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Causality Tests for Public School Performance and Funding

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Abstract

This paper seeks to shed light on the role of school funding in individual school performance. A unique data set is utilized for the Metropolitan Nashville – Davidson County School District in Tennessee, known colloquially as Metro. In 2005 the Metro school board undertook the task of breaking down individual school spending levels by funding source. The resulting 2004-2005 financial data are combined with academic test scores and demographic data for 2003-2004 and 2004-2005 academic years for each of 70 elementary schools. Econometric tests are then conducted to examine whether contemporaneous test score performance is determined by funding, or whether funding is determined by prior performance, or whether other school characteristics influence both.

Key words: education, public schools, performance

JEL category: I22, I28

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The large literature on the determinants of public school performance has ignited a debate over the contribution of school resources or funding to that performance. See the exchange between Hanushek (2003) and Krueger (2003), for example. Many studies find that resources and/or funding levels are not significant determinants of student performance on standardized tests. More recent studies view school expenditures and performance as simultaneously determined (Card and Payne; Dee; Eff and Klein) necessitating the use of simultaneous equations estimation methods to generate consistent and efficient estimates of the effect of resources on performance. Another strand of literature examines the equity of funding levels across schools, finding that latent discrimination against students from households of low socio-economic status may inject bias into school funding decisions (Iatarola and Stiefel; Rubenstein). Nevertheless, it is not clear whether these results arise because resources really don't matter in public education, or whether local school districts seek to induce better performance by allocating additional resources to the poorer performing schools, or because funding decisions are biased against improving poorly performing schools.

This paper seeks to shed some light on the role of school funding in individual school performance. A unique data set is utilized for the Metropolitan Nashville – Davidson County School District in Tennessee, known as Metro.[1] In 2005 the Metro school board undertook the task of breaking down individual school spending levels by funding source. The resulting 2004-2005 financial data are combined with academic test scores and demographic data for the 2003-2004 and 2004-2005 academic years for each of 70, K-4 elementary schools. Econometric tests for funding equity across schools, for the determinants of school performance, and for causal relationships among measures of performance are conducted.

These tests find no evidence for discrimination against low status groups in school funding decisions. In fact, funding appears to mildly favor schools with a high proportion of students from low income households. Neither does funding respond to the performance level of a school's students, however, indicating no evidence for the incentive effects that the No Child Left Behind Act attempts to achieve. Moreover, while government funding is not significantly associated with performance at the school level, a measure of a school's access to community funding sources is significantly related to reading performance, suggesting that resources do matter in education under the right circumstances. Some evidence for inverse causal influences from reading value-added scores to reading proficiency and from math proficiency scores to math value-added is found.

The following section discusses simple models of funding decisions and relationships between funding and performance. The data are then presented followed by a summary of the empirical tests and results. A conclusion ends the discussion. All tables are provided at the end of the paper.

Models of Funding and Performance

Consider a public school district's allocation of budgeted funds to individual schools. Some state and federal grant funding will be either school specific or allocated by a formula based on the socio-economic status of the student population, such as federal Title I funds that flow to schools in which 50% or more of students qualify for the subsidized lunch program. Schools may also raise money on their own or through community groups, such as PTO's and Pencil Partners. Maximum class sizes are mandated by state law, reducing flexibility in setting staffing levels and personnel expenditures at the school level. Every school will have a principle, an assistant principle, and at least one guidance counselor, regardless of the number of students attending the school, producing fixed costs. Funds may be provided to schools with low performance on standardized tests in order to improve performance, or funds may be withheld from such schools as punishment. Previous studies have detected the possibility that funding is allocated so as to discriminate against low-income or minority groups (Iatarola and Stiefel; Rubenstein).

