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District Fiscal Policy and Student Achievement: Evidence from Combined NAEP-CCD Data

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Abstract
School restructuring raises questions about the role of school districts in improving student learning. Centralization by state governments and decentralization to individual schools as proposed in systemic reform leave districts' role unsettled. Empirical research on the district role in the context of ongoing reform is inadequate. This analysis of combined data from the NAEP and the Common Core of Data (CCD) was intended to address the issue. We analyzed 1990, 1992, and 1996 NAEP 8th grade mathematics national assessment data in combination with CCD data of

corresponding years to examine the extent to which student achievement was related to districts' control over instructional expenditure, adjusting for relevant key factors at both district and student levels. Upon sample modification, we used hierarchical linear modeling (HLM) to estimate the relationships of student achievement to two district fiscal policy indictors, current expenditure per pupil (CEPP) and districts' discretionary rates for instructional expenditure (DDR). Net of relevant district factors, DDR was found unrelated to districts' average 8th grade math performance. The null effect was consistent in the analysis of the combined NAEP-CCD data for 1990, 1992, and 1996. In contrast, CEPP was found related to higher math performance in a modest yet fairly consistent way. Future research may be productive to separately study individual states and integrate the findings onto the national level.

The role of the local school district is problematic in the on-going school restructuring that focuses on student learning. Centralization by state governments and decentralization to individual schools as proposed in systemic reform leaves districts' role unsettled (Elmore 1993). Research is needed to examine the impact of district policymaking on student learning. Such research entails linking standardized achievement measures at the student level to district-level policy information comparable across jurisdictions.

This study explored policy and methodological issues relevant to these concerns. We analyzed NAEP data in combination with the Common Core of Data (CCD) to examine the extent to which student achievement was related to districts' control over expenditure, adjusting for relevant key factors at both district and student levels.

Research Background

Education reformers face a dilemma in trying to redefine the local school district role in relation to state government. On the one hand, the local district, as an independent political entity for local control of public schools, is supposed to buffer the schools against external political influences. On the other hand, as a legal creation of the state, the district is expected to work as an instrument of state government and to implement state policies and regulations with minimal change. The notion of simultaneous decentralization and centralization gives states and individual schools more policymaking authority, but leaves the local districts in an ambiguous position (Hannaway 1992; Clune 1993; Keedy 1994; Marsh 1997). As the authority and responsibility of the state governments continue to expand in public education, districts' role as a governmental unit seems to be diminishing (e.g., see Walberg & Walberg 1994; Elmore 1993).

State governments are playing an increasingly important role in fiscal control and prescriptive policymaking in a wide range of areas that were historically the domains of local district decisionmaking. States are contributing a large and growing share to local school revenue, specifying requirements on staffing and instruction (General Accounting Office 1998). State aid formulas have often incorporated specific mechanisms for district inefficiency control, linking spending to performance (Duncombe & Yinger 1998; Marsh 1997). Frequently, state governments threaten to and occasionally do take over local schools when persistent failure by local administration is confirmed (e.g., Iannaccone & Lutz 1994; Guskey 1993).

The districts' power is also threatened by decentralization in forms of site-based management and the school as a professional community (Marsh 1997; Elmore 1993; Clune 1993; Porter 1994; Newmann & Wahlage 1995). State education departments now often select individual schools as administrative units for deregulation and interact directly with them to encourage local initiatives (Fuhrman & Elmore 1995). Local schools are expanding their options in mobilizing community support, making innovations in instruction and curriculum, and making decisions on spending and staffing (Elmore 1993; Hannaway 1993). Research appears to support such restructuring as recent studies focus on school-level professional autonomy and its link to authentic instruction and achievement outcomes (e.g., Lee, Smith & Croninger 1995; Newmann & Wahlage 1995). One implication is that decentralization is reducing bureaucratic influence—including district influence—in local school decisionmaking.

The 16,000 local districts in the U.S. are, however, more than a historical heritage. National data reports describe local districts as solid administrative units with diverse conditions (e.g., Levine & Christenson 1998; Protheroe 1997). The question for reformers is how to adjust the system to the changing environment, since the underlying logic of American federalism requires multiple jurisdictions that compromise different interests and generate productive tension and dependence among jurisdictions (Elmore 1993). Available research suggests that it is possible for local districts to push reform further by building up strong local constituencies and developing policy initiatives (Fuhrman & Elmore 1990; Admundson 1993). This research, however, has been conducted largely with local or state information sources and has rarely used national data. To conduct research at national scale requires nationwide data on both student achievement and local fiscal conditions. Synthetic analysis of the National Assessment of Educational Progress (NAEP) and the Common Core of Data (CCD), explored in this study, seems an efficient approach to this goal.

Conceptual Framework

Our basic assumption is that although state governments are constitutionally responsible for public education, local districts have an important role in improving instruction. An approach districts take in playing that role is to adjust fiscal policy to increase the proportion of expenditure for instruction above the state average.

Instructional expenditure as a district policy

School districts differ in instructional expenditure. A recent study used the Bureau of the Census Annual Survey of Local Government data from 1980 to 1994 to calculate multiple indicators of cross-district disparity in instructional expenditure (Hussar & Sonnenburg 1999). This study found that while disparity in instructional expenditures across districts seemed to decline in many states, disparity measures and the pattern of decline varied substantially. Furthermore, in a fairly large number of states, the disparity measures were inconsistent, and, in a small number of states, disparity increased over the same period of time. While these disparity measures may imply inequity they also reflect local fiscal policy differences because instructional expenditures, relative to current expenditures, are more subject to government control (Hussar & Sonnenburg 1999).

Research is unsettled about the relationship between school expenditure and student achievement (for reviews and debates, see Conn 1995; Lockwood 1994; Hanushek 1994, 1996; Hedges & Greenwald 1996; Hough 1993). An emerging consensus, however, is that overall funding and per-pupil expenditure may be overly simplistic as a predictor of learning outcomes, since schooling is conditioned by complicated factors of administration, family, and community (e.g., Wainer 1993; Hough 1993). While recent research has provided some evidence supporting the view that increased funding relates to better performance (e.g., Payne & Biddle 1999; Wenglinsky 1997), whether overall revenue or average per-pupil expenditure substantially affects academic outcomes remains controversial (e.g., Hanushek 1996; Hedges & Greenwald 1996). Research needs to relate performance outcomes to variations in resource allocation in general and teaching resources devoted to specific program areas in particular (Brent, Roellke & Monk 1997; Monk & Hussain 2000). How the money is spent may be crucial to improving achievement (Childs & Shakeshaft 1986; Conn 1995). Research examining the impact of public school spending, particularly spending for disadvantaged schools, suggests that learning can be improved if investment targets improving teacher quality (e.g., Kazal-Thresher 1993; Ferguson 1991), core curriculum, and standardized achievement (e.g., Lockwood 1994).

Policy analyses in systemic reform highlight the importance of fiscal control as an incentive/sanction mechanism directly linking to academic performance (Lockwood 1994; Elmore 1994). Under this mechanism, schools and teachers are encouraged to develop pedagogical initiatives for reaching high-standard curricular goals and are held accountable for improving student performance. In this line of thinking, the amount of money spent directly on improving instruction/learning *relative* to the amount spent on administrative operations and support services should be a crucial determinant of achievement outcomes (Childs & Shakeshaft 1986; Elmore 1993). On the other hand, current expenditure per pupil (CEPP), which covers spending on broad and immediate local needs, to some extent indicates local initiatives and priorities in fiscal control. Encompassing obligatory capital outlay and district discretionary spending, CEPP may also be a valid predictor of student achievement.

In this study, we ask how districts change state prescribed patterns of expenditure and how such changes relate to academic achievement. The departure of a district's proportional spending on instruction from the state baseline proportion may imply local autonomy in fiscal policy, which has been advocated as a fundamental mechanism for maintaining local stake and accountability (Murphy 1994; Strang 1987). Conceptualizing fiscal control as an essential element of local autonomy, we attempted to pinpoint a key issue in redefining the district role. We hypothesized that, other conditions being equal, a higher district instructional spending rate relative to the state average is associated with higher district average math achievement. In addition, we also examined CEPP, a more generic indicator of local financial control, by assessing its relationship to student performance.

Factors related to district spending

Communities are often constrained from spending more on instruction by local conditions. For example, poor communities have to spend more on basic social services, and sparsely populated areas must pay more for transportation. A large state contribution to district revenue probably constrains local discretion. The larger the share of the state contribution, the more likely the recipient districts fund instruction at a level close to the state baseline. Local cost of living is another factor that needs to be considered when examining school resources as it obviously affects the spending for teacher hiring and instruction.

