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \left[1 + \sum_i (\exp\{b_i C_j^i\} - 1)\right]. \quad (10)$$

Using the same approximation as before, we can also write

$$\hat{S}_j^W \approx a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \left[1 + \sum_i (1 + b_i C_j^i - 1)\right]$$
$$= a_0 \tilde{T}^{a_T} \bar{Z}^{a_Z} \hat{P}_j^{a_P} \left(1 + \sum_i b_i C_j^i\right), \quad (11)$$

which is the same as Eq. (9). In other words, cost indexes and the associated district-specific weights yield approximately the same measures of expenditure need for each district. In one special case, namely, when there is only one category of disadvantage, there is no need for approximation: according to Eqs. (8) and (10), these two approaches yield exactly the same measure of expenditure need.

The accuracy of the approximation used in this derivation diminishes as the cost impact of disadvantaged students in a district increases. This cost impact equals the product of the share of students in category i, C_j^i, and the estimated impact of students in this category on costs, b_i, summed over categories of disadvantage, or $\Sigma_i b_i C_j^i$. Because this approximation is used to derive both Eqs. (9) and (11), however, it is not clear how this feature of the approximation affects the difference between these two equations. Switching to state-level weights adds another type of approximation to the mix, one that hurts districts with district-specific weights above the state average. In a later section, we use data from New York to explore the nature of these approximations by identifying the types of districts that are put at a disadvantage by the use of various state-level weights instead of a cost index.

3.2. Pupil weights estimated directly from an education cost function

The pupil weights in the previous section are approximations because the functional form of a standard education cost function differs from the algebraic form of a student-weight calculation. One way to avoid these approximations, therefore, is to re-specify the education cost function so that it estimates the pupil weights directly.

Consider a cost function of the following form:

$$S_j = \left(e^{\gamma 0} T_j^{\gamma_T} Z_j^{\gamma_Z} P_j^{\gamma_P}\right)\left(1 + \sum_i \omega_i C_j^i\right), \quad (12)$$

where the γ's and the ω's are parameters to be estimated and, as before, T and P are treated as endogenous. This cost function can be estimated with nonlinear two-stage least-squares. The ω's are the pupil weights we are after; with this form they can be estimated directly. Let g stand for an estimate of a γ parameter and w stand for the estimate of a ω parameter. Then, drawing on our earlier notation, with a "D" superscript to indicate direct estimation, expenditure need in district j is

$$\hat{S}_j^D = \left(e^{g0}\tilde{T}_j^{g_T}\bar{Z}_j^{g_Z}\hat{P}_j^{g_P}\right)\left(1+\sum_i w_i C_j^i\right). \quad (13)$$

Recall the approximation noted earlier, namely, that $\exp\{a\} \approx (1+a)$ when a is small. With $a = \Sigma_i \omega_i C_j^i$, this approximation translates Eq. (12) into Eq. (1), or vice versa. Despite this algebraic connection between the two equations, however, they are substantially different in practice. Compared to Eq. (1), the nonlinear Eq. (12) requires a more complicated estimating procedure but results in a dramatic simplification in the calculation of weights and student needs.

The obvious question to ask at this point is whether Eq. (1) or (12) is a better specification of the cost function, that is, which one provides a better explanation for variation in school costs.[9] This is, of course, an empirical question, which we address in a later section. However, a specification test alone cannot determine which approach is best for policy purposes. If the two approaches lead to similar results, then one must weigh the benefits of a relatively simple estimating equation (Eq. (1)) against the benefits of a relatively simple pupil-weight calculation (Eq. (12)). We return to this issue in our conclusion.

3.3. Pupil weights in state aid formulas

The most common type of state aid formula is a foundation formula, which is used to some degree in 43 states (Huang, 2004). This type of formula is designed to bring all districts up to a minimum spending level. Another type of aid formula is a so-called "guaranteed tax base" plan, which is the main aid formula in three states and which is combined with a foundation plan in 10 others. Except in the case of Missouri, which relies exclusively on a GTB formula, the weights in Table 1 refer to foundation plans.[10] Following the emphasis in existing state aid programs, we focus exclusively on the role of pupil weights in a foundation formula.[11]

A foundation formula sets aid per pupil at the difference between an expenditure target, $\tilde{S}$, and the amount of money a district can raise at a standard tax rate, a rate set by state policy makers. This amount of money is the tax rate, $\tilde{t}$, multiplied by the district's tax base, V_j. To be specific,

$$A_j = \tilde{S} - \tilde{t}V_j. \quad (14)$$

A more general approach is to select an educational performance target and then to base the formula on the expenditure needed to reach this target. Suppose $\tilde{S}$ is the expenditure needed to reach the desired level of student performance *in a district with average costs*, namely $\hat{S}_{j*}$, as defined by Eq. (2). Then, as shown by Ladd and Yinger (1994), a cost index, I_j, can be added to yield a performance-based foundation aid program:

$$A_j = \hat{S}_{j*}I_j - \tilde{t}V_j = \hat{S}_j - \tilde{t}V_j. \quad (15)$$

With this approach, total aid to a district obviously equals aid per pupil multiplied by number of pupils.

