The Effect of Education Spending on Student Achievement: Evidence from Property Values and School Finance Rules

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July 14, 2018

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Abstract

Opportunities to estimate the causal effect of school spending on student achievement are infrequent and have been based, almost entirely, on variation in spending from large school finance reforms. Property values also affect school spending through both local property tax revenue and the level of state aid provided to each school district. However, little is known about the effect property values have on student achievement through their impact on school revenue. In this paper, I estimate the effect of education spending on district-level student outcomes in 24 states by leveraging changes in revenue driven by property value variation. I interact state-level changes in property values with fixed school finance formulas that measure how state aid and local revenue respond to those changes to create a simulated instrument for school spending. By collecting administrative data on property values for over 7,000 school districts, I am able to measure a leave-one-out mean change in property values for school districts in each state. The instrument is highly predictive of changes in revenue and spending. My estimates suggest that a 10 percent increase in spending improves graduation rates by 2.1 to 4.4 percentage points and student test scores by 0.05 to 0.09 standard deviations. These results suggest that market variation in property values affects student outcomes through existing school finance formulas.

JEL Classification: H75; I22

Keywords: School Finance; High School Completion; Test Scores; Property Values

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1 Introduction

The United States spends roughly 3.7 percent of its GDP on public K-12 education.[1] Public schools were historically funded primarily through local revenue, the majority of which came from local property taxes, as shown in Figure 1. Reliance on property taxes led to large disparities in school spending across districts based on local income levels and property wealth. In the 1970s and 1980s, state courts started ruling that these disparities made local funding of school districts unconstitutional. States responded by enacting funding formulas that reduced the relationship between local property values and school resources to equalize spending across districts. In many cases, formulas explicitly take into account property values to provide more funding for low-property-wealth districts. Recent research leverages the policy variation from these school finance reforms and finds positive effects of spending on high school completion and other long run outcomes (Jackson, Johnson, and Persico, 2016), as well as student test scores (Lafortune, Rothstein, and Schanzenbach, 2018). Despite the increased importance of state funds, property values are still a major component of local education spending for school districts in most states. While much effort has been devoted to estimating the effect of school spending and quality on property values (Oates, 1969; Black, 1999; Bayer, Ferreira, and McMillan, 2007; Ries and Somerville, 2010), little is known about how changes in property values affect student achievement by influencing school district revenues.

I address this gap by estimating the effect of education spending driven by property value fluctuations on district-level student outcomes in 24 states. Observational analyses of changes in school spending on student outcomes are likely biased because changes in spending are often driven by other factors that also determine student achievement, such as the demographic composition of students or parental support of education. To overcome such sources of endogeneity, I create a simulated instrument for school revenue by interacting

[1] In FY2014, GDP was $17.43 trillion (U.S. Bureau of Economic Analysis, 2017) and total spending on public K-12 was $634 billion (U.S. Department of Education National Center for Education Statistics, 2016b).

state-level changes in property values with fixed school finance formulas that measure how state aid and local property tax revenue respond to changes in district property wealth. My estimates show that a 10 percent increase in simulated revenue increases spending by 1 to 2 percent, which suggests that administrators do not perfectly adjust tax rates and other school finance parameters to offset changes in revenue driven by changes in property values. Simulated revenue is a valid instrument for district spending as long as changes in unobserved factors that affect both student outcomes and spending are not systematically related to changes in property values differentially across districts with different base-year finance policies. I show that measures of student composition that are likely related to student achievement (e.g. fraction of students eligible for free lunch, fraction of minority students) trend similarly for districts with different combinations of high and low initial property tax rates and property wealth, which provides support for the validity of my instrument.

The student outcomes I examine are graduation rates and test scores. Graduation rates are based on district-level information from the National Center for Education Statistics Common Core of Data (CCD) from 1998 to 2010. I use nationally-comparable math and reading test scores for 4th and 8th graders, aggregated to the district level, from the Stanford Education Data Archive (SEDA). These test scores are available from 2009 to 2013.

