Online Appendix

for

Do School Spending Cuts Matter? Evidence from The Great Recession

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Appendix

A Data Appendix

A.1 Data on School Spending and Resources

The data on district level school finances is collected from the Census website.[30] The underlying data come from the Common Core of Data (CCD) School District Finance Survey (F-33). It consists of data submitted annually to the National Center for Education Statistics (NCES) by state education agencies (SEAs) in the 50 states and the District of Columbia. The purpose of the survey is to provide finance data for all local education agencies (LEAs) that provide free public elementary and secondary education in the United States. Both NCES and the Governments Division of the U.S. Census Bureau collect public school system finance data, and they collaborate in their efforts to gather these data. The F-33 data provides information on revenues, expenditures, and the number of students enrolled. Expenditures are reported in a number of categories including instructional spending, capital outlays, and administrative spending. Revenues are reported in several fine categories and aggregated to local, state, and federal sources. We CPI-adjust all spending variables to be in 2015 dollars and divide by district enrollment in the given year to obtain per-pupil spending variables.

The surveys are administered annually from 1992 onward. The last year for which data is available is the 2016-2017 academic year. We link together multiple years of data to create a balanced state-year panel (summarizing first across school districts). In constructing the data set, we found that the financial data contained some extremely large and small values. These values could be valid, but it is more likely that some districts incorrectly reported enrollments or expenditures. We therefore censored the data by winsorizing extreme values. First, we calculated the (unweighted) 99th and 1st percentile district in total per-pupil current expenditures for each state and year. We then capped values of districts with per-pupil expenditures at greater than 200 percent of the 99th percentile of per-pupil revenues or less than 50 percent of the 1st percentile.

For school spending categories (such as capital or instructional salaries), we replace values with missing where the CPI-adjusted per-student categorical spending value is more than twice the 99th percentile. We follow a similar strategy for reported staffing categories, which come from the NCES Common Core of Data LEA Universe surveys (CCD), replacing staffing values with missing if the total staffing variable or the staffing per student (or students per staff) is more than twice the 99th percentile. Note that not all states report staffing data in every year, and so our state-by-year

[30] For instance, data for the school year 2014-2015 is available at https://www.census.gov/data/tables/2015/econ/school-finances/secondary-education-finance.html and data for the other years can be retrieved by modifying the appropriate part of the url.

analytic sample for staffing estimates is not balanced.

A.2 Recession Intensity & Employment Data

Important to our identification strategy is controlling for the direct effect of broader recessionary economic conditions. For this purpose, we construct an index of recession severity and exposure. We exploit the fact that the impact of the recession varied on the basis of local industrial compositions and create two separate shift-share instruments, along the lines of Bartik (1991), which capture changes in economic conditions, namely, the unemployment rate and average annual wage attributable to the onset of the recession.

To do so, we follow the steps broadly outlined in Yagan (2017). We retrieve average annual county-level employment data from the Quarterly Census of Employment and Wages (QCEW).[31]. Each state's time-varying shift-share shock is computed as the projected unemployment and average wages in each year, based on the interaction between the 2007 (pre-recession) employment composition by two-digit NAICS industry categories and the nationwide unemployment and wages by the same groupings in that year. Average annual wages by industry are collected from https://www.bls.gov/oes/tables.htm. Formally, in state s during year t the instrument equals:

$$Unemp\ Bartik_{st} = \sum_j \left(\frac{E_{js2007}}{\sum_{j'} E_{j's2007}} \times \text{National Unemployment}_{jt} \right) \tag{4}$$

$$Income\ Bartik_{st} = \sum_j \left(\frac{E_{js2007}}{\sum_{j'} E_{j's2007}} \times \text{National Wage}_{jt} \right) \tag{5}$$

where j denotes a two-digit industry, E_{js2007} denotes total employment in industry j in state s in 2007, $National\ Unemployment_{jt}$ and $National\ Wage_{jt}$ are the nationwide unemployment rate and average wages in industry j in year t respectively.

From the same dataset (QCEW) above, we also compile the annual total employment number in each county as an additional measure of economic status. As an additional economic indicator, we obtain state-level estimates of housing values from Zillow and use the January index for each year as an annual indicator of home prices.

A.3 NAEP Data

For our main analyses, we use publicly available state-level NAEP test score data from the National Center for Education Statistics. The NAEP is administered (generally) every other year

[31] The QCEW program publishes an annual count of employment and wages reported by employers covering 98 percent of U.S. jobs, available at the county, MSA, state and national levels by industry. Average annual data were downloaded from the Bureau of Labor Statistics for each county and year from https://www.bls.gov/cew/datatoc.htm

to a population-weighted sample of schools and students. Schools are selected from 94 geographic areas, 22 of which are always the same major metropolitan areas. Students are selected randomly within the selected schools to complete the assessments. Note that our main results are invariant to the use of sampling weights.

We use restricted-use individual-level for three purposes: 1) to compute average private school scores, 2) to compute the relationship between district poverty rates and NAEP scores, and 3) to compute the mean and standard deviation of all scores in 2003 for standardization. We infix the raw files to Stata, including all plausible score values per student, and restricting the sample to the NAEP reporting sample and public private school students (for 2 and 3) or private school students (for 1). The restriction to the reporting sample and public school students corresponds directly to the sample used to calculate state averages as reported publicly by NCES.

Our dependent variable in all public school NAEP estimations is the average of all publicly available scores per state, year, grade, and subject, standardized to the base year of 2003 (determined from the restricted-use individual-level scores). We also use publicly available scores by race in the same way. We restrict our analyses to the years 2002 and later, as NAEP sampling increased dramatically after 2001 and testing years became more consistent at this time.

A.4 College Enrollment Data

Our college-going data are obtained from the the Integrated Postsecondary Education Data System (IPEDS). These data report surveys submitted by postsecondary institutions. These data do not have student-level information. Institutions report on the number of first-time college freshmen from each state in each year who graduated high school in the past 12 months. By aggregating these data to the state of origin level, we obtain counts for the number of first-time freshmen from each state in each year. We drop years where the survey was optional, and match each year of college enrollment to spending data from the year prior (when enrolling students would have graduated high school). Note that the resulting years in our analysis correspond to the NAEP results, with one exception. We use data corresponding to 2001 for the college-going models, while the NAEP sample includes 2002. This discrepancy corresponds to required submission years and data availability. To compute college-going rates for these years, we obtain population estimates by age in each state in each year from the Census population estimates from 2001 to 2017. Data from 2000-2010 come from State Intercensal Estimates, while data after 2010 come from Vintage 2019 Estimates (a precursor to Intercensal Estimates). Our college-going measure is the number of first-time college enrollees divided by the average number of 17- and 18-year-olds in the state the year prior to the year of enrollment.

Using information on postsecondary institutions from IPEDS and the Carnegie Foundation, we are able to compute enrollments by college type (2-year vs 4-year), selectivity level, and other

characteristics about populations served. We use information on institution characteristics from Carnegie in 2005. Given that some institutional classifications are based on the populations served, which may be endogenously affected by the recession and K12 spending cuts, we classify institutions based on their 2005 categories for every year in our data. The Carnegie data provides information from IPEDS on the level served (2 or 4 year) and control (public or private), as well as its own selectivity and part-time enrollment categories. Per their definitions, Inclusive 4-year institutions are those for whom test score data was not available or otherwise indicated that admissions were offered inclusively. Selective 4-year institutions were those with test scores that placed them between the 40th and 80th percentiles in selectivity, and More/Most Selective 4-year institutions were those with test scores that placed them between the 80th and 100th percentiles in selectivity.

The Carnegie data also includes IPEDS categories to note Historically Black Colleges and Universities (HBCU's) and Tribal Colleges. However, we use 2005 IPEDS fall enrollment data by race to define categories for Minority Serving Institutions, Hispanic Serving Institutions, and Black Serving Institutions using IES definitions (page V of this document). We define these categories ourselves because exact definitions for 2005 were not available and the data reported by Carnegie did not seem to match any known definitions precisely (for example, not all HBCU's were designated as MSI's).

A.5 Higher Education Finance, Tuition, and Aid

Given that our results on college-going are primarily driven by lower enrollments at public institutions, we explore whether our instrument predicts higher education tuition, revenue, and financial aid. We collect data from several sources for this analysis. First, we gather data on higher education revenues from the Census's Annual Survey of State and Local Finances, using the Tax Policy Center's Data Query System. This data includes information on higher education revenues, including from all charges and charges for tuition and fees (variable definitions are available here). We collect public in-state, public out-of-state, and private tuition rates from IPEDS for all years of our analysis and take an average across all institutions in the state in each year to create a panel of public and private tuition rates. We also collect data from IPEDS on the amount of financial aid awarded at public colleges and universities (from federal, state, and institutional sources) as well as data from the U.S. Department of Education on the amount of Federal Pell grant aid awarded to students at public institutions. Note that while our college enrollment data reflect the state that students are from, our tuition, aid, and Pell grant data are only available at the institutional level and therefore reflect the state of attendance. For all institutional-level data, we determine whether the college or university was public or private based off of 2005 IPEDS classifications.