Pupil weights are designed to replace some, but not all, of the cost index. Specifically, pupil weights do not account for differences in teacher costs or in enrollment effects across districts. (A few states, namely, Colorado, Florida, Maryland, Massachusetts, and Texas, combine pupil weights with an adjustment for teacher costs or the cost of living.)[12] To bring in pupil weights, therefore, one needs to use a spending base that reflects teacher wages but not student characteristics, namely, $\hat{S}_j^0$ as defined by Eq. (5).[13] Moreover, the number of weighted pupils is

$$N_j^W = N_j + \sum_i W^i N_j C_j^i = N_j\left(1+\sum_i W^i C_j^i\right). \quad (16)$$

Pupil weighting applies only to the expenditure target in a foundation aid formula, not to the expected local contribution. Introducing pupil weights therefore leads to the following formula for aid per (unweighted) pupil:

$$A_j = \hat{S}_j^0 \frac{N_j^W}{N_j} - \tilde{t}V_j. \quad (17)$$

In this formula, the ratio of weighted to unweighted pupils plays the role of the student-need component of an education cost index. The wage component of $\hat{S}_j^0$ multiplied by this ratio is equivalent to a full cost index.

4. Results for New York State

To examine the implications of different approaches to estimating the cost of disadvantaged students, we now use data from New York State for the 2000–2001 school year to compare the distribution of state aid using

[9]The specifications in (1) and (12) are not the only possible ones. In fact, some scholars, such as Gyimah-Brempong and Gyapong (1991), have used a more general specification.

[10]Texas is one of the 10 states with a first-tier foundation formula and a second-tier GTP formula. It uses pupil weights in both tiers. See Huang (2004).

[11]The widespread use of foundation plans reflects, among other things, a widespread emphasis on an adequacy objective in recent state supreme court decisions concerning education finance. See Lukemeyer (2002, 2004).

[12]This information was provided by Yao Huang.

[13]In principle, one could also include enrollment effects in this baseline spending number. Baseline spending also sets the efficiency variables at their statewide average values. A higher efficiency standard could be selected, but this would only scale the results; as explained earlier, it is not appropriate to include variation in efficiency across districts, since this variation reflects decisions by school district officials.

Eq. (15) with the aid using Eq. (17) and various forms of pupil weights. As shown in Table 3, we have data for 678 school districts and have classified these districts into eight categories ranging from New York City to small rural districts upstate.[14] These districts differ substantially in terms of enrollment, wages, and the share of students with various disadvantages. This table shows, for example, that the share of students who applied for a free or reduced-price lunch, a commonly used measure of poverty, ranges from 74.9 percent in New York City to 11.2 percent in downstate suburbs. In addition, districts vary widely in their child poverty rates and in their concentrations of students with LEP or in special education. The special education variable, which provides one way to measure the share of students with disabilities, is discussed in more detail below.

The last column of Table 3 presents a student performance index, which we will use in our cost estimation. This index combines the passing rates on elementary and secondary math and reading tests. The elementary tests cover both fourth and eighth grades, and the secondary exams, called Regents exams, are given twice as much weight because students must pass them to graduate from high school.[15] The resulting index can range from 0 (no students pass any test) to 200 (all students pass every test).[16]

4.1. Cost indexes

We begin by estimating standard education cost models. These models use the functional form given in Eq. (1), with operating spending per pupil as the dependent variable and selected performance variables and student characteristics as key explanatory variables. These regressions also account for the possibility that school officials do not deliver the selected performance variables at the lowest possible cost—that it, that their decisions may result in inefficiency. Several approaches to the issue of efficiency, each with limitations, have been proposed.[17] Following Duncombe et al. (2003), our approach is to include explanatory variables that have a conceptual link to efficiency. We argue, for example, that districts with relatively loose budget constraints, as measured by their property value, income, and state aid (all on a per-pupil basis), have less incentive to be efficient in delivering any given set of student performance outcomes.

We estimate four versions of this model. These models are distinguished by (a) the variable used to measure economic disadvantage and (b) whether special education students are included. We use two different variables to measure economic disadvantage: the child poverty rate in the school district, which is provided by the Census every two years, and the number of students in grades K–6 who sign up for a free lunch or for a reduced-price lunch.[18] The latter variable fluctuates significantly from year to year, so we use a two-year average in all of our estimations.

[14]The major sources of data are various publications from the New York State Education Department and New York State Office of the Comptroller. Child poverty rates and population are from the 2000 Census of Population.

[15]For more information on this index, see Duncombe et al. (2003). This index is treated as endogenous. We used geographic proximity to identify instruments. Specifically, our list of potential instruments consists of averages, minimum and maximum values for adjacent school districts for various measures of fiscal capacity (income, school aid, and property wealth), student need (poverty, LEP, subsidized lunch, and special education), physical conditions (pupil density, population density, and enrollment), and student performance (test scores). To select instruments from this list, we used three standard rules. The instruments must (1) make conceptual sense, (2) help to explain the endogenous explanatory variables, and (3) not have a significant direct impact on the dependent variable. We also implemented an over-identification test (Woolridge, 2003) to check the exogeneity of our final set of instruments and the Bound, Jaeger, and Baker (1995) procedure to check for weak instruments. The latter procedure is not formally specified for a model like ours, so we examined various combinations of the instruments and used the set that produced the highest F-test for most endogenous variables. In most cases, the F-statistic was 5.0 or above, indicating reasonably strong instruments for that endogenous variable. When estimating Eq. (12) we use the same instruments selected for estimating (1).

[16]Alternative cost functions, which yield similar results, could be estimated with each passing rate entered separately or with the addition of a drop-out rate variable. See, for example, Duncombe and Yinger (1997, 1998, 2000).

[17]One alternative approach, which yields similar results, is to include in the cost model a measure of efficiency based on Data Envelopment Analysis. See Duncombe et al. (1996), Duncombe and Yinger (1997, 1998, 2000), and Reschovsky and Imazeki (1997, 2001, 2003). This approach identifies efficiency based on a functional form restriction instead of on the basis of assumed linkages between efficiency and certain school district characteristics. Another approach is to collect panel data and to estimate district fixed effects, which control for all time-invariant district characteristics, including efficiency (Downes & Pogue, 1994). This approach is not suitable for our purposes, because the cost impact of across-district variation in student characteristics is captured by the fixed effects and the limited remaining variation make it difficult, if not impossible, to obtain precise estimates of the b_i coefficients.

