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Assessing the Impact of Expenditure on Achievement in Virginia Public Education

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ASSESSING THE IMPACT OF EXPENDITURE ON ACHIEVEMENT:

SOME METHODOLOGICAL AND POLICY CONSIDERATIONS

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The strength of the relationship between student achievement and school resources has important implications for public policy in general, and for the appropriate role of state funding in local education in particular. It is well known that, to the extent that higher expenditures render improved educational performance, vexing issues of legal and economic equity arise.[1] Of course, it is also well known that the findings of extensive empirical analysis suggest that the expenditure-achievement nexus is, at best, of secondary importance among the factors affecting education.[2]

This paper examines the relationship between achievement and expenditure in Virginia public schools. Our focus falls in the category of educational production studies which have taken an essentially macro orientation. These studies use cross-sectional and/or longitudinal observations aggregated at a school or school district level.[3] This method thus relates average achievement

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[1] Though predominantly of economic orientation, Feldstein (1975) and Cohn (1983) provide particularly succinct expression of these broad issues.

[2] So concluded the generally acknowledged father of the empirical literature, Equality of Educational Opportunity (1966), better known as the "Coleman Report". Subsequent early studies reaching similar conclusions are Kiesling (1967) and Cohn (1968). A survey of the early literature is provided by Averch et al. (1972). Hanushek (1979) presents a useful survey/critique of empirical estimation of educational production. For a forceful statement that prior research offers no support for the spending-achievement link, see Hanushek (1981). For a more sanguine view of the general implications of the research to date, see Murnane (1984).

[3] Of the 130 studies evaluated by Hanushek (1981), roughly half use aggregate data. Examples are the studies by Kiesling (1967), Cohn (1968), Averch & Kiesling (1970), and Sebold & Dato (1981). The alternative approach is to use individual student profiles as the unit of observation. Examples of this micro focus are Hanushek (1971), Murnane (1975), Winkler (1975), Summer & Wolfe (1977) and Murnane & Phillips (1981b). According to Murnane

by district to the level of physical and financial resources (class-size, library volumes, instructional expenditure, etc.). While the policy inferences which can flow from this approach are straightforward, there is concern whether more highly aggregated data are able to capture important details of the educational process. This is the most common explanation offered for the failure of the more highly aggregated studies in demonstrating a significant link between school resources and achievement.[4]

Despite the long and less than robust research record in this area, we believe the present paper contributes modestly in several respects. First, of local interest, we deal exclusively with public education in Virginia. Toward this end, we have compiled a data base which is perhaps unique for its array of socio/economic and educational variables at the Virginia division level (city or county). Furthermore, we apply a recently developed method for constructing locality-level price indices. Finally, we suggest some general modeling techniques which augment the reduced-form specification of the achievement-expenditure relationship common in this literature. Specifically, we demonstrate the usefulness of integrating socioeconomic effects econometrically via an "unobservable variables" technique.

Section I presents our model and discusses general estimation considerations. Section II provides a detailed description of the data and variables used in the model. Section III presents our results. Policy implications and directions for further inquiry are discussed in Section IV.

(1984), the micro approach has proven more successful in providing "clear support for the belief of most Americans - that schools matter." However, he also acknowledges that "having determined that more learning takes place in some schools and classrooms than in others...there is no concensus regarding the role of any school resource in contributing to student achievement" (p. 195).

[4]For example, see Summers and Wolfe (1977; p. 640).

I. The Model

Research to date suggests that an empirical model of the achievement equation should consider four broad explanatory components: 1) aptitude, 2) socioeconomic factors, 3) peer group effects, and 4) the quantity and quality of educational inputs.[5] The impacts of these factors on student achievement have typically been estimated by ordinary least squares (OLS) in a single equation reduced-form model.

In general form our model may be written:

(1) $$ACH_i = f(APT,\ SCH,\ SES)_i\ ;$$

where ACH = mean standardized test score,

APT = mean aptitude score,

SCH = vector of school system descriptors,

SES = vector of upper and lower socioeconomic indices, and

i = Virginia school division.