B Appendix Tables and Figures

Table A1: NAEP Availability

Year	4th Grade Math	8th Grade Math	4th Grade Reading	8th Grade Reading	Tested Students
2015	X	X	X	X	430438
2014					
2013	X	X	X	X	575298
2012					
2011	X	X	X	X	619789
2010					
2009	X	X	X	X	571308
2008					
2007	X	X	X	X	620220
2006					
2005	X	X	X	X	589458
2004					
2003	X	X	X	X	642244
2002			X	X	240228
2001					
2000	X	X	X		22246
1999					
1998			X	X	15391
1997					
1996	X	X			10805
1995					
1994			X		6030
1993					
1992	X	X	X		16719

Notes: This table reports the availability of NAEP scores by year, grade, and subject using restricted-use individual NAEP data.

Table A2: Values of State Reliance on State Revenues in 2008

State Name	Share of Revenue from State Sources	State Name	Share of Revenue from State Sources
D.C.	0	MONTANA	0.4903511
NEBRASKA	0.3225271	WISCONSIN	0.4917012
ILLINOIS	0.3286418	SOUTH CAROLINA	0.5057849
SOUTH DAKOTA	0.3314429	OKLAHOMA	0.5115958
PENNSYLVANIA	0.3426996	OREGON	0.5239304
NORTH DAKOTA	0.346946	WYOMING	0.5280697
NEW HAMPSHIRE	0.37133	MISSISSIPPI	0.5370823
CONNECTICUT	0.3776729	MICHIGAN	0.5464625
RHODE ISLAND	0.3847986	UTAH	0.5630575
FLORIDA	0.3943167	NEVADA	0.5747569
NEW JERSEY	0.3997393	CALIFORNIA	0.5787138
VIRGINIA	0.4034221	KENTUCKY	0.5787908
MISSOURI	0.4079654	WEST VIRGINIA	0.5809737
MASSACHUSETTS	0.4178207	KANSAS	0.5836266
MARYLAND	0.4198564	NORTH CAROLINA	0.588497
COLORADO	0.4210965	ALABAMA	0.6017246
OHIO	0.4298248	DELAWARE	0.6121683
TEXAS	0.4308234	WASHINGTON	0.6192372
MAINE	0.4324811	MINNESOTA	0.6437633
LOUISIANA	0.4355786	ALASKA	0.6485088
IOWA	0.4484535	IDAHO	0.6549695
GEORGIA	0.4513427	VERMONT	0.6830685
NEW YORK	0.4522685	NEW MEXICO	0.7123612
TENNESSEE	0.4590126	ARKANSAS	0.7566826
INDIANA	0.4733	HAWAII	0.8475864
ARIZONA	0.4808847		

Notes: This table reports the share of the state's 2007-2008 public K12 education revenues that came from state sources, Ω_s.

Table A3: First Stage and Reduced Form, Preliminary Models

	(1)	(2)	(3)	(4)	(5)	(6)
	First Stage		**Reduced Form**			
Outcome	*Per-Pupil Spending (thousands)*		*Average NAEP*		*College Enrollment Rate*	
I_{post}	1.193	1.861	0.0727	0.0375	-0.0166	0.0668
	[0.265]	[1.695]	[0.0387]	[0.0562]	[0.0156]	[0.0262]
$I_{post} \times (.33 < \Omega_s < .66)$	-1.248	-1.101	-0.0508	-0.0497	0.00322	0.00747
	[0.304]	[0.317]	[0.0400]	[0.0405]	[0.0167]	[0.0206]
$I_{post} \times (\Omega_s > .66)$	-2.598	-2.438	-0.024	-0.0207	0.0182	0.02
	[1.030]	[1.022]	[0.0425]	[0.0425]	[0.0165]	[0.0206]
$I_{post} \times (T-2008) \times (\Omega_s < .33)$	0.448	0.284	0.0123	0.00887	-0.00163	-0.00565
	[0.194]	[0.298]	[0.00806]	[0.00824]	[0.00336]	[0.00379]
$I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$	-0.256	-0.432	-0.0146	-0.0183	-0.00797	-0.0124
	[0.0405]	[0.119]	[0.00318]	[0.00392]	[0.00114]	[0.00226]
$I_{post} \times (T-2008) \times (\Omega_s > .66)$	-0.511	-0.672	-0.0218	-0.0247	-0.0127	-0.0175
	[0.0631]	[0.124]	[0.00482]	[0.00636]	[0.00197]	[0.00272]
Observations	459	459	459	459	459	459
Kleibergen-Paap Wald F-Stat (slope only)	37.02	31.19	14.62	9.457	30.33	16.55
State Trends	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X
Bartiks		X		X		X

Notes: Robust standard errors in brackets cluster by state. This table reports the first stage and reduced form models corresponding to specifications without year fixed effects as an extension of Table 2. Column (1) is a direct replication of Column (1) of Table 2. Columns (1), (3), and (5) report the first stage and reduced form models corresponding to the specification used in models (1) and (5) of Table 3, which includes no year fixed effects and no bartik instruments. Columns (2), (4), and (6), correspond to models (2) and (6) of Table 3, which includes bartik instruments but no year fixed effects.

Table A4: First Stage, College-Going Sample Years

	(1)	(2)	(3)	(4)
	Per-Pupil Spending (thousands)			
I_{post}	0.703	-0.162		
	[0.251]	[0.839]		
$I_{post} \times (.33 < \Omega_s < .66)$	-0.837	-0.836	-0.837	-1.418
	[0.287]	[0.305]	[0.290]	[0.909]
$I_{post} \times (\Omega_s > .66)$	-2.143	-2.103	-2.143	-2.641
	[1.016]	[1.013]	[1.025]	[1.261]
$I_{post} \times (T - 2008) \times (\Omega_s < .33)$	0.295	0.253		
	[0.159]	[0.206]		
$I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$	-0.282	-0.324	-0.577	-0.528
	[0.0360]	[0.0739]	[0.164]	[0.109]
$I_{post} \times (T - 2008) \times (\Omega_s > .66)$	-0.523	-0.553	-0.819	-0.789
	[0.0322]	[0.0682]	[0.163]	[0.105]
Observations	459	459	459	459
Kleibergen-Paap Wald F-stat (slope)	109.6	46.27	21.93	36.97
State Trends	X	X	X	X
State Fixed Effects	X	X	X	X
Bartiks		X		X
Year Fixed Effects			X	X

Notes: Robust standard errors in brackets cluster by state. This table replicates the first stage panels of Table 2 and Table A3 with data from 2001 instead of 2002 in order to correspond to the college-going sample. These results can be interpreted as the first stage for the 2SLS models when we examine the outcome College Enrollment Rate.

Table A5: OLS Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
Per-Pupil Spending (thousands)	0.00551	0.000318	0.00458	0.00643	0.00635	0.00435	0.00218	0.00139
	[0.00318]	[0.00347]	[0.00324]	[0.00340]	[0.00214]	[0.00174]	[0.00142]	[0.00177]
Observations	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X

Notes: Robust standard errors in brackets cluster by state. State-by-year observations include all states in years 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. Models predicting NAEP scores also include 2002 while models predicting College Enrollment include 2001. For each column, we regress the outcome (Average NAEP Score or College Enrollment Rate) on per-pupil spending, state fixed effects, state trends, and an indicator for whether the observaton occurred after 2008 (I_{post}). We add additional controls (employment and income bartik instruments, year fixed effects) to account for additional trends in timing. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well.

Table A6: 2SLS Main Effects, Log Specification

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
Log (Per-Pupil Spending)	0.642	0.507	0.557	0.568	0.321	0.374	0.195	0.186
	[0.133]	[0.138]	[0.183]	[0.221]	[0.0511]	[0.0801]	[0.0680]	[0.0787]
Kleibergen-Paap Wald F-stat	26.31	29.58	18.55	35.93	41.01	24.08	15.39	21.92
	Predicted NAEP Score				*Predicted College Enrollment Rate*			
Log (Per-Pupil Spending)	0.0451	0.0624	-0.00195	-0.00238	0.063	0.0618	0.0588	0.0447
	[0.0267]	[0.0304]	[0.0441]	[0.0512]	[0.0163]	[0.0278]	[0.0551]	[0.0622]
Observations	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X

Notes: This table replicates Table 3 using the Log of Per-Pupil Spending (2015 dollars) instead of Per-Pupil Spending (2015 thousands of dollars). Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey, IES NAEP results, and IPEDS. All models include state-by-year observations for 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. NAEP models also include 2002 while College Enrollment models include 2001. In models with year fixed effects (columns 3-4 and 7-8), we instrument for spending using $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T - 2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. Models without year fixed effects (columns 1-2 and 5-6) also include $I_{post} \times (T - 2008) \times (\Omega_s < .33)$. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. The top panel presents our main results regressing Average NAEP Scores and College Enrollment Rates on instrumented log spending. The bottom panel regresses the same outcomes as predicted by economic and demographic variables (see Table A8) on instrumented log spending to demonstrate that instrumented spending is not endogenous to economic and demographic characteristics that are also correlated with academic outcomes.

