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Who Benefits from Local Financing of Public Services? A Causal Analysis

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Abstract

The efficiency-equity trade-offs in public service delivery may be influenced by the dependency of local governments on their own resources rather than inter-governmental grants. School districts in the United States are expected both to produce human capital efficiently and to provide educational opportunity equally. To ascertain school district trade-offs, we estimate effects of revenue source on student performances in math and reading. Achievement is estimated from 225,000 observations weighted to be district representative. Estimates are made with OLS, geographic discontinuity models exploiting differences at state borders, and 2SLS models that use changes in housing prices as an instrument. For every 10 percent increase in local revenue share, achievement increases by a sizeable 0.02 to 0.06 standard deviations. Gains for students from low socio-economic backgrounds are about half those from higher ones. Both voice and exit channels moderate the efficiency-equity trade-off. Implications for federalism and state policy are discussed.

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1 Introduction

Public policy often requires trade-offs between efficiency and equality. Efficiency may generate economic growth but at the price of growing inequality (Hochman and Rodgers, 1969). In the United States, the lowest tier of government is regularly tasked with finding a balance between efficiency and equity. Local governments are thought to give efficiency higher priority if their revenues come from local sources (Oates, 1972; Peterson, 1981; Tiebout, 1956).

Localities expend a larger share of fiscal resources on elementary and secondary education than on any other public service. In 2007 K-12 education expenditures accounted for 35 percent of all local government spending, or over $455 billion (US Bureau of the Census, 2019).[1] A large share of these expenditures are obtained from property taxes and other local revenues. In 2007, 45 percent of school revenues came from local sources, 45 percent from state grants, and the remaining 11 percent from the federal government (Snyder, de Brey and Dillow, 2019). The mean masks wide variation across the country. In our data set, the share of total revenues coming from local sources ranges between one percent and 92 percent, with an inter-quartile range of 31 percentage points. The local revenue share has declined over time. In 1920, 83 percent of all revenues came from local governments, but with the consolidation of school districts and the growth of the inter-governmental grant system, the percentage declined to 44 percent by 2007 (Berry and West, 2008). Still, the national average is twice as large as the mean of 22 percent for all member countries of the Organization for Economic Cooperation and Development (OECD, 2014).

Education is also an arena in which discussions of the efficiency-equity trade-off are intense. Schools are supposed to enhance human capital and contribute to national growth (Hanushek and Woessmann, 2012; Murnane et al., 1995) but are no less expected to provide all students with equal educational opportunities (Coleman et al., 1966). While school officials usually promise to secure both objectives, trade-offs are likely.

[1]Local expenditures include all expenditure by counties, municipalities, townships, school districts, and special districts.

Student performances on standardized tests provide a window on the efficiency-equity trade-off in education. After adjusting for student background, test scores are predictive of important life outcomes, such as college enrollment, degree attainment, earnings in adulthood, teen-age pregnancy rates, and rates of criminal activity (Chetty, Friedman and Rockoff, 2014*a*,*b*).[2] At state and national levels, performance on standardized tests have been shown to be correlated with economic growth rates (Hanushek and Woessmann, 2012). When tests are used to assess the educational efficiency and equity of U.S. schools, they seem to fall short on both sides of the trade-off. U.S. mean student performance on international tests in math, reading and science ranks well below that of many other countries (Hanushek, Ruhose and Woessmann, 2016; Pál, Marec and SchwabeHenderson, 2019). Meanwhile, the divide between those at the top and bottom deciles of the income distribution may have increased over the past half century (Reardon, 2011).

The U.S. Supreme Court has found no constitutional basis for addressing these issues. In *San Antonio Independent School District v. Rodriguez* (1973), the Court said that, even though a state could not segregate students by race *Brown v. Board of Education* (1954), education was not a right guaranteed by the Constitution and therefore district disparities in per pupil expenditures do not violate the equal protection clause of the Fourteenth Amendment. However, the Fourth Circuit Court of Appeals in *Gary B. v. Whitmer* (2020), has revisited this question and further litigation is probable (Ogletree and Robinson, 2015). At the state level, California's highest court, in *Serrano v. Priest* (1976), ruled that per pupil expenditure disparities violate its state constitution and ordered larger grants to districts with fewer local resources. Other state courts have issued similar rulings, and, in many states, finance policy has been declared unconstitutional because it is both inequitable and inadequate (Hanushek, 2006; West and Peterson, 2007). Still, serious fiscal inequalities between

[2] However, the tests do not directly measure other desirable educational outcomes, such as socio-emotional learning, grit, trustworthiness, or civic-mindedness.

districts persist (Brunner, Hyman and Ju, 2018; Guin et al., 2007; Lafortune, Rothstein and Schanzenbach, 2018).

Federalism research has explored each side of the efficiency-equity trade-off. Scholars have theorized that the local tier of government is more efficient than higher tiers, and moral hazards arise if local government services are funded from other than local sources (Cutler and Zeckhauser, 2000; Rodden, 2006, 2016; Tiebout, 1956). Empirical studies (Berry, 2009; Lastra-Anadón and Mukherjee, 2019; Ostrom, Parks and Whitaker, 1973) have shown that services are more efficiently provided if funded locally. But these analyses of local efficiency typically ignore the distributional consequences of local finance.

On the equality side, a robust literature has documented the conservative bias of local government (Ejdemyr, 2017; Oates, 1972; Peterson, 1981; Rae, 2008; Trounstine, 2018). However, states reduce inequalities if left-oriented parties are in power (Kelly and Witko, 2012). In education, court-ordered reforms and other state policies reduce expenditure inequalities and narrow achievement gaps across socio-economic divides (Jackson, Johnson and Persico, 2015; Lafortune, Rothstein and Schanzenbach, 2018), particularly if teacher unions are influential (Brunner, Hyman and Ju, 2018). But these studies have not estimated equity-efficiency trade-offs within districts.

In this paper we build on prior research on efficiency and equity in the delivery of local services by simultaneously estimating the effects of variation in funding from local revenue sources (rather than from inter-governmental grants) on mean levels of student achievement and heterogeneities by student SES. Specifically, we estimate effects of variation in the local district revenue share on the combined math and reading performances on tests administered by the National Assessment of Educational Progress (NAEP) to more than 225,000 nationally and state representative 8th grade students in 2007. Post-stratification weights are applied to make observations representative at the district level. We identify the efficiency of service delivery by estimating the effects of funding arrangements on mean performances in the two subjects. We estimate heterogeneous effects by SES, using as indicators student reports of parental attainment and administrative data on household income, as measured by student eligibility for free and reduced lunch.

After showing the simple relationship between local revenue share and mean student achievement, we estimate relationships with ordinary least squares (OLS) models that control for a wide range of student background characteristics (income, education, ethnicity, gender, special education status, and English Language Learner status) included in the NAEP data set as well as a set of school district characteristics obtained from the 2000 U. S. census (per pupil expenditures, mean household income, mean house values, percent urban, and percent of adults above the age of 25 with a college degree. See Online Appendix Table B.1 for summary statistics. We use similar models to estimate heterogeneous effects by SES.

Since relationships may be endogenous even after controlling for a wide array of observables, we next estimate effects with two causal models. First, we employ geographical discontinuity regressions to estimate effects on achievement levels in districts at borders of states with disparate fiscal regimes (Tolbert and Sizer, 1996). The differences in funding shares of bordering districts are plausibly exogenous if observed characteristics of those on either side of state borders do not differ significantly and if observables capture differences in "taste for education". Second, we estimate the effects of local revenue share on achievement with two-stage least squares (2SLS) models that use changes in housing prices between 2000 and 2007 as the instrument for local revenue share. These models exploit the apparently irrational and highly uneven upward shift in housing prices between 2000 and 2007 (Glaeser and Nathanson, 2015).

The OLS, geographic discontinuity, and 2SLS models all find efficiency effects of an increase in local revenue share, and all models show a trade-off between efficiency and equity. Estimations show that 8th grade math and reading performances are approximately 0.02 to 0.06 standard deviations higher for every 10 percent increase in the share of revenues received from local sources. The efficiency gains come at the price of equity. Most models show gains are about twice as large for students from higher SES backgrounds as for those from lower ones.

We follow Hirschman (1970) by exploring both "voice" and "exit" channels as potential moderators that connect local revenue share to outcomes. Prior research has shown a positive relationship between achievement and both pupil-teacher ratios and the instructional share of school expenditures (Brewer, 1996; Jacques and Brorsen, 2002; Krueger, 1999; Wenglinsky, 1997), and opinion surveys have identified strong public support for smaller class sizes and higher salaries for teachers, both costly instructional expenses (Peterson, Henderson and West, 2014). Consistent with this literature, we show both that pupil-teacher ratios decline and the share of expenditures allocated to instruction increases with increments in the share of funding from local sources. We then show that the share of resources allocated to instruction and pupil-teacher ratios are both correlated with student achievement (controlling for district characteristics, including expenditure levels). These results suggest that the voice channel may be a moderator of the connection between local revenue share and achievement. However, we cannot exclude the possibility that school boards choose these policies not simply because voters prefer them but also because they wish to forestall potential exit to other localities.

To ascertain exit effects more fully, we, following (Hoxby, 2000), hypothesize that exit potential is greater when school districts are more densely concentrated within a geographic area and that districts are responsive to exit potential if their funding comes from local sources. Our results are consistent with these hypotheses. We find that local revenue share has a larger impact on mean achievement in commuter zones with greater district density. Exit potential also heightens the efficiency-equity trade-off. Positive effects are greater for students from more advantaged backgrounds. We infer that the efficiency-equity trade-off at the local level is moderated by both the voice and exit channels.

Our concluding discussion considers the implications of the efficiency-equity trade-off for inter-governmental grants such as those under consideration by courts in equity and adequacy lawsuits. We estimate that a 50 percentage point shift in the share of revenue coming from intergovernmental grants would reduce the SES-achievement gap by about 0.1 of a s.d. by 8th grade. But the shift would also positively affect student learning by about twice this amount for the average 8th grader.

The paper is divided into five sections. The next section describes data and sources; the third presents our analytical models; the fourth shows our results; and the fifth discusses. A review of the federalism literature bearing on this topic is available in an Online Appendix, which also presents supplementary results in tables and a figure.

2 Data

The main sample consists of 110,240 math and 115,970 reading test performances on the National Assessment of Educational Progress (NAEP) administered under the auspices of the National Center for Educational Statistics (NCES) to nationally representative and state representative samples of students (Rogers and Stoeckel, 2008).[3] Observations are weighted to be district representative (Little, 1993).[4] In all analyses we combine results from math and reading test-takers. Similar results obtain for each subject (See Online Appendix Table B.3).[5] All outcomes are reported in standard deviations, which are calculated by converting test scores into z-scores for each subject (the difference between the student's average and the sample mean, divided by the standard deviation of the sample).[6]

[3]Researchers with restricted-use data licenses may obtain NAEP individual-level microdata from the NCES, which has approved for disclosure all results reported in this paper.

[4]This differs from the weighting used by Rogers and Stoeckel (2008, p. 45), who weight data to be representative at the state level. Our results are robust to either weighting scheme.