An initial reaction to this specification is perhaps the apparent omission of peer-group effects from the model. One could argue, however, that this is not entirely so. Recognize that studies which have demonstrated the significance of peer-group effects have all used student-specific data. The finer detail provided by student profiles more readily accomodates distinctions between peer-group and socioeconomic variables. When aggregating at the

[5]Of course, this modeling agenda is more easily compiled than implemented. Indeed, much of the research has been devoted to refining operational variables within each of these catagories. For example, a great amount of attention has focused on detecting differential "quality" of teaching input [Hanushek (1972), Summers & Wolfe (1977), Link & Ratledge (1979), Murnane & Phillips (1981a)]. Interesting treatments of peer group effects are Winkler (1975), Henderson et al. (1978), and Murnane (1983). All of these studies provide examples of specifications of socio-economic variables.

school division level, however, it is not clear that meaningful operational definitions can be drawn beyond the broader realm of socioeconomic factors. Thus peer-group effects are considered, at least implicitly although not independantly. Further, some degree of implicit peer-group measurement also enters the model through the statistical procedure by which we control for socioeconomic factors in general.

Specifically, SES is described as a vector of indices rather than separate socioeconomic variables. Technically, these indices treat socioeconomic effects as "unobservable variables". An unobservable-variables framework seems particularly appropriate in this research setting. The array of variables typically employed (e.g. income, racial balance) are really very pale proxies of a far more complex interaction among factors. Conceptually, the attribute we are attempting to capture in the model might be thought of as a "preference" or "value" of education. This preference for education is thus an amalgam of many factors which neither can nor should be distilled and cast as having separate *ceteris paribus* effects. Furthermore, the unobservable-variable technique eliminates a cohort of variables within which substantial collinearity is likely.

We should also highlight the fact that the SES indices are constructed to control for upper as well as lower socioeconomic influences. This treatment is unusual in that most equations tend to be laden with predominantly lower-end (e.g., percent of families receiving AFDC) and/or average (e.g., per capita income) socioeconomic variables. We believe that consideration of upper-end influences is a necessary departure in explaining average achievement. Socio-economic and peer-group factors are known to play an important role in scholastic achievement, especially at the extremes of the socioeconomic scale. In a state like Virginia which runs the gamut from very poor agrarian districts to very wealthy cosmopolitan areas, middle-level indicators such as median or per capita income reveal little about these extremes. Second, even studies which have incorporated more finely honed lower socioeconomic variables (e.g., percent in poverty) commit errors of omission by not allowing for the parallel positive impact of upper socioeconomic effects in above average districts.

A final noteworthy aspect of this study is the application of locality-level cost-of-living indices.[6] This indexation seems especially desirable in an analysis of Virginia data considering the clear cost-of-living differences which exist between the more metropolitan northern Virginia localities and the largely rural south and southwestern regions of the state. The significance of this adjustment is the obvious appeal of being able to measure educational expenditure in real terms. It is also evident that estimation of an achievement-expenditure model in purely nominal terms can dilute any real correlation that may exist. For example, consider two conceptually equivalent cases: 1) an above average achievement school district with above average real expenditure in a below average cost-of-living region; 2) a below average achievement district with below average real expenditure in an above average cost-of-living area. Casting these data point in nominal terms will tend to diminish, and possibly invert, the hypothesized positive relationship between expenditure and achievement. The statistical impact of these observations is clearly to increase the standard error of the estimated expenditure coefficient. This scenario may be a factor in explaining why analyses using school district averages in nominal terms often fail to find a statistically significant

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[6] These indices are based on the methodology recently developed by Fournier & Rasmussen (1985) in "Salaries in Public Education: The Impact of Geographic Cost of Living Differentials."

expenditure coefficient.[7]

In sum, this study is notable for its treatment of socioeconomic effects as well as the application of locality-level price indices. For reasons noted above, we would argue that these adjustments render a conceptually improved model for testing the achievement-expenditure relationship with school division data.

II. Estimation

Virginia administers two series of nationally standardized tests: 1) Science Research Associates (SRA) Achievement Series; and 2) Educational Ability Series (EAS). The SRA series contains a reading (R), language (LA), and math (M) section, while EAS measures general ability. Both series are given at the 4th, 8th, and 11th grade level. We employ a j subscript to indicate grade level (j = 4, 8, 11) and a k subscript to denote test section (k = R, LA, or M). Therefore, Section III will present results for nine (jk) separate OLS regressions.