Table A7: NAEP by Grade and Subject (2SLS)

	(1)	(2)	(3)	(4)
	Average NAEP Score			
	Math	*Reading*	*4th Grade*	*8th Grade*
Per-Pupil Spending (thousands)	0.055	0.0159	0.0448	0.0326
	[0.0230]	[0.00396]	[0.0158]	[0.00939]
Observations	408	454	454	453
State Trends	X	X	X	X
State Fixed Effects	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X
Bartiks	X	X	X	X
Year Fixed Effects	X	X	X	X

Notes: Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey and the NCES Public NAEP Data. All models include state-by-year observations for 2002, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. There was no Math NAEP test in 2002 (see Table A1. Not all NAEP by grade/subject scores were available for every state in 2002 (AK, CO, NH, NJ, and SD do not have any grade/subject specific scores for 2002, Iowa does not report 8th grade specific scores for 2002). We instrument for spending using $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group.

Table A8: Exogeneity Test of Instrument (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Unemployment Rate	*Child Poverty Population*	*Log(Child Poverty Population)*	*Annual Average Employment*	*Log (Annual Average Employment)*	*Employment Ratio**	*Median Household Income*	*K12 Enrollment*	*Log (K12 Enrollment)*	*Black Population*	*White Population*
Per-Pupil Spending (thousands)	0.0227	-4,445	-0.0135	14,478	0.011	0.00384	499.1	-4,420	0.0171	3,370	2,181
	[0.152]	[5,487]	[0.0309]	[16,258]	[0.00548]	[0.00897]	[326.9]	[8,409]	[0.0167]	[5,018]	[88,353]
Observations	459	459	459	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X	X	X	X
Bartiks	X	X	X	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X	X	X	X

*Employment ratio = Log(Annual Average Employment) - Log(Total Population)

Notes: Robust standard errors in brackets cluster by state. This table reports results from 2SLS analyses where each economic or demographic indicator is regressed on instrumented per-pupil spending. Spending data are collected from the F33 School District Finance survey. Other data sources include BLS, SAIPE, NCES CCD, Zillow, and ACS. All models include state-by-year observations for 2002, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. We instrument for spending using $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group.

Table A9: Predicted Outcomes

	(1)	(2)
	Average NAEP Score	*College Enrollment Rate*
Unemployment Rate	0.00399	-0.00186
	[0.00431]	[0.00231]
% Total Population in Poverty	-0.0151	0.00498
	[0.00949]	[0.00407]
% Child Population in Poverty	0.00202	-0.00183
	[0.00836]	[0.00352]
Log (Child Population)	-0.395	-0.00788
	[0.230]	[0.101]
Log (Total Population)	-0.055	0.279
	[0.494]	[0.136]
Log (Child Population in Poverty)	0.0604	0.0459
	[0.103]	[0.0469]
Annual Average Employment	3.52E-08	3.20E-09
	[1.99e-08]	[1.15e-08]
Log (Annual Average Employment)	-0.31	-0.2
	[0.241]	[0.106]
K12 Enrollment	1.13E-07	-1.02E-07
	[1.90e-07]	[6.97e-08]
Median Household Income	1.85E-06	4.45E-06
	[3.85e-06]	[1.64e-06]
White Population	4.14E-09	5.98E-10
	[1.28e-08]	[6.85e-09]
Black Population	6.64E-08	2.94E-08
	[1.05e-07]	[4.21e-08]
Observations	459	459
R-squared	0.972	0.955
Within R-Squared	0.0558	0.0789
State Trends	X	X
State Fixed Effects	X	X
Year Fixed Effects	X	X

Notes: Robust standard errors in brackets cluster by state. We regress outcomes on economic and demographic covariates, state fixed effects, state trends, and year fixed effects and create linear predictions of the outcomes based on the model. The samples here include state by year observations for 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. Column 1 also includes data from 2002, while Column 2 includes data from 2001. Predicted outcomes are used as placebo outcome measures in our main results reported in table Table 3.

Table A10: Private School NAEP Scores (2SLS)

	(1)	(2)	(3)	(4)
	Private School NAEP Score			
Per-Pupil Spending (thousands)	0.00913	-0.00175	0.0429	0.0655
	[0.0316]	[0.0320]	[0.0343]	[0.0405]
Observations	388	388	388	388
State Trends	X	X	X	X
State Fixed Effects	X	X	X	X
I_{post}	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X
Bartiks		X		X
Year Fixed Effects			X	X

Notes: Robust standard errors in brackets cluster by state. This table reports results from 2SLS analyses where average private school NAEP scores are regressed on instrumented per-pupil spending. Spending data come from the F33 School District Finance survey. We calculate private school NAEP scores using the restricted-use NAEP data. We calculate NAEP scores for private school students, standardizing to 2003 private school NAEP scores. We take the mean for each state and year, weighting by the ORIGWT sampling weight. We are not able to calculate a mean private school NAEP score for every state and year, but all states and years are represented in the sample. All models include state-by-year observations for 2002, 2003, 2005, 2007, 2009, 2011, 2013, and 2015. In models with year fixed effects (columns 3-4), we instrument for spending using $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. Models without year fixed effects (columns 1-2) also include $I_{post} \times (T-2008) \times (\Omega_s < .33)$. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group.

Table A11: 2SLS Main Results, Controlling for Predicted Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
Per-Pupil Spending (thousands)	0.0519	0.0419	0.0366	0.0385	0.0211	0.0207	0.00868	0.00894
	[0.0108]	[0.0110]	[0.0105]	[0.0106]	[0.00350]	[0.00507]	[0.00325]	[0.00336]
Kleibergen-Paap Wald F-stat	38.63	29.36	15.6	29.43	100.3	53.55	21.7	37.96
Observations	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X
Predicted Outcome	X	X	X	X	X	X	X	X

Notes: This table replicates the top panel of table Table 3, including additional controls for the predicted outcomes (predicted NAEP scores or predicted college enrollment) (see Table A8. Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey, IES NAEP results, and IPEDS. In models with year fixed effects (columns 3-4 and 7-8), we instrument for spending using $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T - 2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. Models without year fixed effects (columns 1-2 and 5-6) also include $I_{post} \times (T - 2008) \times (\Omega_s < .33)$. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group.

Table A12: Saturated Models (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
Per-Pupil Spending (thousands)	0.0385	0.0476	0.0537	0.0495	0.0124	0.0142	0.0135	0.0143
	[0.0110]	[0.0225]	[0.0200]	[0.0159]	[0.00387]	[0.00674]	[0.00458]	[0.00427]
Observations	459	459	459	456	459	459	459	456
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X
Population Controls		X	X	X		X	X	X
Economic Controls			X	X			X	X
Housing Values				X				X

Notes: Robust standard errors in brackets cluster by state. This table presents results of models that build on results presented in Table 3 by including additional economic and demographic covariates. All models include state-by-year observations for 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. NAEP models also include 2002 while College models include 2001. We instrument for spending using $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T - 2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. Columns (1) and (5) directly replicate the results presented in columns (4) and (8) from Table 3. Columns (2) and (6) add population controls (total population and child population), columns (3) and (7) add economic controls (unemployment rates, child poverty rate, total poverty rate, and log(employment)), and columns (4) and (8) add a control for the housing value index (not available for North Dakota in 2002, 2003, or 2005). X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group.

Table A13: 2SLS Main Results: Dropping States

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				**College Enrollment Rate**			
	Dropping DC							
Per-Pupil Spending (thousands)	0.0522	0.0318	0.0354	0.0283	0.0267	0.0297	0.0117	0.01
	[0.0107]	[0.00707]	[0.0172]	[0.0120]	[0.00417]	[0.00595]	[0.00459]	[0.00501]
Kleibergen-Paap Wald F-Stat	36.56	77.34	15.68	24.08	108.7	81.61	20.49	24.54
Observations	450	450	450	450	450	450	450	450
	Dropping Hawaii							
Per-Pupil Spending (thousands)	0.0517	0.0426	0.0389	0.0428	0.0258	0.0276	0.0127	0.0125
	[0.0106]	[0.0104]	[0.0111]	[0.0110]	[0.00429]	[0.00611]	[0.00328]	[0.00427]
Kleibergen-Paap Wald F-Stat	28.21	25.94	10.53	17.45	71.87	34.74	17.46	32.31
Observations	450	450	450	450	450	450	450	450
	Dropping DC, CA, and HI							
Per-Pupil Spending (thousands)	0.0549	0.0364	0.0404	0.0346	0.0267	0.029	0.0115	0.00975
	[0.0117]	[0.00694]	[0.0197]	[0.0122]	[0.00445]	[0.00627]	[0.00516]	[0.00555]
Kleibergen-Paap Wald F-Stat	27.54	62.38	12.4	20.84	70.56	54.82	15.7	21.15
Observations	432	432	432	432	432	432	432	432
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X

Notes: This table replicates the top panel of Table 3 dropping states from the analysis. DC and Hawaii represent the two extremes of the share of public K12 spending that comes from state sources. All of DC's funding comes from local (DC) and federal sources, while Hawaii operates one single district and therefore receives no local funding. The top two panels demonstrate the robustness of our main results when dropping these states, while the bottom panel simultaneously drops DC, HI, and CA (see table Table A14 for results dropping California alone). Robust standard errors in brackets cluster by state.