[5]Student's performance on the test is estimated by NAEP from the portion of the test taken by that individual; we take the average of the first five plausible values the NAEP estimates for each observation. Results are robust to the use of the first plausible value instead of the average of the first five. See Online Appendix Table B.2.

[6]As Jacob and Rothstein (2016) note, there is no guarantee of comparability of transformations across samples that use different scales. We are fortunate in that we use a homoge-

Our main independent variable is the local share of revenue in the test-taker's school district for the school year 2006-07, as reported in the NCES Common Core of Data (NCES, 2019). We divide the total local revenue (TLOCREV) by the total revenue (TREV) from all local, state, and federal sources.[7] Per pupil expenditure data also come from this source.

The NAEP dataset contains two binary variables, household income and parental education, which we use to estimate SES. Forty-four percent of sampled students are classified as low-income rather than high-income based on administrative records of eligibility for participation in the free and reduced lunch program, which in 2007 was limited to those from households with incomes of no more than 180 percent of the poverty line. Fifty-two percent of students are classified as having parents with a high rather than low educational attainment level depending on whether or not students reported at least one parent had earned a four-year college degree (Rogers and Stoeckel, 2008). NAEP also provides the other individual level co-variates used in the analysis, including gender, special education status, English language learner status, and disadvantaged minority (neither white nor Asian) status.

We obtain from the US Bureau of the Census (2019) district-level co-variates as of 2000 –household median income, median house price, percent urban, and percent of those 26 years and over with a 4-year college degree. In the analytical strategy that leverages house prices, we use the 741 commuting zones defined by the Bureau of the Census based upon the contrast in the intensity of self-reported commuting patterns within and across counties in 1990 (Tolbert and Sizer, 1996). For other scholarly uses, see Autor and Dorn (2013); Chetty et al. (2014). House prices by zip code are obtained from the Zillow Home Value Index (Zillow, 2018), which estimates them from sales prices and public records (for its use see e.g.

neously scaled exam for the whole country, which gives us confidence in our within sample estimates. However, we avoid comparisons of our results with other interventions.

[7]TLOCREV is defined as "revenues from such sources as local property and non-property taxes, investments, and revenues from student activities, textbook sales, transportation and tuition feed, and food service revenues" (NCES, 2019).

Guerrieri, Hartley and Hurst, 2013). A sizeable share of zip codes within the United States does not have a sufficiently thick housing market to generate reliable estimates. House price data are available for just 72 percent of the weighted observations in our sample.

3 Analytical Strategies

We estimate the relation between a district's local revenue share and student performance with the following regression specification:

$$Y_{ids} = \beta L_d + \delta \mathbf{X_i} + \xi \mathbf{D_d} + \gamma E_d + B_s + R_i + \epsilon_{ids}, \tag{1}$$

where Y is the NAEP test score for individual i in district d, in state s, measured in standard deviations, and L is the local share of revenues in the district. In certain specifications, we include $\mathbf{X}$, a vector of individual-level covariates, including binary indicators for income, education, as well as gender, special education status, English language learner status, and disadvantaged minority (neither white nor Asian) status. $\mathbf{D}$ are 2000 district demographics from the school district: household median income, share urban, share of those 26 and older with a 4-year college degree, and median house prices. E is current per pupil expenditure in the district, B, state fixed effects, R, an indicator for whether the test is a reading or math test and ϵ is the error term, which we cluster by district d to account for interactions among student observations within a school district.

When analyzing heterogeneous effects we consider cleavages driven by differences in either the income indicator or level of parental education, by adding the interaction term $L_d \times SES_i$ in addition to using these SES_i variables as co-variates:

$$Y_{ids} = \zeta L_d \times SES_i + \beta L_d + \eta SES_i + \delta \mathbf{X_i} + \xi \mathbf{D_d} + \gamma E_d + B_s + R_i + \epsilon_{ids} \tag{2}$$

Estimation of those models via OLS may be biased by an endogenous relationship between revenue share and student performance. For example, observables may not distinguish those who seek high quality schools by migrating to districts that receive more of their funding from local school revenues. To estimate causal effects, we use geographic regression discontinuity models that exploit funding formula discontinuities at state borders and predict local revenue share with an instrument that exploits the seemingly irrational boom in housing prices between 2000 and 2007. We explain each approach next.

3.1 Geographic Discontinuities Across State Borders

Since intergovernmental grants are largely determined at the state level, students attending schools close to state borders may find themselves in districts receiving widely disparate funding shares via inter-governmental grants. The discontinuity may be used to estimate causal effects on student performance if other unobserved state policies do not affect performance and if observed differences in the background characteristics of both students and districts near borders capture all unobserved difference.[8]

To estimate a local average treatment effect of differences in local revenue share near state borders, we employ a fuzzy geographic regression discontinuity design with linear distance of the student's school to the border as the running variable. The effect of local revenue share is estimated as the magnitude of the difference between linear intercepts at the border between higher and local revenue share states. Following Cattaneo, Idrobo and Titiunik (2019, ch. 4.2), we select the bandwidth that minimizes the mean squared error (MSE) of the point estimator. In the estimation of the mean effect, the bandwidth is 11.9 km (7.39 miles) on

[8]Similar causal estimations inferred from policies or institutions with geographical variation have been used to study the effects of urban policies in US cities (Gerber, Kessler and Meredith, 2011), media penetration on political attitudes (Kern and Hainmueller, 2009), ballot initiatives on voter turnout (Keele and Titiunik, 2015), and teacher union effects (Brunner, Hyman and Ju, 2018).

either side of the border. The bandwidth contains 17,140 student observations located within 236 school districts, along 25 state borders.

To be consistent in our estimates of the efficiency-equity trade-off, we use the same bandwidth to estimate heterogeneities by SES. In a robustness check, we also estimate effects that use the optimal bandwidth for each subgroup specification. We also follow Keele and Titiunik (2015) by estimating effects using three alternative bandwidths of 10km., 20km., and 30 km. in order to mitigate concerns about linear indicators in contexts where distance is bi-dimensional. In the implementation of this strategy, we restrict our sample of students to those living near the borders of states with fiscal regimes that differ by an average of ten percentage points or more. Consistent with Keele and Titiunik (2015), we further restrict the sample to borders where student ethnicity (white and Asian versus others) does not differ by more than 10 percentage points.

By restricting the sample to borders and bandwidths that meet these specifications, we observe students who (with one exception) have characteristics that do not significantly differ on either side of the border. We also see no significant difference in seven observable district characteristics (including expenditures per pupil) and three state policies that affect teacher effectiveness.[9] The observed individual and district characteristics are the same as the thirteen used in our OLS model 2 presented in Table 2. The estimated covariate differences at the borders are shown in Table 1. The one exception where we do observe a difference is the share of English Language Learners on either side of the border. The sign on this variable is negative, which indicates that the percentage is greater on the side of the border

[9]The strength of teacher unions is affected by right-to-work laws, an indicator we prefer to collective bargaining agreements, because the latter are set at the district rather than the state level. Licensing and certification practices affect the flexibility with which districts can recruit teachers. Some states allow alternatives to traditional state licenses obtained by earning a given number of courses in teacher education. Performance pay policies are expected to reward and retain the more effective teachers.

with districts more dependent on local revenue, a value that potentially biases our estimates toward zero. Ten of the fifteen variables for which differences are insignificant also had signs that potentially biased estimates towards zero. In our estimated models, we control for three state policies that affect teacher quality because the effectiveness of the teacher is the school factor most closely correlated with educational outcomes (Chetty, Friedman and Rockoff, 2014*b*).[10]

We also test whether there is "bunching", that is a piling up of observations on one side of state borders. Bunching might suggest strategic migration of individuals to take advantage of the discontinuity, undermining the plausibility of the exogeneity assumption. We see no evidence of bunching on a particular side of the border, though we do see greater population density along state borders, probably because rivers, which are often used to mark state borders, are an historic means of transport that attract dense populations (See Online Appendix Figure B.1). Crucially, the spike in observations at state borders is symmetrical on either side of the border. The slight difference in number of observations on either side is not unusual in size compared to other discontinuities occurring at other arbitrary "placebo" thresholds of distance to the state line. Following Cattaneo, Jansson and Ma (2019), based on McCrary (2008), we perform a formal density manipulation test to establish whether there are unusual discontinuities in the density on either side of the border. In particular, we test whether the estimated difference in densities on approaching the border from each side is significantly different from zero (estimated using local polynomials of degree 2 and the MSE-optimal bandwidth). The test statistic for the hypothesis of there being a difference between density on the left and right of the border is an insignificant T=-1.03.

[10]As discussed in Cattaneo, Idrobo and Titiunik (2019, ch. 4.4) including covariates in the regression discontinuity specifications should not affect our point estimates if, as we show, covariates are orthogonal to the discontinuity treatment. However, they serve to increase the precision of our treatment estimates.

Table 1: Geographic regression discontinuity estimates of differences in covariates at borders of states with contrasting local shares of revenue

Individual-level covariates		*District-level covariates*	
Variable	Estimate	Variable	Estimate
Low Income	0.01334	Right to work state	-0.09093
	(0.03687)		(0.1245)
Low Education	-0.03697	Alternative certification	-0.03661
	(0.04005)		(0.04556)
White or Asian	-0.0081	Performance pay policy	0.02014
	(0.03172)		(0.0817)
Disabled	-0.03339	Share white	0.05108
	(0.02277)		(0.0312)
English Learner	-0.04905*	Share low income	-0.21087
	(0.01905)		(0.04582)
Index of disadvantage	-0.02029	Share commute >30min	.03128
	(0.01605)		(.02438)
Male	-0.03859	Expenditure per pupil	0.8989
	(0.04178)		(0.5193)
		Own house value	-15676
			(22513)
		Household income	-1247.3
			(1126.8)

Note: Estimate is the effect of location in a high local revenue share state. Estimations restricted to borders of states with differences in average local share of revenue of ten percentage points or more and difference in non-white or Asian share is less than 10 percent. Index of disadvantage is the average of the listed individual social indicators (above that line). Uses `rdrobust` software of Cattaneo, Idrobo and Titiunik (2019), implemented with the MSE-optimal bandwidth for the pooled analysis on zscores and a triangular kernel. (11.9 km. across the state border). Robust standard errors, clustered by district, are in parentheses. $^{+}$ 0.10, * 0.05, ** 0.01, *** 0.001

The geographic discontinuity estimates are local average treatment effects only for those students attending schools in districts near borders of states with different funding regimes. To estimate causal effects for a larger share of the sample, we also employ a 2SLS model that exploits the changes in housing prices between 2000 and 2007.

3.2 House Price Changes and Local Revenue Share Changes

As a separate source of plausibly exogenous variation, we use unanticipated, short-term changes in housing prices between 2000 and 2007 as an instrument for local revenue share. During this period housing prices in the average zip code within the continental United States increased by 7.6 percent each year or by a cumulative 75 percent. The increases varied widely, with some zip codes reporting 25 percent increases annually. Economists do not agree on the causes (Shiller, 2007). Some attribute it to the ready availability of subprime loans (Mayer and Pence, 2008), while others think "trend-chasing" can drive up prices in specific markets (Glaeser and Nathanson, 2015). That prices were frothy and seemingly irrational during the period has been offered as a factor contributing to the financial crisis of 2008 (Mishkin, 2009; Taylor, 2009).