Our basic estimating equation is written:

$$(2)\quad SRA_{jk} = \underset{(+)}{EAS_j} + \underset{(-)}{RATIO_j} + \underset{(+)}{\$SAL_j} + \underset{(+)}{\$SUPV} + \underset{(+)}{\$OI} + \underset{(+)}{\$ADMN} + \underset{(+)}{ADM_j} + \underset{(+)}{\%LOCL} + \underset{(-)}{POP} + \underset{(-)}{\%PVT} + \underset{(?)}{YFAM} + \underset{(-)}{SES.L1} + \underset{(-)}{SES.L2} + \underset{(-)}{SES.L3} + \underset{(+)}{SES.U1} + \underset{(+)}{SES.U2} + \epsilon$$

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[7]A related, yet separate factor which might be contributing to insignificant parameter estimates is the likely collinearity between nominal expenditure and nominal income measures, the latter of which are typically included as a socio-economic variable.

The parenthetical signs below the exogenous variables indicate the predicted direction of the relationship of each independent variable ($\partial SRA/\partial x$). In particular, Equation (2) suggests that Achievement at the j^{th} grade on the k^{th} test level (SRA_{jk}) is a positive function of the corresponding aptitude (EAS_j), teacher salary ($\$SAL_j$), other distinquishable components of per-pupil expenditure ($\$SUPV_j$ - instructional supervisors, \$OI - other instructional, \$ADMN = administrative), and two separate indices of upper socioeconomic factors (SES.U1 and SES.U2). Higher pupil-teacher ratios (RATIO) and three lower socioeconomic factors (SES.U1-SES.U3) are posited to vary inversely with achievement. Average daily membership (ADM) is cast in quadratic form to test for scale economies in education at the school division level. The percent of total educational expenditure provided by local taxes (%LOCL) may reflect local effort and thus is hypothesized to be a proxy for local interest in education. Population growth (POP) across school divisions is included as a control for infrastructural lags between growth in demand for educational services in a locality and the actual provision thereof. These lags, depending on the length and severity, should adversely influence school district performance, *ceteris paribus*. The percent of the student-aged population in a division attending private schools (%PVT) is held to be negative. This prediction presumes a filtering of higher-achieving students out of public schools. We make no prediction as to the influence of median family income (YFAM). This is surprising in light of the myriad studies finding a positive coefficient for this variable. Those studies did not control for both lower and upper socioeconomic conditions, however. Since we have, YFAM represents improvements in middle class economic conditions without any change in lower- or upper-level conditions. We are less sure of the relationship between

Table 1: Variables within the Model

Variable	Mean & Std. Dev.[a]	Definition and Comment
Achievement		
SRA_{jk}		Divisional average percentiles[b] (nationally normalized) on the Science Research Associates Achievement Series by grade level (j=4,8,11) and major skill areas (k=reading, language arts, mathematics). For example, SRA8M represents the average percentile rank of the division's 8th graders in mathematics. The national average for each measure is the fiftieth percentile.
Aptitude		
EAS_4	49.20 10.53	Divisional average percentiles on the Educational Ability Series for grade levels 4, 8 and 11, respectively. The national average at each level is the fiftieth percentile. The appropriate level's EAS is used in each achievement equation.
EAS_8	48.81 12.02	
EAS_{11}	46.25 11.92	
School System (Annual Series)		
$\$SAL_4$[c]	16.01 1.54	Average teacher salary ($1,000) in kindergarten through through seventh grade. Used in achievement equations for grade 4.
$\$SAL_{8,11}$[c]	17.32 1.75	Average teacher salary ($1,000) in grades 8-12. Used in achievement equations for grades 8 and 11.
$RATIO_4$	16.87 1.92	Pupil-to-teacher ratio in kindergarten through seventh grade. Used in achievevment equations for grade 4.
$RATIO_{8,11}$	13.83 1.52	Pupil-to-teacher ratio in grades 8-12. Used in achievement equations for grades 8 and 11.
$SUPV[c]	1.24 0.21	Per-pupil expenditure ($100) on instructional supervisory personnel.
$OI[c]	2.24 0.68	Per-pupil expenditure ($100) on instruction other than personnel.
$ADMN[c]	0.61 0.26	Per-pupil expenditure ($100) on administration.
ADM_4	4.64 7.85	Student enrollment (1,000) in K-7 grades as measured by average daily membership. Entered in quadratic form for grade 4 to allow for possible scale effects.