Table A14: 2SLS Main Results: Alternative IV for California and Dropping California

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				**College Enrollment Rate**			
	Alternative IV: Counting Property Tax Revenue as State Revenue for California							
Per-Pupil Spending (thousands)	0.05	0.0394	0.0364	0.0385	0.0258	0.0279	0.0131	0.013
	[0.0102]	[0.0105]	[0.0108]	[0.0114]	[0.00415]	[0.00604]	[0.00303]	[0.00395]
Kleibergen-Paap Wald F-stat	22.58	22.23	8.356	13.94	34.26	19.98	9.195	17.13
Observations	459	459	459	459	459	459	459	459
	Dropping California							
Per-Pupil Spending (thousands)	0.0499	0.0406	0.0366	0.0387	0.0251	0.026	0.0127	0.0124
	[0.0100]	[0.0103]	[0.0104]	[0.0110]	[0.00402]	[0.00543]	[0.00306]	[0.00390]
Kleibergen-Paap Wald F-stat	36.79	30.63	13.24	21.35	109	45.43	21.48	36.22
Observations	450	450	450	450	450	450	450	450
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X

Notes: The top panel of this table replicates the top panel of table Table 3 using an alternative specification of our instrument for California. The majority of school district property tax revenue in California is collected and redistributed by the State. In our main models, we classify this revenue as "local." In results presented here, we re-classify property tax revenue reported by independent school districts as "state" revenue instead. This causes our instrument for California (share of 2008 education revenues from state sources) to increase from .58 to .78. The bottom panel of this table replicates the top panel of Table 3 dropping California from the sample entirely. Robust standard errors cluster by state.

Table A15: Main Results (Weighted)

	(1)	(2)	(3)	(4)	(5)	(6)
	Average NAEP Score			**College Enrollment Rate**		
Per-Pupil Spending (thousands)	0.0237	0.0241	0.0238	0.00935	0.00942	0.00933
	[0.00696]	[0.00694]	[0.00689]	[0.00222]	[0.00213]	[0.00215]
Kleibergen-Paap Wald F-Stat	73.5	74.2	74.59	75.02	80.76	78.38
Observations	459	459	459	459	459	459
State Trends	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X
Bartiks	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X
Weight	K12 Enrollment	Total Population	Child-Age Population	K12 Enrollment	Total Population	Child-Age Population

Notes: This table replicates our preferred group models (columns (4) and (8) from Table 3), weighting the regressions by population measures. Robust standard errors in brackets cluster by state. Columns (1) and (4) weight by public school K12 enrollment, columns (2) and (5) weight by total state population, and columns (3) and (6) weight by the state's school-aged child population. K12 enrollment data are obtained from the F33 School District Finance Survey, while Total and Child-Aged population estimates are obtained through the Small Area Income and Poverty Estimates (SAIPE).

Table A16: Additional Spending Categories (2SLS)

	(1)	(2)	(3)	(4)	(5)
Overall Spending Category:	**Elem/Sec Operating**	**Salaries & Benefits**			
Sub Spending Category:	*Support Services*	*Instructional Salaries*	*Non-Instructional Salaries*	*Instructional Benefits*	*Non-Instructional Benefits*
Per-Pupil Spending (thousands)	47.45	231.9	35.01	210.9	-41.51
	[105.9]	[55.35]	[35.23]	[75.87]	[84.72]
Mean(Dependent Var.)	4019	4549	2212	1411	733.8
Average Share	0.3	0.343	0.168	0.105	0.055
P(Average=Marginal)	0.0207	0.0492	0.000433	0.169	0.26
Observations	459	459	459	459	459
State Trends	X	X	X	X	X
State Fixed Effects	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X
Bartiks	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X

Notes: Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey. All models include state-by-year observations for 2002, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. We instrument for spending using $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T - 2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. Coefficients on per-pupil spending can be interpreted as the amount of additional funds cut from each category for every one thousand dollars in exogenous educational spending cuts. More spending categories are reported in Table 5.

Table A17: 2SLS: College-Going by Institution Type, Continued

	(1)	(2)	(3)	(4)
	Black-Sering Institution	*Inclusive (4-year)*	*Selective (4-year)*	*Most Selective (4-year)*
Per-Pupil Spending (thousands)	0.000971	0.000933	0.000608	0.00126
	[0.00141]	[0.000699]	[0.00296]	[0.00182]
Average Rate	0.0417	0.0344	0.168	0.0988
Effective % Change	0.0233	0.0271	0.00362	0.0128
Observations	459	459	459	459
State Trends	X	X	X	X
State Fixed Effects	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X
Bartiks	X	X	X	X
Year Fixed Effects	X	X	X	X

Notes: This table is a continuation of Table 7. Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey, IPEDS, IPUMS, and the Carnegie Foundation. All models include state-by-year observations for 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. Enrollment rates are calculated from the number of first time enrollees at institutions meeting the stated criteria (e.g. inclusive) that graduated from high school in the past year, by which state the students lived at the time of application (IPEDS), divided by the average number of 17 and 18 year-olds the year prior to the enrollment year (IPUMS). We report the average enrollment rate at each type of institution over all states and years to scale the effects to be respective to each institution type's representation in overall enrollment rates. We instrument for spending using $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. Black-Serving Institutions are defined according to IES definitions (page V) using 2005 undergraduate enrollment data from IPEDS. BSI's include Historically Black Colleges and Universities or institutions where undergraduate enrollment is at least 25% black, and no other minority group makes up more than 25% of the undergraduate student body. Inclusive, Selective, and Most Selective schools are defined by Carnegie Classifications from 2005 for all institutions. Inclusive institutions are those for whom test scores are not available or suggests that admission is offered broadly. Selective institutions are those whose incoming test scores classify the institutions between the 40th and 80th percentile of selectivity. Most Selective institutions fall between the 80th and 100th percentile in selectivity. Minority Serving Institutions and Hispanic-Serving Institutions are defined according to IES definitions (page V) using 2005 undergraduate enrollment data from IPEDS.

Table A18: Higher Education Finances

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	State Higher Ed Revenue (millions)		**Tuition**			**Financial Aid at Public Institutions (millions)**		
	Total Charges	*Tuition and Fee Charges*	*Public In-State*	*Public Out-of-State*	*Private*	*Total*	*State Aid*	*Pell Grants*
Per-Pupil Spending (thousands)	-41.36	-29.86	-137.7	-241.4	220.4	-0.462	-0.521	-6.012
	[70.12]	[61.57]	[114.5]	[110.3]	[388.8]	[1.928]	[1.122]	[9.271]
Kleibergen-Paap Wald F-stat	36.97	36.97	36.97	36.97	30.82	36.97	36.97	36.97
Observations	459	459	459	459	454	459	459	459
	Dropping DC							
Per-Pupil Spending (thousands)	-90.65	-69.02	22.91	-131.9	534.4	-0.279	-0.321	-13.81
	[76.67]	[72.52]	[50.91]	[123.0]	[640.0]	[3.106]	[1.907]	[9.181]
Kleibergen-Paap Wald F-stat	24.54	24.54	24.54	24.54	20.96	24.54	24.54	24.54
Observations	450	450	450	450	445	450	450	450
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
$I_{post} \times I_{gs}$	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X