[18]The free lunch and reduced-price lunch programs are separate, but we combine them in all our analyses. Eligibility rules and funding for these lunch programs are provided by the federal government. Subsidized lunches are also offered after sixth grade, but many eligible students do not sign up for them, so a subsidized lunch variable for nonelementary grades does not appear to be useful.

Table 3
Description of New York school districts, 2001

	Number of districts	Average enrollment	Average teacher salary ($)	Percent child poverty	Percent subsidized lunch (K6)	Percent LEP[a]	Percent special education[b]	Student performance index[c]
Large cities								
New York City	1	1,069,141	39,561	34.90	74.86	12.32	7.41	103
Yonkers	1	24,847	47,237	31.31	59.72	16.42	8.52	107
Upstate big three	3	35,575	33,113	46.46	74.53	6.76	9.46	96
Small cities								
Downstate	7	5647	47,947	16.62	33.48	7.73	6.07	148
Upstate	49	4324	34,848	25.39	41.73	2.23	6.68	145
Suburbs								
Downstate	168	3387	46,082	8.80	11.22	3.20	4.85	169
Upstate	242	2450	35,004	13.24	19.39	0.32	4.44	160
Rural								
Upstate	207	1113	33,135	21.57	29.09	0.22	4.33	156
Statewide	678	1657	35,413	14.67	21.81	0.00	4.72	161

Note: Except in column 1, statewide figures are for the median district.
[a]LEP stands for "limited English proficiency".
[b]The share of students who require placement for 60 percent or more of the school day in a special class, or require special services or programs for 60 percent or more of the school day, or require home or hospital instruction for a period of more than 60 days.
[c]Index reflects passing rates on elementary middle school and high school tests; maximum possible value is 200.

Although these two variables are correlated, they are by no means identical.[19] As shown in Table 3, for example, the subsidized lunch variable tends to have a substantially larger value than the child poverty variable. Moreover, the two variables have different strengths and weaknesses. The Census poverty variable has the desirable feature that it cannot be manipulated by school officials, but it is not available every year, it is often excluded from data bases maintained by state education departments, and we have no evidence about its accuracy in years not covered by a decennial Census. The subsidized lunch variable has the advantages that it is available every year, is included in many state data bases, and covers a broader population than does the poverty variable. This variable has the disadvantage, however, that it reflects parental participation decisions, and perhaps even school management policies. Given these contrasting strengths and weaknesses, we do not believe that either variable dominates the other and we present results using each of them.

One final difference between the two variables arises when another measure of student disadvantage, the share of students with LEP, is added to the cost model. As shown below, this LEP variable is highly significant in cost models that include the Census poverty variable. In contrast, this variable is not close to significant in models that include the subsidized lunch variable.[20] Thus, in case of New York, the subsidized lunch variable appears to capture the cost effects both of poverty and of LEP, and the LEP variable is dropped from the models in which the subsidized lunch variable appears.

The second distinction is whether the model includes a third measure of student disadvantage, namely, the share of students in a special education program. We focus on a measure of students with relatively severe disabilities, because these students have a relatively large impact on educational costs and because the identification of these students is largely insulated from district discretion.[21] To be specific, this variable indicates the share of students who require placement for 60 percent or more of the school day in a special class, or who

[19]For the year 2000, for example, the correlation between the share of *K*–6 students who sign up for a subsidized lunch and the child poverty rate is 0.773. Correlations in other years are similar.

[20]To be specific, the coefficient is small in magnitude, occasionally negative, and never significant at even the 40 percent confidence level.

[21]Although our data set includes a few other measures of student disability, they are not measured consistently across districts and may be manipulated by district officials.

require special services or programs for 60 percent of more of the school day, or who require home or hospital instruction for a period of more than 60 days. As we will see, this variable is highly significant when it is included in a cost regression. However, this variable does not provide a full analysis of the extra costs imposed by student disabilities. It does not include students with relatively minor disabilities, for example, and it does not recognize the wide variations in spending required for different students in the special education category. Moreover, some states prefer to treat special education with categorical grants, instead of incorporating them into basic measures of expenditure need and operating aid. As a result, we present all of our results with and without special education students in the analysis.

These cost models include several cost variables in addition to student characteristics, namely, teacher salaries (treated as endogenous)[22] and student enrollment categories. The omitted enrollment category is districts with enrollment below 1000 students. As explained earlier, we do not include enrollment effects in our analyses of education costs, expenditure need, or state aid.

Selected parameter estimates from the cost models are presented in Table 4. (Full results for two of these cost models are presented in Appendix A.[23]) The performance index is highly significant in all cases, and the teacher wage variable has an elasticity close to unity. The student characteristics also have large, statistically significant impacts on costs. A school district's costs increase with the share of students in poverty (whether measured by Census poverty or subsidized lunches), with LEP, or with a severe handicap. As noted earlier, the LEP variable is not close to significant in models that use the subsidized lunch variable so it has been dropped from these models.

The second panel of Table 4 presents results for Eq. (12), which provides direct estimates of the pupil weights. This equation also performs well, and the results in this panel are similar to those in the first panel. We conducted specification tests to determine whether Eq. (1) (the first two panels) or Eq. (12) (the last panel) provides a better fit for any given column.[24] We find that neither one of these models can be rejected in favor of the other; that is, there is no statistical basis for selecting one of them. This choice must be made on other grounds.

