

# ENVIRONMENTAL FACTORS AND THE COST OF EDUCATION

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## ABSTRACT

This paper estimates cost indexes for the 180 school districts in the State of Georgia in. It uses two-stage-least square regression technique to estimate a cost model that controls for environmental factors, educational performance measures and teacher salary.

*The study finds overwhelming evidence that environmental factors have a significant effect on educational cost. Districts with higher percentages of pupils living under poverty or lack English proficiency require higher per pupil educational spending to achieve a certain academic standard.*

## INTRODUCTION

How much should a school district spend on education in order to achieve a certain level of academic performance? This is a question that pre-occupied researchers, policy makers and tax-payers for a long time. Two issues arise in attempting to answer this question: first, how do we measure academic performance? Second, what is the cost of meeting this performance?

Some researchers like Guthrie and Rothstein (1998) have estimated a “cost index”, which is supposed to measure the amount of spending a school district requires in order to achieve equal educational performance of an average district, that only accounted for differences in input prices. Teachers’ salaries obviously account for a large portion of educational cost and maybe by far the most dominant factor in determining cost. Other researchers, like Bradbury et al (1984), Ratcliffe, Riddle and Yinger (1990), Ladd and Yinger (1994), Hamadeh (1998), Duncombe and Yinger (1997, 1998, & 2005) and Reschovsky and Imazeski (2001 & 2003) have built upon the work of Bradford, Malt and Oates (1969) who realized the important role of environmental factors in determining the cost of providing a certain level of public service. A careful treatment of the environment in which students live is required to determine the cost of education. Districts with harsh environments, high percentage of disabled or poor students, for example, require high levels of educational spending in order to achieve a certain level of educational performance.

This paper estimates cost indexes for the 180 school districts in the State of Georgia. It highlights the important role of environmental factors in determining the required educational spending to achieve a certain level of educational performance. To this end, an educational cost model that includes a set of educational outcomes and environmental factors is estimated.

Many studies have controlled for educational outcomes indirectly by controlling for factors like district’s income, tax price and voters’ characteristics. Researchers like Bradbury et al (1984) have employed this method. This method regresses districts’ expenditures against income, price and a set of environmental factors. The difficulty of this regression is that policy makers might find it difficult to understand how could income and tax price possibly control for educational outcomes? The link might not be obvious, and a more straightforward measurement is required.

This paper uses a set of standardized test scores and other direct educational outcomes in the educational cost equation. As first pointed out by Duncombe and Yinger (1998), and Hamadeh (1998), in addition to enabling us to derive the cost indexes, this approach also leads to the derivation of a district's performance index. It could be derived directly from the weighted average of the performance measures included in the cost regression.

### THE COST FUNCTION

Let  $E_i$  be spending per pupil in district  $i$ ,  $S$  equals a vector of educational performance measures,  $W$  equals teacher salary and  $Z$  be a vector of environmental factors. A standard educational cost equation to be estimated takes the form:

$$E_i = a \cdot S_i^b \cdot W_i^c \cdot Z_i^d \quad (1)$$

By taking logarithm of equation (1), it becomes:

$$\log E_i = a + b \log S_i + c \log W_i + d \log Z_i + e \quad (2)$$

where  $e$  is the error term.

The above equation could be estimated using standard regression models where  $\log E$  is the dependent variable and the coefficients  $a$ ,  $b$ ,  $c$  and  $d$  are to be estimated. The estimated cost equation will then be used to derive the cost indexes mentioned above. In addition, the coefficients of the outcome variables in the above cost equation that prove to be statistically significant could be used to establish a school district performance index. Duncombe and Yinger (1998) are the first to point out that the weights of those coefficients can be interpreted as demand weights. This proves to be very useful since it allows researchers to identify the educational outcomes that are important to voters, and thus can be used in educational demand analysis.

### DATA AND VARIABLE DESCRIPTIONS

This study was applied to 180 school districts in Georgia. 159 districts out of the 180 districts are coterminous with counties. The remaining 21 districts are coterminous with cities. This was a source of considerable advantage in terms of data availability. A more comprehensive socioeconomic data set could be found at the county and the city level than at the school district level. School data is obviously more readily available at the district level. Since they are the same in Georgia, I did not encounter data matching problems.