(Continued)

Table 1 (continued)

Variable	Mean & Std. Dev.[a]	Definition and Comment
$ADM_{8,11}$	2.90 5.42	Student enrollment (1,000) in grades 8-11 as measured by average daily membership. Entered in quadratic form in the grades 8 and 11 achievement equations.
Locality		
%LOCL	39.92 12.33	Local effort: percentage of total school system expenditure provided by local taxes (annual series).
%POP	17.69 20.23	Infrastructure lags: percentage population growth between the 1970 and 1980 Censuses.
YFAM[c]	23.48 4.89	Middle-level economic stability: median family income in 1979.
Lower-Level Socioeconomic Conditions (Used to Generate SES.L1 - SES.L3)		
%RURL	61.24 41.55	Rurality: percentage of the division's population not living in a 1980 census-classified urban area.
%NONW	21.30 17.57	Racial composition: percentage of nonwhites in the population, 1980 Census.
%CHLD.POV	16.82 6.94	Economic stability of home life: percentage of all dependent children living in households with incomes below the federal poverty level in 1979.
$SSI.HH[c]	9.02 4.71	Socioeconomic stability of home life: Average monthly Supplemental Security Payment per household, June 1982.[d]
DIVORCE	3.86 1.00	Social stability of home life: divorce rate per 1,000 population, 1980 Census.
%FFAM	13.48 4.16	Social stability of home life: percentage of families with a female head of household, 1980 Census.
%DROP	4.90 1.65	Family attitude toward education: dropout rate in grades 8-12, by school year.
%PLMB	8.05 5.86	Housing conditions: percentage of housing units which lack complete plumbing facilities, 1980 Census.
%1RM	4.27 1.87	Housing conditions: percentage of housing units with more than one person per room, 1980 Census.
%UNMP	5.64 1.86	Economic opportunity: unemployment rate, 1980 Census.
%YHHO.10	32.13 8.66	Economic opportunity: percentage of households with incomes less than $10,000 in 1979.
%FAM.POV	10.72 4.15	Economic opportunity: percentage of families with incomes below the federal poverty level in 1979.

Table 1 (continued)

Variable	Mean & Std. Dev.[a]	Definition and Comment
Upper-Level Socioeconomic Conditions (Used to Generate SES.U1 & SES.U2)		
%URBN	38.76 41.67	Urbanity: percentage of the divisions population living in a census-classified urban area, 1980 Census.
%YHH.GE40	6.30 6.18	Economic stability of home life: percentage of households with incomes at least $40,000 in 1979.
%ED12	51.79 12.65	Parental attitude toward education: percentage of persons aged 25 or more who have at least 12 years of education, 1980 Census.
%ED16	12.66 7.91	Parental attitude toward education: percentage of persons aged 25 or more who have at least 16 years of education, 1980 Census.
%OUTC	14.70 6.82	Mobility: percent of 1980's population living in a different county of Virginia in 1985.
%OUTS	10.04 7.45	Mobility: percent of 1980's population not living in Virginia in 1985.
%VOTE	48.55 6.18	Social awareness in the home: percentage of adults voting in 1980 presidential election.

[a]The sample consists of 512 observations -- four academic years (1980-81 - 1983-84) for 128 of the 140 Virginia divisions. Certain cities were merged with counties because of missing data in certain series.

[b]Means and Standard Deviations for the nine achievement variables are included in Table 2.