We then use the cost models in Table 4 to calculate cost indexes, using the approach presented earlier. Our cost indexes reflect teacher wage costs (based on exogenous factors only) and student characteristics. Not surprisingly, the resulting cost indexes vary widely by district category. The first panel of Table 5 presents cost indexes based on the Census poverty and LEP variables. As shown in Table 5, our first cost index ranges from about 94 in upstate suburbs and rural districts to 170.2 in New York City. This index also has relatively high values in Yonkers, the Big Three, and downstate small cities, and intermediate values in downstate suburbs and upstate small cities. The other cost indexes in the first panel exhibit similar patterns, with slightly more variation across types of district when the special education variable is included.

The second panel of Table 5 presents cost indexes based on the share of students in grades *K*–6 who applied for a free or reduced-price lunch. The cost indexes in this panel exhibit a larger variance than those in the first panel; the range in the first column, for example, is from 84.4 in the upstate rural districts to 195.7 in New York City. Moreover, the index for New York City exceeds 200 if special education students are included or if the pupil weights are estimated directly.

4.2. *Pupil weights*

Our next step is to calculate statewide pupil weights and to extract the pupil weights estimated using Eq. (12). The results are in Table 6. All the weights in this table are above 1.0, indicating that the cost of educating a student with any one of the three disadvantages we observe is more than twice as high as the cost of educating a student with none of these disadvantages. These weights are therefore higher than the weights used by any state except Maryland (see Tables 1 and 2).

[22]The teacher wage variable was first limited to teachers with five years or less of experience. Teacher wages for individual teachers were then regressed on teacher experience and whether the teacher had a graduate degree. The results of this regression were used to construct a predicted teacher salary for each district for a teacher with statewide average experience (among those with no more than 5 years of experience) and average probability of a graduate degree. The potential instruments for this variable are pupil density in the district, private wages in professional occupations, unemployment rate, concentration of area teachers in the district, and the average (maximum and minimum) salaries of adjacent districts. The final list was selected using the rules presented in an earlier footnote.

[23]The two regressions in this Appendix A table, along with comparable regressions for other models, which are not presented, indicate that the performance index always has the expected positive impact on costs and is statistically significant. The three efficiency variables also have the expected signs and are significant in most cases, and all districts in all enrollment classes except the largest have significantly lower costs per pupil than districts in the smallest enrollment class.

[24]We use the specification tests in Davidson and MacKinnon (2004, Chapter 15) for nonnested nonlinear regression models. Intuitively, these tests set up a regression that combines an initial and an alternative specification to determine whether the alternative adds any explanatory power.

Table 4
Estimated performance and cost coefficients

	Without special education		With special education	
	Census poverty	Subsidized lunch	Census poverty	Subsidized lunch
Standard cost models[a]				
Performance index	0.0073	0.0105	0.0079	0.0140
	(2.87)	(3.12)	(3.26)	(3.2)
Average teacher salary[b]	1.0006	1.4030	0.9392	1.3541
	(8.06)	(15.07)	(8.82)	(13.87)
Percent child poverty (2000)[c]	1.3071		1.1424	
	(4.06)		(4.17)	
Two-year average LEP[c]	0.9883		0.9908	
	(2.09)		(2.46)	
K6 subsidized lunch rate[c]		0.9819		1.1258
		(3.78)		(3.68)
Special education students[c,d]			1.9547	1.7762
			(3.34)	(2.63)
Direct estimate of pupil weights[e]				
Performance index	0.0075	0.0117	0.0079	0.0142
	(2.85)	(3.00)	(3.32)	(3.07)
Average teacher salary[b]	1.0045	1.5639	0.9520	1.5519
	(7.93)	(9.69)	(9.13)	(8.11)
Percent child poverty (2000)[c]	1.6672		1.5915	
	(3.21)		(3.11)	
Two-year average LEP[c]	1.3078		1.4236	
	(1.81)		(2.07)	
K6 subsidized lunch rate[c]		1.6896		2.1452
		(2.36)		(1.96)
Special education students[c,d]			2.6440	3.0157
			(2.69)	(1.75)

[a]Estimated with linear two-stage least-squares regression, with the student performance and teacher salaries treated as endogenous. Operating spending per pupil is the dependent variable; *t*-statistics are in parentheses. Full results for the first two columns of Panel 1 are in Appendix A.

[b]For fulltime teachers with 1–5 years of experience. Expressed as a natural logarithm.

[c]Variables expressed as percentages. Coefficients are similar to elasticities.

[d]The share of students who require placement for 60 percent or more of the school day in a special class, or require special services or programs for 60 percent or more of the school day, or require home or hospital instruction for a period of more than 60 days.

[e]Estimated with nonlinear two-stage least-squares regression. Other features are the same as in note a.

Moreover, the weights for special education students are all above 1.8.

In every case, the pupil weight goes up as one moves from column 1 to column 2 or from column 2 to column 3. In other words, enrollment-weighted weights are larger than weights for the average district, and directly estimated weights are larger than the weights calculated from a standard education cost function. In addition, the poverty weights in the first and third models, which are based on the Census child poverty variable, decline by a small amount when students requiring special education are added to the analysis, whereas the LEP weight increases slightly when this change is made. Overall, this poverty weight ranges from 1.22 to 1.67, the LEP weight ranges from 1.01 to 1.42, and the special education weight varies from 2.05 to 2.64.

Table 6 also presents estimated weights using the number of students applying for a subsidized school lunch. Without either the special education variable or a direct estimating procedure, the extra weight for an economically disadvantaged student is higher with the child poverty variable than with the subsidized lunch variable. If the pupil weights are estimated directly or if the special education variable is included in the estimation, the weight based on subsidized lunch is larger, sometimes considerably larger, than the weight based on Census poverty.