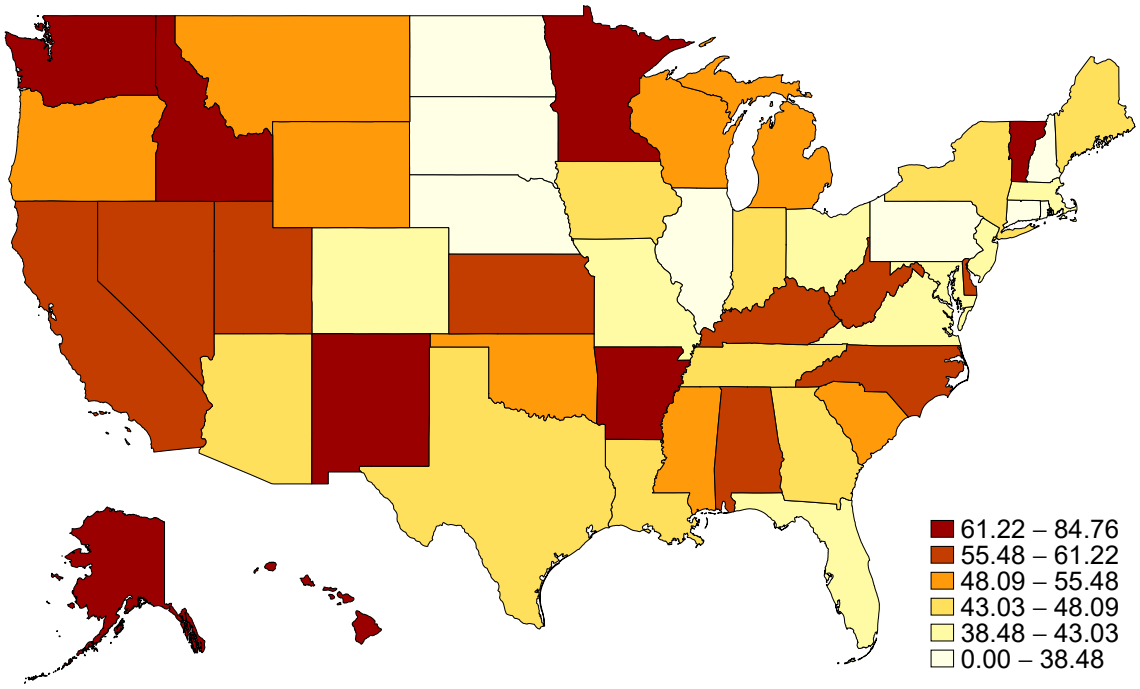
Notes: Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey, IPEDS, the Census Survey of State and Local Finances, and the U.S. Department of Education. All models include state-by-year observations for 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. We instrument for spending using $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. The top panel presents results from our preferred specification regressing higher education finance variables on instrumented school spending for all states and years in our sample, while the bottom panel drops DC from this analysis.

Table A19: 2SLS Main Effects, 4-Year Spending

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
4-Year Avg Per-Pupil Spending (thousands)	0.05	0.0651	0.0493	0.0529	0.0264	0.0431	0.0197	0.0201
	[0.00881]	[0.0194]	[0.0166]	[0.0208]	[0.00334]	[0.00956]	[0.00622]	[0.00706]
Kleibergen-Paap Wald F-stat	42.71	11.76	15.24	10.97	47.95	9.637	11.54	6.452
	Predicted NAEP Score				*Predicted College Enrollment Rate*			
Log (Per-Pupil Spending)	0.0037	0.00457	-0.00021	-0.00031	0.00499	0.00674	0.00477	0.00426
	[0.00208]	[0.00457]	[0.00422]	[0.00486]	[0.00110]	[0.00390]	[0.00535]	[0.00641]
Observations	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times I_{gs}$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Fixed Effects			X	X			X	X

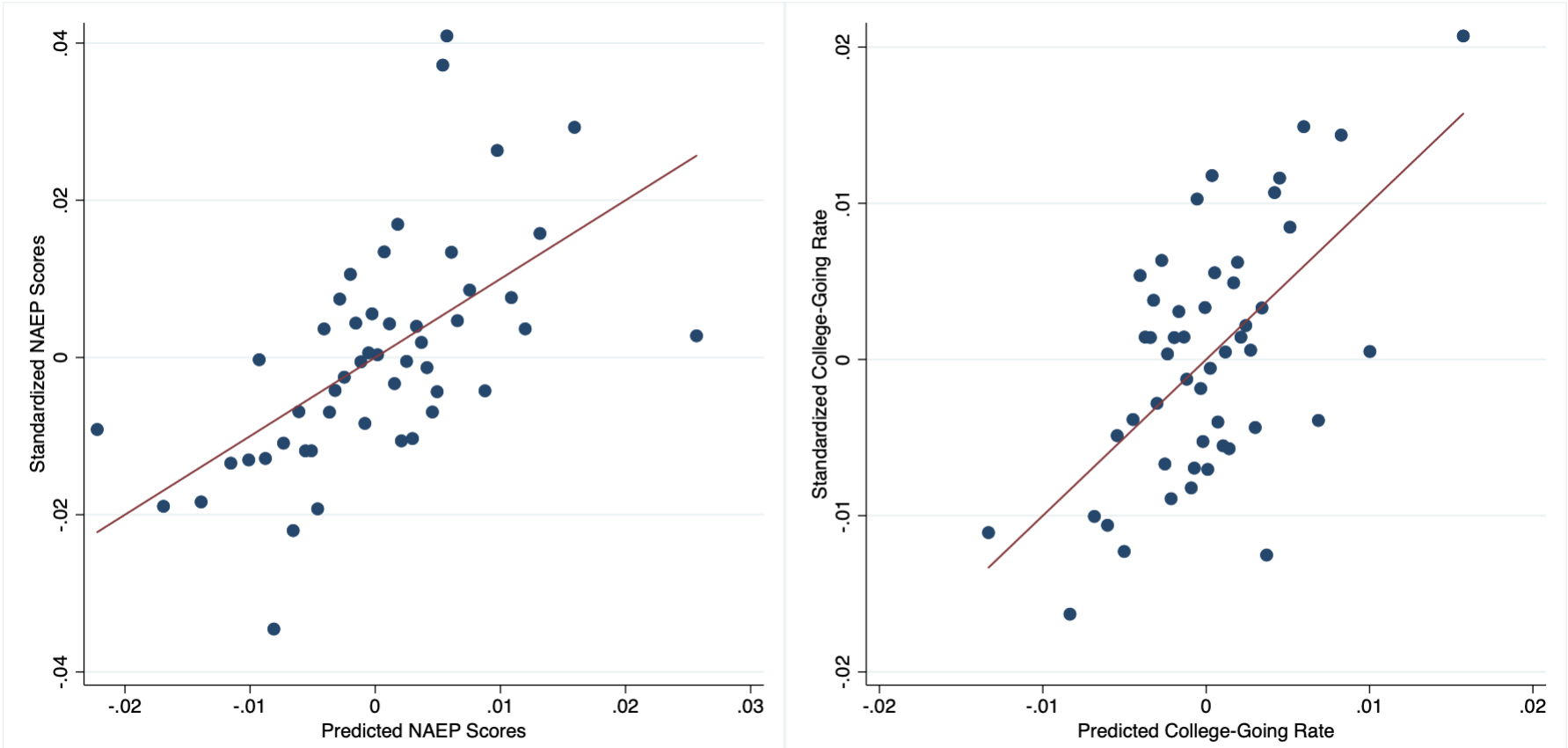
Notes: This table replicates Table 3 using a 4-year moving average of Per-Pupil Spending (2015 dollars) instead of contemporaneous Per-Pupil Spending (2015 thousands of dollars). Robust standard errors in brackets cluster by state. Data are collected from the F33 School District Finance survey, IES NAEP results, and IPEDS. All models include state-by-year observations for 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017. NAEP models also include 2002 while College Enrollment models include 2001. In models with year fixed effects (columns 3-4 and 7-8), we instrument for spending using $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T - 2008) \times (\Omega_s > .66)$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. Models without year fixed effects (columns 1-2 and 5-6) also include $I_{post} \times (T - 2008) \times (\Omega_s < .33)$. X indicates that the corresponding variable was controlled for, while X^s indicates that the corresponding variable was subsumed by other variables, effectively controlling for it as well. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. The top panel presents our main results regressing Average NAEP Scores and College Enrollment Rates on instrumented 4-year spending. The bottom panel regresses the same outcomes as predicted by economic and demographic variables (see Table A8) on instrumented 4-year spending to demonstrate that instrumented spending is not endogenous to economic and demographic characteristics that are also correlated with academic outcomes.