This suggests the following reduced form for individual school funding:

$$F_i = F(G_i, E_i, P_i, O_i, Z_i) \quad (1)$$

where F_i is annual local public school district funding for school i, G_i is governmental grant funding for school i, E_i is annual student enrollment at school i, P_i is the academic performance of students at school i, O_i is outside or community funding for school i, and Z_i is a vector of socio-economic status characteristics. The signs of the partial derivatives of F with respect to its arguments may take positive or negative signs. For example, local funding could be used to offset federal grants, $F_g < 0$, or to reinforce such funding for needy schools, $F_g > 0$; $F_p > 0$ indicates aid to low performing schools, while $F_p < 0$ suggests low performance is "punished" with reduced funding; local funds may reinforce, $F_o > 0$, outside funding sources (to prevent middle class student flight to private schools, perhaps) or offset them, $Fo < 0$; funds could be allocated to discriminate for ($F_z < 0$) or against ($F_z > 0$) low status groups.

Similarly, the literature on public school performance suggests that academic performance is determined by school level funding (or resources) and the socio-economic status of students:

$$P_i = P(F_i, G_i, O_i, E_i, Z_i). \quad (2)$$

The similarities between equations (1) and (2) also suggest the possible simultaneous determination of funding and performance levels.

A further issue is the proper measurement of academic performance itself and the incentives various measures may create. The federal No Child Left Behind Act rests on schools meeting proficiency standards for broad categories of students defined by students' racial, socio-economic, or disability characteristics. That is, X% of students in a category must score "proficient" or above on standardized tests in order for a school to "pass". Another approach adopted in some states is to measure "value-added" or the change in an individual student's performance on standardized tests over the course of the school year, which are then summed and averaged over all students in a particular grade level at each school. Schools are then ranked or graded on the basis of these average value-added scores.

Each of these methods has its adherents for the purpose of assessing learning, but the interest here is in the incentives created for funding decisions. Proficiency standards emphasize bringing all students to or above a minimum performance level. This creates an incentive to increase funding for schools with a large proportion of low-performing students in order to raise their performance above the standard. There is no incentive to improve performance above the minimum standard. Value-added standards, however, create incentives to increase the average change in performance over the year and this allows trade-offs between encouraging large gains by high-ability learners at the expense of lesser gains (or declines) by lower-ability learners. Thus, raising value-added could reduce proficiency and vice versa.

A related issue is whether proficiency testing and value-added scores measure the same thing or not. This suggests that Grainger causality tests could be applied to appropriate data to investigate this question. If proficiency scores and value-added scores "cause" each other, then they may be measuring similar underlying phenomena.

Testing these hypotheses requires data. The data used here are described below.

Data Description

A unique data set for the Metropolitan Nashville – Davidson County School District in Tennessee, locally known as Metro, has been assembled from a 2005 Metro school board study that broke down individual school spending levels by funding source. Oddly, this is not done on a regular basis. Overall school district expenditures are tracked precisely, but in broad categories across all schools (Long, 2005b). The resulting 2004-2005 budgeted expenditure data were reported by school along with enrollment, percentages of students scoring proficient or better on standardized Reading and Math tests, and percentages of minority and low income students. Due to small numbers of middle and high schools, only elementary (K-4) school data are analyzed here.

Additional data on academic test scores and demographic data for 2003-2004 and 2004-2005 academic years were collected from the Tennessee Department of Education for each school. Data on the number of Internet connected computers and enrollment per school for the 1999-2000 school year were obtained from the Tennessee Regulatory Authority which had collected the data for a "digital divide" study in 2001 (Gregory and Klein).

{TABLE I ABOUT HERE}

Variable definitions and descriptive statistics are provided in Table I. The budgeted expenditures/funding per school exclude "system-wide" expenses such as food service, transportation (busing), lawn maintenance, and district administration. This leaves primarily expenses related directly to instruction and to school level administrators (principles,etc.), making the figures especially relevant to evaluating the relationship between instructional resources and student performance. The expenditure/funding variables are budgeted and not actual figures. This makes the data excellent for examining budgeting behavior by the school board and district administrators.