Using my measure of simulated revenue as an instrument for spending in a two-stage least squares framework, I find that a 10 percent increase in spending in the final two years of high school increases graduation rates by 2.1 to 4.4 percentage points. I find that only spending in the last two years of high school affects graduation rates, which suggests that students on the margin of dropping out quickly respond to education investments. These estimates are comparable to, but slightly larger than, those found in recent papers using variation from school finance reforms.[2] Two potential reasons my estimates are larger than

[2] Jackson, Johnson, and Persico (2016) find that a 10 percent increase in spending from school finance reforms, across 12 years of school, increases graduation rates by 3.55 percentage points. Candelaria and Shores (2017) replicate this result and also find an effect size of 5 percentage points when restricting to the highest poverty districts. Each of these papers uses the number of graduates per 8th grader (four years prior) as a proxy for graduation rates, which is the measure for which I get the largest magnitude estimate of 5.1 percentage points.

those using variation from school finance reforms include the impact of spending in high income areas and the differential effect of spending cuts. My estimates suggest that the benefits of increased spending are concentrated in districts with high incomes. Because school finance reforms predominantly affect low-income districts, estimates for high-income districts using this variation likely do not have a strong first stage. My instrument is strong for both low- and high-income districts, so I am able to reliably estimate the effect of spending in high-income areas. Also, my estimates are identified off of both expansions and reductions in resources, while school finance reforms provide only expansions. This means my estimates are less sensitive to bias from secular trends.

For test scores, I find that a 10 percent increase in average spending 5 to 8 years prior to the tests increases 4th grade math and reading scores by about 0.09 standard deviations and 8th grade reading scores by 0.07 standard deviations. My estimate for 8th grade math scores suggests an increase of 0.03 standard deviations but is not precisely estimated. Importantly, spending before students enter school improves their future test scores, which suggests that investments in schooling inputs have a lasting effect. Whether or not increased spending improves student test scores is not a new question in the literature. Since Coleman et al. (1966) there have been dozens of studies attempting to estimate the education production function (Todd and Wolpin, 2003). This debate has been contentious and has not yet lead to a consensus (Hanushek, 2003; Krueger, 2003). This lack of consensus is driven by the endogeneity between spending and student outcomes and the difficulty in identifying a causal relationship. My estimates are consistent with the most recent, well-identified estimates, which suggest that increasing total school resources does indeed improve test scores (Lafortune, Rothstein, and Schanzenbach, 2018).

My primary contribution is new empirical evidence for the effect of spending on student achievement using more regular, high-frequency variation than in past studies. My estimates are identified by year-to-year variation in funding within the existing policy structure rather than large, targeted overhauls of those structures as in school finance reforms. The findings suggest that large, structural changes in school finance formulas are not prerequisites for spending to affect student outcomes.

As a result of my novel identification strategy, I make three additional contributions. First, I compile a new administrative data set from 24 states that contains property values for over 7,000 school districts. This information is valuable for other research questions in local public finance. Second, I simulate expected changes in revenue based solely on changes in property values by coding up the key features of school finance formulas in 1999. Finally, the reduced-form of my estimates provides the first evidence of a causal effect of market fluctuations in property values on student achievement.[3] My first-stage estimates show that increased property values significantly increase school revenue through both local sources and state aid. Although school finance reforms decreased the cross-sectional relationship between local property values and school spending, there remains a significant time-series relationship that influences student outcomes.

My findings have several implications for policy. First, I find that changes in property values indirectly affect student outcomes by changing the level of available resources. This connection means that volatile housing prices can lead to volatile student outcomes, which is an undesirable outcome for school districts. I also provide suggestive evidence that students are harmed more by spending cuts than they benefit from equivalent increases in spending. Taken together, these results suggest that policymakers can improve student outcomes by allowing school districts opportunities to smooth spending through borrowing and saving. Loosening the credit constraints of school districts can help insulate against volatile housing markets and the harmful effects of spending cuts. Second, a concern with increasing education spending is that we are already at the "flat of the curve," meaning, spending is sufficiently high that the marginal effect of each additional dollar is low. My results suggest that, even during the 2000s when spending per pupil was historically high, the United States has not yet reached that theoretical plateau. Finally, increased spending improves

[3] Davis and Ferreira (2017) estimate the effect of housing values on school finances, but are limited in the test score outcomes they are able to investigate due to the timing restriction of their identification strategy.

test scores even when the spending occurs prior to when students enter school. This relationship suggests that there are durable or delayed effects of investments in school inputs on test scores. This is another reason that simply comparing the current level of funding with contemporaneous outcomes is not likely to capture the relationship between spending and student achievement.