Figure A1. Percentage of Education Revenue from State Sources



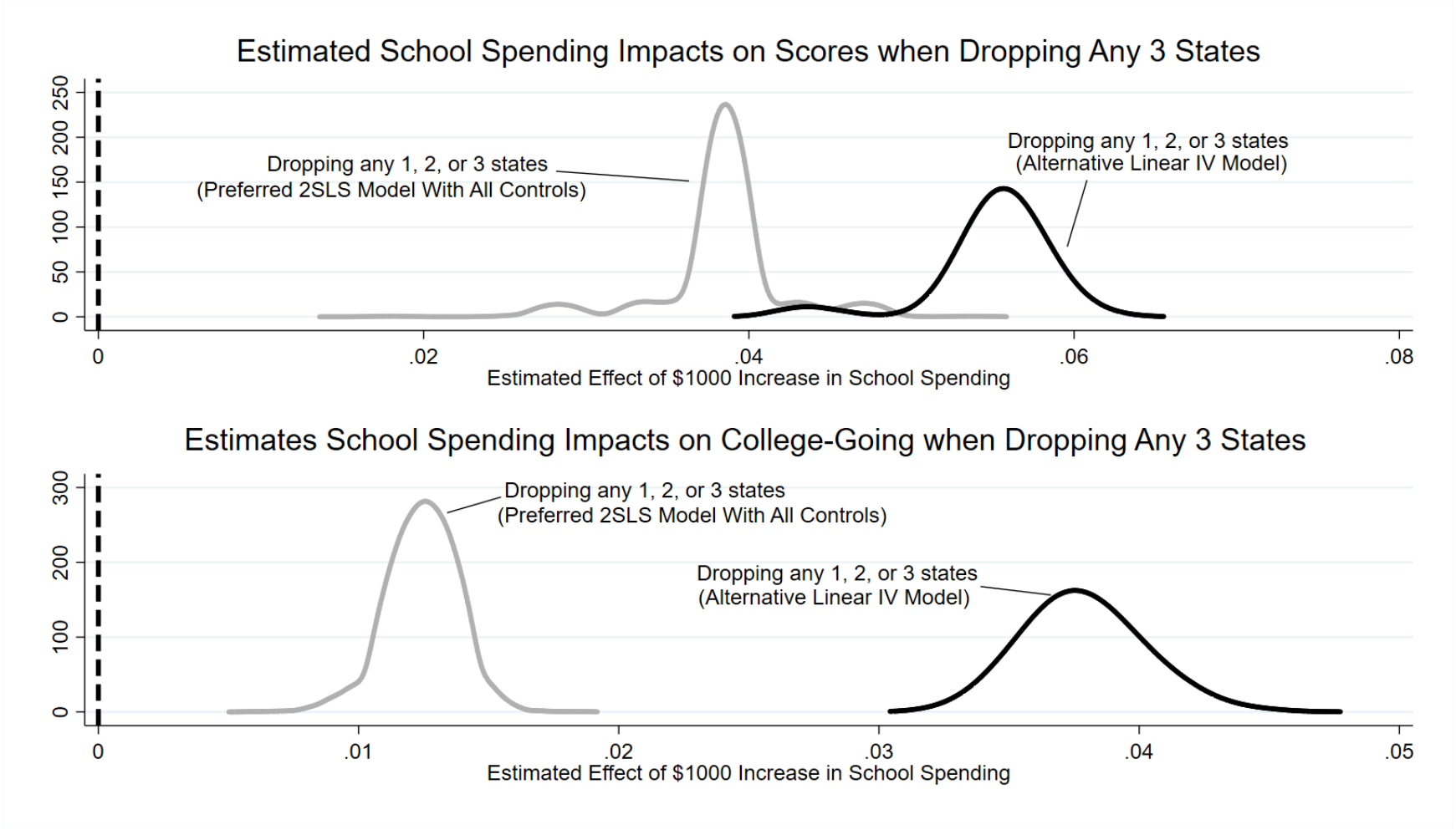
Notes: This map shows the extent of variation in $(\%)State_s$ across the United States.

Figure A2. *Predicted Scores Versus Actual Scores.*



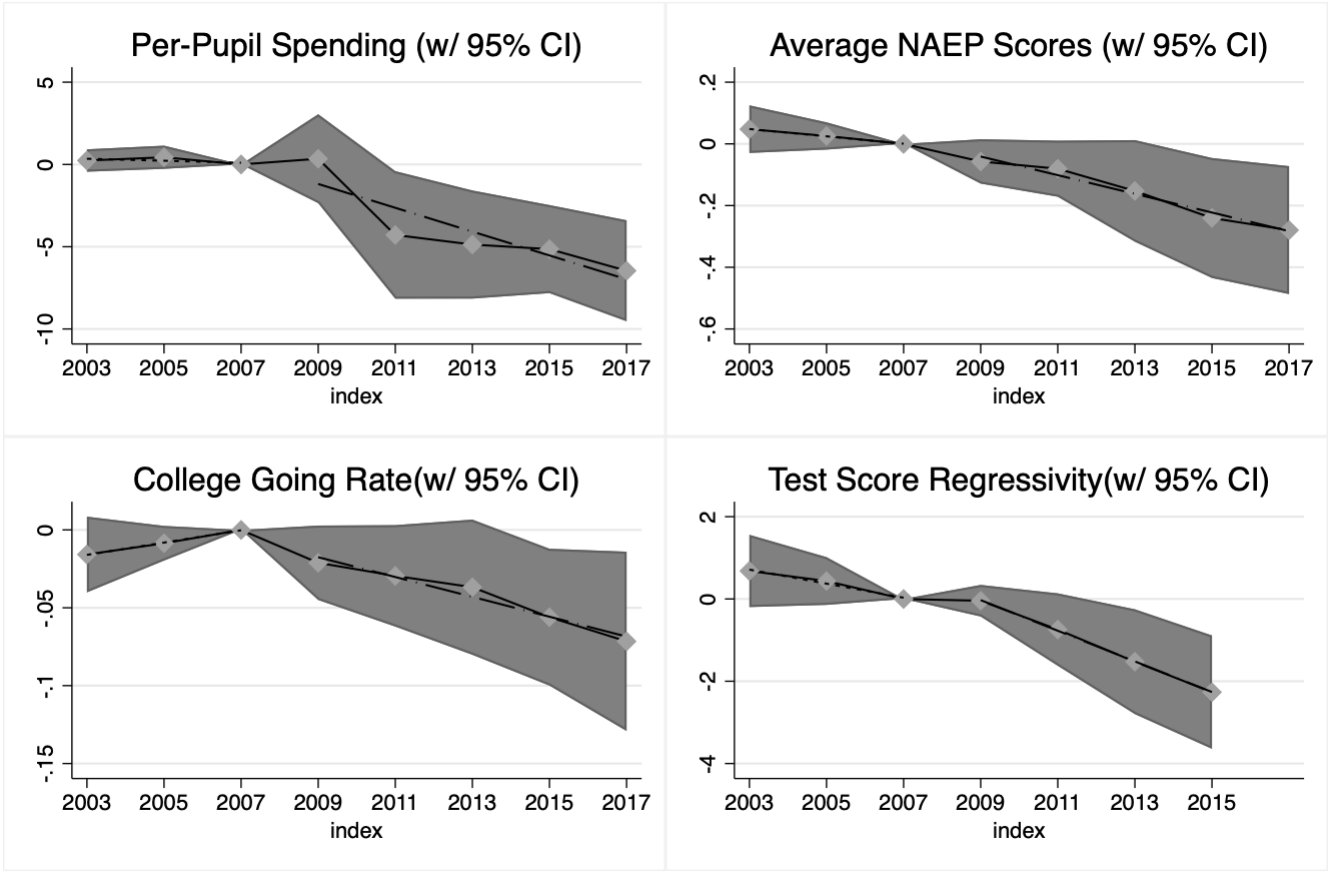
Notes: The two figures are binned scatter plots of the actual annual standardized NAEP test scores and actual college enrollment rates on the predicted annual NAEP scores and college enrollment rates respectively. To construct these binned scatter plots, we first predict the x-axis variable using measures of state-level population, poverty, and (un)employment. To ensure that our predictions are valid in our preferred Linear IV model, we next residualize all variables with respect to state trends, state fixed effects, and the year-group indicators. We then divide the predicted outcomes into fifty equal-sized groups and plot the means of the y-variable residuals within each bin against the mean value of the predicted outcome within each bin. The coefficient of predicted outcomes on actual outcomes is 1 (by construction). The t-statistic on the predicted outcome is 6.78 for NAEP scores and 6.97 for college-going.

Figure A3. *Outcome Impacts under Permutation Test.*



Notes: This density plot depict the distribution of estimated impacts while dropping states. The dashed black line depicts the distribution of estimated coefficient of log spending on NAEP scores if one drops any single state in the main model. The dashed gray line depicts the distribution of estimated coefficient of log spending on NAEP scores if one drops any two states in the main model. The solid black line depicts the distribution of estimated coefficient of log spending on NAEP scores if one drops any three states in the main model. Finally, the solid gray line depicts the distribution of estimated coefficients of log spending on NAEP scores if one drops any three states in the conservative model.

Figure A4. *Event Study Figures Controlling for Year Fixed Effects*



Notes: The dashed connected lines depicts the coefficients on the individual calendar year indicators interacted with an indicator for high reliance on state revenue in 2008, $\Omega_s > 0.33$. The dashed lines represent the linear fit during the pre–recession period/cohorts (negative values of exposure) and post-recession periods/cohorts (non-negative values of exposure). All models include year fixed effects. The pattern for per-pupil spending is presented in top-left panel; the pattern for test scores is presented in top-right panel; the pattern for college-going is in the bottom-left; and the slope between the poverty rate and NAEP scores is shown in the bottom-right.