#### Expenditures

The measure of expenditures used is FTE (full time equivalence) per pupil expenditures for the year 1999 obtained from Georgia's Department of Education. The average per pupil expenditures in Georgia's school districts was \$5,673. The district with the highest per pupil expenditures was Taliaferro County School District with \$10,796 and the lowest was that of Chickamauga City School District with \$4,263.

## **Educational Outcomes**

Several educational outcome variables are available from the Georgia Department of Education. They include different standardized test scores and graduation rates for the academic year 1999-2000 and high school dropout rate. Most educational cost studies have used some variations of those measures. I used two outcomes: the high school non-drop out rate and the percentage of 4<sup>th</sup> graders who exceeded expectations in math tests respectively (Criterion Referenced Competency Test). I found those choices to be reasonable since they cover both primary and high school. In addition, those two variables proved to be robust in regard to model specification.

## **Input Prices**

To accurately measure differences in input prices, different salaries of teachers of same quality should be considered. That is why one cannot simply use salaries since differences in salaries could reflect differences in experience or educational levels, and not only difference in cost. To control for input prices, I estimated a teacher salary indexes. It was determined by regressing salary on average years of experience and educational levels. Then the error term was used as an index. The error terms measures differences in salaries that result from variations not related to educational levels or experience, and this is exactly what is needed. Data on administrators' salaries is available. However, being highly correlated with teachers' salaries, it was not used.

The teachers' salary data was obtained from Georgia Department of Education for the year 2000. The explanatory variables used were the average years of experience and the percentage of teachers with masters and doctoral degrees.

## **Environmental Factors**

To control for differences in environmental factors, six variables were used: the percentage of students enrolled in special education programs, the percentage of pupils living under poverty, the log of enrollment and the square of log of enrollment, the percentage of students' whose English is their second language and the log of population. Data on all those variables were obtained from Georgia's Department of Education. Population and the percentage of households living under poverty are obtained from the census bureau.

Districts with higher percentage of students enrolled in special education programs and those with higher percentage of students with limited English proficiency require higher expenditures per pupil in order to provide equivalent quality of education as those with lower percentages. Also, assuming economies of scale, the higher the enrollment, the lower the average cost of education. The square of log enrollment is used to test for the U-shaped average cost curve. Previous studies have shown that a higher percentage of students living under poverty requires higher educational spending in order to provide a certain quality of education. Finally, population is used as a proxy for unobserved district characteristics like congestion, attractions and other disruptions, which means that pupils need more attention to achieve a certain level of achievement.

## ESTIMATION AND RESULTS

First, the teacher's salary index was estimated. Annual salary was regressed against the average years of experience and the percentage of teachers with master degrees and the percentage of teachers with doctoral degrees. The estimated equation led to the following:

$$\text{Salary} = 31,652 + 119.2 M + 546 D + 242.6 \text{ EXP} \quad (3)$$

(3.7)      (7.7)      (2.98)      (3.67)

The numbers between parentheses are t-ratios, and thus, all variables are significant at the conventional level.

The above equation shows that, other things being equal, as the percentage of teachers holding masters degrees increases by 1%, the average teacher salary increases by \$119, and as the percentage of doctoral degrees increases by 1%, the average teacher salary increases by \$546. Finally, when the average years of experience increases by 1 year, average teacher salary increases by \$243. As mentioned earlier, the goal is to estimate cost differences across districts. The error term captures variations in salary for reasons other than experience and educational levels, i.e., it captures cost differences. As such, the error term derived from the above equation was then used as the salary index.

After estimating the salary index, a two-stage-least-square (2SLS) approach is used to estimate the cost equation. Teachers' Salary and Educational Outcomes are treated as endogenous. Unobserved school characteristics, like generosity of school officials, affect both spending and salaries. Generous school officials, for example, pay high salaries and, in general, spend more. In addition, some of the same unobserved variables affect educational outcomes and expenditures. This grants the use of 2SLS technique since ordinary-least squares technique (OLS) leads to biased estimates.

In looking for suitable instruments for the educational outcome, I used generally accepted variables in the demand for public services. The instruments used include the percentage of adults (25 years or more) in the district with college education since more educated adults are likely to have stronger preference toward education. The other instruments include median income as a proxy for the median voter demand, tax share which is measured by the ratio of median housing value to total property value per pupil, the ratio of state aid to median income and percentage of owner-occupied houses.