[c]This variable has been adjusted for cost-of-living differences across divisions. A division-specific index was generated following the procedure developed by Fournier and Rasmussen (1985). An index value is calculated by the formula,

COL = 15,344.66 - 36.751 ln(population in $100) + 645.505 ln(median housing value in $)
+ 1.630 (per capita revenues from the state) + 3.030 (per capita local taxes, all sources)

Since we are only interested in relative living costs, we have standardized this index to a mean of 1.00 with a standard deviation of 0.10 for use as a deflator.

Additionally, the GNP deflator has been employed to tranlate these values into 1983 dollars.

[d]Computed as (number of recipients) x (average monthly payment per recipient) / (number of households).

achievement and purely middle-level changes than we are in changes at the extremes. Finally, ϵ is an error assumed to be distributed normally with zero mean and constant variance.

A more detailed description of the variables are presented in Table 1. Though not noted explicitly in Equation (2), all observations are specific to 128 school divisions in Virginia (i = 1-128). Further, the data set spans four academic years (1980-1984) and therefore each estimation reflects four years of results on the j^{th} level and k^{th} test.[8]

Turning to the latter portions of Table 1, note that we present two broad catagories of variables, denoted Lower-level and Upper-level Socioeconomic Conditions. These are the variables upon which a factor analysis was conducted to obtain the SES unobservable variables.[9] Three factors emerged representing lower-level socioeconomic conditions and two more at the upper level. Table 2 presents correlation coefficients between each lower-level socioeconomic index and each observed indicator variable. For clarity, correlations below 0.3 in absolute value have been deleted. Differerent lower-level portraits are depicted by each of the three indices. The first index portrays a family

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[8]A careful reading of Table 1 leads to the correct conclusion that, within a complete school division record, observations for specific variable are used with differing degrees of overlap across the nine estimations we perform. For example, SRA is the only varaible which is unique in each regression. At a given grade level, irrespective of test area, all exogenous variables for a division will be the same. Further, for the assorted school system variables (e.g. salaries, pupil-teacher ratios, components of per-pupil expenditure, ADM), our data only distinguish between grades K-7 and 8-12. Therefore, in the estimation of SRA_{jk}, certain school system observations are different in the case of k = 4 versus k = 8 & 12. Finally, we generate only one set of the five SES indicies for each locality and therefore these indices are used in each estimation.

[9]Technically, a maximum-likelihood, exploratory factor analysis was employed with varimax orthogonal rotation. We allowed the procedure to continue extracting common factors until the eigen value for the last factor fell below 0.5.

Table 2

Correlations Between Lower-Level Socioeconomic Indices and their Observed Indicator Variables

	SES.L1	SES.L2	SES.L3
%RURL		0.93	
%NONW			0.98
CHLD.POV	0.85		0.47
SSI.HH	0.74		
DIVORCE		-0.71	
PCT.FFAM	0.44	-0.57	0.59
%DROP	0.46		0.35
%PLMB	0.36	0.84	
%1RM	0.47	0.53	0.49
%UNMP	0.59		
YHH00.10	0.81	0.31	
FAM.POV	0.86	0.33	0.33

Table 3

Correlations Between Upper-Level Socioeconomic Indices and their Observed Indicator Variables

	SES.U1	SES.U2
%URBN	0.59	
%VOTE		0.67
%OUTC	0.50	
%OUTS	0.80	
%ED12	0.95	
%ED16	0.92	
%YHH.GE40	0.87	0.35

in poverty, receiving government assistance, headed by a female, with high dropout rates, living in substandard housing, unemployed, and very low income. The second broad type of poor are rural, intact families, living in crowded conditions, with low income. The last category is nonwhite, with female head of household, high dropout rates, living in crowded conditions, and in poverty.

Table 3 presents correlation coefficients between the upper-level socio-economic indices and their observed counterparts. The first index correlates well with all variables save one, percent voting in the 1980 presidential election. This index portrays an urban community which is attractive enough to drow migrants from other parts of Virginia as well as other states. It has a well-educated populace and a relatively high proportion of high-income earners. The second index depicts a politically-aware, high-income populace.

III. Results

The results from the nine estimations of Equation (2) are presented in Table 4. While the amount of statistical information contained in this table is admittedly overwhelming at a glance, the rather packed format is useful because it accomodates ready comparisons across test areas at a given grade level as well as across grade levels. To ease interpretation, the significant variables as they conform to the predicted signs in Equation (2) are marked by asterisks.