The limitation to elementary schools facilitates cross-school comparisons as the outputs and activities of each school are very similar. There are no sports or arts programs, nor college prep versus job skills classes for students to choose as there are in high schools. Schools may have differential access to PTO or community funds, however, and these are not included in the expenditure/funding amounts.

To capture the effects of past funding differences and/or the ability of schools to raise extra funds from the community, the number of Internet connected computers per student for the 1999-2000 academic year is computed to form the variable ComperS. The logic behind this is that during the 1990s computers were rarely funded through the Metro budget, but were often paid for by PTO fundraisers, gifts, or non-governmental grants. By lagging this variable by four years, it should not be correlated directly with the socio-economic characteristics of current students. ComperS allows tests for whether Metro funding decisions are affected by the "wealth" of individual schools, as well as for effects of "wealth" on performance.

Coefficients of variation expressed as percentages are reported in Table I because a value of 10% or less has been associated with "funding equity" across schools on theoretical grounds (Odden and Picus). The range of coefficients of variation for funding of Metro Nashville elementary schools of 12.3% (Mpers) to 14.9% (Totpers) come closer to funding equity by this standard than did schools in Chicago and New York City in the 1990s. Iatorola and Stiefel found coefficients of variation ranging from 12.6% to 19.1% for elementary school funding in New York City in 1997-98. Rubenstein found coefficients of variation for funding of elementary schools in Chicago of 12% to 27% in 1995. Note that NonMperS, the difference between MperS and TotperS, displays a coefficient of variation of nearly 70% as one might expect for funds that target schools with specific student characteristics. The value for ComperS is also very high (102%), indicating high variability in outside funding wealth across schools. Interestingly, the Reading proficiency variable achieves the equity standard (7.8%) and Math proficiency is very close (11.5%).

Empirical Results

The determinants of the allocation of budgeted funds across schools are investigated first. Table II shows representative results of regressions of Metro-only and total budgeted funds per student against various non-performance related explanatory variables. The percentage of minority students and the school wealth variable are uniformly insignificant. The Metro portion of school funding is not significantly related to the level of non-Metro funding. Thus, budget decisions do not appear to offset the effects of other governmental funding sources, nor to discriminate for or against minorities. The regressions based on ComperS found only a slight positive relationship with the percentage of low income students significant at the 10% level, all other variables failing to attain significance.

{TABLE II ABOUT HERE}

Enrollment and the income status of students are significantly related to budgeted funding levels and these likely are non-linear relationships as the quadratic forms in Table II indicate.[2]

The results on enrollment suggest economies of scale that are exhausted at a school size of about 786 students. As only one school in the sample attains this size and only two exceed 700 students, most Metro schools appear to be too small to capture the available economies of scale. The results for Low Income suggest that funding decreases as the percentage of low income students increases, reaching a minimum at 64.67% and increasing thereafter. The interaction term (ExL) is positive, further suggesting that funding increases with the percentage of low income students holding enrollment constant. Hence, budgeting decisions appear to mildly favor schools with high percentages of low income students.

{TABLE III ABOUT HERE}

Table III adds lagged measures of performance to the quadratic form funding regressions in Table II. None of the lagged performance variables attain significance at the 10% level. This suggests, oddly, that budgeting practices do not allocate funds to schools based on their students' performance, neither to correct poor performance nor to reward excellence. The incentive effects of No Child Left Behind as well as Tennessee's own testing program are nowhere to be seen.

{TABLE IV ABOUT HERE}

Table IV reports regressions seeking to explain proficiency scores on standardized math and reading tests. Neither funding nor socioeconomic variables attain significance in the Math equations, although the regressions are significant at 10% by the F-test and display adjusted R-squares in the area of 0.2. The Reading results are somewhat surprising in that ComperS is highly significant and positive, while Low Income is negative and significant at only the 10% level. Contemporaneous value-added performance is not significant, but lagged proficiency scores are significantly positive and lagged value-added scores are significantly negative. Note that TotperS displays a negative coefficient in all regressions, but is not significant.