4.3. Expenditure need

Tables 7 and 8 compare expenditure-need calculations using various approaches to the cost of disadvantaged

Table 5
Cost index results[a]

	Standard cost function		Direct weight estimation	
	Without special education	With special education	Without special education	With special education
Using Census poverty and LEP				
Large cities				
New York City	170.2	172.0	165.4	169.9
Yonkers	159.2	166.3	155.9	164.3
Upstate big three	135.5	143.6	131.0	141.8
Small cities				
Downstate	140.3	141.7	141.1	140.0
Upstate	110.8	113.9	110.6	112.6
Suburbs				
Downstate	114.8	115.1	114.7	113.7
Upstate	93.8	93.9	93.7	92.7
Rural				
Upstate	93.6	93.0	93.8	91.8
Using percent of students receiving subsidized lunch				
Large cities				
New York City	195.7	233.9	207.6	222.3
Yonkers	157.5	199.1	176.1	194.9
Upstate big three	142.8	181.7	148.4	160.0
Small cities				
Downstate	146.0	165.8	165.1	173.5
Upstate	108.7	130.3	121.1	128.4
Suburbs				
Downstate	108.8	111.9	111.9	111.8
Upstate	86.7	93.2	94.0	93.7
Rural				
Upstate	84.4	96.0	94.8	96.0

[a]These indexes incorporate cost adjustments for teacher salaries and student needs, but not for enrollment. A district with statewide average characteristics has an index value of 100.

students. Table 7 is based on the Census child poverty variable; Table 8 uses the subsidized lunch variable. The baseline in all cases is expenditure need with a full cost index, which we regard as the most direct approach with the clearest conceptual foundation. Our objective is to determine how much expenditure need diverges from this baseline when pupil weights are used. As explained earlier, pupil weights approximate a cost-index approach, so our objective is equivalent to calculating which categories of districts are placed at a disadvantage by this type of approximation. All our calculations include an adjustment for teacher wages.

The first row in each panel of Tables 7 and 8 compares aggregate expenditure need using the weights identified in each column with aggregate expenditure need using a standard cost index. A value below 1 indicates that aggregate expenditure need falls below the baseline value and a value above 1 indicates that aggregate expenditure need is higher with those weights than with the baseline cost index.

The first column in Table 7 shows how much expenditure need diverges from the baseline when student characteristics are not accounted for at all. In the first panel, without special education, this approach lowers aggregate expenditure need substantially, namely, by almost 30 percent, compared to the baseline and places large cities at a significant disadvantage. To be specific, the expenditure-need numbers for New York City, Yonkers, and the Big Three fall about 40 percent below the baseline. In contrast, this approach leads to expenditure needs that are only about 10 percent below the baseline in suburbs, both upstate and downstate.

The introduction of pupil weights brings the expenditure-need calculations much closer to the baseline for all types of districts. As shown in the second and third columns of the first panel in Table 7, expenditure need

Table 6
Estimated pupil weights

	Simple average	Enrollment-weighted average	Directly estimated
Using Census poverty and LEP			
Without special education			
Child poverty	1.415	1.491	1.667
LEP	1.007	1.030	1.308
With special education			
Child poverty	1.224	1.281	1.592
LEP	1.009	1.033	1.424
Special education	2.049	2.081	2.644
Using share of students signed up for subsidized lunch			
Without special education			
K6 free and reduced price lunch share (2-year average)	1.108	1.294	1.690
With special education			
K6 free and reduced price lunch share (2-year average)	1.361	1.552	2.145
Special education	1.853	1.880	3.016

falls no more than 8 percent below the baseline for big cities, and no more than 1 percent below the baseline for suburbs (on average), when estimated statewide pupil weights are used. Because the enrollment-weighted average weights tend to be larger than the simple average weights, the use of an enrollment-weighted average boosts expenditure need and narrows the divergence from the baseline. Indeed, the results in the third column of Table 7 reveal almost no divergence from the baseline outside the large cities. The divergence in the large cities is about 6 percent.

One simple approximation to estimated weights that is similar to the program passed in Maryland is to use a weight of 1.0 for both poverty and LEP. The fourth column of the first panel in Table 7 indicates that this approach provides a reasonable approximation to estimated weights in the suburbs, where expenditure need is about 3 percent below the baseline, but only a rough approximation in the big cities, where expenditure need falls about 15 percent below the baseline. Finally, as shown in the last column of this panel, a calculation using weights that are directly estimated comes very close to matching the results of a cost-index calculation. Indeed, with this approach, New York City and the Big Three are only 1 percent below the baseline and no group of districts falls above or below the baseline by as much as 3 percent. This result is not surprising; as shown earlier, cost indexes and directly estimated pupil weights are approximately the same thing.

The second panel of Table 7 provides comparable results based on a cost model with special education students included. The results from this model are similar to those in the first panel, although the first two models (with no weights and with simple average weights) and the last model (with directly estimated weights) diverge from the baseline somewhat more than the comparable models in the first panel. With enrollment-weighted weights, for example, the big cities now fall about 10 percent below the baseline.

Table 8 presents results from an alternative pair of models that use the subsidized lunch variable instead of the child poverty and LEP variables in both the baseline cost-index approach and in all the calculations with pupil weights. This table reveals that leaving out weights altogether results in an even larger divergence from the baseline with the subsidized lunch variable than with the Census poverty variable. Results in the other columns are similar to the comparable ones in Table 7, particularly those based on directly estimated pupil weights. Recall that with a single cost variable, as in the first panel of Table 8, a district-specific weight is identical to a cost index. Hence, the only source of deviations from the baseline in the second and third columns of this panel is the averaging procedure. The results in these two columns therefore demonstrate that moving from district-specific weights to statewide weights is unfair to high-cost districts, particularly large cities, and that an enrollment-weighted average is preferable to a simple average.