C Using a Linear Specification

In our preferred instrumental variables model, we put states into groups and compare the differences in the change in trend for states with low, medium, or high level of reliance on state-appropriated funds. We will refer to this model as the Group IV model. The benefit of the chosen Group IV model is that it mimics the nature of the relationship between Ω_s and the change in slope – yielding a strong first stage and precise 2SLS point estimates. In fact, using the interaction between Ω_s itself (as opposed to groups) and recession timing yields weak first stages and very imprecise point estimates. We will refer to this model as the Linear IV model. However, the point estimates using this linear IV model are positive and cannot be distinguished from the preferred specification. First we show these models (which have a weak first stage). Next, we present an alternate linear IV model that relies on slightly different (but reasonable) identifying assumptions as our preferred Group IV model but yields very similar results.

Consistency Between Linear Instrument Model and the Preferred Model

Formally, using the state-by-year level panel, we estimate systems of equations of the following form by 2SLS.

$$\begin{aligned} PPE_{st} = \pi_1 \cdot (\Omega_s \times I_{post} \times (T - 2008)) + \phi_1 \cdot (\Omega_s \times I_{post})] \\ + \delta_1 C_{st} + \theta_{1t} + \alpha_{1s} + (\tau_{1s} \times T) + \varepsilon_{1st} \end{aligned} \tag{6}$$

$$Y_{st} = \beta \cdot (PPE_{st}) + \phi_{2g} \cdot (\Omega_s \times I_{post}) + \delta_2 C_{st} + \theta_{2t} + \alpha_{2s} + (\tau_{2s} \times T) + \varepsilon_{2st} \tag{7}$$

All variables are defined as in equations 2 and 3. Now the excluded instrument is simply $\Omega_s \times I_{post} \times (T - 2008)$. As in our preferred model, the identifying variation comes from comparing the change in trend at recession onset for states with higher levels of reliance on state-appropriated revenues (modelled linearly).

Column 1 of Table A20 shows the first stage for this model. The coefficient on the excluded instrument is negative (as expected), but the F-statistic on the excluded instrument is 7.37. To show the relative improvement in explanatory power from using the groups, we also present the first stage using the linear instrument interacted with the recession timing and also the group instrument used in our main model. In this model, the F-statistic on all the instruments (the linear and the state groups) is 15.97 - considerably larger than that using the linear model alone. To test whether the linear model yields a different answer from our preferred specification, we do two things. First we show the 2SLS estimates in a model that includes both the linear instrument and the group instruments and then test whether this model is overidentified. If the two sets of instruments are not consistent with each-other (i.e. the model is overidentified), the p-value on Hansen's J-statistic will be small, and conversely if one cannot reject that all the instruments identify the same parameter, then the p-value on Hansen's J-statistic will be large (Parente and Santos Silva, 2012).

Columns 5-8 of Table A21 show these results. As one can see, the 2SLS estimates using all the instrument are very similar to our preferred estimates in Table 3 and Table 6. Consistent with this, the p-value of the J-statistic for NAEP scores is 0.211, that for college going is 0.51, that for the regressivity slope is 0.17 and that for the black-white test score gap is 0.319. That is, the formal statistical tests indicate that a linear instrument and the preferred group specification yields largely similar results. To see this *informally*, we also present the 2SLS estimates using only the linear instruments in Columns 1-4. The point estimate for college-going is similar to the preferred estimate 0.0094, but is very imprecisely estimated. The estimate for NEAP scores is positive but smaller than the preferred estimate 0.0068 and very imprecise. The point estimate for test score regressivity is 0.492, and that for the black-white test score gap is -0.037 – both very similar to those for our preferred model. Consistent with the tests for overidentification, for each of these outcomes the preferred 2SLS estimates lie well within the 95% confidence intervals for the linear IV models. While the results thus far indicate that a linear specification of our instrument would yield statistically similar results as our preferred model, one may wish to see a linear specification of our instrument that yields a strong first stage and

is similar to the preferred estimates.

C.1 An Alternate Linear Instrument

The models thus far rely only on the differential change in the linear trend after recession onset by controlling for all common time effects with individual year fixed effects. While this makes for a compelling empirical design, the similarity of the estimates in Table 3 that included Bartik predictors for economic condition with and without the individual year fixed effects suggest that the this is not necessary for identification. Specifically, we show that the 2SLS estimates with and without year fixed effects are similar. As such, we relax the set of controls to allow for identification not only based on the differential time trend for high versus low reliant states, but also based on the linear change in the national trend (while controlling for common time shocks associated recessing timing itself).

Specifically, in lieu of individual year fixed effects to account for common time shocks, we include year group indicators to put individual calendar years into groups. In principle, the I_{post} indicator would control for changes in outcomes that occur after the recession. However, the recession was not a permanent shift, but rather a period of elevated unemployment between 2008 and 2011. To account for this transitory pattern, we also include year-group indicators I_{pre} for years 2007 and before, I_{during} for years 2009 and 2011, I_{after} for years 2013 and 205 , and $I_{longafter}$ for 2017. As before, while these timing indicators account for national economic conditions, we follow convention in the urban and regional economics (see Baum-Snow and Ferreira (2015)) and also account for *state-specific recessionary shocks* by including Bartik predictors of each state's unemployment rate *and* average income level in the state in C_{st}. As we show below, these controls remove systematic correlation between our instrument and economic conditions that predict our outcomes. We estimate equations as below by two-stage-least-squares (2SLS).

$$\begin{aligned} PPE_{st} = \pi_1(\Omega_s \times I_{post} \times [T-2008]) + \pi_2(I_{post} \times [T-2008]) + \rho_{11}(\Omega_s \times I_{post}) + \rho_{12}(I_{post}) + \\ \eta_{11} I_{pre} + \eta_{12} I_{during} + \eta_{13} I_{after} + \eta_{14} I_{longafter} + \delta_1 C_{st} + \alpha_{1s} + (\tau_{1s} \times T) + \varepsilon_{1st} \end{aligned} \tag{8}$$

$$\begin{aligned} Y_{st} = \beta \cdot (PPE_{st}) + \rho_{21}(\Omega_s \times I_{post}) + \rho_{22}(I_{post}) + \\ \eta_{21} I_{pre} + \eta_{22} I_{during} + \eta_{23} I_{after} + \eta_{24} I_{longafter} + \delta_2 C_{st} + \alpha_{2s} + (\tau_{2s} \times T) + \varepsilon_{2st} \end{aligned} \tag{9}$$

As before, the endogenous treatment, PPE_{st}, is per-pupil school spending in state s during year t. To capture the roughly linear-in-time decline in spending after the recession, which is most pronounced for more reliant states, we rely on *two* excluded instruments: the interaction between reliance on state funding in 2008 and the post-recession change in linear time trend, $\Omega_s \times R \times I_{post}$, and the overall linear change in trend after recession onset $I_{post} \times [T-2008]$. Importantly, because we use $I_{post} \times [T-2008]$ for identification, this linear IV model does not *solely* rely on the differential change in trend for high and low-reliance states. Instead, this model also uses the change in the linear trend for all states for identification, while controlling for the recession timing itself. Specifically, the school spending effect (in this model) is identified off the fact that the recession was a temporary decline in economic activity that recovered a few years later, while the decline of K12 spending for high-reliant states was roughly linear over time and continued well after the economy recovered (likely due to in part to the crowd-out effect documented in Figure 2.

The idea is that any change that is due to the recession should have peaked in 2009 and 2011, but should have dissipated by 2015 and certainly by 2017. In contrast, because the school spending declines associated with high reliance on state funds was linear over time and persisted well past the recession, a secular decline in outcomes after the recession onset (that is most pronounced in the most reliant states) and continues well after the recession ends can be attributed to school spending. Importantly, we will show that this identification strategy (so long as key control for economic conditions are included) yields similar results to our preferred model.

Results: The first stage using this alternate linear IV is presented in Table A22. In models both with and without

the Bartik controls or the year groups indicators, there is post recession trend increase for states that are not heavily reliant on state procured funding and negative slope for those that are highly reliant (consistent with the patterns in Table 2 without year fixed effects). The F-statistic on the excluded instruments with all controls (the Bartik controls and the year groups fixed effects) is 41.61.

Table A23 presents the effects using the alternative linear instrumental variables model with various sets of controls. Looking at NAEP scores, the point estimates are very similar to those in Table 3, while those for college-going are similar, but somewhat larger. Indeed, formal statistical tests fail to reject that the effects are the same at the 5 percent significance level for either outcome. Also note that in the preferred linear model (with Bartik controls and the year group effects) instrumented school spending is unrelated to predicted outcomes – further evidence that this alternative linear IV identification strategy is valid. Finally, Table A24 shows the distributional effects of school spending cuts using the linear IV. As one can see, the point estimate are very similar to those from the preferred models and also those from the model that uses both the linear IV and the group IV (while controlling for year fixed effects). In sum, the alternative linear IV models yield estimates that are statistically indistinguishable from our preferred models. As such, our results are robust across different modelling assumptions and somewhat different sources of identification.