{TABLE V ABOUT HERE}

To take into account the possible simultaneity of funding decisions and performance, Table V reports the results of three-stage least squares estimation of regressions similar to those in Table IV. The signs of the coefficients for TotperS become positive in three of the four equations, but remain insignificant, while the negative coefficient on Low Income attains significance in the Math equations. Otherwise the results are similar to those in Table IV.

The performance results suggest that budgeted resources are not significant determinants of proficiency performance, while socio-economic status (Low Income) and lagged performance measures are significant factors. The surprise here is the high degree of significance of CompErS in the Reading equations. To the extent this reflects the wealth of the school, then additional resources that can be directed by on-the-spot school administrators, perhaps with the aid of parents, appear to be highly effective at improving reading proficiency. On the other hand, CompErS may indicate the presence of parents with a high demand for education for their children and who are willing to raise money for the school as well as to provide home environments conducive to educational activities. Note that CompErS does not appear to proxy merely for household income levels, as it is mildly positively related to Low Income in the regression in Table II.

Finally, the causal relationships, if any, between proficiency and value-added scores are investigated. Grainger causality tests, which ask whether a variable is explained better by lagged values of another (causal) variable or by lagged values of itself, are usually applied in a Vector Auto-Regressive (VAR) context. Here, where there is a cross-section with only a one-period lag, the proper estimation technique is Seemingly Unrelated Regression (SUR) in which an equation for the proficiency score and an equation for the value-added score are estimated as a system accounting for any interrelationships in the error terms (Greene). The results of this estimation are reported in Table VI.

{TABLE VI ABOUT HERE}

The Reading equation again performs relatively well, with significant coefficients for Low Income, ComperS, Reading Lag, and VAR Lag. The entry for "Restrict" at the bottom of the table indicates that the hypothesis that the coefficient on VAR Lag is equal to zero can be rejected at the 5% level under a Lagrange multiplier test. The VAR equation displays a significant coefficient only for VAR Lag and the hypothesis that the coefficient on Reading Lag is zero cannot be rejected. This suggests that value-added inversely "causes" reading proficiency, but reading proficiency does not "cause" value-added.

The Math and VAM equations perform relatively poorly. None of the coefficients in the Math equation are significant, other than the intercept, while Math Lag is the only significant coefficient in the VAM equation and it takes a negative sign. The Restrict entries indicate only that math proficiency may inversely "cause" math value-added.

The Lagrange multiplier test, however, is not the best test of the causality restrictions, but was as close as I could come under the time constraints of preparing this paper. The results above should be considered tentative for this reason. The preferred test of the Grainger causality restrictions in this context is a likelihood ratio test. That test will be forthcoming in future versions of this paper.

Note that the indicated inverse relationship between the proficiency scores and value-added suggests a trade-off. Higher value-added may lead to lower proficiency, if the high scoring students are pushed even higher, causing value-added to rise, while some lower performing students are left behind and fail to achieve proficiency. The mixed results also reinforce the apparent confusion among the general populace, and some educators, over the meaning of the reported value-added scores.

Conclusion

Analysis of budgeted instructional expenditure levels for public K-4 elementary schools in Metro Nashville - Davidson County, Tennessee, show little evidence of discriminatory behavior. Budgeted funds mildly favor schools with high proportions of students qualifying for the subsidized lunch program and favor small schools over large schools. The latter is likely due to economies of scale or size at the school level, with almost all of Nashville's schools failing to achieve all of the available economies of size. Further, budgeted expenditures do not appear to depend upon performance levels at individual schools, demonstrating no evidence of the incentive effects expected to flow from the No Child Left Behind Act.

As many other studies have found, no statistically significant relationship between budgeted government expenditures and school performance appeared. Nevertheless, a strong statistical relationship between non-governmental funds, or individual school "wealth," and reading proficiency scores was found. One may speculate that budgeted governmental funding per student is so highly determined by pre-defined rules, such as class-size restrictions and teacher pay based on seniority, in conjunction with school size, in which fixed costs are spread over more students as schools grow, that variations in per-student funding do not reflect meaningful variations in resources across schools. When school specific resources are made available that do vary greatly across schools, as with outside fundraising, these resources do appear to affect performance significantly.