One contrast between Tables 7 and 8 can be found in the fourth column of the panel with special education. In this case, the use of rounded weights (1.0 for subsidized lunch, 1.0 for LEP, and 2.0 for special education) leads to a much larger underestimate of expenditure need, particularly in the big cities, in Table 8 than in Table 7. This understatement is implicitly predicted by the relevant directly estimated weights in Table 6, which are 2.1 for subsidized lunch and 3.0 for special education.

Table 7
Estimated expenditure need with pupil weights relative to baseline, using Census child poverty variable

Regions	No student needs adjustment	Pupil weights (simple average)	Pupil weights (enrollment-weighted average)	Poverty and LEP weights = 1 special education weight = 2[a]	Directly estimated pupil weights
Without special education					
Ratio of total cost with this adjustment to spending with full cost index	0.713	0.956	0.967	0.898	1.004
Large cities					
New York City	0.592	0.923	0.939	0.847	0.991
Yonkers	0.611	0.931	0.945	0.866	1.000
Upstate big three	0.583	0.921	0.938	0.833	0.986
Small cities					
Downstate	0.764	0.980	0.990	0.937	1.027
Upstate	0.734	0.973	0.985	0.909	1.018
Suburbs					
Downstate	0.880	0.995	1.000	0.970	1.019
Upstate	0.899	1.001	1.006	0.972	1.019
Rural					
Upstate	0.814	0.992	1.002	0.941	1.024
With special education					
Ratio of total cost with this adjustment to spending with full cost index	0.650	0.930	0.940	0.900	1.019
Large cities					
New York City	0.539	0.890	0.903	0.851	1.003
Yonkers	0.539	0.889	0.901	0.856	1.003
Upstate big three	0.514	0.876	0.889	0.832	0.988
Small cities					
Downstate	0.687	0.955	0.963	0.931	1.041
Upstate	0.662	0.945	0.955	0.912	1.031
Suburbs					
Downstate	0.796	0.980	0.985	0.966	1.038
Upstate	0.830	0.991	0.996	0.975	1.039
Rural					
Upstate	0.761	0.979	0.986	0.951	1.044

[a]Special education weight of 2 only applies in the model with special education students (lower panel).

4.4. Foundation aid

As explained earlier, expenditure-need calculations feed into foundation aid formulas. Thus, baseline state aid is the aid a district would receive with a foundation aid formula that incorporates a full cost index. Our simulations define a baseline aid program by setting the student performance index at 160, which is the current state average. Tables 9 and 10 show how switching to pupil weights alters state aid for each category of district compared to this baseline. To make the columns comparable, we hold the total budget constant (that is, equal to the baseline amount) in all cases by raising or lowering the foundation level.[25]

[25]These simulations set the required local property tax rate, $\tilde{t}$, at 1.5 percent, which is lower than the rate in most districts. Alternative tables that hold the foundation level constant and allow the state aid budget to change are available from the authors upon request, as are tables with a performance standard of 140 instead of 160.

Table 8
Estimated expenditure need with pupil weights relative to baseline, using subsidized lunch variable

	No student needs adjustment	Pupil weights (simple average)	Pupil weights (enrollment-weighted average)	Poverty and LEP weights = 1 special education weight = 2[a]	Directly estimated pupil weights
Without special education					
Ratio of total need with this adjustment to total need with full cost index	0.580	0.922	0.962	0.914	1.079
Large cities					
New York City	0.453	0.875	0.926	0.874	1.070
Yonkers	0.509	0.914	0.962	0.942	1.100
Upstate big three	0.437	0.862	0.913	0.835	0.058
Small cities					
Downstate	0.635	0.966	1.006	0.977	1.119
Upstate	0.588	0.947	0.990	0.916	1.113
Suburbs					
Downstate	0.813	0.986	1.007	0.992	1.066
Upstate	0.804	1.004	1.028	0.981	1.096
Rural					
Upstate	0.687	0.985	1.020	0.947	1.124
With special education					
Ratio of total need with this adjustment to total need with full cost index	0.470	0.852	0.899	0.802	1.075
Large cities					
New York City	0.353	0.790	0.845	0.734	1.044
Yonkers	0.396	0.830	0.883	0.801	1.083
Upstate big three	0.327	0.758	0.811	0.686	1.009
Small cities					
Downstate	0.525	0.911	0.957	0.877	1.136
Upstate	0.476	0.882	0.931	0.810	1.118
Suburbs					
Downstate	0.699	0.951	0.978	0.935	1.100
Upstate	0.714	0.985	1.016	0.938	1.145
Rural					
Upstate	0.595	0.952	0.996	0.877	1.162

[a]Special education weight of 2 only applies in the model with special education students (lower panel).

Results for a baseline aid program defined by a student performance index of 140 are very similar to those in Tables 9 and 10.

As in Tables 7 and 8, the first column of these two tables indicates the impact of ignoring student characteristics. In Table 9, which examines aid programs based on the Census poverty and LEP variables, this step would cut the aid of the big-city districts by 20 percent or more (compared to the baseline) and would greatly boost the aid of all other categories of districts. Indeed, both the upstate and downstate suburbs would receive at least 46 percent more aid, on average, with this approach than with the baseline approach.[26]

[26]One implication of these findings is that moving from an aid program without pupil weights to an equal-budget aid program based on a cost index or on statistically based pupil weights would result in a dramatic redistribution of aid from suburbs to large cities. If a state has a hold-harmless provision, that is, a provision to ensure that no district experiences a drop in aid, aid to large cities cannot be raised to the level specified by a cost-adjusted foundation aid program without a large increase in the state aid budget.