The power of districts varies depending on local socioeconomic conditions, enrollment size, and geographic locale. Local socioeconomic conditions as a determinant of local autonomy may alter the intended consequence of district policy. Wealthy districts with their well educated populations and organized political support may push reform farther and benefit more from focusing on instruction and learning (Elmore 1993). In contrast, poor districts with populations of low education and income but high mobility often cannot come up with powerful political support for reform. Increasing spending on instruction may compromise desperately needed social services and ultimately undermine student learning. The influence of district policy probably also varies across urban-rural areas. Traditionally, rural residents are demographically homogeneous within communities but diverse across communities (Nachtigal 1982), have strong ties to local schools, and are skeptical about external governance (DeYoung 1990). Within different sociodemographic contexts, districts' investment in instruction may result in quite different achievement outcomes.

Prior studies have explored school funding in connection to standard achievement by synthetic analyses of data from CCD and NAEP (Wenglinsky 1997, 1998) or international standardized tests (Payne & Biddle 1999). In particular, Wenglinsky (1997) aggregated achievement measures to the district level and used both school-level and district-level variables to predict achievement. Taking the district as the unit of analysis, single-level analyses of aggregated performance show that average performance is positively associated with school resources. While such aggregated studies deal with the broad issues linking school resources to performance, they were not meant to and did not address specific questions concerning *district* fiscal policy in relation to individual student achievement. Furthermore, there are methodological problems in converting NAPE's multi-level stratified sample design into a single-level district sample design. The district sample resulting from attaching aggregated NAEP performance data to CCD district records does not necessarily represent the national population of school districts.

In a second study, Wenglinsky used a hierarchical linear model (HLM) technique to analyze merged 1992 NAEP and CCD data on 12th grade mathematics (Wenglinsky 1998). Again, this analysis did not focus on district fiscal control. It addressed the broad concern of school resources in connection to social distribution of academic achievement. Further, the study did not distinguish district and school spending measures in the analysis. It did not deal with the methodological difficulty stemming from the data merge, namely, the possible unreliability of the estimates resulting from the merged data. (Note 1) Our study was designed to continue this line of research by synthesizing national data on student achievement and district spending, using sampling adjustment procedures and the technique of two-level hierarchical linear modeling.

Research questions

The first question in our study was whether or not student achievement varies across districts. The answer to this question sets the basis for addressing the substantive concern of district-level effect and for statistical testing of two-level models. The second question was how student achievement relates to district instructional spending—and CEPP. As the central issue in this analysis, we asked how district mean achievement related to district fiscal policy, adjusting for other variables at the district level and sociodemographics at the student level. District fiscal policy was indicated by two variables, CEPP and District Discretionary Rate of instructional spending. The latter was simply the difference of the district instructional spending rate from the state instructional spending rate. Compatible to the concept underlying such disparity measures as the coefficient of variation and the Gini coefficient (see Hussar & Sonnenberg 1999), DDR should make it straightforward to interpret the HLM estimates of the district fiscal policy effect.

The third question was: to what extent did DDR and CEPP, together with other district factors, account for the achievement outcome variance after adjusting for relevant district-level factors (e.g., enrollment size, state contributed share to district revenue, minority rate, poverty rate, geographic locale). In addition, we examined the possible interaction effects of DDR with three district conditions: the proportion of district revenue that came from the state, the average socioeconomic status (SES), and urban-rural locale. This would allow us to ask whether DDR had different effects on achievement under different conditions.

A final question about the achievement gaps: did higher district instructional spending help reduce math achievement gaps associated with race and SES? In other words, did increased instruction spending above the state average not only work to promote academic excellence, but also equity?

Data Sources and Methodology

For this study, we combined data from NAEP 1990, 1992, and 1996 National Comparison Grade 8 Files and the Common Core of Data (CCD) in school years 1989—90, 1991—92, and 1995—96. As the most comprehensive and reliable national data source on academic achievement, the NAEP math tests in these three years shared a framework supported by the National Council of Teachers of Mathematics (Reese, Miller, Mazzeo & Dossey 1997).

CCD, covering the universe of U.S. public school districts, provides district-level itemized revenue/expenditures on an annual basis (National Center for Education Statistics 1995). It also contains a state file that gives spending data at the state level, which can be used to compute DDR. CCD offers information for examining district fiscal policies, including core expenditures per pupil, current expenditures per pupil, total expenditures per pupil, percent of total instruction expenditures, and percent of total salary expenditures, as well as related state spending measures. Additionally information on local sociodemographic conditions is available, including extensive 1990 Census data that were incorporated into district records. A linkage file is available for linking NAEP national and state assessments files with CCD data for the years between 1990 and 1998 (Westat 1998).

File Merge

First, we extracted data from the 1990, 1992, and 1996 NAEP National Comparison of math in 8th grade and CCD district files for school years 1989—90, 1991—92, and 1995—96. Using district identification code in both the NAEP and CCD files, we merged the two datasets for these years. With assistance from Westat and ETS, the three years' data were matched reasonably well. Most districts contained adequate numbers of students for two-level analysis (see Table 1).

Table 1
Sample size at district and within-district levels:
Combined NAEP-CCD data (1990, 1992, and 1996, unweighted)

Year	District sample size	Mean within-district student sample size	Standard deviation	Minimum	Maximum
1990	144	43.2	23.2	[1]2.0	157.0
1992	177	45.2	27.1	[2]1.0	185.0
1996	160	34.9	18.6	10.0	113.0

[1] For the 1990 data one district (LEAID 3701530) had two cases and was excluded from the

analysis.

[2] For the 1992 data two districts (with LEAIDs 5304920 and 1713970) had fewer than three cases and were excluded from the HLM analysis.

The resulting files contain NAEP 8th grader records, with affiliated district variables attached. Additionally, district-level cross-product terms were constructed to represent the interaction effects of DDR and the child poverty rate, DDR and urban locale, and DDR and the percentage of district revenue from the state (see Tables 2.1—2.3 for unweighted descriptive statistics at the two levels).

Table 2-1
Descriptive statistics at student- and district-levels: 1996 NAEP-CCD data

Student Level 1						
Variable name	Variable label	N	Mean	SD	Minimum	Maximum
DSEX	Student sex	5,590	1.50	0.50	1.00	2.00
MRPCM1	Plausible value 1	5,590	268.97	36.46	127.98	388.50
MRPCM2	Plausible value 2	5,590	269.17	36.03	120.35	393.46
MRPCM3	Plausible value 3	5,590	268.87	36.52	124.06	384.47
MRPCM4	Plausible value 4	5,590	268.89	36.01	138.54	378.93
MRPCM5	Plausible value 5	5,590	269.14	35.87	121.28	381.77
MINORITY	Non-Asian minorities	5,590	0.33	0.47	0.00	1.00
PARHI_ED	Parent education	5,590	0.58	0.49	0.00	1.00
District level 2						
ASIER	Average state instruction expenditure rate	160	60.99	6.48	50.08	77.85
DDR	District Discretionary instruction spending Rate	160	-0.24	6.78	-24.99	17.35
URBAN2	Urban district	160	0.27	0.43	0.00	1.00
RURAL	Rural district	160	0.21	0.41	0.00	1.00
ENROLL_K	District total enrollment in thousand	160	41.84	110.32	0.14	1,049.04
BLACK_P	Black student rate	160	19.00	24.75	0.00	99.00
P7118TP	District poverty rate	160	17.01	11.19	0.00	58.50
PC30ETP	District at-risk student rate	160	3.68	3.40	0.00	15.80
C_STREVP	District revenue percentage from state	160	47.61	18.96	1.80	78.90
CURPPE_K	Current per pupil expenditure in $K	160	5.36	1.43	3.38	11.27
LEV2WT	District weight	160	1.00	1.37	0.06	10.29
DDR_RUL	Interaction DDR by rural	160	-1.11	4.18	-24.99	6.35

DDR_URB	Interaction DDR by urban	160	0.40	2.94	-18.96	13.44
DDR_STP	Interaction DDR by revenue percentage from state	160	-27.66	355.46	-1404.46	921.62
DDR_SES	Interaction DDR by poverty rate	160	-20.10	153.74	-753.19	529.19
DDR_RSK	Interaction DDR by at-risk student rate	160	-2.16	35.07	-189.98	112.78

Table 2-2
Descriptive statistics of at student- and district-levels: 1992 NAEP-CCD data