Finally, attempts at testing for causal relationships among proficiency and value-added scores yielded mixed results. Inverse relationships between reading value added and reading proficiency and between math proficiency and math value added were indicated. This suggests that the two types of performance measures are not capturing the same underlying phenomenon. It also suggests a tradeoff between the two types of performance measures such that incentive schemes to promote better performance are unlikely to produce consistent results under both methods of measuring performance.

Table I: Variable Definitions, Means, and Coefficients of Variation
Individual Metro Elementary Schools, 2004-05 Academic Year (except as noted)

Variable Name	Mean	C.V.	Definition
Enrollment	437.27	34.7	Number of Students per School, Fall 2004
TotperS	5966.5	14.9	Total school expenditures per student
MperS	5387.3	12.3	Metro school expenditures per student
NonMperS	579.2	69.6	Non-Metro school expenditures per student
ComperS	0.1015	102.1	Internet connected computers per student (2000-01)
Minority	62.23	36.0	% Non-white students, 2003-04
Low_Income	64.17	36.6	% Students qualified for subsidized lunch, 2003-04
Reading	88.83	7.8	% Students rated “Proficient” or better in 4th grade
Math	82.30	11.5	% Students rated “Proficient” or better in 4th grade
ReadingLag	79.53	13.2	% Students Reading Proficient, previous year
MathLag	76.39	13.9	% Students Math Proficient, previous year
VAR	1.97	177	Mean Change in Individual Student Reading Score
VAM	1.60	383	Mean Change in Individual Student Math Score
VAR_1	-0.93	290	VAR for previous year
VAM_1	-3.20	160	VAM for previous year
VA_Read	1.81	96.7	Three-year average, School VAR
VA_Math	2.00	87.0	Three-year average, School VAM

Table II: Determinants of the Allocation of Funds Across Schools
(t statistics in parentheses)

Dependent Variable

Explanatory Variables	MperS	MperS	TotperS	TotperS	ComperS
Intercept	6514.1* (21.77)	10490* (11.45)	6455.8* (17.08)	11609* (10.26)	0.0982 (0.47)
Enrollment	-2.54* (-5.91)	-13.888* (-5.72)	-3.106* (-5.87)	-16.188* (-5.40)	0.0002 (0.37)
Low Income	-3.011 (-0.64)	-52.751* (-3.10)	10.45** (2.01)	-66.564* (-3.16)	-0.0023 (-0.59)
Minority	-0.181 (-0.04)		0.8367 (0.16)		
NonMperS	0.2601 (1.22)				
ComperS	261.99 (0.36)		1325.2 (1.50)		
Esq		0.0084* (4.41)		0.0103* (4.37)	-1.47E-7 (-0.34)
LIsq		0.2920* (2.74)		0.5146* (3.91)	0.00004*** (1.77)
ExL		0.0432** (2.49)		0.0401*** (1.87)	-0.000004 (-1.00)
Adj. R-sq.	0.4360	0.5976	0.5224	0.6612	0.1494
F	10.43*	21.50*	17.68*	27.94*	3.42*
N	62	70	62	70	70

*significant at 1% **significant at 5% ***significant at 10%

Table III: Test Scores and Allocation of Funds Across Schools
(t statistics in parentheses)
Dependent Variable