Table 9
State aid relative to baseline for a given state aid budget using Census child poverty rate and LEP rate

	No student needs adjustment	Pupil weights (simple average)	Pupil weights (enrollment-weighted average)	Poverty and LEP weights = 1 special education weight = 2[a]	Directly estimated pupil weights
Without special education					
Large cities					
New York City	0.780	0.957	0.963	0.928	0.983
Yonkers	0.800	0.965	0.969	0.952	0.994
Upstate big three	0.788	0.959	0.965	0.917	0.979
Small cities					
Downstate	1.136	1.050	1.046	1.079	1.046
Upstate	1.049	1.028	1.028	1.021	1.019
Suburbs					
Downstate	1.579	1.096	1.079	1.190	1.035
Upstate	1.459	1.084	1.071	1.146	1.026
Rural					
Upstate	1.230	1.062	1.058	1.078	1.031
With special education					
Large cities					
New York City	0.781	0.949	0.952	0.934	0.981
Yonkers	0.767	0.944	0.946	0.937	0.981
Upstate big three	0.761	0.937	0.940	0.916	0.966
Small cities					
Downstate	1.099	1.052	1.048	1.065	1.045
Upstate	1.034	1.027	1.026	1.023	1.018
Suburbs					
Downstate	1.527	1.121	1.108	1.165	1.045
Upstate	1.490	1.120	1.109	1.151	1.037
Rural					
Upstate	1.280	1.089	1.083	1.096	1.040

Note: Performance standard is set at an index value of 160; required local tax rate is set at 1.5 percent.
[a]Special education weight of 2 only applies in the model with special education students (lower panel).

The next four columns show that introducing pupil weights would bring all categories of districts much closer to their baseline aid. Indeed, regardless of which pupil weights are used, the big cities would all be within 8 percent of their baseline aid. In all cases, both the upstate and the downstate suburbs receive more aid with pupil weights than with the baseline cost index. In columns 2–4, the aid in these districts is between 6 and 20 percent above the baseline. Not surprisingly, the divergence from the baseline is smallest with directly estimated weights (the last column). Indeed, in this case, aid to large cities and suburbs is always within 4.5 percent of the baseline amount.

Note that the use of either averaged or rounded weights is less disadvantageous to large cities in Table 9 than in Table 7. This result reflects the fact that Table 9 holds the state aid budget constant and thereby, in effect, eliminates the absolute decline in expenditure need in the earlier table. Finally, a comparison of the two panels of Table 9 indicates that deviations from baseline aid are somewhat larger when special education is included in the analysis. However, the difference between a result in the second panel and the comparable result in the first panel is rarely above 2 percentage points.

As shown in Table 10, the patterns across districts are similar when the subsidized lunch variable is used instead of the Census poverty and LEP variables. In most cases, the divergence from baseline is somewhat larger in Table 10 than for the comparable result in Table 9, particularly when special education is included. With rounded weights and special education, for

Table 10
State aid relative to baseline for a given state aid budget using share of students signed up for subsidized lunch

	No student needs adjustment	Pupil weights (simple average)	Pupil weights (enrollment-weighted average)	Poverty and LEP weights = 1 special education weight = 2[a]	Directly estimated pupil weights
Without special education					
Large cities					
New York City	0.740	0.937	0.950	0.942	0.980
Yonkers	0.846	0.988	0.996	1.039	1.017
Upstate big three	0.727	0.925	0.938	0.896	0.969
Small cities					
Downstate	1.186	1.078	1.072	1.109	1.058
Upstate	0.039	1.038	1.036	0.999	1.032
Suburbs					
Downstate	1.972	1.145	1.092	1.170	0.976
Upstate	1.699	1.153	1.113	1.121	1.014
Rural					
Upstate	1.312	1.106	1.090	1.050	1.052
With special education					
Large cities					
New York City	0.707	0.918	0.935	0.905	0.965
Yonkers	0.803	0.972	0.985	1.007	1.009
Upstate big three	0.662	0.880	0.896	0.842	0.930
Small cities					
Downstate	1.195	1.112	1.111	1.150	1.097
Upstate	1.032	1.053	1.056	1.022	1.053
Suburbs					
Downstate	2.067	1.225	1.174	1.326	1.055
Upstate	1.927	1.281	1.237	1.306	1.112
Rural					
Upstate	1.430	1.190	1.178	1.155	1.124

Note: Performance standard is set at an index value of 160; required local tax rate is set at 1.5 percent.
[a]Special education weight of 2 only applies in the model with special education students (lower panel).

example, the Big Three fall 8 percentage points below the baseline when child poverty is used but 16 points below the baseline with subsidized lunch. Most of the other differences are considerably smaller than this.

5. Conclusions and policy implications

There is widespread agreement among scholars, policy makers, and state courts that school districts with relatively high concentrations of disadvantaged students should receive relatively more state aid per pupil, all else equal. In the academic literature, the state-of-the-art approach is to estimate an education cost function that includes measures of student disadvantage, to calculate an education cost index on the basis of this estimation, and then to introduce this education cost index into a foundation aid formula. Although a few state aid formulas contain elements of the cost-index approach, most state aid formulas adjust for the presence of disadvantaged students using pupil weights. Pupil weights appear to be more appealing to policy makers than the more abstract notion of an education cost index. The key problem is that, in almost every case, the weights that appear in state aid formulas are determined on an ad hoc basis and are far below the weights estimated by scholars.