The instruments associated with the salaries are manufacturing and construction wages to control for cost in the non-service sector. A district with a higher cost of living needs to pay more in order to attract teachers. Also, the district's population density was used in accordance with urban economics assumption that wages increase with density.

Table (1) shows the descriptive statistics of the cost model. Assuming a log-linear functional form for the cost function, the estimated equation is shown in table (2). It shows that the two outcome variables, the non- drop out rate and the 4th grade math test, have the expected positive sign and are significant.

All the cost variables have the expected signs. The statistically significant coefficient of teacher salary is the highest coefficient among all variables indicating that teachers' salary has the strongest effect on educational cost. The coefficient of enrollment is negative as expected with t-ratio = -3.11. Also the square of enrollment has the expected positive sign indicating the usual U-shaped average cost curve.

The coefficients of the percentage of households living under poverty, the percentage of students who are enrolled in special education programs, the percentage with limited English proficiency and population have the expected positive signs and are highly significant.

**Table 1**  
**Descriptive Statistics**

<b>Variable</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Standard Deviation</b>
Log of expenditures	8.36	9.29	8.63	0.12
% non-drop out	84.1	100	92.8	2.89
% of 4 <sup>th</sup> grade pupils meeting expectations in math test	19	85	59	11.58
Log of teacher salary	10.5	10.69	10.6	0.0023
% of pupils registered in special education programs	6.2	27.1	12.8	2.74
% of households living under poverty	1.5	29.6	13.6	5.78
log of enrollment	4.92	11.55	8.2	1.11
Square of log of enrollment	24.21	133.4	68.86	18.87
% of pupils whose English is their second language	0	17.2	1.1	2.39
Log of population	7.6	13.38	9.96	1.11

**Table 2**  
**Cost Model Estimates**

Variable	Coefficient	t-ratio
Constant	3.3	1.46
% of non-drop out rate	0.006	2.51
% of 4 <sup>th</sup> graders passing the math test	0.004	2.96
Log of teachers' salary	0.53	2.61
% of pupils in special education programs	0.01	3.69
% Living under poverty	0.006	3.66
Log of enrollment	-0.1	-3.11
Log of square enrollment	0.011	2.16
% of pupils whose English is their second language	0.009	3.66
Log of Population	0.15	3.96

*Adjusted R<sup>2</sup> = 0.8; F = 10.68*

### THE EDUCATIONAL COST INDEXES

The next step is to use the estimated cost model in order to derive the educational cost indexes. Duncombe and Yinger (2005) presented a thorough explanation about the derivation of the cost index. Once the cost equation is estimated, the required spending in each district to reach a performance target (expenditure need) is calculated. This is done first by setting the test score variables at the same performance levels for all districts and environmental variables at their actual values in each district. The coefficients of the cost variables included in the cost equation are used as the weights of the indexes. The second step is to divide  $E_i$  by its value in a district with average student characteristics. Thus, the cost index becomes:

$$I_i = (E_i) / (\text{average } E_i) \tag{4}$$

$$I_i = [(W_i^{ci} \cdot Z_i^{di}) / (\text{average } W \cdot \text{average } E)] * 100 \tag{5}$$

Note that since  $S$  is the same in each district (the average performance level is taken to calculate the index), it cancels when the expression  $I_i$  is calculated. As such, if district  $i$  has an index of 110, then it requires 10% higher spending than the average district in order to achieve an average performance level.

Table (3) below presents the educational cost indexes of all the school districts in Georgia. The top 159 districts in the table are county districts and the bottom 21 districts

(starting with Atlanta City) are city districts. The table shows that Baker County School District has the highest index of 121. This means that the District's per pupil spending should be 21% more than the average district in order to achieve similar academic performance. On the other hand, the index of Chickamauga City School District is 87, indicating that it can spend 13% less than the average district and still achieve similar academic performance.

From table (3), 56 out of the 159 county districts (37%) have indexes above 100, meaning that 37% of all county districts need above average per pupil expenditures in order to achieve average academic performance. The county districts have an average index of 99.7. On the other hand, 12 out of the 21 city districts (57%) have indexes above 100 with an average 101.9 to all city districts. This means that on average, city districts are in need of higher spending per pupil in order to achieve similar academic performance as county districts.