Explanatory Variables	MperS	MperS	TotperS	TotperS
Intercept	11779*	10584*	13142*	11273*
	(9.02)	(9.30)	(8.16)	(7.99)
Enrollment	-13.737*	-13.317*	-14.544*	-14.311*
	(-4.59)	(-4.47)	(-3.94)	(-3.11)
Enrollsq	0.0076*	0.0074*	0.0086*	0.0086*
	(3.36)	(3.32)	(3.08)	(3.14)
Low Income	-56.355*	-54.833*	-67.571*	-64.688*
	(-2.97)	(-2.83)	(-2.89)	(-2.69)
LIsq	0.232**	0.2634**	0.4579*	0.5034*
	(2.01)	(2.26)	(3.21)	(3.48)
ExL	0.054*	0.0505**	0.0404	0.0359
	(2.71)	(2.50)	(1.65)	(1.44)
ReadingLag	-15.850		-19.877	
	(-1.61)		(-1.64)	
MathLag	4.412		10.9094	
	(0.50)		(0.06)	
VAR_1		2.7692		4.831
		(0.14)		(0.20)
VAM_1		11.675		17.865
		(0.84)		(1.04)
Adj. R-sq.	0.5456	0.5323	0.6333	0.6195
F	11.47*	10.92*	16.05*	15.19*
N	62	62	62	62

*significant at 1% **significant at 5% ***significant at 10%

Table IV: Determinants of Proficiency
(t statistics in parentheses)

	Reading			Math		
	1	2	3	1	2	3
Intercept	73.57* (6.42)	76.84* (6.54)	77.51* (6.84)	79.33* (4.56)	78.32* (4.43)	80.32* (4.60)
TotperS	-0.001 (-1.19)	-0.001 (-1.04)	-0.0008 (-0.91)	-0.0008 (-0.54)	-0.0008 (-0.53)	-0.0007 (-0.45)
ComperS	31.85* (4.07)	30.75* (3.92)	29.62* (3.85)	14.28 (1.12)	14.32 (1.12)	13.32 (1.04)
Minority	0.025 (0.53)	0.024 (0.50)	0.015 (0.32)	-0.049 (-0.62)	-0.051 (-0.64)	-0.051 (-0.64)
Low Income	-0.091*** (-1.81)	-0.096*** (-1.91)	-0.095*** (-1.94)	-0.097 (-1.24)	-0.102 (-1.28)	-0.103 (-1.31)
Reading Lag	0.280* (3.03)	0.246** (2.55)	0.220** (2.32)			
VA Read		-0.471 (-1.19)				
VAR Lag			-0.358*** (-2.00)			
Math Lag				0.194 (1.40)	0.205 (1.44)	0.169 (1.20)
VA Math					0.293 (0.43)	
VAM Lag						-0.197 (-0.94)
Adj. R. sq.	0.4630	0.4670	0.4903	0.2321	0.2207	0.2304
F	11.52*	9.91*	10.78*	4.69*	3.88*	4.04*
N	62	62	62	62	62	62

*significant at 1% **significant at 5% ***significant at 10%

Table V: Determinants of Proficiency
Three Stage Least Squares Estimation
(t statistics in parentheses)

	Reading		Math	
	1	2	1	2
Intercept	74.662**	79.677*	37.656	51.852
	(2.41)	(3.15)	(0.80)	(1.30)
TotperS	0.0011	-0.0006	0.0061	0.0036
	(0.34)	(-0.24)	(1.14)	(0.78)
Enrollment	0.0009	-0.0021	0.0161	0.0115
	(0.08)	(-0.22)	(0.85)	(0.70)
Minority	0.0191	0.0154	-0.0339	-0.0470
	(0.39)	(0.33)	(-0.43)	(-0.59)
Low Income	-0.163*	-0.1066**	-0.2050**	-0.1549***
	(-2.99)	(-2.10)	(-2.22)	(-1.76)
CompperS	27.881*	28.478*	15.723	12.141
	(3.87)	(3.48)	(1.35)	(0.89)
Reading Lag	0.1690	0.2010***		
	(1.41)	(1.82)		
Math Lag			0.1889	0.1834
			(1.15)	(1.19)
VAR Lag		-0.3677***		
		(-1.97)		
VAM Lag				-0.1544
				(-0.68)
System Wtd. R-sq.	0.5858	0.5948	0.5681	0.5392