The apparently irrational and unanticipated nature of much of the growth in housing values between 2000 and 2007 makes price changes within commuting zones a useful instrument for estimating changes to local revenue shares. While rapid and erratic price changes can be expected to have a direct impact on revenues from the property tax within each commuting zone, they are unlikely to have any direct or indirect impact on student test scores except via their impact on local tax resources. To minimize any endogenous effects of school quality on price change, we control for math performance in 2000 (the subject in which NAEP tested students that year), and we estimate predicted price changes at the commuting zone level (CZ) rather than at the school district level.

Changes in house prices on local revenue share are likely to be substantial. Most districts depend heavily upon the property tax. These rates are sticky (Davis and Ferreira, 2017; Lutz, 2008), in part because local assessments of property values typically are periodic. The lag can be expected to boost local revenues for school districts. It can also be expected to reduce the size of inter-governmental grants, since state funding formulas tend to favor districts with more limited taxable resources (Chingos and Blagg, 2017). The combined effect of a growth in local resources and reduced state grants in districts with sharp rises in housing values can be expected to shift upward the share of resources generated locally.

For the first stage, we use equation (3) to predict local share of revenue in 2007 with changes in house prices, controlling for math performance in 2000, and all individual level and 2000 district characteristics, including house prices, that are used in Table 2, model 2.

Specifically, the first stage equation is:

$$\widehat{L_d^{2007}} = \beta \triangle HP_{cz} + \eta L_d^{2000} + \delta \mathbf{X_i} + \xi \mathbf{D_d} + \theta M_d^{2000} + B_s + \epsilon_{ids}, \tag{3}$$

where $\widehat{L_d^{2007}}$ is the predicted level of local revenue share in 2007 in district d, and $\triangle HP_{cz}$ is the change in house prices 2000-07 in the commuting zone in which d is located. L_d^{2000} is the observed local revenue share in 2000 and M_d^{2000} is the average math scores in 2000. Remaining variables are defined as in equations (1) and (2).

In the second stage, we take these predicted values from (3) to estimate the 2SLS effect of local revenue share in 2007 on test scores, controlling for 2000 local revenue share, math averages, and all 2000 district controls and state fixed effects, as in equation (1) (implemented in Table 2, Model 2). We use equation (4) to estimate mean effects, and (5) to estimate effects by socioeconomic subgroup:

$$Y_{ids} = \beta \widehat{L_d^{2007}} + \eta L_d^{2000} + \theta M_d^{2000} + \delta \mathbf{X_i} + \xi \mathbf{D_d} + \gamma E_d + B_s + R_i + \epsilon_{ids} \tag{4}$$

$$Y_{ids} = \zeta \widehat{L_d^{2007}} \times SES_i + \beta \widehat{L_d^{2007}} + \eta SES_i + \delta \mathbf{X_i} + \xi \mathbf{D_d} + \eta L_d^{2000} + \theta M_d^{2000} + \gamma E_d + B_s + R_i + \epsilon_{ids} \tag{5}$$

In a robustness check we predict changes in local revenue share between 2003 and 2007 with housing price changes between 2000 and 2007, and this predicted change is then used to predict achievement in 2007 while controlling for achievement in 2003.[11]

4 Results

We report results from OLS models, geographic discontinuity models, and 2SLS models that use changes in house prices as instruments. In most estimations an efficiency-equity trade-off is detected.

4.1 OLS models

Table 2 displays the results of the following four OLS models that estimate the impact of local revenue share on mean educational outcomes in math and reading: 1) a simple relationship between local revenue share and educational outcomes; 2) relationships after controlling for student background characteristics, 2000 district characteristics, per pupil expenditure and state fixed effects; 3) model 2 plus the inclusion of a term that interacts the low income indicator with local revenue share; and 4) model 2 plus a term that interacts the low education indicator with local revenue share.

Results in models 1 and 2 in Table 2 suggest that local governments are more efficient if revenues come from local sources. The simple model 1 indicates that average student math performance increases by 0.09 standard deviations for every ten percentage point increase in the share of revenue coming from local sources. The effect is reduced to 0.05 s.d. in model 2, when per pupil expenditure, individual characteristics, district demographic characteristics, and state fixed effects are introduced as controls. The two remaining models indicate an efficiency-equity trade-off: students from higher SES backgrounds disproportionately benefit

[11] For a recent use of a similar strategy see Deming and Walters (2017).

Table 2: OLS estimated relationship between local share of revenue and student achievement, math and reading combined.

	(1)	(2)	(3)	(4)
Local revenue share	**0.0943*****	**0.0530*****	**0.0599*****	**0.0744*****
	(0.00757)	(0.00497)	(0.00525)	(0.00659)
Low Income X Local revenue share			**-0.0158*****	
			(0.00459)	
Low Education X Local revenue share				**-0.0287*****
				(0.00488)
Low Income		-0.282***	-0.204***	-0.283***
		(0.00678)	(0.0187)	(0.00673)
Low Education		-0.205***	-0.204***	-0.105***
		(0.00635)	(0.00623)	(0.0160)
Per pupil expenditure		-0.0121**	-0.0122**	-0.0127***
		(0.00386)	(0.00380)	(0.00378)
Number of students	226210	194950	194950	194950
Number of districts	3,033	2,959	2,959	2,959
R^2	0.054	0.259	0.259	0.260

Test scores in standard deviations, from the average of first five plausible values. Local revenue share in 10 percentage point units. Per pupil expenditure in thousands of dollars of current expenditure. Weighted observations are district-representative. Income indicated by free or reduced lunch; (parental) education is indicated by college degree for at least one parent. Observations rounded to nearest tenth to comply with privacy requirements. Models 2, 3, and 4 include state fixed effects, a reading test indicator and individual controls for disability (Individualized Education Program), English learner, Race (White or Asian) and Gender. They also include district controls for 2000: share White or Asian, household median income, share urban, and share of those age 26 and older with a 4-year college degree, as well as median house prices. Robust standard errors, clustered by district, in parentheses. Sources: NAEP 2007; NCES 2007; U.S. Census Bureau's Education Demographic and Geographic Estimates project (EDGE).

$^{+}$ 0.10, * 0.05, ** 0.01, *** 0.001

from greater local funding.[12] For every 10 percent increase in local share, the performance of low-income students increases by just 0.04 standard deviations as compared to 0.06 standard deviations for high-income students (model 3). In Model 4, the increase for students of parents with less than a college degree is just 0.04 s.d., while for students with higher levels of parental education it is 0.07 s.d.[13]

[12]Heterogeneous effects by ethnicity are similar to (though smaller than) SES heterogeneities. See Online Appendix Table B.4.

[13]In Online Appendix Table B.5 we show results from a similar analysis using test score data from the Stanford Education Data Archive (SEDA) (Reardon et al., 2017). This dataset contains comprehensive data on the aggregate test scores for districts on state tests in grades three through eight, from 2009-2016 in reading and math. The state tests are "high stakes" tests required by the federal law, No Child Left Behind, that were used to assess the performance of school districts, schools, and, in some cases, teachers and students. The usefulness of "high stakes" tests as indicators of student performance has been questioned, given the incentives to over-prepare test-takers, discourage participation by low-performing students, and even to cheat (Jacob and Levitt, 2003; Koretz, 2002). The dataset has other challenges. Each state has its own proficiency tests and standards, and strong assumptions must be made when performances on those tests are placed on a common scale by linking each state's performances on NAEP to the state's own proficiency standards (Jacob and Rothstein, 2016). Further, the dataset lacks information on individual student performance and student background characteristics, and only mean performance in aggregate and by ethnic (not SES) subgroup is available. However, one can estimate the effects of local revenue share on the mean scores in each district, controlling for district (if not individual) characteristics and one can estimate effects on achievement by ethnicity (if not by SES).

Despite our strong preference for the NAEP-administered low-stakes tests, which are the same throughout the United States, we conduct a robustness check using 2011 SEDA data, which does not include 2007 test score performance. By that year schools had had the opportunity to recover from the Great Recession (NBER, 2020). Results show an efficiency-

The OLS relationships we have just described are displayed graphically in Figure 1. Notice that all lines have an upward slope but diverge as the percentage of revenue from local resources increases. A local revenue stream appears to lift all boats even though luxury liners rise higher than canoes.

4.2 Geographic Discontinuity Across State Borders

We also find efficiency effects of local funding when employing the geographic discontinuity model. For the first stage of the discontinuity regression, we estimate a 15.6 percentage point average difference in local revenue share at state borders (see Figure 2). At the second stage, we estimate that this difference has an effect on achievement of 0.09 standard deviations (Table 3). The effect on achievement of this 15.6 percentage point difference in revenue share is equivalent to a 0.06 standard deviation increase for every 10 percentage point increase in local revenue share, a result very similar to the 0.05 effect estimated by Model 2 in the OLS estimations reported in Table 2.

A trade-off between efficiency and equity is detected when the geographic discontinuity model estimates heterogeneous impacts, though equity estimations are noisy, given the smaller sample size. We show in Table 3 substantial, statistically significant effects at the border of 0.13 standard deviations on the achievement of students from high income households but no significant effects for students from low-income ones. However, we do not detect significant SES differentials when using parental education as our SES indicator.

Online Appendix Table B.6 shows results from the MSE-optimal bandwidth for subgroup specifications and Table B.7 displays the same for bandwidths of 10 km., 20 km., and 30 km. Efficiency effects of local funding are consistently observed in all estimations, as are directionally similar adverse effects on equity. Some of the latter estimates fall short of standard

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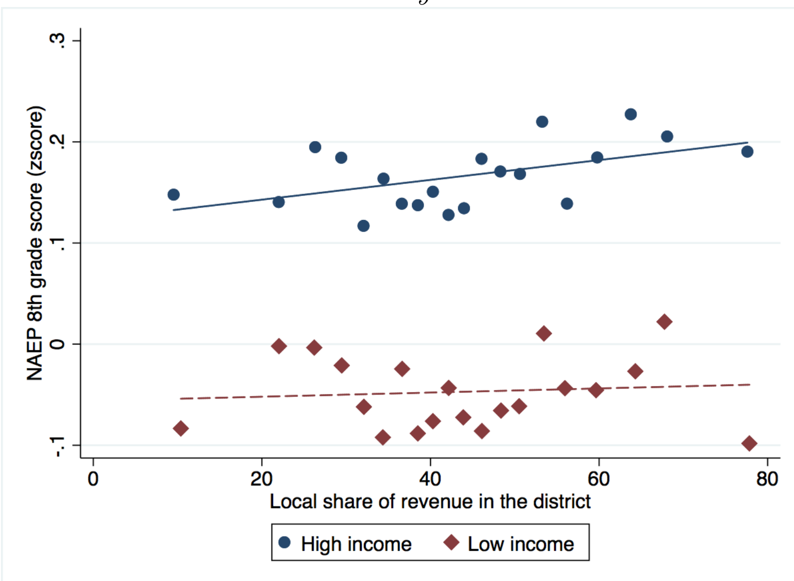
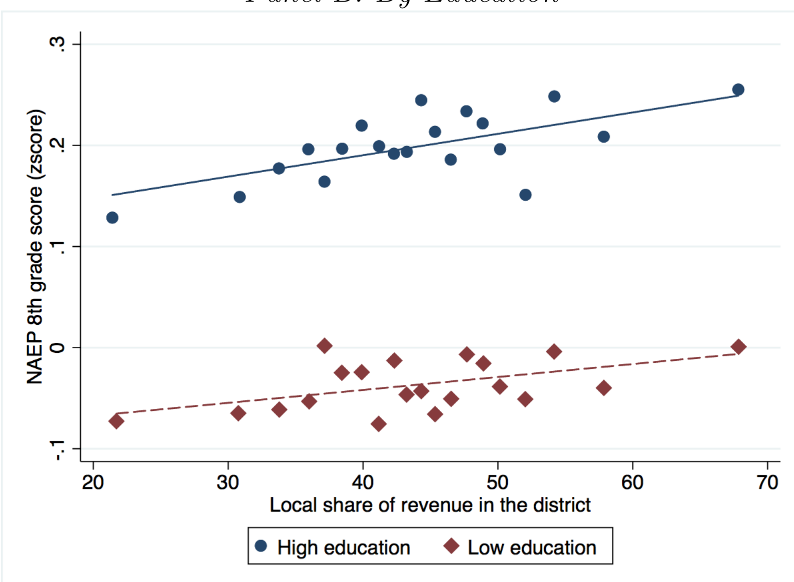
equity trade-off not unlike that reported in our main analyses, However, the magnitude of both the efficiency gains and the equity disparities by ethnic and racial background are somewhat larger than we otherwise find.