The next section provides background information about the prior literature, property taxes, and school finance programs in the United States. The data is discussed in Section 3. Section 4 explains my simulated instrument and empirical strategy. I present my results in Section 5, and Section 6 concludes.

2 Background

2.1 Prior Literature

A large literature attempts to apply the framework of production technologies to the education process. These studies estimate the relative importance of primary inputs, which include an individual endowment of ability and the influence of families, peers, and schools (Todd and Wolpin, 2003). The output of the education process is cognitive and noncognitive skills that culminate in persistence in education and eventual labor market earnings.

The first study to examine the relative importance of school inputs and family inputs on student achievement was Coleman et al. (1966). Coleman finds that family characteristics explain the majority of variation in test scores and spending explains little. At the time, people took these results to mean that schools did not matter and the variation in student outcomes is a result of family and peer effects. The methodology used in the analysis were severely criticized at the time (Bowles and Levin, 1968; Cain and Watts, 1970; Mosteller and Moynihan, 1972). Even so, the counterintuitive results in Coleman et al. (1966) ignited decades of hotly-debated research into the relationship between spending and student achievement, which find contrasting evidence (see Hanushek, 2003; Krueger, 2003). Most of these studies require strong assumptions to be interpreted as causal because they lack exogenous variation in spending.

Recently, more well-identified studies leverage experimental or quasi-experimental variation in school inputs to examine their effect on student outcomes. These inputs include class size (Krueger, 1999; Angrist and Lavy, 1999; Hoxby, 2000; Krueger and Whitmore, 2001; Chetty et al., 2011), teacher quality (Chetty et al., 2011), and capital spending (Cellini, Ferreira, and Rothstein, 2010; Martorell, Stange, and McFarlin, 2016; Hong and Zimmer, 2016). Others exploit large changes in spending due to school finance reforms (SFRs). SFRs increased spending and decreased spending gaps between high- and low-income school districts by 19 to 34 percent (Murray, Evans, and Schwab, 1998). Card and Payne (2002) find that increased spending from SFRs decreased the gap in SAT scores across family background groups. Jackson, Johnson, and Persico (2016) find that increased per pupil spending increased educational attainment and adult earnings, and Hyman (2017) finds that Michigan's SFR improved college-going and completion.

Most relevant to the present study are those that use variation in spending from SFRs to examine the relationship between spending and student outcomes such as graduation rates, test scores, and labor market outcomes. Jackson, Johnson, and Persico (2016) use individual-level data from the Panel Study of Income Dynamics to link adults to the school district in which they grew up to measure the effect of court-ordered school finance reforms on long-run outcomes. They find that a 10% increase in spending increased high school graduation rates by 7.1 percentage points, years of schooling by 0.3 years, and adult earnings by 7 percent. Using the same district-level graduation data from the CCD as the current study, they find that a 10% increase in spending increased graduation rates by 3.55 percentage points. Candelaria and Shores (2017) replicate this finding and also estimate that a 10% increase in spending increased graduation rates by 5 percentage points in the quartile with the highest fraction of free-lunch eligible students.

Most SFR studies that examine test scores do so in individual states. These include

Clark (2003) who finds no test score gains in Kentucky, and Papke (2005) who finds increased proficiency scores in Michigan. The one study to use SFRs to examine the effect of spending on standardized test scores nationwide is Lafortune, Rothstein, and Schanzenbach (2018). Using restricted-access individual-level information from the state NAEP, they create state-level measures of test score disparities between low and high income school districts. They find that after reforms, low-income districts close the gap between their test scores and those in high-income districts by 0.1 standard deviations, which gives an effect size of 0.12 to 0.24 standard deviations per $1,000 in annual spending per pupil. My paper is the first to estimate the causal effect of spending on test scores at the district level that are nationally comparable.