Student level 1						
Variable name	Variable label	N	Mean	SD	Minimum	Maximum
DSEX	Student sex	8,014	1.48	0.50	1.00	2.00
MRPCM1	Plausible value 1	8,014	258.94	37.53	130.75	372.33
MRPCM2	Plausible value 2	8,014	259.07	37.93	127.82	380.17
MRPCM3	Plausible value 3	8,014	259.29	37.91	110.48	389.45
MRPCM4	Plausible value 4	8,014	259.33	37.65	126.88	380.38
MRPCM5	Plausible value 5	8,014	259.30	37.74	123.39	389.55
MINORITY	Non-Asian minorities	8,014	0.36	0.48	0.00	1.00
PARHI_ED	Parent education	8,014	0.54	0.50	0.00	1.00
District level 2						
ASIER	Average state instruction expenditure rate	177	60.73	6.69	50.08	77.85
DDR	District Discretionary instruction spending Rate	177	0.31	5.20	-13.54	16.26
URBAN2	Urban district	177	0.30	0.45	0.00	1.00
RURAL	Rural district	177	0.15	0.35	0.00	1.00
ENROLL_K	District total enrollment in thousand	177	43.93	98.04	0.17	962.27
BLACK_P	Black student rate	177	15.82	24.58	0.00	99.00
P7118TP	District poverty rate	177	15.94	11.57	0.30	68.70
PC30ETP	District at-risk student rate	177	4.03	4.09	0.00	23.60
C_STREVP	District revenue percentage from state	177	42.40	20.98	0.00	84.60

CURPPE_K	Current per pupil expenditure in $K	177	4.92	1.34	2.98	10.07
LEV2WT	District weight	177	1.00	1.27	0.06	8.55
DDR_RUL	Interaction DDR by rural	177	-0.59	2.40	-13.54	6.42
DDR_URB	Interaction DDR by urban	177	0.38	2.59	-11.16	16.26
DDR_STP	Interaction DDR by revenue percentage from state	177	5.36	266.05	-1063.18	757.29
DDR_SES	Interaction DDR by poverty rate	177	-3.26	100.04	-472.35	306.73
DDR_RSK	Interaction DDR by at-risk student rate	177	-0.05	27.16	-162.26	98.59

Table 2-3
Descriptive statistics at student- and district-levels: 1990 NAEP-CCD data

Student level 1						
Variable name	Variable label	N	Mean	SD	Minimum	Maximum
DSEX	Student sex	6,213	1.48	0.50	1.00	2.00
MRPCM1	Plausible value 1	6,213	256.24	33.43	149.28	370.23
MRPCM2	Plausible value 2	6,213	256.28	33.21	138.77	375.86
MRPCM3	Plausible value 3	6,213	256.61	33.11	159.70	367.46
MRPCM4	Plausible value 4	6,213	256.14	33.44	139.74	377.80
MRPCM5	Plausible value 5	6,213	256.32	33.17	145.25	352.46
MINORITY	Non-Asian minorities	6,213	0.32	0.47	0.00	1.00
PARHI_ED	Parent education	6,213	0.52	0.50	0.00	1.00
District Level 2						
ASIER	Average state instruction expenditure rate	143	59.61	5.71	49.16	76.82
DDR	District Discretionary instruction spending Rate	143	0.19	7.59	-20.70	22.36
URBAN2	Urban district	143	0.26	0.44	0.00	1.00
RURAL	Rural district	143	0.37	0.48	0.00	1.00
ENROLL_K	District total enrollment in thousand	143	37.28	103.39	0.09	918.01
BLACK_P	Black student rate	143	14.92	20.48	0.00	93.00
P7118TP	District poverty rate	143	19.55	12.35	1.00	60.40

PC30ETP	District at-risk student rate	143	4.50	4.55	0.00	25.30
C_STREVP	District revenue percentage from state	143	48.43	18.39	1.60	82.40
CURPPE_K	Current per pupil expenditure in $K	143	4.31	1.15	2.41	8.69
LEV2WT	District weight	143	0.99	1.71	0.01	8.44
DDR_RUL	Interaction DDR by rural	143	-1.17	4.42	-20.70	9.21
DDR_URB	Interaction DDR by urban	143	0.85	3.10	-7.24	15.37
DDR_STP	Interaction DDR by revenue percentage from state	143	10.84	392.55	-1,340.28	1,551.92
DDR_SES	Interaction DDR by poverty rate	143	2.70	169.59	-494.14	673.09
DDR_RSK	Interaction DDR by at-risk student rate	143	3.01	40.59	-142.15	153.75

Sample Modification and Overall Weight

The resulting student subsamples within districts might not have been reliable in presenting the student populations of the given districts, because schools, not districts, were a sampling stage in the original NAEP design. Therefore, we reweighted and poststratified the data to improve its statistical reliability. The purpose was to shift the sampling stage from the school to the district in order to examine differences across groups of students who were hypothetically influenced by local districts' instructional.

The modification of the NAEP school-student sample into a district-student sample entailed reweighting the original sample and establishing the formal statistical status of the district-student sample. Within a sampled PSU, the NAEP school sample via "post-allocation" *induced* a district sample that included districts with which the sample schools were affiliated. With modification the representativeness of the school sample to PSUs would lead to the representativeness of the district sample to PSUs. The procedure is highlighted below; see Appendix I for details.

Student sample weighting

We assigned weights to each sample district within a PSU according to the district's *post-inclusion* probability, which was defined as the inclusion probability of the union of sample schools in the district. The calculation of this probability is described in Appendix I. The post-inclusion probabilities were used as a reference scale for assigning the district weights. The weight assigned to a sample district was proportionate to the reciprocal of its post-inclusion probability.

The students within a district were weighted by the reciprocal of the student sampling rate within the district. To calculate the weight we used the student population size of the sample district at a given grade. The CCD school file provided student enrollment size for each grade of the school, which was aggregated to the district level. We made a ratio adjustment (Deville & Sarndal 1992; Deville, Sarndal & Sautory 1993; Little 1993) of the student weights within the districts via poststratification according to important geographic/demographic features. We used this procedure to improve the representativeness of the student samples within districts to the district student populations.

The PSU weights remained intact. The obtained student weights were further adjusted at the national level in the same way as the poststratification conducted for the 1992 NAEP (see Wallace & Rust 1994, section 5.1.4). The resulting student sample preserved the goal of the original NAEP sampling design; namely, the targeted number of students at the given grades for the assessment were selected at a uniform probability nationwide (Wallace and Rust 1994, chapter 2).

District sample weighting

Multilevel linear modeling requires the use of level-2 unit (district) weights in analysis to assure that the level-2 sample represents the specified population (Bryk & Raudenbush 1992). We weighted the district sample to make it represent the national district population using the national district population information from CCD. To improve the representativeness of the district sample calibration (ratio adjustment), poststratification was carried out along race and Census region. These demographic and geographic characteristics were selected after a comparison of the sample and population distributions of those characteristics (Deville, Sarndal & Sautory 1993; Little 1993) (see Appendix II for the modified sampling distribution of race and Census region).

Analytical Approach

Before data analysis, we edited the data, examined missing data patterns, and constructed indicators to represent concepts to be analyzed (see Tables 2.1—2.3 for descriptive statistics of the variables at the student- and district levels).

Expenditure measures

District instructional spending measures and other fiscal variables were made comparable across locations by adjusting for local cost of living and inflation. We used the Teacher Cost Index (TCI) for states and districts available from NCES for the adjustment (National Center for Education Statistics 1995; also see Fowler & Monk 2001). TCI, an index of costs for hiring teachers, was developed through a regression analysis that estimated the effects of multiple factors, including the cost of living and quality of life for each state and district. The TCI score for states were centered by the national average of 100 (National Center for Education Statistics 1995).

We multiplied each state's total capital outlay per pupil by the TCI score for the given state and each district's by the district's TCI. Instructional expenditure rates at both district and state were calculated by dividing instructional expenditure per pupil with the adjusted total capital outlay per pupil. The resulting district rate was centered around the given state rate to generate the DDR in instructional expenditure. This TCI adjustment did not change the values of DDRs within a state, but it adjusted the difference in DDR for districts in different states.

Rescaling data

We recoded student race/ethnicity into a binary variable (White/Asian vs. minorities) and parent's education into two binary variables (with some postsecondary education vs. without). All per-pupil total expenditure measures were rescaled in thousands of dollars, total expenditure in millions of dollars, and total enrollment in thousands of students. In HLM modeling, each of the district-level variables was further centered around the grand mean, whereas each student variable was centered around the district mean.

Missing data

We examined nonresponse patterns to assure there were no systematic missing data to bias statistics. Approximately 12 percent of the 1992 NAEP student records and 3 percent of the 1996 records had missing data on one or more district variables due to unmatched records. There were no such missing data for 1990. We flagged the cases that had no district fiscal data in each file with a single missing indicator. One indicator was sufficient because missing data occurred quite consistently for most of the district fiscal measures. We then imputed data with grand mean on each missing variable and examined the missingness in a series of single-level regular regression analyses that included all the predictor variables of math achievement (for rationale see Cohen & Huang 2000; Little & Rubin 1986). We found that the missing data were largely random as the regression coefficient for the missing flag was not statistically significant in the three years. Thus, in the HLM analysis, we simply used the mean-imputed values for the missing data without using the missing flag.