Figure 1: Relationship between local share of revenue and student achievement, as estimated in models 3 and 4 of Table 2

Panel A: By Income

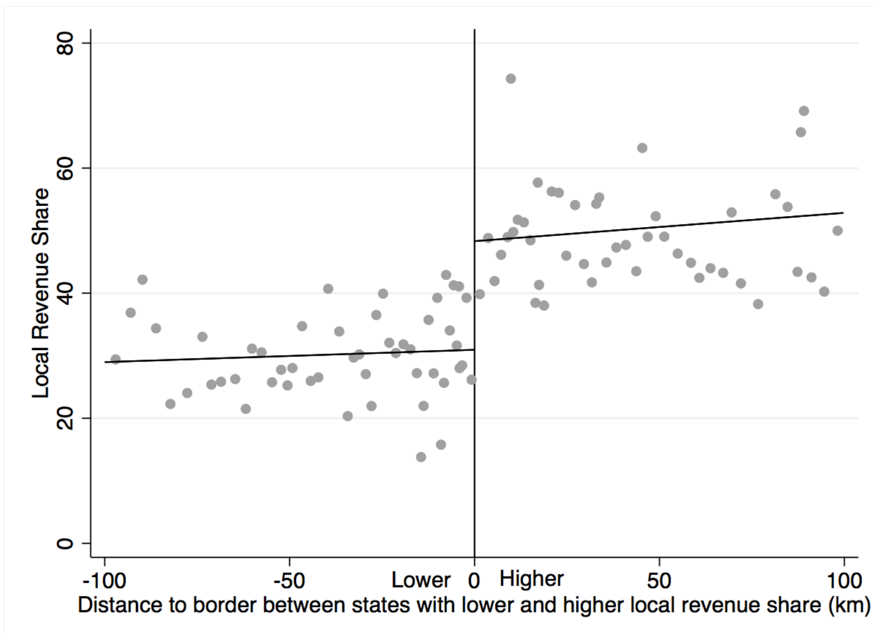


Panel B: By Education



Individual observations are grouped into 20 equally sized bins.

Figure 2: Estimated differences in local revenue share in districts near borders included in geographic discontinuity model (first stage)



Note: Means for observations grouped in 50 equally sized bins on each side of 25 state borders.

levels of statistical significance, however. In sum, results from the geographic discontinuity models tend to confirm the efficiency-equity trade off estimated in the OLS models.

4.3 Housing Price Changes in 2SLS Models

We predict local revenue shares in 2007 with changes in house prices in the commuting zone between 2000 and 2007. The first stage model shows a 0.36 correlation between changes in housing prices 2000-07 and local revenue share in 2007 when controlling for 2000 math scores, for individual characteristics, district characteristics including house prices in 2000, and state fixed effects, as in OLS model 2 in Table 2. In the second stage, we estimate a 0.02 s.d. effect on mean effect for each predicted 10 percentage point increase in local revenue share (model 2, Table 4), as compared to the 0.05 s.d. effect estimated from in OLS model 2 in Table 2. In models 3 and 4 of Table 4 we show heterogeneous effects by SES that suggest an efficiency-equity trade-off. A predicted 10 percent increase in local share has an 0.02 s.d. effect on high SES students and nil to negative impacts on low SES students (see bolded estimates in Table 4).

In the robustness check that estimates the effects on achievement of predicted changes in revenue share between 2003 and 2007 (by including both cross-sections in the model), we find directionally similar but noiser impacts (Online Appendix Table B.8).

5 Mechanisms

Following Hirschman (1970), we examine the potential of voice and exit channels as moderators connecting local revenue share and policy outcomes.

5.1 Voice: Fiscal Allocation

Surveys of public opinion find that sizeable majorities favor smaller class sizes and higher salaries for teachers, both costly instructional expenses (Peterson, Henderson and West,

Table 3: Geographic regression discontinuity estimates of the effects on achievement of attending a school in a state with higher rather than lower mean local revenue share.

Sample	Effect of high local revenue share	Obs.
All students	0.08615* (0.03721)	17140
High income	0.12848* (0.05956)	10250
Low income	0.01257 (0.0558)	11102
High education	0.0583 (0.0552)	7980
Low education	0.0568 (0.0533)	7420

Note: Estimate is the effect of location in a high local revenue share state. Estimations restricted to borders of states with differences in average local share of revenue of ten percentage points or more and difference in non-white or Asian share is less than 10 percent. First specification pools all observations, while others restrict samples to each subgroup. Bandwidth defined as the optimal in the specification that pools all observations (11.9 km, including 236 unique districts). Linear specification on either side of the border as in Table 2, model 2. Robust standard errors, clustered by district, in parentheses.

Table 4: 2SLS estimates of relationship between local revenue share and student achievement in 2007, using house price changes 2000-07 as instrument for local revenue share in 2007

	(1)	(2)	(3)	(4)
Local Revenue Share	**0.0557*****	**0.0203***	**0.0196***	**0.0208**$^{+}$
	(0.00144)	(0.0103)	(0.0862)	(0.0102)
Low income X Local revenue share			**-0.0255***	
			(0.0104)	
Low Education X Local revenue share				**-0.0317****
				(0.00982)
Local Revenue Share 2000	0.0104***	-0.0117	-0.0101	-0.0108
	(0.00142)	(0.00912)	(0.0153)	(0.0153)
Average math score 2000	0.552***	0.174***	0.176**	0.171**
	(0.0121)	(0.0358)	(0.0557)	(0.0558)
Low Income		-0.301***	-0.186***	-0.301***
		(0.0123)	(0.0455)	(0.0158)
Low Education		-0.255***	-0.253***	-0.106*
		(0.00992)	(0.0159)	(0.0419)
Per pupil expenditure		-0.000103	-0.000109	-0.000104
		(0.00527)	(0.00327)	(0.00416)
Observations	73000	70500	70500	70500
R^2	0.083	0.303	0.303	0.303

Two stage least square models regressing z-scores in 2007, with local revenue share instrumented by predicted changes to house prices at the commuting zone level 2000-07. Additional controls, not shown, are as in Table 2, models 2, 3, and 4. Robust standard errors, clustered by district, in parentheses.

2014; Henderson, Peterson and West, 2019). Prior research also shows a positive correlation between student achievement and both the proportion of expenditures allocated to instruction (Brewer, 1996; Jacques and Brorsen, 2002; Wenglinsky, 1997) and the pupil-teacher ratio (Krueger, 1999).

We hypothesize that public demand for allocating a larger share of resources toward instruction and smaller classes could be a channel connecting local resource share and educational outcomes. To test the hypothesis we draw upon data from NCES (2019), which reports district-level pupil-teacher ratios and allocations of district expenditures to instruction and other school operations. Using an OLS model that controls for per pupil expenditure and the same individual and district-level characteristics as in Table 2, model 2, we find that, for every 10 percent increase in the share of revenue funded locally, districts allocate one percent more of their resources toward instruction and that the pupil-teacher ratio is reduced by 0.25 pupils. These are shown in Table 5. We also show that an increase in the percentage allocated to instruction is positively correlated with mean student achievement, and that the pupil-teacher ratio is negatively correlated with achievement at a marginally significant level.

Table 5: Relationship of local revenue share and share of spending in instruction and pupil-teacher ratio, and of these last two variables with student achievement in reading and math.

	(1) Instruction share	(2) Pupil-teacher ratio	(3) Student achievement	(4) Student achievement
Local revenue share	0.0956*	-0.250**		
	(0.0450)	(0.00943)		
Instruction share			0.0677**	
			(0.0293)	
Pupil-teacher ratio				-0.000629+
				(0.000368)
Observations	12010	12010	66880	136410
R^2	0.226	0.255	0.257	0.255

District-level OLS model 1 regresses percentage share of spending on instruction on local revenue share (both in units of 10 percentage points) as defined by NCES (2019), controlling for expenditures per pupil and other controls as in Table 2, model 2. Model 2 regresses pupil-teacher ratio on local revenue share using the same model. Robust standard errors in models 1 and 2 are clustered by state. Models 3 and 4 regress individual test performance (z-scores) in reading and math combined on indicated variables, with controls as in Table 2, model 2. Robust standard errors in models 3 and 4 are clustered by district.

These results suggest that the voice channel may be a moderator of the connection between local revenue share and achievement. However, we cannot exclude the possibility that when districts are more locally funded, school boards reduce pupil-teacher ratio and spend more on instruction to forestall migration to other localities, the exit option to which we now turn.

5.2 Exit: Tiebout Choice Effects

Hirschman (1970) hypothesizes that residents of a community can influence policy because they are able to leave one community for another in order to secure outcomes they prefer (also, see Epple and Zelenitz (1981) and Nechyba (1997)). To estimate the exit channel, we build on Hoxby (2000) and hypothesize that the effects of local revenue share on the efficiency-equity trade-off are larger in districts located in areas where exit potential is greater. To test this proposition, district density (the number of school districts) within a commuting zone is used as a proxy for the plentitude of exit options. In our sample, there are 20 districts in the the mean commuting zone, and the inter-quartile range is also 20 districts. The mean percentage local revenue share is 43 percent.

To estimate moderating effects of greater exit opportunities, we use OLS models with the same co-variates as those used for model 2 in Table 2. As shown in Table 6, model 2, the interaction between district density (our indicator of increased exit potential) and local revenue shares enhances the effect of local revenue share on achievement by a significant 0.003 s.d. per 10 districts over and above the main effects of 0.04 s.d. The total efficiency effect of a 10 percent change in local share of revenue is 0.05 s.d. for observations in commuting zones with the mean number of districts.