Table (4) compares the characteristics of the districts with the 4 highest indexes with the districts with the 4 lowest indexes. Three of the highest 4 indexes and 2 of the lowest 4 indexes belong to city school districts. Baker County School District is characterized by very high rates of pupils registered in special education program and households living under poverty. This gave it the highest cost index, although its teacher salary index is not among the highest. The unfavorable environmental factors mean that the district needs higher per pupil spending in order to achieve average academic performance. Gainesville City School District is characterized by high salary index, percentage of household living under poverty and percentage of households with limited English proficiency. This gave the District the second rank. Dalton City School District, which is ranked third, has a high salary index, high percentage of pupils living under poverty and a high percentage of pupils with limited English proficiency. The fourth-ranked district is Marietta City School District. It has a high salary index, a high percentage of pupils enrolled in special education programs and a high percentage of pupils with limited English proficiency. As for the districts with the lowest indexes like Chickamauga City School District, Lee County School District and Heard County School District they are all characterized by favorable environmental factors like low poverty rates, low percentage of pupils registered in special education programs and low percentage (0%) of pupils with limited English proficiency

## **CONCLUSIONS AND RECOMMENDATIONS**

This paper used a two-stage-least square approach to estimate an educational cost model and then derived educational cost indexes for the 180 school districts in the State of Georgia. The model controlled for teacher salary index, performance scores, a vector of variables that measures the percentage of disadvantaged students (the percentage of students registered in special education programs, the percentage of students with limited English proficiency and the percentage of households living under poverty), enrollment, the square of enrollment and education. Given the fact that teacher salary could differ among districts because of non-cost variables (experience, educational levels...), a teacher salary index was estimated by regressing actual average teacher salary on average years of experience and educational levels. The error term of the regression was then used as a salary index. The estimated cost model was then used to derive educational cost indexes to each school district in the State of Georgia. The study finds overwhelming evidence that districts with higher percentage of disadvantaged students require higher spending per pupil in order to achieve a certain academic performance.

Policy makers should be aware of the effects of environmental factors of their districts on educational performance and should take them into consideration when allocating the

educational budgets of the different school districts. Harsher environments require higher spending. Equity requires that districts with harsh environmental factors like high poverty rates, high percentage of students with limited English proficiency and high percentage of pupils registered in special education programs, should receive higher per pupil federal and state aid than districts with favorable environmental factors.

**Table 3**  
**Cost Indexes**

<b>District</b>	<b>INDEX</b>	<b>District</b>	<b>INDEX</b>	<b>District</b>	<b>INDEX</b>
Appling	103	Cook	100	Hart	98
Atkinson	105	Coweta	98	Heard	91
Bacon	104	Crawford	98	Henry	93
Baker	121	Crisp	104	Houston	97
Baldwin	103	Dade	94	Irwin	101
Banks	98	Dawson	93	Jackson	102
Barrow	98	Decatur	102	Jasper	101
Bartow	99	Dekalb	99	Jeff Davis	100
Ben Hill	102	Dodge	99	Jefferson	102
Berrien	98	Dooly	100	Jenkins	104
Bibb	100	Dougherty	101	Johnson	103
Bleckley	100	Douglas	97	Jones	94
Brantley	98	Early	102	Lamar	93
Brooks	100	Echols	106	Lanier	100
Bryan	94	Effingham	94	Laurens	96
Bulloch	100	Elbert	99	Lee	91
Burke	101	Emanuel	108	Liberty	97
Butts	95	Evans	109	Lincoln	99
Calhoun	105	Fannin	99	Long	98
Camden	94	Fayette	93	Lowndes	101
Candler	105	Floyd	100	Lumpkin	96
Carroll	99	Forsyth	97	McDuffie	99
Catoosa	95	Franklin	102	McIntosh	98
Charlton	99	Fulton	101	Macon	100
Chatham	98	Gilmer	98	Madison	100
Chatahoochee	102	Glascok	97	Marion	97
Chattooga	104	Glynn	99	Meriwether	108
Cherokee	94	Gordon	101	Miller	101
Clarke	106	Grady	99	Mitchell	107
Clay	109	Greene	102	Montgomery	99
Clayton	98	Gwinnette	97	Monroe	97
Clinch	111	Habersham	101	Morgan	107
Cobb	96	Hall	100	Murray	94
Coffee	100	Hancock	107	Muscogee	98
Colquitt	103	Haralson	101	Newton	97
Columbia	92	Harris	93	Oconee	92