C.2 Linear Instrument Tables

Table A20: First Stage, Linear and Linear + Group IV's

	(1)	(2)
	Per-Pupil Spending (thousands)	
$I_{post} \times \Omega_s$	-3.428	-0.498
	[2.596]	[3.430]
$I_{post} \times (.33 < \Omega_s < .66)$		-1.773
		[0.811]
$I_{post} \times (\Omega_s > .66)$		-2.883
		[1.827]
$I_{post} \times (T-2008) \times \Omega_s$	-0.943	-0.0985
	[0.347]	[0.418]
$I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$		-0.643
		[0.168]
$I_{post} \times (T-2008) \times (\Omega_s > .66)$		-0.887
		[0.254]
F(slope)	7.373	15.97
Observations	459	459
State Trends	X	X
State Fixed Effects	X	X
I_{post}	X^s	X^s
Bartiks	X	X
Year Fixed Effects	X	X

Notes: Robust standard errors in brackets cluster by state. This table reports the first stage of models including linear specifications of the instrument. Column (1) regresses per-pupil spending (in 2015 dollars) on $I_{post} \times \Omega_s$ and $I_{post} \times (T-2008)\Omega_s$, as well as state fixed effects, state trends, Bartik instruments, and year fixed effects. This model corresponds to equation (6). Column (2) adds additional variables that correspond to our group-level identification of the instrument. F(slope) reports the F-statistic for the variables indicating differences in post-trends of Ω_s ($I_{post} \times (T-2008) \times \Omega_s$ for column (1) and $I_{post} \times (T-2008) \times \Omega_s$, $I_{post} \times (T-2008) \times (.33 < \Omega_s < .66)$, and $I_{post} \times (T-2008) \times (\Omega_s > .66)$ for column (2)).

Table A21: Linear and Linear + Group Instruments (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Linear Instrument				**Linear + Group Instruments**			
	Average NAEP Score	*College Enrollment Rate*	*Slope*	*Black-White Gap*	*Average NAEP Score*	*College Enrollment Rate*	*Slope*	*Black-White Gap*
Per-Pupil Spending (thousands)	0.00681	0.00945	0.492	-0.0381	0.037	0.0125	0.383	-0.0607
	[0.0305]	[0.00867]	[0.551]	[0.0275]	[0.0114]	[0.00404]	[0.160]	[0.0343]
Weak Identification F-stat	7.373	10.39	1.584	6.958	15.97	24.58	10.49	17.33
Hansen J Statistic					3.107	1.352	3.45	2.284
Hansen J p-value					0.211	0.509	0.178	0.319
Observations	459	459	390	392	459	459	390	392
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s	X^s	X^s	X^s
$I_{post} \times I_{gs}$					X	X	X	X
$I_{post} \times \Omega_s$	X	X	X	X	X	X	X	X
Bartiks	X	X	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X	X	X
Weight			Test Count				Test Count	

Notes: Robust standard errors in brackets cluster by state. This table reports the results of 2SLS analyses that regress outcomes on instrumnted per-pupil spending. Columns (1)-(4) instrument for spending using the linear instrument $I_{post} \times (T - 2008) \times \Omega_s$, while columns (4)-(8) instrument for spending using the group instruments, $I_{post} \times (T - 2008) \times (.33 < \Omega_s < .66)$, in addition to the linear instrument. I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. I_{gs} is an indicator variable for whether the state's value of Ω_s is in the low, middle, or high group. The outcome variables examined here include Average NAEP Scores and College Enrollment Rates, as examined in Table 3, and Slope (a measure of test score regressivity) and the Black-White test score gap, as examined in Table 6. Models (3) and (4) also weight by the total count of test scores used to calculate the slope coefficient.

Table A22: First Stage: Alternative Linear Instrument

	(1)	(2)	(3)	(4)
	Per-Pupil Spending (thousands)			
I_{post}	0.875	1.453		
	[0.595]	[1.631]		
$I_{post} \times (T - 2008)$	0.264	0.107	0.275	0.112
	[0.209]	[0.315]	[0.242]	[0.337]
$I_{post} \times \Omega_s$	-1.954	-1.689	-1.954	-1.613
	[1.314]	[1.396]	[1.319]	[1.406]
$I_{post} \times (T - 2008) \times \Omega_s$	-1.012	-1.045	-1.012	-1.039
	[0.392]	[0.402]	[0.393]	[0.400]
F(Slopes)	25.61	44.8	28.24	41.61
Observations	459	459	459	459
State Trends	X	X	X	X
State Fixed Effects	X	X	X	X
Bartiks		X		X
Year Group Fixed Effects			X	X

Notes: Robust standard errors in brackets cluster by state. This table reports the first stage of models of an alternative linear specification of the instrument corresponding to Equation (8). I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. All models include state trends and state fixed effects. Models (2) and (4) also include Bartik instruments, while (3) and (4) also include year group fixed effects (indicators for time being before, during, or after the recession, or 2017). F(slope) reports the F-statistic for the variables indicating differences in post-trends, $I_{post} \times (T - 2008)$ and $I_{post} \times (T - 2008) \times \Omega_s$.

Table A23: Alternative Linear Instrument (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average NAEP Score				*College Enrollment Rate*			
Per-Pupil Spending (thousands)	0.0434	0.0281	0.0335	0.0316	0.0267	0.0299	0.0216	0.024
	[0.0101]	[0.0110]	[0.0115]	[0.0127]	[0.00422]	[0.00666]	[0.00464]	[0.00621]
Weak Identification F-stat	25.61	44.8	28.24	41.61	38.76	33.08	40.03	34.13
	Predicted NAEP Score				*Predicted College Enrollment Rate*			
Per-Pupil Spending (thousands)	0.00285	0.00392	0.00346	0.00466	0.00542	0.00555	0.00396	0.00486
	[0.00227]	[0.00286]	[0.00290]	[0.00303]	[0.00141]	[0.00256]	[0.00247]	[0.00316]
Observations	459	459	459	459	459	459	459	459
State Trends	X	X	X	X	X	X	X	X
State Fixed Effects	X	X	X	X	X	X	X	X
I_{post}	X	X	X^s	X^s	X	X	X^s	X^s
$I_{post} \times \Omega_s$	X	X	X	X	X	X	X	X
Bartiks		X		X		X		X
Year Group Fixed Effects			X	X			X	X

Notes: Robust standard errors in brackets cluster by state. This table reports the results of 2SLS analyses that regress outcomes on instrumented per-pupil spending using the linear instruments outlined in equation (8) and Table A22. The excluded instruments are $I_{post} \times (T-2008)$ and $I_{post} \times (T-2008) \times \Omega_s$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T-2008)$ represents years relative to the 2008-09 school year. All models control for state trends, state fixed effects, I_{post} and $I_{post} \times \Omega_s$. Additional models also include Bartik instruments and/or year group fixed effects (indicators for time being before, during, or after the recession, or 2017). The top panel regresses actual outcomes (NAEP scores and College Enrollment Rates) on instrumented spending, while the bottom panel regresses predicted outcomes on instrumented spending.

Table A24: Alternative Linear Instrument, Results by Race and Income (2SLS)

	(1)	(2)	(3)	(4)	(5)
	Slope	**Black-White Gap**	**Average NAEP Score by Race**		
			White	*Black*	*Hispanic*
Per-Pupil Spending (thousands)	0.261 [0.0639]	-0.0348 [0.0186]	0.0339 [0.00872]	0.0391 [0.0168]	0.022 [0.0121]
Weak Identification F-stat	54.03	44.62	34.07	28.02	115.3
Observations	390	392	452	392	402
State Trends	X	X	X	X	X
State Fixed Effects	X	X	X	X	X
I_{post}	X^s	X^s	X^s	X^s	X^s
$I_{post} \times \Omega_s$	X	X	X	X	X
Bartiks	X	X	X	X	X
Year Group Fixed Effects	X	X	X	X	X
Weight	Test Count		White Population (2000)	Black Population (2000)	Hispanic Population (2000)

Notes: Robust standard errors in brackets cluster by state. This table replicates Table 6 using the alternative linear instruments outlined in equation (8) and Table A22. The excluded instruments are $I_{post} \times (T - 2008)$ and $I_{post} \times (T - 2008) \times \Omega_s$, where I_{post} is a dummy variable equal to 1 if the observation is after 2008, Ω_s represents the share of the state's education funding from state sources in 2008, and $(T - 2008)$ represents years relative to the 2008-09 school year. All models control for state trends, state fixed effects, I_{post} and $I_{post} \times \Omega_s$, Bartik instruments, and year group fixed effects (indicators for time being before, during, or after the recession, or 2017). The variable "Slope" is computed by regressing individual-level NAEP scores on the district poverty rate (in 2007) for each year in each state, through 2015.