In models 3 and 4 the inegalitarian consequences of exit potential become apparent. When the interaction term in model 2 is interacted once again with the two SES indicators (income in model 3, education in model 4), the signs of the triple interaction terms are significantly negative in both instances. The substantial size of the negative coefficients on the triple interaction terms (of SES, local revenue share, and number of districts) imply that virtually all of the efficiency benefits of exit potential are concentrated on students from higher SES backgrounds. For example, the triple interaction with low parental education in model 4 is

Table 6: OLS estimated relationship between student achievement and the interaction of local revenue share and district density.

	(1)	(2)	(3)	(4)
Local revenue share	0.0528***	**0.0443*****	0.0483***	0.0516***
	(0.00243)	(0.00329)	(0.00369)	(0.00379)
Local revenue share X No. districts		**0.00330*****	**0.00395*****	**0.00654*****
		(0.000885)	(0.00110)	(0.000997)
Low Income X Local rev. X No. districts			**-0.00208**+	
			(0.00107)	
Low Education X Local rev. X No. districts				**-0.00550*****
				(0.00131)
No. districts in CZ	**0.00853***	**0.00418**	**0.00824**	**0.0177****
	(0.00335)	(0.00493)	(0.00609)	(0.00596)
Low Income X No. districts			0.00981	
			(0.00722)	
Low Income X Local revenue			-0.00794+	
			(0.00475)	
Low Income	-0.252***	-0.251***	-0.219***	-0.252***
	(0.00695)	(0.00694)	(0.0210)	(0.00695)
Low Education X Local revenue share				-0.00767+
				(0.00419)
Low Education X No. districts				0.0216***
				(0.00638)
Low Education	-0.248***	-0.248***	-0.246***	-0.199***
	(0.00536)	(0.00537)	(0.00538)	(0.0194)
Observations	194950	194950	194950	194953

Specifications as in Table 2, model 2. Number of districts in tens. Robust standard errors, clustered by commuting zone, in parentheses.

-0.00550. This negative effect nearly eliminates the impact of competition in enhancing the effect of local revenue share on students from high parental education backgrounds (a positive 0.00654 s.d.). In other words, only students from high education backgrounds benefit from the enhancement of local revenue effects induced by greater district density. The cleavage between low and high income students in model 3 is similar, but of lesser magnitude. But both models indicate that efficiency gains from greater competition come at the price of equity.

Finally, we note that in specification 1 of Table 6, without interactions, district density has a positive and significant effect on achievement. But once district density is interacted with local revenue share, the main density variable is no longer statistically significant in models 2 and 3, indicating that exit potential has no efficiency effect when funding comes more from inter-governmental grants. However, the coefficient becomes significant in model 4, when heterogeneities by education are estimated. Otherwise, all the efficiency benefits of increased exit opportunities (greater district density) occur in districts more dependent upon local revenue sources.

6 Discussion

The higher the share of revenues from local sources, the more efficiently the district converts resources into student achievement, as measured by test score performance. Depending on the model, the efficiency gains are roughly 0.02 s.d. to 0.06 s.d. for every 10 percent increase in local revenue share. At the same time, school districts are more likely to trade off equity for efficiency if a larger share of their revenue comes from their own resources. For every 10 percent increase in local revenue share, heterogeneities increase by about 0.01 s.d. to 0.03 s.d., approximately half the size of the efficiency gains, though estimates of the equity price for increased efficiency are noisy in some models.

Both voice and exit channels appear to act as moderators through which these impacts occur. The voice mechanism is evident from the way in which districts allocate their resources. The public has been shown to strongly favor smaller class sizes and higher salaries for teachers, both of which require higher allocation of expenditures toward instruction. That allocation of resources is correlated with achievement, as is the pupil-teacher ratio. An exit mechanism also seems to connect citizen preferences to policy outcomes, as greater inter-district competition within commuting zones induces higher mean levels of achievement in districts with higher local revenue shares. But competition also aggravates disparities by students' socio-economic background in these districts. Apparently, policy makers concentrate more resources on the better-off when the potential for exit is greater.

Our work is limited in several ways. Although observed characteristics of individuals included in the geographical discontinuity analyses hardly differ across state borders on observables, we cannot rule out uncorrelated differences in tastes for education. Unobserved differences in the taste for education among movers across commuting zones between 2000 and 2007 could also confound models that exploit house price changes, though moves of this magnitude are usually driven by job and other life changes. It is also possible that families use additional capital generated by increases in house values to purchase additional educational services for their children. However, our models control for school district variation in housing prices and household income. And if the greater wealth generated by changes in housing prices is being efficiently invested in education by high SES households, two-stage estimations should estimate larger heterogeneities by SES than those obtained from OLS models. In fact the size of SES heterogeneities in OLS and 2SLS models in Tables 2 and 4 remain essentially the same.

Generalizability is another concern. Our main estimates come from 2007, a year selected to avoid contamination by the recession that began the following year. The recession could well have introduced a new world where inter-governmental grants have different consequences, although average levels of local share of revenue by 2017 are similar to pre-crisis levels (Table 235.10 Snyder, de Brey and Dillow, 2019). Also, while achievement tests are correlated with desired downstream outcomes, these might be affected by financing regimes in quite different ways. Nor can we generalize from the United States to other countries.

To extend this research, scholars may wish to explore the efficiency-equity trade-off in other local policy domains, such as housing, transportation, medical services and police and fire protection. Eventually, it will be possible to see whether the pandemic of 2020 has altered the efficiency-equity trade-off. The closing of schools, declining revenues and rising debts at state and local levels might—but also might not—change school finance dynamics. The mechanisms linking funding regimes to educational and other service-delivery outcomes also requires more research. The voice mechanism is especially in need of further attention. To ascertain whether political activities shape the impact of funding arrangements, one might survey public opinion as to the appropriate allocation of the educational dollar across categories of expenditure. More research is also required on the connections between policy and participation rates in school board campaigns and elections as well as public engagement at school board and city council meetings.

This is the first empirical study to use nationally representative data on student achievement to provide causal estimates of the trade-off between efficiency and equity in local education policy. We find a larger share of revenue from local sources has a beneficial impact on the efficiency of local service delivery but the benefits from increased efficiency accrue disproportionately to students from more advantaged backgrounds.

Our findings are relevant to contemporary legal and political conversations about *Rodriguez v. San Antonio Independent School District* (1973), *Gary B. v. Whitmer* (2000), and state equity and adequacy lawsuits (Ogletree and Robinson, 2015). A reversal of *Rodriguez* would likely require more extensive use of intergovernmental grants, perhaps including federal as well as state equalizing grants. Our results suggest that a shift in funding of 50 percentage points to higher tiers of government would reduce the 8th grade socio-economic achievement gap by around 10 percent of a standard deviation. However, the closing of the gap would come at the price of roughly 20 percent of a standard deviation reduction in mean student achievement. When decisions must be made as to the appropriate tier of government asked to finance U.S. schools, an efficiency-equity trade-off seems likely.

References

Autor, David H and David Dorn. 2013. "The growth of low-skill service jobs and the polarization of the US labor market." *American Economic Review* 103(5):1553–97.

Berry, Christopher R. 2009. *Imperfect Union: Representation and taxation in multilevel governments.* Cambridge University Press.

Berry, Christopher R and Martin R West. 2008. "Growing pains: The school consolidation movement and student outcomes." *The Journal of Law, Economics, & Organization* 26(1):1–29.

Brewer, Dominic J. 1996. "Does more school district administration lower educational productivity? Some evidence on the "administrative blob" in New York public schools." *Economics of Education Review* 15(2):111–124.

Brunner, Eric, Joshua Hyman and Andrew Ju. 2018. "School Finance Reforms, Teachers' Unions, and the Allocation of School Resources." *Review of Economics and Statistics* pp. 1–47.

Cattaneo, Matias D, Michael Jansson and Xinwei Ma. 2019. "Simple local polynomial density estimators." *Journal of the American Statistical Association* pp. 1–7.

Cattaneo, Matias D, Nicolás Idrobo and Rocío Titiunik. 2019. *A Practical Introduction to Regression Discontinuity Designs: Volume I.* Cambridge University Press.

Chetty, Raj, John N Friedman and Jonah E Rockoff. 2014*a*. "Measuring the impacts of teachers I: Evaluating bias in teacher value-added estimates." *American Economic Review* 104(9):2593–2632.

Chetty, Raj, John N Friedman and Jonah E Rockoff. 2014*b*. "Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood." *American Economic Review* 104(9):2633–79.

Chetty, Raj, Nathaniel Hendren, Patrick Kline and Emmanuel Saez. 2014. "Where is the land of opportunity? The geography of intergenerational mobility in the United States." *The Quarterly Journal of Economics* 129(4):1553–1623.

Chingos, Matthew M and Kristin Blagg. 2017. "Do Poor Kids Get Their Fair Share of School Funding?" *Washington, DC: Urban Institute* .

Coleman, James S, Ernest Campbell, Carol Hobson, James McPartland, Alexander Mood, Frederick Weinfeld and Robert York. 1966. *Equality of Educational Opportunity.* NCES.

Cutler, David M and Richard J Zeckhauser. 2000. The anatomy of health insurance. In *Handbook of health economics.* Vol. 1 Elsevier pp. 563–643.

Davis, Matthew and Fernando V Ferreira. 2017. Housing Disease and Public School Finances. Technical report National Bureau of Economic Research.

Deming, David and Chris Walters. 2017. "The impacts of price and spending subsidies on US postsecondary attainment." *NBER Working Paper* 23736.

Ejdemyr, Simon. 2017. "Essays on the allocation of public goods." Stanford University Dissertation.

Epple, Dennis and Allan Zelenitz. 1981. "The implications of competition among jurisdictions: does Tiebout need politics?" *Journal of Political Economy* 89(6):1197–1217.

Gerber, Alan S, Daniel P Kessler and Marc Meredith. 2011. "The persuasive effects of direct mail: A regression discontinuity based approach." *The Journal of Politics* 73(1):140–155.

Glaeser, Edward L and Charles G Nathanson. 2015. "Housing Bubbles." *Handbook of Regional and Urban Economics* 5:701–751.

Guerrieri, Veronica, Daniel Hartley and Erik Hurst. 2013. "Endogenous gentrification and housing price dynamics." *Journal of Public Economics* 100:45–60.

Guin, Kacey, Betheny Gross, Scott Deburgomaster and Marguerite Roza. 2007. "Do districts fund schools fairly." *Education Next* 7(4):68–73.

Hanushek, Eric A. 2006. *Courting failure: How school finance lawsuits exploit judges' good intentions and harm our children.* Vol. 551 Hoover Press.

Hanushek, Eric A, Jens Ruhose and Ludger Woessmann. 2016. "It pays to improve school quality: States that boost student achievement could reap large economic gains." *Education Next* 16(3):52–61.

Hanushek, Eric A and Ludger Woessmann. 2012. "Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation." *Journal of economic growth* 17(4):267–321.

Henderson, Michael, Paul E. Peterson and Martin R. West. 2019. "Trends in the EdNext Survey: Question wording and data over time.".

Hirschman, Albert O. 1970. *Exit, voice, and loyalty: Responses to decline in firms, organizations, and states.* Vol. 25 Harvard university press.