On the basis of R^2s, the general explanatory power of the model is quite good. Over 80 percent of the variance in achievement is explained in eight of the nine estimations. Generally, the model appears to account for reading and language achievement better than math, and also performs slightly better

Table 4

Results of Least-Squares Regression;
Achievement in Grades 4, 8, 11
for Reading, Language Arts, Mathematics

	SRA4R	SRA4LA	SRA4M	SRA8R	SRA8LA	SRA8M	SRA11R	SRA11LA	SRA11M
SSAL	0.619**	0.523**	0.354*	-0.008	0.437**	0.336*	0.406**	0.278*	0.185
	(4.29)	(3.60)	(1.67)	(0.07)	(4.07)	(2.12)	(3.72)	(2.10)	(1.37)
RATIO	-0.399**	-0.295*	0.137	-0.278*	-0.156	-0.294	-0.213	-0.198	-0.279*
	(2.96)	(2.17)	(0.70)	(2.20)	(1.20)	(1.53)	(1.61)	(1.24)	(1.71)
$SUPV	0.596	3.465**	4.110**	-0.754	1.251	1.232	-1.127	-0.595	-0.144
	(0.54)	(3.14)	(2.56)	(0.88)	(1.43)	(0.95)	(1.27)	(0.55)	(0.13)
$OI	-0.022	-0.798	-0.230	-0.143	-0.137	0.206	-0.039	-0.948	0.085
	(0.06)	(2.13)	(0.42)	(0.50)	(0.46)	(0.47)	(0.13)	(2.61)	(0.23)
$ADMN	0.449	-0.311	-3.131	-1.449	0.889	-1.757	-1.329	-1.878	-1.157
	(0.39)	(0.26)	(1.83)	(1.60)	(0.95)	(1.28)	(1.40)	(1.64)	(0.99)
EAS	0.953**	0.818**	0.802**	0.766**	0.683**	0.925**	0.725**	0.961**	0.824**
	(33.14)	(28.24)	(19.04)	(39.36)	(34.08)	(31.25)	(32.98)	(36.13)	(30.33)
ADM	-0.004	-0.004	-0.003	-0.012	-0.002	0.002	-0.008	-0.004	-0.001
	(0.58)	(0.53)	(0.23)	(1.31)	(0.22)	(0.13)	(0.83)	(0.33)	(0.11)
ADM.SQ	0.005	-0.005	-0.005	0.025	0.006	0.010	0.018	0.019	0.015
	(0.44)	(0.41)	(0.30)	(1.41)	(0.34)	(0.38)	(0.98)	(0.82)	(0.64)
%LOCL	-0.020	-0.029	-0.052	-0.005	-0.010	-0.002	-0.003	0.019	0.044
	(0.62)	(0.89)	(1.11)	(0.21)	(0.46)	(0.06)	(0.14)	(0.69)	(1.52)
%POP	0.042	0.038	0.015	0.000	0.003	-0.038**	0.028	-0.004	0.014
	(3.23)	(2.92)	(0.77)	(0.01)	(0.31)	(2.48)	(2.64)	(0.29)	(1.06)
%PRVT	0.154	0.141	0.303	-0.120**	-0.161**	-0.102	-0.118*	0.070	-0.020
	(2.36)	(2.14)	(3.17)	(2.46)	(3.20)	(1.37)	(2.29)	(1.12)	(0.31)
YFAM.MED	-0.343*	-0.333*	-0.264	-0.242*	-0.370**	-0.271	-0.494**	-0.038	-0.282
	(2.38)	(2.29)	(1.25)	(2.13)	(3.17)	(1.57)	(4.20)	(0.27)	(1.94)
SES.L1	-1.114**	-1.019**	-0.249	-1.489**	-1.434**	-0.156	-1.444**	0.884	-0.510
	(2.87)	(2.60)	(0.44)	(4.77)	(4.46)	(0.33)	(4.54)	(2.29)	(1.30)
SES.L2	0.100	-0.263	-0.622	-0.350	-0.640*	0.405	-0.820**	0.570	-0.144
	(0.27)	(0.70)	(1.14)	(1.21)	(2.15)	(0.93)	(2.72)	(1.57)	(0.39)
SES.L3	-0.732**	1.808	0.149	-1.615**	1.105	0.767	-1.778**	2.364	0.465
	(2.71)	(6.64)	(0.38)	(7.53)	(5.00)	(2.35)	(7.80)	(8.56)	(1.65)
SES.U1	0.439	1.721**	1.541	2.371**	2.175**	1.459*	3.020**	-0.776	1.092*
	(0.67)	(2.60)	(1.60)	(4.66)	(4.15)	(1.89)	(5.67)	(1.20)	(1.66)
SES.U2	-0.360	0.181	0.407	0.058	0.490*	-0.365	0.147	0.095	-0.165
	(0.96)	(0.48)	(0.74)	(0.24)	(1.67)	(0.84)	(0.50)	(0.26)	(0.45)
Constant	7.203	14.637**	8.437	21.685**	18.133**	15.835*	21.837**	3.386	18.169**
	(1.36)	(2.75)	(1.09)	(5.06)	(4.11)	(2.43)	(4.90)	(0.63)	(3.30)
R Squared	0.85	0.81	0.66	0.92	0.88	0.82	0.91	0.84	0.85
Mean	50.912	52.943	52.248	46.123	48.611	56.008	45.049	46.100	50.184
Std. Dev.	11.136	9.983	10.845	12.044	9.758	11.990	11.847	10.538	11.093