Two-level hierarchical modeling

After reweighting the samples, we conducted univariate and bivariate analyses to examine data quality. Single-level multiple regression analyses were run with conceptually important variables to explore the general pattern of relationships between district variables and math achievement. We also examined the data to make sure that no obvious anomalies existed.

The central research question was whether student achievement was related to district discretionary rates in instructional spending (DDR). To address this question with data for each specified year, the two-level modeling took the math composite plausible values as the independent variables and DDRs as the predictor variables controlling for district- and student-level variables. See appendix III for a formal discussion of the HLM procedure. We used software package HLM Windows 5.03, which has a component to run the repeated procedure with multiple plausible values and to average the estimated coefficients (see Bryk, Raudenbush & Congdon 1996).

We conducted the two-level analysis in four steps. First, we examine the extent to which achievement varied across districts and the proportion of variability attributed to student effects and to district effects. With a *one-way random effects ANOVA model,* we separated the total variance of math achievement into between- and within-district components. By assessing the intraclass correlation and reliability of district means, we determined that district-level variance was substantial and statistically significant for further modeling.

Second, we estimated the relationships of a district's average math score to DDR and CEPP, adjusting for the effects of total enrollment size, minority student rate, poverty rate, state contribution to the district revenue, and geographic locale. With a *random-interception model,* we examined the extent to which district average achievement related to DDR and CEPP, controlling for the district-level variables specified above.

Next, we explored the interaction effects between DDR and district factors that might have potential combined effect on achievement. We asked of the DDR effect on achievement differentiated by some district characteristics. For example, DDR was probably more influential to achievement in disadvantaged districts; or, DDR might affect achievement in districts that relied more on local revenue than on state contributions. We specifically estimated the effect of the cross-product terms of DDR and poverty, DDR and rural-urban locale, and DDR and the state share in district's revenue.

Finally, we tested three important student-level variables—sex, SES, and minority status—in a *random coefficient regression model*. We assess the extent to which these three individual effects varied between districts. Given that these gaps did vary across districts, we then tested full models that included these student variables. The full model accounted for both district average achievement and district achievement gaps. We first determine whether DDR related to district average math score, adjusting for both district- and student-level variables. Then, we asked whether achievement gaps due to sociodemographic backgrounds related to DDR (or, whether DDR helped reduce math achievement gaps).

Including student variables in the model was also methodologically important. Students were not randomly associated with districts; the district-level estimates might be biased if we did not control for student background effects. Second, sex, SES, and minority status at student level were established background factors that strongly related to achievement. Controlling for these variables could reduce unexplained level-1 error and thus improve the precision of the estimates of district spending rates as well as the power of hypothesis tests (Bryk & Raudenbush 1992).

Problems and limitations

It is typically more difficult to model slopes than means with HLM techniques. Prior analyses of the NAEP data have reported unreliable estimation with slope equations (for example, Arnold 1995). While concentrated in intercept models, we did test slope models with limited number of variables at the two levels. The resulting slope estimates were considerably less reliable than those of intercept models.

Findings

Data across the three years appeared reasonably compatible in univariate statistics. At the student level, sex (with male coded 1 female coded 2) and minority (with the Asian and White coded zero, all the other groups coded 1) distributions were quite steady with data of the three years. Parents' educational levels seemed slightly rising. The rate of sample students whose parents had at least some college education was 52 percent in 1990, 54 percent in 1992, and 58 percent in 1996. The NAEP math achievement on average was higher in 1996 than in the other two years (approximately 268 in 1996, 259 in 1992, and 256 in 1990) with compatible standard deviations and ranges (see Tables 2-1 to 2-3).

At the district level, the descriptive statistics were reasonably compatible across years as well. The average state instructional spending rate (ASIER) barely differed over the years, ranging from 59.61 to 60.99 percent. DDR averaged very close to zero because by definition the scores were centered by the state average. This measure's standard deviation was similar across years though the range shifted slightly. CEPP on average rose from $4,310 in 1990 to $5,360 in 1996. The average proportion of district revenue that came from the state (C_STREVP) also seemed acceptable, with estimates ranging from 42.40 percent in 1992 to 48.43 percent in 1990. These sample estimates from the NAEP-CCD combined data were quite consistent with the released national statistics (e.g., National Center for Education Statistics 1996). Likewise, district level demographic statistics (total enrollment, Black student rate, poverty rate, and at-risk student rate) appeared reasonable for the three years. Tables 2.1—2.3 also present descriptive statistics for the interaction terms between DDR and district demographic variables.

A possible anomaly was with the geographic locale. While the rate of urban districts ranged 26 to 30 percent for the years—again reasonable estimates—the rate of rural districts shifted somewhat excessively from 15 percent in 1996 to 37 percent in 1990. This problem could be indicative of the unreliability of the merged NAEP and CCD data.

Bivariate Statistics

A number of patterns revealed in the bivariate correlation analysis must be noted. First, fiscal measures at district level were correlated, often in large magnitude. The total expenditure and current expenditure, for example, had a correlation coefficient around 0.98 in all three years (the full matrix of the correlation coefficients is available upon request to the first author). Per pupil spending items (for example, CEPP, per pupil total expenditure, and per pupil instruction expenditure) were correlated to each other. These measures were substantially correlated with the total expenditure measures, albeit to a moderate extent. Expenditure measures were also closely related to enrollment size. Table 3 shows the estimates of bivariate correlation among the selected district-level variables.

Note that even in this selected group, there were pairs of variables that were well correlated. Proportion of district revenue from the state was strongly associated with CEPP (0.68 in 1996, 0.70 in 1992, and 0.66 in 1990). Poverty rate and at-risk student rate were also strongly related (0.62, 0.75, and 0.40, respectively, for the three years). We excluded at-risk student rate from the equation because it presumably overlapped with poverty rate to indicate the disadvantaged condition of a district, yet its range was smaller than the poverty rate. For similar reasons, we dropped rural locale and retained urban locale to make the model parsimonious. (Note 2)

The high multicollinearity required model specification with high selectivity of independent variables at the district level such that the included variables were not highly correlated to each other and adequately represented our conceptual model. After testing OLS regression analyses with SAS and an initial run of two-level models with HLM, we decided to specify in the final model the following independent variables at the district level:

- District discretionary rate in instructional spending,
- State average instructional spending rate,
- CEPP (in thousands of dollars),
- Proportion of revenue from the state,
- Total enrollment (in thousands of students),
- Black student enrollment rate,
- Child poverty rate, and
- Urban locale (in contrast with suburban).

Table 3
Correlation coefficients of the selected district level variables: NEAP-CCD district level data 1996 1992 and 1990 (weighted with district weight)

1996 (N=160)	State average instruction spending rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

DDS (1)	*-0.19								
Total enrollment (thousand) (2)	-0.05	*0.26							
Black student rate (3)	*-0.30	0.03	0.15						
Current expenditure per pupil in $k (4)	*0.68	-0.12	-0.03	-0.15					
Poverty rate (5)	*-0.28	*-0.22	0.00	0.15	-0.11				
At-risk student rate (6)	*-0.34	0.02	0.05	*0.28	-0.14	*0.62			
Percent of revenue from state (7)	*-0.29	*-0.19	-0.14	0.07	*-0.24	0.12	0.08		
Urban district (8)	-0.06	*0.22	*0.24	*0.23	0.02	0.02	*0.18	-0.10	
Rural district (9)	0.04	*-0.50	-0.16	*-0.18	-0.08	0.10	-0.16	*0.29	*-0.31
1992 (N=177)									
DDS (1)	*0.16								
Total enrollment (thousand) (2)	-0.03	*0.18							
Black student rate (3)	0.07	0.08	-0.10						
Current expenditure per pupil in $k (4)	*0.70	-0.01	-0.06	-0.02					
Poverty rate (5)	*-0.30	*-0.28	-0.07	-0.10	*-0.20				
At-risk student rate (6)	*-0.31	-0.13	-0.10	-0.12	*-0.21	0.75			
Percent of revenue from state (7)	*-0.27	*-0.18	0.06	-0.14	*-0.40	*0.35	*0.38		
Urban district (8)	0.00	0.11	*0.32	*-0.19	-0.04	*0.16	0.10	0.08	
Rural district (9)	*-0.28	*-0.47	-0.11	-0.02	*-0.17	*0.16	0.09	0.13	*-0.22
1990 (N=143)									
DDS (1)	*-0.34								
Total enrollment (thousand) (2)	0.00	0.14							
Black student rate (3)	*-0.24	*0.27	0.14						
Current expenditure per pupil in $k (4)	*0.66	*-0.25	0.03	*-0.20					