Hochman, Harold M and James D Rodgers. 1969. "Pareto optimal redistribution." *The American economic review* 59(4):542–557.

Hoxby, Caroline M. 2000. "Does competition among public schools benefit students and taxpayers?" *American Economic Review* 90(5):1209–1238.

Jackson, C Kirabo, Rucker C Johnson and Claudia Persico. 2015. "The effects of school spending on educational and economic outcomes: Evidence from school finance reforms." *The Quarterly Journal of Economics* 131(1):157–218.

Jacob, Brian A and Steven D Levitt. 2003. "Rotten apples: An investigation of the prevalence and predictors of teacher cheating." *The Quarterly Journal of Economics* 118(3):843–877.

Jacob, Brian and Jesse Rothstein. 2016. "The measurement of student ability in modern assessment systems." *Journal of Economic Perspectives* 30(3):85–108.

Jacques, Charles and B Wade Brorsen. 2002. "Relationship between types of school district expenditures and student performance." *Applied Economics Letters* 9(15):997–1002.

Keele, Luke J and Rocio Titiunik. 2015. "Geographic boundaries as regression discontinuities." *Political Analysis* 23(1):127–155.

Kelly, Nathan J and Christopher Witko. 2012. "Federalism and American inequality." *The Journal of Politics* 74(2):414–426.

Kern, Holger Lutz and Jens Hainmueller. 2009. "Opium for the masses: How foreign media can stabilize authoritarian regimes." *Political Analysis* 17(4):377–399.

Koretz, Daniel M. 2002. "Limitations in the use of achievement tests as measures of educators' productivity." *Journal of human resources* pp. 752–777.

Krueger, Alan B. 1999. "Experimental estimates of education production functions." *The quarterly journal of economics* 114(2):497–532.

Lafortune, Julien, Jesse Rothstein and Diane Whitmore Schanzenbach. 2018. "School finance reform and the distribution of student achievement." *American Economic Journal: Applied Economics* 10(2):1–26.

Lastra-Anadón, Carlos Xabel and Sonia Mukherjee. 2019. "Cross-country evidence on the impact of decentralisation and school autonomy on educational performance.".

Little, Roderick JA. 1993. "Post-stratification: a modeler's perspective." *Journal of the American Statistical Association* 88(423):1001–1012.

Lutz, Byron F. 2008. "The connection between house price appreciation and property tax revenues." *National Tax Journal* pp. 555–572.

Mayer, Christopher J and Karen Pence. 2008. Subprime mortgages: what, where, and to whom? Technical report National Bureau of Economic Research.

McCrary, Justin. 2008. "Manipulation of the running variable in the regression discontinuity design: A density test." *Journal of econometrics* 142(2):698–714.

Mishkin, Frederic S. 2009. "Is monetary policy effective during financial crises?" *American Economic Review* 99(2):573–77.

Murnane, Richard J, John B Willett, Frank Levy et al. 1995. "The Growing Importance of Cognitive Skills in Wage Determination." *The Review of Economics and Statistics* 77(2):251–266.

NBER. 2020. "US Business Cycle Expansions and Contractions.".
URL: *https://www.nber.org/cycles.html*

NCES. 2019. "Digest of Education Statistics Dataset.". data retrieved from https://nces.ed.gov/programs/digest/d17/tables/dt17_236.10.asp.

Nechyba, Thomas J. 1997. "Existence of equilibrium and stratification in local and hierarchical Tiebout economies with property taxes and voting." *Economic theory* 10(2):277–304.

Oates, Wallace. 1972. *Fiscal Federalism.* Edward Elgar Publishing.

OECD. 2014. *Education at a Glance dataset.* Paris: Organisation for Economic Cooperation and Development. stats.oecd.org.

Ogletree, Charles J and Kimberly Jenkins Robinson. 2015. *The Enduring Legacy of" Rodriguez": Creating New Pathways to Equal Educational Opportunity.* Harvard Education Press.

Ostrom, Elinor, Roger B Parks and Gordon P Whitaker. 1973. "Do we really want to consolidate urban police forces? A reappraisal of some old assertions." *Public Administration Review* pp. 423–432.

Peterson, Paul E. 1981. *City limits.* University of Chicago Press.

Peterson, Paul E, Michael B Henderson and Martin R West. 2014. *Teachers versus the public: What Americans think about their schools and how to fix them.* Brookings Institution Press.

Pál, Judit, Camille Marec and Markus SchwabeHenderson. 2019. "PISA 2018: US Country Note.".
URL: *https://www.oecd.org/pisa/publications/PISA2018_CN_USA.pdf*

Rae, Douglas W. 2008. *City: Urbanism and its end.* Yale University Press.

Reardon, Sean F. 2011. "The widening academic achievement gap between the rich and the poor: New evidence and possible explanations." *Whither opportunity* 1(1):91–116.

Reardon, Sean F, Demetra Kalogrides, Andrew Ho, Ben Shear, Kenneth Shores and Erin Fahle. 2017. "Stanford Education Data Archive.".

Rodden, Jonathan. 2006. *Hamilton's paradox: the promise and peril of fiscal federalism.* Cambridge University Press.

Rodden, Jonathan. 2016. Decentralized Rule and Revenue. Research report USAid.

Rogers, AM and JJ Stoeckel. 2008. NAEP 2007 Mathematics and Reading Secondary-Use Restricted-Use Data Files Data Companion. Education Policy Program Research Report NCES 2008-491-494 National Center for Education Statistics Washington, DC: .

Shiller, Robert J. 2007. Understanding recent trends in house prices and home ownership. Technical report National Bureau of Economic Research.

Snyder, Thomas D, Cristobal de Brey and Sally A Dillow. 2019. "Digest of Education Statistics 2017, NCES 2018-070." *National Center for Education Statistics* .

Taylor, John B. 2009. The financial crisis and the policy responses: An empirical analysis of what went wrong. Technical report National Bureau of Economic Research.

Tiebout, Charles M. 1956. "A pure theory of local expenditures." *Journal of political economy* 64(5):416–424.

Tolbert, Charles M and Molly Sizer. 1996. U.S. commuting zones and labor market areas: A 1990 update. Technical report US Census.

Trounstine, Jessica. 2018. *Segregation by Design: Local Politics and Inequality in American Cities*. Cambridge, UK: Cambridge University Press.

US Bureau of the Census. 2019. "U.S. Census of State and Local Government Finance Historical Datasets and Tables.". data retrieved from https://www.census.gov/data/datasets/2007/econ/local/public-use-datasets.html.

Wenglinsky, Harold. 1997. "When Money Matters: How Educational Expenditures Improve Student Performance and How They Don't. A Policy Information Perspective.".

West, Martin R and Paul E Peterson. 2007. *School money trials: The legal pursuit of educational adequacy*. Brookings Institution Press.

Zillow. 2018. *Zillow Home Value Index Dataset*. data retrieved from https://www.zillow.com/research/data/.

Appendix A: Literature on Local Financing of Public Services and Equity and Efficiency

Research has explored one side or another of the equality-efficiency trade-off in U. S. federalism. But a simultaneous examination of the equality-efficiency trade-off has not been estimated empirically, much less using data from nationally representative samples.

Equity Studies

Numerous scholars have examined local government's capacity to provide services in an equitable manner. In a classic case study, (Dahl, 1961, p.92) interprets a pluralist local polity as broadly representative and responsive to a wide range of social groups. But conclusions reached by most research points in a quite different direction. A number of case studies (Logan and Molotch, 2007; Molotch, 1976; Stone, 1993) emphasize the greater emphasis local public officials place on economic growth than on redistribution. (Trounstine, 2018) finds a clear bias toward higher SES groups in urban planning, zoning and land-use policy. Research also finds the broader public to be no less conservative in local politics. For example, homeowners and interest groups object to affordable housing developments expected to have a negative impact on property values (Fischel, 2001; Gerber, Kessler and Meredith, 2011; Hankinson, 2018). Ejdemyr (2017) finds that revenues generated by local bond elections are directed to schools with more affluent students. Other scholars theorize that local governments, facing competition for productive capital and labor, cannot be expected to engage in redistribution (Bailey and Rom, 2004; Kessler and Lülfesmann, 2005; Musgrave et al., 1959; Rae, 2008; Oates, 1972, 2006; Peterson, 1981, 1995; Yinger and Ladd, 1989).

Many political scientists have also queried the responsiveness of local governments to local public opinion (Craw, 2010; Gerber and Hopkins, 2011; Morgan and Watson, 1995; Ruhil, 2003; Yinger and Ladd, 1989; Wolman, Strate and Melchior, 1996). However, Tausanovitch and Warshaw (2014) show that policymakers are generally responsive to the liberal or conservative orientation of municipal residents, though they find little difference in responsiveness by particular governance and representation designs.

Meanwhile, intergovernmental grants appear to have more egalitarian consequences. In education, Jackson, Johnson and Persico (2015) find that intergovernmental grants induced by court-ordered school finance reforms had disproportionately large impacts on life outcomes of students from socio-economically disadvantaged backgrounds. Similarly, Lafortune, Rothstein and Schanzenbach (2018) identify positive impacts of increased intergovernmental grant expenditures on the performance of disadvantaged students in low-income districts. Brunner, Hyman and Ju (2018) also find that increases in intergovernmental grants lifted overall levels of district expenditure and raised the achievement of students in low-income districts. However, these studies estimate only the effects of increased expenditure; they do not estimate the equity-efficiency trade-off.

In sum, research shows that intergovernmental grants are more likely to be used for redistributive purposes than revenues raised from local resources. However, that literature has yet to investigate any shifts in the efficiency-equity trade-off that might occur when the share of funding shifts from one tier of government to another.

Efficiency Studies

The theoretical literature on local government efficiency is extensive. Tiebout (1956) theorizes that a system of local governments necessarily provides efficient services because citizens maximize utilities by migrating to communities that provide preferred services at lowest cost (see also Ostrom, Tiebout and Warren (1961)). Buchanan and Wagner (1977) theorize that a fiscal illusion results whenever there is a lack of "fiscal equivalence" between those who pay and those who benefit from public goods. Individuals who would not pay for services will consume them when paid for largely by others (Cutler and Zeckhauser, 2000). The greater the share of local services covered by revenues from non-local resources, the greater the moral hazard (Hines and Thaler, 1995). In the words of (Rodden, 2016, p.3): "Voters face strong incentives to monitor service provision when they understand their role in paying the bill, and [they] may be willing to tolerate much higher levels of inefficiency... [if money arrives via] intergovernmental transfers."

The efficiency of local governments has been empirically estimated in various ways. That residents are willing to pay for higher quality of government services has been documented by showing clear impacts of services on property values (Black, 1999; Bogart and Cromwell, 2000; Bradbury, Mayer and Case, 2001; Hayes, Taylor et al., 1996; Weimer and Wolkoff, 2001). Berry (2009) shows that services are more efficiently provided when the same governmental jurisdiction (the municipality) is responsible for raising the revenue needed to provide the service. When multiple local governments have access to a common fiscal pool, costs rise but services do not improve. Emanuelson (2003) reports a similar result for services provided by park districts. Elinor Ostrom and her colleagues (Ostrom, Parks and Whitaker, 1973, 1974; Ostrom, 1983; Ostrom, Parks and Whitaker, 1973) find police services are more efficiently provided if paid for by small jurisdictions. In education, Hoxby (2000) reports higher quality service delivery, as measured by student test performance, in metropolitan areas with more dense concentrations of school districts. These "Tiebout choice" effects, as she labels them, are disputed by Rothstein (2007), with a reply by Hoxby (2007).