for grades 8 and 11 than grade 4. Fourth-grade achievement in mathematics seems to be the least easily modeled. Viewed broadly, however, the overall explanatory power of the model is very high, especially for pooled cross-sectional data.

In terms of specific variables, perhaps the most noteworthy finding is the importance of the teacher input. Observe that the quality of teachers, as measured by real salaries, is significant in seven of the nine equations.[10] Teacher quality appears especially important in fourth-grade achievement. Note that the coefficients for $\$SAL_4$ are uniformly significant and of greater magnitude than in the eighth or eleventh grades. The quantity of teachers is also important as indicated by the student teacher-RATIO. Though significant in only four of nine cases, it is interesting that this dimension of teaching inputs is again revealed to be more important at the fourth grade level. In sum, these results reinforce what is perhaps the conventional wisdom -- the quality of education is the quality of its teachers, and this seems especially so early in the educational process.

Regarding non-teacher inputs, observe that expenditure on program coordinators and instructional supervisors in the divisional superintendent's office ($SUPV) plays an important and positive role, but again, only at the fourth-grade level, and only in language arts and mathematics. Although insignificant, the $SUPV coefficents in math and language are positive in eighth grade, but become negative for all eleventh-grade achievement areas. Of course, these results could simply reflect an administrative policy which

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[10] The relationship between average real salary and student achievement seems particularly reasonable if higher real salaries in a district is capturing the effect of having more experienced teachers on average. Studies do generally agree on the importance of teaching experience (Hanushek 1972; Murnane 1975; Murnane & Phillips 1981a, 1981b).

focuses these personnel at the lower grade levels and in the language arts and math areas.

Expenditure on administration ($ADMN) and other instructional inputs ($OI -- textbooks, teachers' aides, educational televison) have no statistically discernible impact on achievement. Indeed, the coefficients on $ADMN are almost uniformily negative, although statistically insignificant.[11] Further, other instructional expenditure is significantly negative for language arts in the fourth and eleventh grades.

While these results are obviously not the final word, considering the four expenditure variables jointly, one would be justified in recommending a reallocation of resources away from non-teacher areas and toward teacher inputs. Among the non-school system variables, aptitude (EAS) has far and away the most powerful influence in achievement. The strength of this relationship is clearly the major factor in the high coefficients of determination. Note the direct correspondence between the t-values on EAS_{jk} and that regression's R^2. The large impact of EAS is, of course, not surprising -- student aptitude obviously enhances the productivity of educational inputs. However, this correlation may be due in part to the possibility that the EAS test is an impure aptitude measure, i.e., it includes an achievement component as well.[12] While this perhaps account for the high t-values on EAS, it also has an important implication for the interpretation of our other variables.