2.2 Property Taxes

Most school districts are governed by a school board with authority to levy property taxes for school funding. This taxing authority is limited by statute and the approval of local voters. Property taxes are *ad valorem* taxes[4] determined by multiplying the aggregate taxable value of property in the district by the property tax rate. The tax rate is often reported in "mills," or thousandths of a dollar. That is, a property tax rate of 1 mill corresponds to a fraction of $\frac{1}{1000} = 0.001$. Nearly all property tax imposing jurisdictions tax real estate such as residential and commercial properties. Other common types of taxable property include motor vehicles, agricultural land, mineral wealth, and certain types of property used in business such as machinery.

States impose a number of restrictions, known as tax and expenditure limits (TELs), on the property taxing behavior of local governments. These restrictions determine the taxable value of property and restrict the allowable level and growth of property tax revenue. TELs were mostly enacted in reaction to the property tax revolts of the 1970s and 1980s as a way of codifying the de facto tax breaks that homeowners were already receiving prior to the

[4] *Ad valorem* (Latin for according to the value) taxes are levied in proportion to the estimated value of the goods considered.

institution of rigorous assessment practices. States determine the fraction of property that is subject to taxation – called the assessment rate – for each type of property. Historical or religious buildings are exempt from taxation and their assessment rate is zero. Other properties are partially exempt and given a lower assessment rate such as homesteads and homes owned by low-income seniors or veterans. Other TELs restrict taxing behavior to reduce the tax burden and limit volatility in property tax payments. To reduce the tax burden, state impose fixed tax limits, such as maximum or minimum millage rate requirements. Some states also limit the annual change in assessed value, revenue, or tax payments.

Previous studies find that introducing TELs decreased school inputs and weakened student outcomes. Student-teacher ratios increased significantly as a result of Oregon's tax limitation (Figlio, 1998). Figlio and Rueben (2001) also find that TELs reduce the test scores of education majors, and presumably their effectiveness as teachers. Downes, Dye, and McGuire (1998) find that the introduction of TELs in Illinois led to a small reduction in 3rd grade math scores, but found no effect for reading scores. Rather than estimated the effect of moving to a new set of TELs, I include the dynamic limits in my simulated instrument since they are predetermined responses to large fluctuations in property values. The fixed limits are accounted for in the base year characteristics and district fixed effects. These rules represent important differences across states in how and when increased property values translate into revenue. As of 1999, 19 states had some sort of dynamic limit on the growth of property tax revenue.[5]

2.3 School Finance

School districts receive about 45 percent of their funding from local sources, 46 percent from state sources, and the remaining 9 percent from federal sources (U.S. Department of Education National Center for Education Statistics, 2016a). Eighty percent of local revenue is generated through property taxes. The majority of state revenue for education comes

[5] Table A2 lists each of the dynamic TELs as of 1999.

from income and sales taxes.[6] State funds are distributed to local school districts based on a formula set by the state legislature, usually on a per pupil basis. In addition to the student counts, state finance formulas depend on the ability of school districts to raise local revenue, usually measured by property wealth. Other supplementary funds are distributed based on program offerings through categorical grants or special circumstances like large geographic districts that need addition funding for transportation.

Funds are available to school districts based on the following relationship:

$$R_t^d = L_t(\tau_t^d \times W_t^d) + S_t(\tau_t^d, W_t^d, \mathbf{\Gamma}_t^d) + Fed_t(\mathbf{\Lambda}_t^d), \tag{1}$$