*significant at 1% **significant at 5% ***significant at 10%

Table VI: Do Value-Added Scores Cause Proficiency Scores?
Seemingly Unrelated Regression Results and Tests of Restrictions

Explanatory Variables	Dependent Variables: Reading	VAR	Math	VAM
Intercept	72.59*	8.64	75.97*	8.78
	(6.84)	(1.33)	(5.27)	(0.96)
Enrollment	-0.0002	-0.0008	-0.0008	-0.0012
	(-0.04)	(-0.29)	(-0.10)	(-0.24)
Minority	0.0184	0.0009	-0.0450	0.0520
	(0.39)	(0.03)	(-0.57)	(1.04)
Low Income	-0.1054**	0.0055	-0.1128	0.0487
	(-2.15)	(0.18)	(-1.46)	(1.00)
ComperS	27.2076*	-0.7650	11.058	-3.4915
	(3.51)	(-0.16)	(0.88)	(-0.44)
Reading Lag	0.2300**	-0.0789		
	(2.40)	(-1.34)		
VAR Lag	-0.3839**	0.3840*		
	(-2.14)	(3.49)		
Math Lag			0.1845	-0.1631***
			(1.33)	(-1.86)
VAM Lag			-0.2049	0.0861
			(-0.97)	(0.65)
Restrict	-2.07**	-1.32	-0.90	-1.78***
System R-sq.	0.4487		0.3830	

*significant at 1% **significant at 5% ***significant at 10%

References:

Card, D. and A. A. Payne. 2002. “School Finance Reform, the Distribution of School Spending, and the Distribution of Student Test Scores.” *Journal of Public Economics*, January, pp.49-82.

Dee, Thomas S. 2005. “Expense Preference and Student Achievement in School Districts.” *Eastern Economic Journal*, 31:1, Winter, pp. 23-44.

Eff, E. Anton and Christopher C. Klein. 2006. “What Can We Learn from Education Production Studies?” Working Paper.

Greene, William H. 2003. Econometric Analysis. 5th ed. Prentice-Hall: Upper Saddle River.

Gregory, Rose M. and Christopher C. Klein. 2001. "Connecting Tennessee: Bridging the Digital Divide." *NRRI Quarterly Bulletin*, 21:3, Spring 2001.

Hanushek, E.A. 2003. “The Failure of Input-Based Schooling Policies.” *The Economic Journal*. 113:F64-F98.

Iatarola, P. and L. Stiefel. 2003. “Intradistrict Equity of Public Education Resources and Performance.” *Economics of Education Review*. 22:69-78.

Krueger, A.B. 2003. “Economic Considerations and Class Size.” *The Economic Journal*. 113:F34-F63.

Long, D. 2005a. “Per-Pupil Spending Varies Across Metro.” *The Tennesseean*. 100(51): 1A.

Long, D. 2005b. “It sounds simple, but it’s not: Matching dollars to schools is daunting task.” *The Tennesseean*. 100(51):11A.

Odden, A. and L. Picus. 2000. *School Finance: A Policy Perspective*. Boston: McGraw-Hill.

Rubenstein, R. 1998. “Resource Equity in Chicago Public Schools: A School-Level Approach.” *Journal of Education Finance*. 23(4): 468-489.

Stiefel, L., R. Rubenstein and R. Berne. 1998. “Intra-district Equity in Four Large Cities: Data, Methods, Results.” *Journal of Education Finance*. 23(4): 447-467.

Tennessee Department of Education, “TCAP Test Results.” http://www.tennessee.gov/education/assessment/tsresults.shtml.

Tennessee Regulatory Authority. 2001. “Connecting Tennessee: Bridging the Digital Divide.” http://www.state.tn.us/tra/reports/digitaldividerpt.pdf.

Notes

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[1] The author thanks Courtney Barrett for capable research assistance in assembling the data for this project.

[2] Similar results were obtained with translog (quadratic in the logarithms) functional forms, but with slightly lower adjusted R-squares.