Poverty rate (5)	*-0.43	0.03	0.02	*0.32	*-0.29				
At-risk student rate (6)	*-0.29	0.11	0.08	0.55*	*-0.30	*0.40			
Percent of revenue from state (7)	-0.12	0.09	-0.04	0.12	-0.05	*0.31	0.01		
Urban district (8)	-0.01	0.12	*0.34	0.14	0.08	0.02	0.08	-0.13	
Rural district (9)	*-0.24	-0.15	-0.13	0.05	*-0.17	*0.41	*0.17	*0.32	*-0.21

* $p < 0.05$

HLM Modeling Results

Unconditional models were tested with each year's data. Without any independent variables, the models separately estimated the variance of the student math achievement at individual and district levels. Table 4 presents the estimates of the unconditional models. For each year, a substantial proportion of variance occurred at the district level, meaning that districts differed in their average math achievement. For 1996, 26 percent of the variance was at the district level, as indicated by the intraclass correlation coefficient. A chi-square statistic of 2401 with 159 degrees of freedom was highly significant for the district variance estimate. The reliability of school means (0.71) was also acceptable for further HLM analysis, as these sampled school means on average represented the true school means reasonably well. (Note 3) The two-level variance distribution pattern was similar in the 1992 and 1990 data. These statistics strongly suggested that HLM modeling with random effect at the both levels was necessary for analyzing student achievement in relation to district fiscal variables.

Table 4
Distribution of variance at the student and district levels: Unconditional models with the 1996, 1992, and 1990 NAEP-CCD data

Estimates	1996 NAEP-CCD	1992 NAEP-CCD	1990 NAEP-CCD
Fixed effect			
Coefficient Average district mean γ_{00} (standard error)	270.06 (1.47)	260.39 (1.66)	256.29 (1.65)
Random effect			
District level variance u_{0j} df	245.00 159	373.39 176	262.38 143

chi-square	2401.18	2950.85	2950.49
p value	0.000	0.000	0.000
Student level variance component r_{ij}	975.56	1160.06	681.59
Intraclass correlation rho	0.20	0.24	0.28
Reliability of the district mean λ_j	0.71	0.78	0.71

District average math achievement in relation to DDR

Using district variables to explain district average math achievement, we tested a series of means-as-outcomes models. At each level, the model specified a random effect. Fixed effects, however, were only specified at the district level, including state average instructional spending rate, DDR, total enrollment in thousands of students, Black student enrollment rate, CEPP in $1000, child poverty rate, at-risk student rate, urban and rural locale (both coded in contrast to suburban), and percent of revenue from the state. The resulting estimates are presented in Table 5.1.

Entering district-level independent variables in the model helped account for approximately a half of the district-level variance (49 percent in 1996, 62 percent in 1992, and 53 percent in 1990). Controlling for other variables, several district variables were found related to district average math achievement in one or more years. District total enrollment was related to low average math achievement in 1992, but not in 1990 and 1996. The minority enrollment rate was strongly related to low average achievement in all three years, with high statistical significance. The child poverty rate was related to low achievement mean, with a significant estimate for each year. These findings were compatible with prior research in school organization and achievement.

The effect of DDR was not substantiated with data for the three years. Net of the effects of other district variables, DDR was not statistically significantly related to district mean math achievement in any year. The estimate in the three years was essentially zero since it was trivial in size and not statistically significant. CEPP, on the other hand, was related to high average achievement, although the estimate for 1992 was not statistically significant (see Table 5).

With the NAEP-CCD combined data for the three years, we failed to find evidence to support our central hypothesis that high district instructional spending relative to the state average would increase district average performance level, holding other things constant.

Table 5
District average achievement and DDR and other district level variables: Means-as-outcomes model (standard error in parentheses)

Estimates	1996[a] NAEP-CCD	1992 NAEP-CCD	1990 NAEP-CCD

Fixed effects			
District mean γ_{00}	268.53 (1.18)	259.23 (1.19)	254.86 (1.28)
State average instructional spending rate γ_{01}	-0.21 (0.24)	-0.19 (0.28)	-0.64 (0.31)
District discretionary rate of instructional spending (DDR) γ_{02}	-0.21 (0.17)	0.42 (0.26)	-0.20 (0.16)
Total enrollment in thousands γ_{03}	-0.01 (0.02)	*-0.03 (0.01)	-0.01 (0.01)
Minority enrollment rate γ_{04}	**-0.45 (0.06)	**-0.54 (0.07)	**-0.36 (0.09)
CEPP $1000 γ_{05}	**2.74 (1.06)	1.49 (1.13)	**4.16 (1.59)
Child poverty rate γ_{07}	*-0.21 (0.11)	*-0.32 (0.14)	**-0.59 (0.13)
Urban district γ_{08}	-0.82 (3.82)	-1.27 (3.01)	1.10 (3.50)
State revenue percentage γ_{010}	-0.03 (0.05)	*-0.16 (0.06)	-0.09 (0.06)
Random effects District mean u0j	125.21	150.41	121.57
chi-square	1303.42	1288.03	1420.38
District level variance explained	0.49	0.62	0.53
Student level variance	974.56	1158.68	671.91

* $p < 0.05$ ** $p < 0.01$

[a] A missing value flag was included in the model but not presented because its coefficient was not statistically significant.

Joint effects between DDR and other district variables

Exploring the possible joint effects between fiscal and demographic variables at the district level, we tested a number of interaction terms and presented selected estimates from the model (see Table 6). We found no evidence of a joint effect between DDR and the state contribution to the district revenue in relation to math achievement. The three years' estimates were all trivial and not statistically significant. In other words, the state funding for local districts and districts' autonomy in instructional spending did not jointly influence achievement in some peculiar way as we might suspect.

Table 6
District average achievement accounted for by DDR and other district-level variables and interaction terms: Means-as-outcomes model (standard error in parentheses)

Estimates	1996[a] NAEP-CCD	1992 NAEP-CCD	1990 NAEP-CCD
Fixed effects			
District mean γ_{00}	268.72 (1.22)	259.17 (1.31)	254.95 (1.17)
State average instructional spending rate γ_{01}	-0.26 (0.23)	-0.15 (0.27)	-0.44 (0.30)
District discretionary rate of instructional spending (DDR) γ_{02}	*-1.03 (0.52)	0.87 (0.65)	0.41 (0.35)
Total enrollment in thousand γ_{03}	-0.02 (0.01)	*-0.03 (0.01)	-0.02 (0.01)
Minority enrollment rate γ_{04}	**-0.47 (0.06)	**-0.53 (0.08)	**-0.36 (0.10)
CEPP $1000 γ_{05}	**2.89 (1.05)	1.57 (1.13)	*3.72 (1.58)
Child poverty rate γ_{06}	-0.10 (0.13)	*-0.41 (0.16)	**-0.58 (0.15)
State revenue percentage γ_{07}	-0.02 (0.06)	*-0.15 (0.06)	-0.09 (0.06)
Urban district γ_{08}	-1.64 (3.69)	-0.11 (3.06)	-0.27 (2.74)
Interaction terms			
DDR x State revenue percentage γ_{09}	0.01 (0.01)	0.00 (0.01)	-0.00 (0.00)
DDR x Urban γ_{010}	-0.36 (0.51)	0.25 (0.63)	**1.47 (0.41)
DDR x Child poverty γ_{011}	*0.03 (0.01)	-0.05 (0.03)	-0.02 (0.01)
*Random*effects District mean u0j	125.47	146.52	116.91
chi-square	1247.82	1306.15	1284.82
District level variance explained	0.49	0.64	0.55
Student level variance	974.18	1158.68	671.91

* $p < 0.05$ ** $p < 0.01$

[a] A missing value flag was included in the model but not presented because its coefficient was not statistically significant.

The combined effect of DDR and urban locale seemed more complicated. It was substantial and statistically significant with the 1990 data (the fixed effect estimate $\gamma_{010} = 1.47$ with $p < 0.001$), but virtually nil with the 1992 and 1996 data. The positive 1990 estimate implied that higher spending on instruction in a district (relative to the state average) was related to higher average achievement for *urban* districts and the effect size was fairly large. The finding, were it substantiated with multiple years' data, would offer important policy implications.

Another interaction term was between DDR and the child poverty rate, which also resulted in inconsistent estimates across years. Only in 1996 was the estimate meaningful (0.03 at $p < 0.05$ level), implying that, among high poverty districts, higher instructional spending than the state average was related to slight better average math achievement; but among low poverty districts, there was no such relationship. Again, this finding would be potentially important should it be confirmed. It was not, however, substantiated with data for 1992 and 1990. In fact, the effect disappeared even with the 1996 data in subsequent analysis where additional variables were statistically controlled for (see Table 8.1). Though the findings on combined effects between district discretionary instructional spending were highly tentative, they posed questions for further studies.