where R_t^d is the sum of revenue from all sources for district d and year t. Local revenue, $L_t(\cdot)$, is a function of the revenue generated by applying the school property tax rate to the property wealth within a district along with any tax and expenditure limits.[7] Thus, W_t^d is the market value of property, τ_t^d is the millage rate, and $L_t(\cdot)$ converts the millage rate into the effective tax rate and accounts for non-linearities imposed by TELs. The effective tax rate is the fraction of market value of property that is received as property tax revenue. It is also useful to define ℓ_t^d such that $\tau_t^d \times \ell_t^d W_t^d = L_t^d(\tau_t^d \times W_t^d)$ for interior values (where the non-linearities are not binding). The state revenue function, $S(\cdot)$, depends on local tax effort – measured by τ_t^d – and tax capacity – measured by W_t^d – as well as characteristics of the district, $\mathbf{\Gamma}_t^d$, such as student counts and participation in certain educational programs like special education or free or reduced-price lunch. Transfers between state and local governments are captured in S_t, so if states redistribute revenue from high-wealth to low-wealth areas, then S_t can be negative. Federal revenue, $Fed_t(\cdot)$, is a function of district characteristics, $\mathbf{\Lambda}_t^d$, that may or may not also be included in $\mathbf{\Gamma}_t^d$, depending on the state.

As shown in Equation 1, changes in total revenue come from multiple sources. For example, states can make legislative adjustments to the state funding formula and districts

[6] In some states property tax revenue for schools is treated more like a state revenue source because states either directly collect the property tax, or receive funds from local districts that they then redistribute.

[7] Although TELs are imposed by the state, they directly affect the collection of local revenue.

can adjust the property tax rate. School finance reforms constitute a fundamental change in the form of S_t that is above and beyond small adjustments to the parameters of the existing system. Hoxby (2001) uses the term inverted tax price to denote "the dollars that a district gets to spend if it raises one dollar in local revenue" regardless of whether that dollar is generated by a change in the tax rate or the tax base. Here, I separate these two factors that determine revenue and use the term tax price to refer specifically to $\frac{\partial R_t^d}{\partial \tau_t^d}$, or the change in revenue given an increase in the tax rate. I separately define the wealth price as $\frac{\partial R_t^d}{\partial W_t^d}$, or the marginal change in revenue given a unit increase in property wealth. The wealth price depends on how W_t^d interacts with each revenue source. By differentiating both sides of Equation 1, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \frac{\partial L_t^d}{\partial W_t^d} + \frac{\partial S_t^d}{\partial W_t^d}. \tag{2}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \frac{\partial L_t^d}{\partial \tau_t^d} + \frac{\partial S_t^d}{\partial \tau_t^d}. \tag{3}$$

Thus, the wealth price and the tax price reflect both changes in local property tax revenue and direct responses in state aid. Districts choose their tax rate based on the tax price, but are unlikely to consider the dynamic effect feeding back through the wealth price in the future.

Nearly every state uses a foundation program, district power equalization, or a combination of the two.[8] The most common school finance policy is the foundation program, which is used in over 40 states. The goal of a foundation plan is to provide adequate funding by guaranteeing an amount of funding per pupil. The guaranteed amount of spending per pupil is called the foundation level. To qualify for state aid, districts are responsible for contributing a local share defined by applying the foundation tax rate, τ^f, to their taxable

[8] Table A1 summarizes the type of school finance programs used in each state. Hawaii's single school district is entirely funded by the state and does not receive property tax revenue. North Carolina provides flat grants to districts, which can be supplemented by local property tax revenue.

property value. Foundation programs do not preclude districts from raising additional funds by taxing above the foundation tax rate. Generally, foundation programs provide state aid based on

$$S_t^d = \max\{0, \text{Foundation}_t \times ADM_t^d - L_t^d(\tau_t^f \times W_t^d)\}, \tag{4}$$

where the guaranteed amount of funding is the product of Foundation_t (the statewide foundation level; dollars per student), and ADM_t^d (average daily membership; the number of students in the district). If we let $F_t^d = \text{Foundation}_t \times ADM_t^d$, then the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} (\tau_t^d - \tau_t^f) \times \ell_t^d, & W_t^d < \frac{F_t^d}{\ell_t^d \tau_t^d} \\ \tau_t^d \ell_t^d, & W_t^d > \frac{F_t^d}{\ell_t^d \tau_t^d} \end{cases} \tag{5}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d, \qquad \tau_t^d \neq \tau_t^f. \tag{6}$$