"Flypaper" studies find that monies granted by higher tiers of government do not substitute for local revenues but instead stick to the hands of local authorities as flies to gummy paper (Hines and Thaler, 1995; Mueller, 2003; Wyckoff, 1991). The flypaper effects have been interpreted as an indicators of inefficiency, but the inference is based on the assumption that services were optimally provided prior to receipt of the inter-governmental grant.

Other scholars have looked more directly at the efficiency of government services paid for by inter-governmental grants. Silkman and Young (1982) show that intergovernmental grants are associated with lower efficiency levels in the provision of school bus transportation and public libraries. Dynes and Martin (2018) report that officials are less likely to misappropriate revenues and more likely to spend them on services citizens prefer if they come from local sources rather than inter-governmental grants. In Brazil external grants generate greater levels of corruption as measured by public audits (Brollo et al., 2013). Similar results are found in Bulgaria by Nikolova and Marinov (2017). However, Litschig and Morrison (2013), exploiting exogenous discontinuities in the formulas for allocating federal funding, report that "flypaper" effects in Brazil produce higher educational outcomes. As mentioned above, Lafortune, Rothstein and Schanzenbach (2018); Brunner, Hyman and Ju (2018) find similar results for the United States. Despite these and other studies of the effects of inter-governmental grants and local policy, the efficiency-equity trade-off has not been estimated simultaneously with data from nationally representative samples of the U.S. population.

References

Bailey, Michael A and Mark Carl Rom. 2004. "A wider race? Interstate competition across health and welfare programs." *The Journal of Politics* 66(2):326–347.

Berry, Christopher R. 2009. *Imperfect Union: Representation and taxation in multilevel governments*. Cambridge University Press.

Black, Sandra E. 1999. "Do better schools matter? Parental valuation of elementary education." *The Quarterly Journal of Economics* 114(2):577–599.

Bogart, William T and Brian A Cromwell. 2000. "How much is a neighborhood school worth?" *Journal of urban Economics* 47(2):280–305.

Bradbury, Katharine L, Christopher J Mayer and Karl E Case. 2001. "Property tax limits, local fiscal behavior, and property values: Evidence from Massachusetts under Proposition 212." *Journal of Public Economics* 80(2):287–311.

Brollo, Fernanda, Tommaso Nannicini, Roberto Perotti and Guido Tabellini. 2013. "The political resource curse." *The American Economic Review* 103(5):1759–1796.

Brunner, Eric, Joshua Hyman and Andrew Ju. 2018. "School Finance Reforms, Teachers' Unions, and the Allocation of School Resources." *Review of Economics and Statistics* pp. 1–47.

Buchanan, James M and Richard E Wagner. 1977. *Democracy in deficit: The Political Legacy of Lord Keynes*. Liberty Fund Indianapolis.

Cattaneo, Matias D, Nicolás Idrobo and Rocío Titiunik. 2019. *A Practical Introduction to Regression Discontinuity Designs: Volume I*. Cambridge University Press.

Craw, Michael. 2010. "Deciding to provide: Local decisions on providing social welfare." *American Journal of Political Science* 54(4):906–920.

Cutler, David M and Richard J Zeckhauser. 2000. The anatomy of health insurance. In *Handbook of health economics*. Vol. 1 Elsevier pp. 563–643.

Dahl, Robert A. 1961. *Who Governs? Democracy and Power in an American City*. New Haven: Yale University Press.

Dynes, Adam and Lucy Martin. 2018. "Revenue Source and Electoral Accountability: Experimental Evidence from Local US Policymakers.".

Ejdemyr, Simon. 2017. "Essays on the allocation of public goods." Stanford University Dissertation.

Emanuelson, David N. 2003. "A comparative analysis of Illinois park districts and Illinois municipal parks and recreation departments." Northern Illinois University Dissertation.

Fischel, William A. 2001. *The homevoter hypothesis: How home values influence local government taxation, school finance, and land-use policies*. Harvard University Press Cambridge, MA.

Gerber, Alan S, Daniel P Kessler and Marc Meredith. 2011. "The persuasive effects of direct mail: A regression discontinuity based approach." *The Journal of Politics* 73(1):140–155.

Gerber, Elisabeth R and Daniel J Hopkins. 2011. "When mayors matter: estimating the impact of mayoral partisanship on city policy." *American Journal of Political Science* 55(2):326–339.

Hankinson, Michael. 2018. "When Do Renters Behave Like Homeowners? High Rent, Price Anxiety, and NIMBYism." *American Political Science Review* pp. 1–21.

Hayes, Kathy J, Lori L Taylor et al. 1996. "Neighborhood school characteristics: what signals quality to homebuyers?" *Economic Review-Federal Reserve Bank of Dallas* pp. 2–9.

Hines, James R and Richard H Thaler. 1995. "The flypaper effect." *Journal of economic perspectives* 9(4):217–226.

Hoxby, Caroline M. 2000. "Does competition among public schools benefit students and taxpayers?" *American Economic Review* 90(5):1209–1238.

Hoxby, Caroline M. 2007. "Does competition among public schools benefit students and taxpayers? Reply." *American Economic Review* 97(5):2038–2055.

Jackson, C Kirabo, Rucker C Johnson and Claudia Persico. 2015. "The effects of school spending on educational and economic outcomes: Evidence from school finance reforms." *The Quarterly Journal of Economics* 131(1):157–218.

Kessler, Anke S and Christoph Lülfesmann. 2005. "Tiebout and redistribution in a model of residential and political choice." *Journal of Public Economics* 89(2-3):501–528.

Lafortune, Julien, Jesse Rothstein and Diane Whitmore Schanzenbach. 2018. "School finance reform and the distribution of student achievement." *American Economic Journal: Applied Economics* 10(2):1–26.

Litschig, Stephan and Kevin M Morrison. 2013. "The impact of intergovernmental transfers on education outcomes and poverty reduction." *American Economic Journal: Applied Economics* 5(4):206–240.

Logan, John R and Harvey Molotch. 2007. *Urban Fortunes: The Political Economy of Place, With a New Preface*. Univ of California Press.

Molotch, Harvey. 1976. "The city as a growth machine: Toward a political economy of place." *American journal of sociology* 82(2):309–332.

Morgan, David R and Sheilah S Watson. 1995. "The effects of mayoral power on urban fiscal policy." *Policy Studies Journal* 23(2):231–243.

Mueller, Dennis C. 2003. “Public choice III.”.

Musgrave, Richard Abel et al. 1959. *Theory of public finance; a study in public economy.* McGraw-Hill.

Nikolova, Elena and Nikolay Marinov. 2017. “Do public fund windfalls increase corruption? Evidence from a natural disaster.” *Comparative Political Studies* 50(11):1455–1488.

Oates, Wallace. 1972. *Fiscal Federalism.* Edward Elgar Publishing.

Oates, Wallace. 2006. The Many Faces of the Tiebout Model. In *The Tiebout model at fifty: Essays in public economics in honor of Wallace Oates*, ed. William Fischel. Cambridge, MA: Lincoln Inst of Land Policy pp. 21–46.

Ostrom, Elinor. 1983. “The social stratification-government inequality thesis explored.” *Urban Affairs Quarterly* 19(1):91–112.

Ostrom, Elinor, Roger B Parks and Gordon P Whitaker. 1973. “Do we really want to consolidate urban police forces? A reappraisal of some old assertions.” *Public Administration Review* pp. 423–432.

Ostrom, Elinor, Roger B Parks and Gordon P Whitaker. 1974. “Defining and measuring structural variations in interorganizational arrangements.” *Publius* 4(4):87–108.

Ostrom, Vincent, Charles M Tiebout and Robert Warren. 1961. “The organization of government in metropolitan areas: a theoretical inquiry.” *American Political Science Review* 55(4):831–842.

Peterson, Paul E. 1981. *City limits.* University of Chicago Press.

Peterson, Paul E. 1995. *The Price of Federalism.* Washington, DC: Brookings Institution Press.

Rae, Douglas W. 2008. *City: Urbanism and its end.* Yale University Press.

Rodden, Jonathan. 2016. Decentralized Rule and Revenue. Research report USAid.

Rothstein, Jesse. 2007. “Does competition among public schools benefit students and taxpayers? Comment.” *American Economic Review* 97(5):2026–2037.

Ruhil, Anirudh VS. 2003. “Structural change and fiscal flows: A framework for analyzing the effects of urban events.” *Urban Affairs Review* 38(3):396–416.

Silkman, Richard and Dennis R Young. 1982. “X-efficiency and state formula grants.” *National Tax Journal* 35(3):383–397.

Stone, Deborah A. 1993. “The struggle for the soul of health insurance.” *Journal of Health Politics, Policy and Law* 18(2):287–317.

Tausanovitch, Chris and Christopher Warshaw. 2014. “Representation in municipal government.” *American Political Science Review* 108(3):605–641.

Tiebout, Charles M. 1956. "A pure theory of local expenditures." *Journal of political economy* 64(5):416–424.

Trounstine, Jessica. 2018. *Segregation by Design: Local Politics and Inequality in American Cities*. Cambridge, UK: Cambridge University Press.

Weimer, David L and Michael J Wolkoff. 2001. "School performance and housing values: Using non-contiguous district and incorporation boundaries to identify school effects." *National Tax Journal* pp. 231–253.

Wolman, Harold, John Strate and Alan Melchior. 1996. "Does changing mayors matter?" *The Journal of Politics* 58(1):201–223.

Wyckoff, Paul Gary. 1991. "The elusive flypaper effect." *Journal of Urban Economics* 30(3):310–328.

Yinger, John and Helen F Ladd. 1989. "The determinants of state assistance to central cities." *National Tax Journal* pp. 413–428.

Appendix B: Tables and Figure

Table B.1: Summary statistics of key variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Individual variables					
Low income	0.43	0.5	0	1	293010
Low education	0.48	0.5	0	1	243720
Disabled	0.13	0.34	0	1	295220
English learner	0.07	0.25	0	1	295220
White or Asian	0.61	0.49	0	1	295240
Male	0.51	0.5	0	1	295180
No. districts in Commuting Zone	19.9	20.6	1	82	281630
District education variables 2007					
Local share of revenue (10 pct)	4.32	2.05	0	10	243720
Current expenditure per pupil (tsd.usd)	10.38	3.02	4.66	62.33	243720
Instruction share	60.07	40.915	0	84.47	243720
Pupil-teacher ratio	14.727	14.134	0	90	243720
District demographic variables 2000					
Median household income	42999	13751	0	192787	243720
Share 26 and older w. 4 yr. college degree	0.23	0.12	0	1	243720
Urban share	0.70	0.36	0	1	243720
Median house price	110057	80364	0	1000001	243720

Table B.2: OLS estimates of relationship between local share of revenue and student achievement, math and reading combined, using first of five plausible values for NAEP estimates of individual scores.