Note that the DDR estimate, again, was trivial after the interaction terms entered into the equation, except for 1996, when the estimate was significant at $p < 0.05$ level, modest, and *negative* (- 1.03). This exception, as we see, should not change the overall finding that DDR was largely unrelated to 8th graders' math achievement. On the other hand, net of the additional interaction effects, CEPP estimate remained largely substantial and significant for 1996 and 1990, indicating a positive relationship with math achievement. The estimate was not statistically significant for 1992.

Math achievement gaps associated with sex, race/ethnicity, and SES

To examine the relationships of DDR to math achievement gaps associated with social and demographic categories, it was necessary first to assess the magnitude of the gaps and their variance; that is, how much the gaps varied across districts. We specified a random-coefficient regression model wherein individual student sex, race/ethnicity, and parental educational attainment were estimated as both fixed and random effects. The estimates are presented in Table 7.

Table 7
Math achievement differences relating to sex race/ethnicity and parents' educational attainment: Random coefficient regression model (standard error in parentheses)

Estimates	1996[a] NAEP-CCD	1992 NAEP-CCD	1990 NAEP-CCD
Fixed effects coefficient			
district mean γ_{00}	269.77 (1.46)	260.20 (1.65)	256.05 (1.62)
sex difference γ_{10}	0.01 (1.26)	0.78 (1.26)	0.57 (1.30)
Race-ethnic difference γ_{20}	**-23.33 (2.15)	**-24.09 (2.00)	**-20.16 (1.90)
Parents' educational attainment difference γ_{30}	**16.75 (1.45)	**15.38 (1.38)	**17.89 (1.31)
Random effects	**256.42	**383.49	**267.97

District mean u0j (df; chi-square)	(136; 2557.89)	(153; 3106.93)	(117; 2853.21)
sex difference u1j (df; chi-square)	**82.69 (136; 212.05)	**80.35 (153; 220.76)	**91.67 (117; 195.57)
Race-ethnic difference u2j (df; chi-square)	**168.08 (136; 202.07)	**191.28 (153; 233.29)	**105.77 (117; 238.53)
Parents' educational attainment difference u3j (df; chi-square)	**69.07 (136; 219.91)	**44.75 (153; 210.52)	**68.04 (117; 227.77)
Student level variance	778.71	962.97	530.74
Correlation among district effects District mean t_{00} Sex difference t_{11} Race/ethnicity difference t_{22} Parents' education difference t_{33}	t_{00} t_{11} t_{22} 1.00 -0.22 0.25 -0.14 0.16 -0.18 0.44	t_{00} t_{11} t_{22} 1.00 -0.01 -0.17 -0.33 0.21 -0.29 0.23	t_{00} t_{11} t_{22} 1.00 -0.03 0.02 -0.03 0.11 -0.22 -0.11
Reliability of regression coefficient estimates			
District mean	0.73	0.79	0.71
Sex difference	0.31	0.33	0.34
Race/ethnic difference	0.31	0.32	0.25
Parents' education difference	0.26	0.23	0.28

* $p < 0.05$ ** $p < 0.01$

[a] A missing value flag was included in the model but not presented because its coefficient was not statistically significant.

There was no evidence from each year's data that 8th grade math achievement differed by sex *within districts* as the fixed effect coefficient was close to zero and was not statistically significant. However, the random variation associated with sex was substantial and statistically significant across the three years (e.g., for 1996 u_{1j} = 82.69, df = 136, c^2 = 212.05), suggesting that sex difference in achievement varied considerably across districts around a mean of zero. This situation was similar to findings from some earlier studies (e.g., Raudenbush, Kidchanapanish, & Kang 1991). Not only the magnitude of the gap, but also the direction of the association, could differ across districts. It is possible to sort out factors that were responsible for the variance in future analysis. However, limited by the scope of this study, we did not include sex as an achievement gap in the subsequent modeling.

Race/ethnicity was clearly a strong predictor of math achievement for all three years. The fixed effect estimate γ_{20} was large (-23.33 for 1996, -24.09 for 1992, and —20.16 for 1990) and highly significant ($p < 0.001$ each year), confirming that minority students (other than Asian American) on average tended to achieve low on the NAEP math test within districts. The random effect for race/ethnicity was substantial and significant, revealing that districts differed in the racial/ethnic gap and that the variance needed further explanation.

As a socioeconomic status indicator, parents' educational attainment was specified in the model. The fixed effect estimate γ_{30} was positive and large for each year (16.75, 15.38, and 17.89 respectively for 1996, 1992, and 1990, all significant at $p < 0.01$ level). The estimate suggested that within districts, on average, students whose parents had college or more education performed better on the NAEP math test. The estimate of the random effect was also substantial and highly significant over the years, revealing that districts differed in the math achievement gap associated with family social background. Obviously, the varying achievement gap relating to parents' education merited further modeling.

Because of the specified student-level variables in the model, student-level variance became considerably small relative to the estimates from the prior means-as-outcomes model (778.71, 962.97 and 530.74 in Table 7, compared with the 974.56, 1158.68, and 681.08 shown in Table 5, respectively, for the three years).

The covariance matrixes generated from the model with the three years' data provided information about the correlation between district-level residual random effects (Table 7, panel 3). One of the consistent findings for all the years was that the district average achievement residual variance positively and moderately related to the residual variance of parents' education-associated achievement gap (0.16, 0.21, and 0.11). This finding implied that, holding other things constant, the higher the district average math test scores, the wider the district-level achievement gap between students whose parents had higher education and students whose parents did not. Another consistent estimate was the correlation between sex gap and parents' education gap (-0.18, -0.29, and —0.22 for the three years). These estimates suggested that, to some modest extent, the wider a district's sex difference in math achievement, the smaller the district's math achievement gap relating to parents' education. The remaining estimates of correlation changed substantially across years and it was impossible to interpret them without further analysis.

A final note for the random coefficient model: For each year, while the reliability of the intercept (district average math achievement) was reasonably high, the reliability measures for slopes (differences associated with sex, race/ethnicity, and parental education) were fairly low. This finding pointed to a frequently encountered problem in HLM analysis of survey data; that is, the difficulty to model the slopes (see Bryk & Raudenbush, 1992, pp. 102—103). Additional analysis was needed to sort out whether the lower reliability for slope statistics was due to the NAEP data collection design, small within-district sample, real differences across districts in the statistics, or simply the error variance in the slope estimation.

Final model

To control for variables at the student and district levels in examining the relationships of DDR and achievement, we integrated the previous modeling into a full HLM model, with both means and slopes as outcomes in the regression analysis. The resulting estimates of fixed effects and random effects are presented separately in Tables 8.1 and 8.2. The findings were consistent with those discussed earlier. Accounting for district's average math achievement, we did not observe any effect by DDR. However, CEPP and a number of district factors did relate to the achievement mean, as interpreted below.

Table 8-1
District mean, racial/ethnic gap, and SES gap in achievement accounted for by DDR and other district variables: Fixed effects (standard error in parentheses)

Estimates	1996 NEAP-CCD[a]		1992 NAEP-CCD		1990 NAEP-CCD	
District average mean γ_{00}	268.64	(1.15)	259.12	(1.17)	254.89	(1.22)
State average instructional spending rate γ_{01}	-0.27	(0.23)	-0.16	(0.27)	-0.44	(0.30)
Total enrollment in thousand γ_{02}	-0.01	(0.02)	-0.03	(0.02)	-0.02	(0.01)
Minority enrollment rate γ_{03}	-0.47	**(0.06)	-0.53	**(0.08)	-0.36	**(0.10)
CEPP in $K γ_{04}	2.85	**(1.07)	1.60	(1.14)	3.69	*(1.56)
Child poverty rate γ_{05}	-0.09	(0.13)	-0.40	*(0.17)	-0.58	**(0.15)
Percent of revenue from state γ_{06}	-0.03	(0.06)	-0.17	**(0.06)	-0.09	(0.06)
Urban locale γ_{07}	-1.97	(3.61)	-0.27	(3.02)	-0.54	(2.79)
DDR γ_{08}	-1.02	(0.52)	0.52	(0.64)	0.38	(0.35)
DDR*urban γ_{09}	-0.36	(0.49)	0.20	(0.64)	1.48	**(0.43)
DDR*state revenue percentage γ_{010}	0.01	(0.01)	0.01	(0.01)	0.00	(0.01)
DDR*poverty rate γ_{011}	0.03	(0.02)	-0.05	(0.03)	-0.02	(0.02)
Race/ethnicity gap γ_{10}	-23.64	**(1.76)	-24.35	**(1.68)	-21.55	**(1.59)
Average state instructional spending rate γ_{11}	0.52	(0.38)	0.56	(0.37)	-0.24	(0.55)
Total enrollment in thousands γ_{12}	0.00	(0.01)	-0.01	(0.01)	-0.03	*(0.01)
Minority enrollment rate γ_{13}	-0.13	(0.10)	-0.07	(0.11)	0.01	(0.15)
CEPP in $K γ_{14}	0.71	(1.74)	0.99	(2.28)	4.08	(2.47)