The relationship between revenue and property wealth and between revenue and the tax rate are shown in panel A of Figure 2. The dashed line shows revenue with no state aid, so the distance between the dashed and solid line represents the amount of state aid. For a district with no property wealth, revenue is exactly the foundation guarantee, F_t^d. As wealth increases, revenue increases by $(\tau_t^d - \tau_t^f) \times \ell_t^d$, or how far the district's tax rate is above the foundation tax rate. This continues until wealth is above $\frac{F_t^d}{\ell_t^d \tau_t^d}$, at which point state aid is zero. Districts with a tax rate below the foundation tax rate receive no state aid and districts with a tax rate above receive aid in the amount $F_t^d - \tau_t^f \ell_t^d W_t^d$, or the guaranteed amount minus the amount of local revenue generated by taxing the foundation rate. Note that there is no upper limit to the local tax rate at which districts receive state aid.

The second most common set of school finance policies are district power equalization programs. To help subsidize funding for low-wealth districts, equalization programs guarantee an amount of revenue per mill regardless of district property wealth. Generally, equalization plans distribute funds based on

$$S_t^d = L_t^d \left(\tau_t^d \times \left(\max\{W_t^d, W_t^*\} - W_t^d \right) \right), \tag{7}$$

where W_t^* is the guaranteed wealth level. The state tops local revenue up to what a district with the guaranteed wealth level would get by levying the same tax rate. The wealth price for this plan is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} 0, & W_t^d < W_t^* \\ \tau_t^d \ell_t^d, & W_t^d > W_t^*, \end{cases} \tag{8}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \max\{\ell_t^d W_t^*, \ell_t^d W_t^d\}. \tag{9}$$

Panel B of Figure 2 the relationship between revenue and wealth and between revenue and the tax rate for a general district power equalization plan. Districts with property wealth less than the guaranteed level receive $\tau_t^d \ell_t^d W_t^*$ in revenue. As property wealth increases, the amount of revenue does not change, but the fraction of revenue from state aid decreases until wealth reaches the guaranteed wealth level and state aid becomes zero. Revenue increases by $\max\{\ell_t^d W_t^*, \ell_t^d W_t^d\}$ as the tax rate increases.

Below, I provide examples from New Mexico and Georgia to explain how I calculate the wealth and tax price.[9] I use the term $wADM_t^d$ to refer to weighted average daily membership or the weighted number of students.[10] These examples also help show why the wealth price varies between districts within states as well as across states. To emphasize this point, Figure 3 shows the distribution of wealth price for each of the states in my analysis. The within state variation comes from differences in property tax rates and property wealth across districts. Variation across states also depends on these factors but is additionally driven by differences in the state's funding formulas. This variation is not obvious based on the finance

[9] The school finance formulas for other states in my sample are described in Appendix C.

[10] I use the same notation for districts across states, but in constructing the state finance formula I take into account the substantial differences in how states weight students in different grades or programs.

formulas and may not even be apparent to districts themselves. Nevertheless, there is a large amount of both within- and between-state variation in the wealth price, which I exploit in my identification strategy.

2.3.1 Foundation Example: New Mexico

New Mexico has a simple foundation program established by the New Mexico Public School Finance Act of 1974. The foundation tax rate is 0.5 mills, so local revenue is $L_t^d(\tau_t^d \times W_t^d)$ and state revenue is

$$S_t^d = \text{Foundation}_t \times wADM_t^d - L_t^d(0.0005 \times W_t^d). \tag{10}$$

Although there is no limitation in the law that requires S_t^d to be positive, the finance rules and characteristics of districts are such that this is not negative in practice. Total revenue is then given by

$$R_t^d = \text{Foundation}_t \times wADM_t^d + L_t^d((\tau_t^d - 0.0005) \times W_t^d) + Fed_t^d. \tag{11}$$

This gives a wealth price of

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.0005) \times \ell_t^d. \tag{12}$$

Thus, without any action by the school district, revenue increases by a set fraction of any additional property wealth and depends directly on the local tax rate and the foundation tax rate. Similarly, the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d \tag{13}$$

which depends on property wealth.