**Table 3**  
**Cost Indexes (Continued)**

<b>District</b>	<b>INDEX</b>	<b>District</b>	<b>INDEX</b>
Oglethorpe	99	Upson	98
Paulding	94	Walker	99
Peach	98	Walton	97
Pickens	97	Ware	104
Pierce	100	Warren	105
Pike	92	Washington	98
Polk	101	Wayne	98
Pulaski	100	Webster	97
Putnam	100	Wheeler	104
Quitman	105	White	96
Rabun	99	Whitfield	99
Randolph	100	Wilcox	97
Richmond	98	Wilkes	99
Rockdale	94	Wilkinson	100
Schley	100	Worth	96
Screven	102	Atlanta	102
Seminole	98	Bremen	99
Spalding	99	Buford	101
Stephens	98	Calhoun	102
Stewart	100	Carrollton	102
Sumter	99	Cartersville	98
Talbot	105	Chickamauga	87
Taliaferro	104	Commerce	100
Tattnall	101	Dalton	115
Taylor	98	Decatur City	96
Telfair	99	Dublin	105
Terrell	106	Gainesville	116
Thomas	103	Jefferson	101
Tift	102	Marietta	113
Toombs	109	Pelham	108
Towns	98	Rome	108
Treutlen	101	Social Circle	96
Troup	101	Thomasville	100
Turner	103	Trion	91
Twiggs	100	Valdosta	105
Union	97	Vidalia	95

**Table 4**  
**Cost Indexes/District Characteristics**

<b>District</b>	<b>Cost index</b>	<b>Salary Index (in \$)</b>	<b>%in special education</b>	<b>%under poverty</b>	<b>% with limited English proficiency</b>
Baker County	121	37,623	27.1	19.9	0.6
Gainesville City	116	45,030	7.3	21.8	17.2
Dalton City	115	45,519	9.6	16	17.1
Marietta City	113	44,348	14.4	15.7	9.9
Chickamauga City	87	41,408	6.2	5.6	0
Lee County	91	41,457	7.9	6.5	0
Heard County	91	40,377	11.3	1.5	0
Trion City	91	42,909	10.8	6.3	0

#### REFERENCES

- Bradbury, K.L., Ladd, H.F., Perrault, M., Reschovsky, A., & Yinger, J.(1984). State Aid to offset Fiscal Disperities Across Communities. *National Tax Journal*, 37, 151-170.
- Bradford, D., Malt, R., & Oates, W.(1969). The Rising Cost of Local Public Services: Some Evidence and Reflections. *National Tax Journal*, 22, 185-202.
- Duncombe, W. & Yinger, J. (2005). How Much More Does a Disadvantaged Student Cost? *Economics of Education Review*, 24, 513-532.
- Duncombe, W. & Yinger, J. (1998). School Finance Reform: Aid Formulas and Equity Objectives. *National Tax Journal*, 51, 239-262.
- Duncombe, W. & J. Yinger. (1997). Why is it So Hard to Help Central City Schools? *Journal of Policy Analysis and Management*, 16, 85-113.
- Georgia Department of Education. (2000). *System and School Report Card*. Retrieved November & December 2005, from <http://techservices.doe.k12.ga.us/reportcard/>
- Guthrie, J. W. & Rothstein, R.( January, 1998). Enabling ‘Adequacy’ to Achieve Reality: Translating Adequacy into State School Finance Distribution Arrangements. Paper presented at a conference sponsored by the Committee on Education Finance, National Research Council, Irvine California, 30-31.

- Hamadeh, M.(1998). *Capitalization of Local Public Services into House Values*. Ph.D. Dissertation. Syracuse University, Syracuse, USA.
- Ladd, H.F. & Yinger, J.(1994). The Case of Equalizing Aid. *National Tax Journal*, 47, 211-224.
- Ratcliff, K., Riddle, B., & Yinger, J. (1990). The Fiscal Condition of School Districts in Nebraska: is Small Beautiful? *Economics of Education Review*, 9, 81-99.
- Reschovsky, A. & Imazeski. (2001). Achieving Educational Adequacy Through School Finance Reform. *Journal of Education Finance*, 26(4), 373-396.
- Reschovsky, A. & Imazeski. (2003). Let No Child Be Left Behind: Determining the Cost of Improving Student Performance. *Public Finance Review*, 3, 263-90.

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