Child poverty rate γ_{15}	0.04	(0.18)	0.38	*(0.17)	-0.08	(0.23)
Urban locale γ_{16}	0.57	(3.53)	-4.08	(3.91)	-7.37	(4.39)
DDR γ_{17}	0.13	(0.40)	-0.16	(0.54)	0.43	(0.36)
SES (parent education) gap γ_{20}	15.95	**(1.22)	14.81	**(1.15)	17.13	**(1.12)
Average state instructional spending rate γ_{21}	-0.24	(0.25)	0.00	(0.21)	-0.05	(0.32)
Total enrollment in thousands γ_{22}	0.01	(0.01)	0.00	(0.02)	0.01	(0.01)
Minority enrollment rate γ_{23}	-0.08	(0.06)	-0.05	(0.05)	-0.07	(0.09)
CEPP in $K γ_{24}	0.35	(1.04)	1.63	(1.14)	-0.47	(1.70)
Child poverty rate γ_{25}	-0.31	**(0.12)	-0.10	(0.09)	-0.03	(0.15)
Urban locale γ_{26}	-1.18	(2.76)	0.46	(2.60)	-1.03	(2.27)
DDR γ_{27}	-0.42	(0.25)	-0.01	(0.21)	0.00	(0.18)

* $p < 0.05$ ** $p < 0.01$

[a] A missing value flag was included in the model but not presented because its coefficient was not statistically significant.

Table 8-2
District mean, racial-ethnic gap, and SES gap in achievement accounted for by DDR and other district variables: Random effects (standard error in parentheses)

Estimates	1996[a] NAEP-CCD	1992 NAEP-CCD	1990 NAEP-CCD
Random effects			
District mean u_{0j}			
df	132.18	151.91	119.94
chi-square	125	142	105
variance explained:	1325.27	1341.32	1259.89
relative to means-as-outcomes- model	-0.05[b]	[b]-0.03	[b]-0.02
relative to random coefficient regression model	0.48	0.61	0.55
Racial/ethnic gap u_{1j}	152.28	165.78	81.67
chi-square	187.61	212.61	209.58

variance explained: relative to random coefficient regression model	0.10	0.14	0.23
SES gap u1j chi-square variance explained: relative to random coefficient regression model	60.80 204.70 0.13	42.14 199.03 0.05	64.82 206.78 0.06
Student level variance	804.03	988.08	545.27

* p < 0.05 ** p< 0.01

[a] A missing value flag was included in the model but not presented because its coefficient was not statistically significant.

[b] The estimate implies that the final model accounted for a smaller portion of the variance of this variable.

Fixed effects: The fixed effect estimate for DDR in 1996 was $\gamma_{08} = -1.02$, not statistically significant ($p = 0.051$, see Table 8.1). The other years' estimates were close to zero and statistically insignificant as well. This finding, again, showed no evidence that district discretionary instructional spending relative to the state average spending would lead to higher average math achievement.

The minority enrollment rate was a consistently strong negative predictor of districts' mean math achievement, with estimates of -0.47, -0.53, and -0.36 for the three years, all highly significant. CEPP was quite consistently estimated as a positive predictor of district achievement level, with estimates of 2.85 in 1996, 1.60 in 1992, and 3.69 in 1990, and statistically significant in 1996 and 1990. The child poverty rate was another predictor with fairly consistent estimates over the years (-0.09 for 1996, -0.40 for 1992, and -0.58 for 1990), and the statistic was significant in 1992 and 1990. Note that the state's share of revenue for the district yielded a statistically significant estimate only for 1992 (-0.17, $p < 0.01$). This suggested that holding other conditions constant, districts that received a higher portion of state contribution tended to achieve somewhat lower in the NAEP test in that year, probably due to the fact that states' contribution was typically prioritized for low-achieving local schools.

Estimates of interaction effects from the full model confirmed those from the previous modeling. For one, the interaction between DDR and urban locale was quite strong and statistically significant for 1990 (1.48, at $p < 0.01$ level). DDR seemed to connect to the somewhat higher average math score of urban districts relative to districts in suburban or rural areas. The 1996 and 1992 data, however, failed to produce consistent estimates and therefore this finding is tentative as well. We note that the estimate for the DDR-poverty interaction effect was no longer found to be different from zero for 1996 data with the full model.

Gaps associated with race/ethnicity and parents' education were substantiated with the full model. Controlling for both within and between district variables, both race/ethnicity and parents' education had sizable fixed effect on mean achievement across the three years. For race/ethnicity, the estimate was -23.64 in 1996, -24.35 in 1992, and -21.55 in 1990, significant at $p < 0.01$ level. Two variables showed some unstable effect on the gap, but only for one year. One was district total enrollment, related to a trivially narrowed gap (-0.03 at $p < 0.05$ level) for 1990. The child poverty rate, on the other hand, related to a smaller racial gap (0.38 at $p < 0.05$ level) for 1992, suggesting that in districts of high poverty, minority students' achievement was slightly closer to White and Asian students' than it was in districts of low poverty. Again, without across-year consistent estimates, this interpretation requires additional analyses to confirm.

Accounting for the gap associated with SES as indicated by parents' educational attainment, none of the fixed estimates were statistically significant, except that of the child poverty rate

(-0.31 at $p < 0.01$ level) estimated with 1996 data. This effect may be interpreted in a similar way to that for the poverty rate and race/ethnicity gap. It may imply that for students who attended high poverty districts, parents' education made a smaller difference in their math achievement than it did for students in other districts. Poverty at the district level thus seemed to "dampen" the racial and socioeconomic differences at the student level. We may speculate that this finding perhaps hints of narrow ranges of both student background measures and achievement measures in a high poverty district. In other words, poverty-related social homogeneity might underlie the reduced achievement gaps. Without consistent results across years, such a "dampening" hypothesis about district-level poverty on the individual achievement gaps awaits additional analysis to substantiate.

Random effects:

The final model's goodness of fit estimates were quite comparable for the three years (see Table 8.2). In general, the model has been improved in regard to accounting for the slope but not for the district mean. For example, between-district variance as estimated in the final model was actually smaller than it was estimated in the means-as-the-outcome model (see Table 6), which contained the same district-level variables as did the final model. This pattern, similar across the three years, may suggest that the multiple predictor variables of slopes caused the model to fit less well as most added variables were not related to the slopes as expected. Nevertheless, the variance of the two slopes was substantially reduced. Relative to the random-coefficient regression model which contained only random effect for the slopes, the final estimates showed that the slope equations fit better.

Conclusions

Our findings did not support the hypothesis that drove this study, namely, that local districts could improve academic performance by increasing instructional spending. Net of district factors known to affect student achievement, school district discretionary spending in instruction, defined as the difference between the district instructional spending rate and the average instructional spending rate in a state, did not relate to a district's 8th grade average math performance. The null effect was consistent in the analysis of the combined NAEP-CCD data for 1990, 1992, and 1996. On the other hand, fairly consistently, the analysis has found that some district characteristics were related to average achievement. Specifically, other conditions being equal, a district's current expenditure per pupil (CEPP) was found related to higher math performance in a modest yet consistent way. Demographic attributes at the district level, including the minority student enrollment rate and the child poverty rate, were strongly related to lower math achievement, net of other effects.

The finding of the null effect of local districts' control over instructional spending as indicated by DDR may lead to different directions for future research on the district role in reform. First, considering the complex procedures of local decisionmaking on educational financing, research needs to deepen the inquiry about districts' fiscal policymaking, especially the changing patterns of instructional spending in connection to other capital outlays and revenue. Variation in instructional spending might reflect distinctive school conditions and policy concerns other than academic performance. For example, new technologies and equipment often demand a large budget for upgrading and staff training; school security is a pressing issue calling for increasing funding in some areas; aging buildings incur extremely high costs to renovate. Many continuing or lump sum expenditures may cause instructional spending to fluctuate considerably, which may or may not have an immediate impact on academic test results. On the revenue side, federal or state funding and related requirements may vary depending on changes in the government and the legislation as well as economic conditions in a larger context. Investigators must consider specific motives underlying decisions on spending and the broad conditions leading to such motives, together with DDR in order to understand local fiscal policymaking in relation to academic performance.