2.3.2 Foundation + Equalization Example: Georgia

Georgia's Quality Basic Education Act provides funds per weighted pupil based on a foundation program with an optional equalization component. The foundation tax rate is 5 mills. The equalization component provides the difference between the revenue generated from 5 to 8.25 mills and what would have been generated by a district with that same millage rate and property wealth as a district at the 90th percentile of wealth in the state. Local revenue is $L_t^d(\tau_t^d \times W_t^d)$ and state revenue is

$$\begin{aligned} S_t^d &= \text{Foundation}_t \times wADM_t^d - L_t^d(0.005 \times W_t^d) \\ &\quad + \min\{0.00325, \tau_t^d - 0.005\} \times L_t^d(\max\{W_t^d, W_t^{90}\} - W_t^d), \end{aligned} \tag{14}$$

where W_t^{90} is the 90th percentile of wealth across districts. There is no statutory limitation on S_t^d that keeps this value from being negative, but the total state aid given to all districts is restricted by limiting the local share to less than 25 percent of the total foundation guarantee aggregated across all districts. Total revenue is then given by

$$\begin{aligned} R_t^d &= \text{Foundation}_t \times wADM_t^d + L_t^d((\tau_t^d - 0.005) \times W_t^d) \\ &\quad + \min\{0.00325, \tau_t^d - 0.005\} \times L_t^d(\max\{W_t^d, W_t^{90}\} - W_t^d) + Fed_t^d. \end{aligned} \tag{15}$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} \left(\tau_t^d - 0.00825\right) \times \ell_t^d, & \text{if } \tau_t^d \geq 0.00825 \text{ and } W_t^d \leq W_t^{90} \\ 0, & \text{if } \tau_t^d \leq 0.00825 \text{ and } W_t^d \leq W_t^{90} \\ \left(\tau_t^d - 0.005\right) \times \ell_t^d, & \text{if } W_t^d > W_t^{90} \end{cases} \tag{16}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \ell_t^d W_t^d & \text{if } W_t^d \geq W_t^{90} \\ \ell_t^d W_t^{90} & \text{if } W_t^d < W_t^{90} \end{cases}. \tag{17}$$

So, if districts have wealth below the 90th percentile, they gain state revenue and lose local revenue from each dollar of increased property wealth. For districts with a tax rate between 5 and 8.25 mills the increase in local revenue and decrease in state revenue cancel each other out and total revenue is unchanged. Districts at or above the 90th percentile of wealth are not effected by the equalization component and only experience the foundation portion of the plan.

3 Data

3.1 Data Sources

The data for this project are combined from several sources. My primary source of data is the National Center for Education Statistics' Common Core of Data (CCD). I supplement the CCD with additional district-level information including a database of district property values collected from individual states, test scores, and median household income.

3.1.1 NCES Common Core of Data

The CCD is a comprehensive, national database of all public schools and school districts in the United States. Fiscal information is available annually back to 1995 and non-fiscal characteristics are available back to 1987. The variables I use from the CCD include expenditures, revenues, and the number of students in several race categories and in certain educational programs. Expenditures are reported in a number of categories including instructional spending, capital outlays, and administrative spending.[11] Revenues are reported in several fine categories and aggregated to local, state, and federal sources. One subcategory necessary for my identification strategy is property tax revenue, which I divide by district property wealth to calculate the effective tax rate. The endogenous variable of interest that I

[11] I consider both log spending and spending per pupil in my analysis. Results are consistent between the two measures, but I primarily discuss the log spending measures.

instrument for in my identification strategy is total expenditures, which I report in thousands of dollars per pupil. I use student count data to create controls for total student enrollment, the fraction of students who are black or Hispanic, have an individualized education plan (IEP)/are in special education, or are eligible for free or reduced price lunch.

3.1.2 School District Property Wealth Database

The CCD does not include a measure of district property wealth, which is crucial for my estimation strategy. Most states have an agency (usually a Department of Revenue or Department of Taxation) that oversees local auditors who assess values for property tax purposes. Due to this responsibility, summaries of property values at each geographic level of taxation (e.g. county, municipality, school district) are often available from these state agencies. I collected this information individually from states and created the first school district-level database of property values covering years 1999-2014.[12] This database includes information for 24 states.[13] The data necessary to perform my analysis is not currently available for other states. Measures of property wealth are predominantly made up of residential and commercial real property but may also include other types of property (e.g. automobiles or mineral resources).