We show that a state aid formula using pupil weights can be thought of as an approximation for a state aid formula using a cost index. The closeness of this approximation cannot be determined a priori, but it can readily be calculated on the basis of an estimated education cost function. We show that a state aid formula combining pupil weights and teacher wage cost adjustments derived from a standard cost function distributes aid in a way that is approximately the same as an aid formula based on a cost index. For the large, urban school districts where most disadvantaged students are concentrated, aid based on statistically based pupil weights provides a reasonable approximation for aid based on the preferred cost-index approach. These two approaches differ somewhat more in their treatment of suburban and rural school districts, which receive almost 20 percent more aid with some types of weights than with a cost index. Finally, switching to a nonlinear cost function that estimates pupil weights directly yields an aid formula that closely approximates the baseline approach in almost every case. Indeed, with directly estimated weights, aid to big cities never falls more than 4 percent below baseline aid (and aid to suburban districts falls within 5 percent of the baseline), unless special education is included in the formula and subsidized lunch is the measure of poverty.

The pupil weights we estimate are much larger than the weights that appear in any state aid formula except for Maryland's. In a typical aid formula, the extra weight for a pupil from a poor family or with LEP is about 25 percent. We estimate that these extra weights should be between 111 and 215 percent. The use of pupil weights obviously results in a much poorer approximation of our preferred aid formula when these lower weights are used. At the extreme, defined by extra weights of zero, the aid received by large urban districts falls at least 20 percent below the baseline level, and the aid received by suburban districts may exceed the baseline by over 100 percent. The low weights used in most state aid programs yield results not too different from this extreme case. The key problem, therefore, is not the use of pupil weights per se; it is the use of pupil weights that are far below the levels supported by the evidence.

We estimate similar weights for the Census poverty and subsidized lunch variables. We also conclude that in New York the LEP variable need not be included in an aid formula based on the subsidized lunch variable, at least not when the weight on the subsidized lunch variable is high enough, but find that rounded weights of 1.0 for both subsidized lunch and LEP provide a reasonable approximation to a cost-index approach. We also estimate an extra weight of at least 185 percent for a student in special education, but this weight obviously is linked to our special education variable and may not apply to the special education variables that appear in state aid formulas.

Overall, public officials who design state aid formulas face two key choices regarding disadvantaged students.[27] The first choice is whether to account for the extra cost of educating these students using a cost index or pupil weights. Judging from the choices states have made so far, the use of pupil weights appears to be a more appealing approach, and we show that, for most districts, it can result in aid amounts that closely approximate the aid amounts from a formula based on a cost index, which is the approach many scholars prefer.

The second choice is how to select pupil weights. The ad hoc process used in most states is not up to the task. Indeed, the weights used by most states are far below the weights estimated in this paper and by other scholars. These low weights result in aid payments that support far lower levels of student performance in school districts with more disadvantaged students than in other school districts. This outcome violates the key objective of a foundation aid formula, namely, to bring all districts up to the same minimal performance standard. Finally, we find that any pupil weights based on an estimated cost function provide a reasonable approximation to the use of a full education cost index, but that an even better approximation can be obtained using pupil weights estimated directly from a nonlinear cost function. We find no statistical basis for preferring a standard cost function to this nonlinear version, so the choice of method depends on whether policy makers prefer the complexity of the weight calculation with a standard cost function to the complexity of a nonlinear estimating procedure.

A state aid program is not consistent with student performance objectives unless it accounts for the higher cost of reaching a performance target in districts with a relatively large share of disadvantaged students. The use of state aid formulas with extra weight for disadvantaged students is a reasonable approach to this problem, but the fairness of this approach can be greatly enhanced through the use of statistically based pupil weights.

Acknowledgements

The authors are grateful to the Rockefeller Foundation for financial support.

[27]Another key choice, which is not examined in this paper, is whether to use a teacher wage index. Even with accurate pupil weights, an aid formula would not be fair to high-wage locations unless in it included a wage index or a cost-of-living index. Only about a dozen states have this type of index now (Huang, 2004).

Appendix A. Results of education cost models

Estimated with linear two-stage least-squares regression, with student performance and teacher salaries treated as endogenous; operating spending per pupil is the dependent variable

Variables	With Census poverty		With subsidized lunch	
	Co-efficient	*t*-Statistic	Co-efficient	*t*-Statistic
Constant	−2.6253	−2.53	−7.4910	−5.47
Performance index	0.0073	2.87	0.0105	3.12
Efficiency variables[b]				
Full value	0.0000	9.31	0.0000	10.30
Aid	0.8583	3.05	0.6872	2.39
Income	0.0000	1.55	0.0000	−0.70
Average teacher salary[c]	1.0006	8.06	1.4030	15.07
Percent child poverty (2000)[d]	1.3071	4.06		
Two-year average LEP[d]	0.9883	2.09		
K6 subsidized lunch rate[d]			0.9819	3.78
Enrollment classes[e]				
1000–2000 students	−0.0823	−3.31	−0.0859	−3.28
2000–3000 students	−0.0896	−3.00	−0.0957	−3.15
3000–5000 students	−0.1067	−2.87	−0.1218	−3.35
5000–7000 students	−0.0915	−2.27	−0.1110	−2.73
7000–15,000 students	−0.1019	−2.12	−0.1208	−2.53
Over 15,000 students	0.0236	0.22	0.0308	0.27
Adjusted R-square[e]	0.485	0.457		

[b]Calculated as the difference between district value and the average in peer group.

[c]For fulltime teachers with 1–5 years of experience. Expressed as a natural logarithm.

[d]All variables expressed as a percentage. Coefficients are similar to elasticities.

[e]The base enrollment is 0–1000 students. The coefficients can be interpreted as the percent change in costs from being in this enrollment class compared to the base enrollment class.

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