The finding that CEPP was positively related to math achievement leads to questions about the value of instructional spending as a key indicator of district fiscal control in explaining student achievement. Instructional spending is probably a concept too narrow to capture the complexities involved in a district's fiscal decisionmaking. In contrast, current spending adjusted to student enrollment could be more predictive of student performance as it appears encompassing such issues as diverse district and community context and various needs for funding. Therefore, future research may test alternative indicators of district fiscal policy control in connection to student academic performance and other outcomes. CEPP definitely should be a useful candidate for such research.

Furthermore, we recognize that the district has limited instructional spending control as the range of DDR was quite narrow (over the years, approximately 20 percent below or above the state average, see Tables 2.1—2.3). Such control may have little impact—relative to district policymaking in other respects—on student achievement. Hence, we may want to shift research attention to other aspects of district policymaking and operation. For example, research may focus on district differences in handling curriculum and instructional standard development; teacher recruitment, training, participation in decisionmaking, and accountability; community involvement and support; effectiveness in managing technological upgrading, school and class size, facilities maintenance, student services, and other administrative roles.

This analysis did offer some interesting albeit unsettled clues for learning about how district discretionary instructional spending might function jointly with other variables to influence achievement. The 1990 data showed that high DDR in urban districts was related to substantially higher average math performance, although the relationship was not evident in analysis of the 1996 and 1992 data. On the other hand, with the 1996 data, higher DDR in poor districts appeared to relate to slightly higher math achievement than it did in other districts. Limited reliability of the reweighted NAEP-CCD data is a likely culprit for the inconsistence. But unknown or shifting circumstances wherein instructional spending interacted with local conditions may also have contributed to such inconsistent patterns. It may be promising to expand the research to conceptualize and examine such joint effects between local instructional spending and local conditions. It is possible that, with more reliable data and precise measures, future inquiries could identify this sort of "equalizing" effect on district instructional spending.

Another intriguing yet uncertain issue that emerged in the analysis was sex difference in math achievement. Within districts, sex difference in 8th grade math achievement was estimated to be virtually zero with the three years' data. But between districts, the variance of sex effect was estimated high and statistically significant for all of the three years. Factors at the institution level—including school and district—should be part of the explanation. However, classroom instructional practice and other organizational environmental influences are probably more salient relative to fiscal policy in explaining the between-district variance of sex difference. Again, this question awaits future investigation.

Combining NAEP and CCD data into a synthetic analysis proved to be a challenging task. A series of difficulties emerged in the process of data merging and data editing because of changes over the years in both data collections (for a detailed discussion, see the Technical Report). In addition to addressing technical problems, future research would call for re-conceptualizing district fiscal management processes, examining district-state interaction regarding education financing, pinpointing joint effects of fiscal policymaking and local/regional conditions, and improving the reliability of the measurement and data quality of district fiscal status.

Specifically, it may be fruitful to separately study individual states and to integrate the findings onto the national level. This approach would require using data from NAEP State Tests and CCD for individual state analyses in a much more extensive scale than that attempted in the current analysis. It would also entail thoughtful interpretation and reconciliation of the possibly incongruent findings from the state analyses to generate cogent narratives about education financing at the state and district levels. Such narratives would probably involve in-depth qualitative analyses with information sources other than the survey data. A study of this sort would be a large-scale, challenging undertaking. But it appears more likely to produce comprehensive and in-depth knowledge about the local district's role in performance-driven reform, particularly its fiscal control in connection to student achievement.

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Notes

1. In fact, the two studies came up with quite inconsistent results regarding the relationship between central administration per pupil expenditure and math achievement. The aggregated study indicated a positive strong relationship between the two variables (Wenglinsky 1997 pp. 230—231). The HLM study found no relation at all between the two measures; rather it found per pupil instructional expenditure to be associated with a smaller socioeconomic status (SES)-related achievement gap (Wenglinsky 1998 p. 276). Such inconclusive results call for further research to clarify both the methodological and the substantive issues involved in synthetic analysis of NAEP and CCD data.

2. However, recognizing that rural conditions differ from urban districts, we plan to specifically examine the rural-urban difference in district spending patterns and achievement during another project.

3. With the original NAEP data, the reliability for school means is substantially higher, around 0.90 for the three years. The lower reliability was apparently a result of sample modification.

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Appendix I
Modification of the Sample and Weights

Appendix I is available for downloading as a Rich Text Formatted file.

Appendix II
Race-Census Region with Modified Sample

NAEP-CCD 1990

Frequencies of students by region-race using sum of Level-1 weight 10
Based on original weight (ORIGWT) in NAEP data

Race-Region	Freq.	%	Cum. Freq.	Cu. %
White-Northeast	877022.5	12.37	877022.5	12.37
White-Midwest	1501565	21.18	2378587	33.55
White-South	1975736	27.87	4354323	61.42
White-West	600752.9	8.47	4955076	69.89
Non-hispanic black	1147326	16.18	6102402	86.08
Hispanic	771106	10.88	6873508	96.95
Non-hispanic other	216087.6	3.05	7089596	100.00

Frequencies of students by region-race using sum of Level-1 weight 11
Based on adjusted weight (ADJWT) for merged NAEP-CCD data

Race-Region	Freq.	%	Cum. Freq.	Cu. %
White-Northeast	959336.4	13.53	959336.4	13.53
White-Midwest	1393679	19.66	2353015	33.19
White-South	1501023	21.17	3854038	54.36
White-West	964005.8	13.60	4818044	67.96
Non-hispanic black	1137725	16.05	5955769	84.01
Hispanic	838602.6	11.83	6794371	95.84
Non-hispanic other	295224.5	4.16	7089596	100.00

NAEP-CCD 1992

Frequencies of students by region-race using sum of Level-1 weight 19
Based on original weight (ORIGWT) in NAEP data

Race-Region	Freq.	%	Cum. Freq.	Cu. %

White-Northeast	454207.7	11.27	454207.7	11.27
White-Midwest	766619.7	19.01	1220827	30.28
White-South	982156.5	24.36	2202984	54.64
White-West	523640.3	12.99	2726624	67.63
Non-hispanic black	711623.6	17.65	3438248	85.28
Hispanic	432971.2	10.74	3871219	96.02
Non-hispanic other	160653	3.98	4031872	100.00

Frequencies of students by region-race using sum of Level-1 weight 20
Based on adjusted weight (ADJWT) for merged NAEP-CCD data

Race-Region	Freq.	%	Cum. Freq.	Cu. %
White-Northeast	446802.1	11.15	446802.1	11.15
White-Midwest	753990.9	18.81	1200793	29.96
White-South	965832.3	24.10	2166625	54.05
White-West	515042	12.85	2681667	66.90
Non-hispanic black	635054.6	15.84	3316722	82.75
Hispanic	505862.2	12.62	3822584 95.37	
Non-hispanic other	185603.8	4.63	4008188	100.00

NAEP-CCD 1996

Frequencies of students by region-race using sum of Level-1 weight 14
Based on original weight (ORIGWT) in NAEP data

Race-Region	Freq.	%	Cum. Freq.	Cu. %
White-Northeast	402880.7	12.65	402880.7	12.65
White-Midwest	615135.1	19.31	1018016	31.95
White-South	705724	22.15	1723740	54.11
White-West	437100.6	13.72	2160840	67.82
Non-hispanic black	477674.1	14.99	2638514	82.82
Hispanic	402241.1	12.63	3040756	95.44
Non-hispanic other	145152.3	4.56	3185908	100.00

Frequencies of students by region-race using sum of Level-1 weight 15
Based on adjusted weight (ADJWT) for merged NAEP-CCD data

Race-Region	Freq.	%	Cum. Freq.	Cu. %

White-Northeast	389907.8	12.24	389907.8	12.24
White-Midwest	598667.2	18.79	988575.1	31.03
White-South	684636.9	21.49	1673212	52.52
White-West	387357.9	12.16	2060570	64.68
Non-hispanic black	538638.3	16.91	2599208	81.58
Hispanic	432200.4	13.57	3031409	95.15
Non-hispanic other	154499.4	4.85		100

Appendix III
Analytic procedures with two-level HLM modeling

Appendix III is available for downloading as a Rich Text Formatted file.

The World Wide Web address for the *Education Policy Analysis Archives* is **epaa.asu.edu**

General questions about appropriateness of topics or particular articles may be addressed to the Editor, Gene V Glass, glass@asu.edu or reach him at College of Education, Arizona State University, Tempe, AZ 85287-2411. The Commentary Editor is Casey D. Cobb: casey.cobb@unh.edu .

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