	(1)	(2)	(3)	(4)
Local revenue share	0.115***	0.0646***	0.0740***	0.0771***
	(0.00763)	(0.00427)	(0.00466)	(0.00514)
Low Income X			-0.0253***	
Local share of revenue			(0.00509)	
Low Education X				-0.0276***
Local revenue share				(0.00503)
Low Income		-0.321***	-0.217***	-0.321***
		(0.00845)	(0.0221)	(0.00843)
Low Education		-0.243***	-0.242***	-0.125***
		(0.00759)	(0.00760)	(0.0227)
Per pupil expenditure		-0.00701*	-0.00756*	-0.00746*
		(0.00335)	(0.00327)	(0.00328)
Number of students	226210	194950	194950	194950
Number of districts	3,033	2,959	2,959	2,959
R^2	0.077	0.308	0.309	0.309

Test scores in standard deviations, from the first of five plausible values for individual NAEP score. Specifications, controls, and weights as in Table 2. $^+$ 0.10, * 0.05, ** 0.01, *** 0.001

Table B.3: OLS estimates of relationship between local share of revenue and student achievement, separately for math and reading.

	(1)	(2)	(3)	(4)
Panel A: Math				
Local revenue share	0.105***	0.0602***	0.0686***	0.0794***
	(0.00801)	(0.00537)	(0.00599)	(0.00771)
Low Income X Local revenue share			-0.0191**	
			(0.00617)	
Low Education X Local revenue share				-0.0259***
				(0.00675)
Low Income		-0.268***	-0.186***	-0.269***
		(0.0105)	(0.0272)	(0.0105)
Low Education		-0.274***	-0.272***	-0.151***
		(0.0115)	(0.0114)	(0.0296)
Per pupil expenditure		-0.0124**	-0.0125**	-0.0127**
		(0.00432)	(0.00425)	(0.00428)
Number of students	110,380	95,120	95,120	95,120
Number of districts	3,033	2,959	2,959	2,959
R^2	0.067	0.275	0.276	0.276
Panel B: Reading				
Local revenue share	0.0884***	0.0463***	0.0501***	0.0610***
	(0.000838)	(0.000619)	(0.000675)	(0.000770)
Low Income X Local revenue share			-0.00877	
			(0.00566)	
Low Education X Local revenue share				-0.0199***
				(0.00562)
Low Income		-0.240***	-0.202***	-0.240***
		(0.0112)	(0.0271)	(0.0112)
Low Education		-0.223***	-0.222***	-0.128***
		(0.0100)	(0.0100)	(0.0250)
Per pupil expenditure		-0.0111*	-0.0111*	-0.0112*
		(0.00460)	(0.00458)	(0.00457)
Number of students	115830	99830	99830	99830
Number of districts	3,033	2,959	2,959	2,959
R^2	0.046	0.265	0.265	0.265

Test scores in standard deviations. Local revenue share in 10 percentage point units. Per pupil Expenditure in thousands of dollars of current expenditure. Weighted observations are district-representative. Income indicated by free or reduced lunch; parent education indicated by college degree for at least one parent. Observations rounded to nearest tenth to comply with privacy requirements. Additional individual and district controls, and weighting as in Table 2. Robust standard errors, clustered by district, in parentheses. $^{+}$ 0.10, * 0.05, ** 0.01, *** 0.001

Table B.4: OLS estimates of relationship between local revenue share and student achievement, by ethnicity.

Local revenue share	0.0505***
	(0.00484)
African American X Local revenue share	-0.0175
	(0.00992)
Hispanic American X Local revenue share	-0.0156*
	(0.00706)
Asian American X Local revenue share	0.0289**
	(0.0112)
Native American X Local revenue share	-0.00241
	(0.0162)
Other race X Local revenue share	0.0759***
	(0.0206)
African American	-0.508***
	(0.0340)
Hispanic American	-0.219***
	(0.0304)
Asian American	0.0917
	(0.0590)
Native American	-0.344***
	(0.0533)
Other	-0.367***
	(0.0961)
Low income	-0.234***
	(0.00792)
Low education	-0.246***
	(0.00804)
Expenditure per pupil	-0.00513
	(0.00337)
Observations	194,950
R^2	0.279

Specifications, controls and weights as in Table 2, model 2.

Table B.5: Relation between average district level student achievement in 2011 and local revenue share in state-administered high-stake tests, grades 3 through 8, using SEDA dataset.

	(1) All students	(2) Whites	(3) African Americans	(4) Hispanics
Local revenue share	0.139^{***}	0.152^{***}	0.0910^{*}	0.106^{**}
	(0.0243)	(0.0427)	(0.0403)	(0.0501)
Observations	105375	105370	25696	26169
R^2	0.499	0.626	0.283	0.044

OLS models of relationship between mean achievements (in aggregate and by subgroup) and gaps and local revenue share, in 2011. Outcome variables are mean achievement in the district in state tests by subgroup (additional ethnicities have much smaller support), measured in z-scores, by district-subject-grade with respect to national mean and standard deviation. Linear regression models include, subject (reading and math) grade (3-8), and state fixed effects. It also includes linear district controls as in Table 2, model 2. Robust standard errors, clustered by district in parentheses. Source: Stanford Education Data Archive (SEDA) (Reardon et al., 2017). $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.6: Geographic regression discontinuity estimates of the effects on achievement of attending a school in a state with higher rather than lower mean local revenue share using a separate MSE-optimal bandwidth in each specification.

	Estimates	Observations	Districts	Bandwidth (km)
Average	0.08615* (0.03721)	17140	180	11.9
High income	0.15264** (0.0558)	6540	740	13.4
Low income	0.11275* (0.05616)	7970	460	9.7
High education	0.06999* (0.0317)	8560	500	13.3
Low education	0.06715 (0.0419)	7750	760	12.7

Note: Estimates of effect of being in high local revenue share district. Specification as in Table 3 (except bandwidths), including controls as in Table 2, model 2. In Table 1 and Table 3, we use the same bandwidth across specifications to ensure comparability.

Table B.7: Geographic regression discontinuity estimates on the effects on achievement of attending a school in a state with higher rather than lower mean local revenue share, with bandwidths of 10 km., 20 km., and 30 km.

	Bandwidth 10 km.			*Bandwidth 20 km.*			*Bandwidth 30 km.*		
	Estimates	Obs.	Dist.	Estimates	Obs.	Dist.	Estimates	Obs.	Dist.
Average	0.1647*** (0.0430)	14220	193	0.1599*** (0.0271)	27020	392	0.1400*** (0.0217)	35630	545
High income	0.1334* (0.0664)	8990	186	0.1094*** (0.0334)	17040	373	0.1262*** (0.02624)	22410	522
Low income	0.0797 (0.0537)	5180	186	0.1080*** (0.0433)	9790	376	0.0915** (0.0362)	12960	520
High education	0.1568** (0.0637)	6550	191	0.1418*** (0.0401)	12540	386	0.1547*** (0.311)	16620	538
Low education	0.0868 (0.0614)	6160	190	0.0935** (0.0388)	11740	387	0.0624+ (0.0319)	15360	539

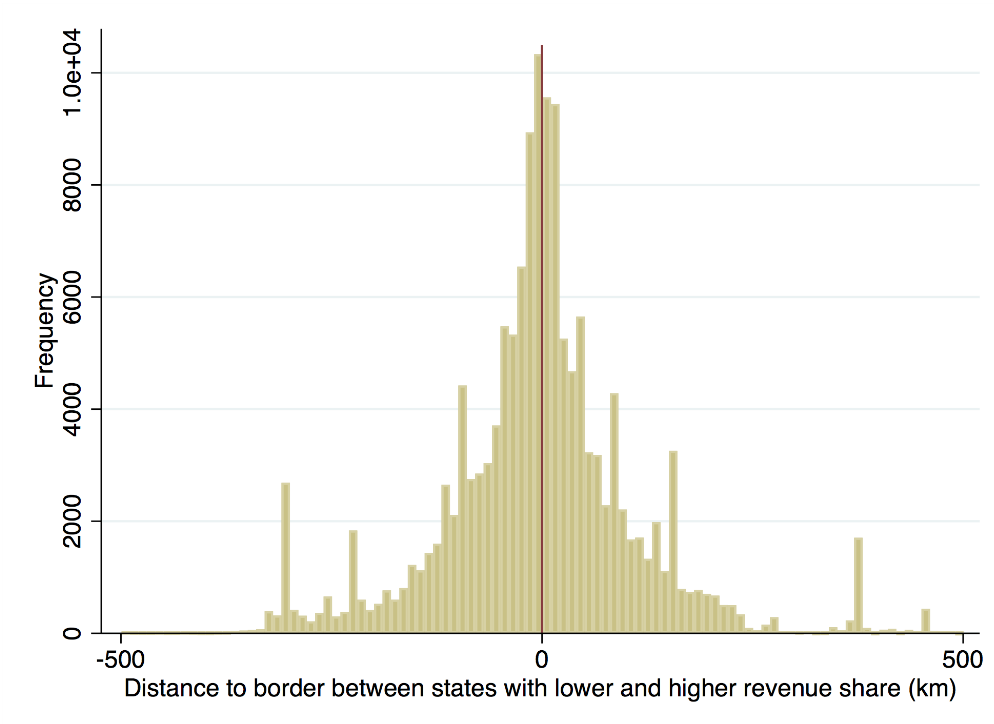
Note: Estimates of effect of being in high local revenue share district. Other than bandwidths, specification as in Table 3, including controls as in Table 2, model 2.

Table B.8: Effects on changes in achievement between 2003 and 2007 of predicted local share of revenue, using house price changes 2000-2007.

	(1)	(2)	(3)	(4)
Local revenue share	0.0533**	0.0134	0.0189+	0.0167
	(0.0172)	(0.00962)	(0.00998)	(0.0110)
Low Income X Local revenue share			-0.0170+	
			(0.00888)	
Low Education X Local revenue share				-0.00751
				(0.00834)
Low Income		-0.340***	-0.267***	-0.340***
		(0.0199)	(0.0482)	(0.0200)
Low Education		-0.259***	-0.259***	-0.225***
		(0.0164)	(0.0163)	(0.0430)
Per pupil expenditure		0.0000001674	0.000000215	0.000000323
		(0.000000185)	(0.000000264)	(0.000000258)
Number of students	194800	194800	194800	194800
Number of districts	3,270	3,270	3,270	3,270
R^2	0.009	0.177	0.177	0.177

Models include 2003 and 2007 cross sections of NAEP and district fixed effects. We regress contemporaneous achievement on the local share of revenue for 2003 and the predicted local share of revenue for 2007. 2007 local revenue share is predicted by: the level in 2003 plus the predicted change in local revenue share 2003-2007 (predicted by changes in house prices 2000-07 at the commuting zone level). Additional individual controls, and weighting as in Table 2. Robust standard errors, clustered by district, in parentheses. + 0.10, * 0.05, ** 0.01, *** 0.001

Figure B.1: Distribution of observations around the geographic discontinuities included in our model.



Note: Each vertical bar shows the number of observations on each distance interval.

Includes 25 state borders.