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[11]This result is rather interesting in view of a clear secular trend in administrative inputs. Brimelow (1983) notes a dramatic increase nationally in adminsitrative personnel relative to student enrollment and faculty in public education. The ratio of pupils per administrator has fallen from 523 in 1950 to 293 in 1980.

[12]Scepticism regarding the EAS test as an aptitude measure, void of achievement sensitivity, was expressed by Dr. Joseph Roberts, Research Evaluation and Testing Section, Virginia Department of Education.

If EAS controls for beginning-level achievement, albeit imperfectly, it lends a value-added interpretation to the model. For example, the significant teacher salary coefficients represent their contributions to learning during the year.

The results for percent of school-aged population enrolled in private schools (%PRVT) supports our prediction (-) in three of the six regressions for eighth and eleventh grade. It is interesting, however, that at the fourth grade level the coefficients on %PRVT are uniformly positive and significant. Though we did not anticipate this result, it supports a rather provocative interpretation *ex post*. %PRVT represents the percent of all school age children in the division who attend private school. Presumably, parents who send their children to private school have not only the wherewithal to do so, but also a very strong interest in education. If, as seems likely, a higher proportion of high school children are in private schools than are elementary school children, then these highly-motivated children remain in the public grade schools. The consequence is higher achievement at that level. Their withdrawal from the public high schools, however, lowers their average achievement, *ceteris paribus*.

Finally, the unobservable variables approach to socioeconomic effects (SES) performs remarkable well (the exception is the second upper socioeconomic index SES.U2). The results on SES.L1 and SES. U1 are especially strong. From a general modeling perspective, the most noteworthy point is simply that controlling for upper as well as lower socioeconomic character contributes statistically as well as conceptually, as argued in Section I.

IV. Concluding Remarks

Strictly interpreted, the model has several implications for educational spending in Virginia. From an efficiency standpoint, the results clearly indicate that should we choose to spend more, we should spend it on teachers. Should we choose to spend the same or even less, the results still suggest that we could spend more wisely. For example, reallocaing dollars from non-teaching to teaching inputs is predicted to raise student achievement, especially if such reallocation comes at the expense of administration. Further, the results indicate a greater achievement-return per dollar at the elementary vis-a-vis secondary levels.

To the extent that equity in achievement were a policy goal, at strict reading of the model would buttress the outlook of the "Great Society" -- educational expenditure is capable of off-seting the strong negative impact of low socioeconomic character on student achievement. Of course, in the current era of "New Federalism", the fiscal pragmatist's response might be "Well, perhaps, but at what price?"

Based on the estimated parameter of the model, it is possible to address this question with regard to any of the various policy recommendations noted above. For example, were the objective to raise locality achievement above some state-mandated minimum, the cost by locality of such an undertaking could be estimated controling for both school and non-school locality characteristics. Furthermore, cast in conjuction with the structure of Virginia's educational funding formula, one could estimate the tax and/or income-

income-redistributive effects of financing such policy initiatives.[13] Of course, while such simulations are feasible in concept, the authors are the first to acknowledge the boldness of such extrapolations, certainly too bold for the monent at least. We think the model developed here is promising, but stress that this is a first pass.

Broadly, we see two tacks for further inquiry. First, from a data standpoint, we would be more confident of the model's quantitative implications were the educational cost components a bit more finely detailed. Second, prior research suggests that empirical analyses of educational achievement benefit from a value-added rather than levels of achievement approach. The longitudinal nature of our four-year panel data would accomodate a tracking of changes in mean locality achievement between eighth and eleventh grades. Thus, a reestimation of the model is possible which would appear to offer a useful test of the robustness of the results. However, whether this approach makes sense with aggregate data is unclear to us at this time. One would have to assume a level of stability among the student population in each locality which may be unreasonable.

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[13] In 1973, Virginia began implementing a program designed to guarantee a foundation level of funding for education. The state share is based on a locality index of ability pay. The Virginia composite index is relatively sophisticated by national standards in its sensitivity to local wealth and commerce in determining local ability to finance education. Nonetheless, localities in Virginia send widely different nominal amounts on education.

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