I digitized the raw data based on state records and converted the property wealth measures to total market value of property within the district, wherever possible.[14] I then merged these state records with school district information from the CCD. I most frequently matched on district name, but in some cases I used unique identifiers consistent between the state and CCD records when they were available. See Online Appendix B for a full description of data sources and steps taken to create the database.

[12] Property wealth data is not available in each state and year. See Online Appendix B for a description of data sources and availability for each state.

[13] The states in the database are Arkansas, Connecticut, Florida, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Massachusetts, Minnesota, Mississippi, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Texas, and Washington.

[14] Some states provide enough information for me to match assessment rates for different types of property with the relevant assessed values to back out market values.

3.1.3 School Finance Formulas

I compile information about school finance formulas from multiple sources. U.S. Department of Education National Center for Education Statistics (2001) provides an overview of each state's funding formula as of the 1998-1999 school year, which provides a useful starting point. I supplement these descriptions with additional information from laws and statutes as well as documentation from state Departments of Education.

I do not attempt to capture every factor that influences state funding. Instead, I focus on the bulk of funding that comes from foundation entitlements and parts of state funding that depend on property wealth. The main feature that needs to be reflected in the school finance formulas is the wealth price. This means that the response to a change in property wealth will be correct in terms of direction and relative magnitude, but the scaling will be off to the extent that I have not accounted for all other categorical grants or other components that are unrelated to property wealth. These differences may weaken the power of my simulated instrument but do not invalidate my instrumental variables estimates.

3.1.4 Student Achievement Data

Graduation rate data come from the CCD and test score measures come from the Stanford Education Data Archive (SEDA). Each data source has its own strength and limitations.

Graduation data comes from the CCD completion information at the district level for most years from 1992 to 2010. I calculate graduation rates by taking the number of diplomas awarded in a given year and dividing by the number of students in the cohort expected to graduate that year based on lagged student counts. Thus, the completion rate can be calculated using a number of cohorts such as the number of students in 11th grade the previous year, number of students in 10th grade two years ago, and so on. Specifically,

$$\text{Grad}_t^g = \frac{\text{Diplomas}_t}{\text{Students}_{t-(12-g)}^g}, \tag{18}$$

where Grad_t^g is the gth grade cohort graduation rate in year t, Diplomas_t is the number of diplomas awarded, and $\text{Students}_{t-(12-g)}^g$ is the number of students in gth grade $12 - g$ years prior to t. There is some year-to-year variation in district coverage. One important example is years 2003 to 2005, when completion information was only recorded for school districts serving more than 1000 students.[15] My preferred estimates only include districts with data from 2003 to 2005, but results are not sensitive to this restriction. It is important to note that this measure is only a proxy for the graduation rate. This measure will also pick up changes in student composition that occur between the year the cohort is measured and when the number of diplomas is measured. It also does not account for students who receive a GED or transfer to a different school district.

The SEDA is a collection of academic achievement, achievement gaps, and school and neighborhood economic and racial composition at various levels of aggregation. The SEDA includes a comprehensive database of district-level test scores for school years 2009 to 2013. The basis for these measures are state standardized tests, which are then adjusted based on comparing the distributions of those tests with the NAEP.[16] For a subset of large, diverse districts, there are also measures of the average gap between white students and black students. These test score measures are reported on the scale of NAEP scores, but I standardize these at the grade-subject level based on the mean and standard deviation in 2009. After 2009 I allow the mean and standard deviation to evolve as the distribution of achievement shifts over time. One of the strengths of the SEDA test score measure is that it covers over 80 percent of districts in the United States. The second key strength is that the measures are comparable across time and geography, which allows me to do this district-level, nationwide analysis. The primary limitation of these data is that they are currently only available for a limited number of years.

[15] The number of diplomas awarded was not reported from 2003 to 2005. For these years, I use the reported dropout rate and the base number of students to calculate a measure of diplomas awarded that is consistent with the other years.

[16] See Reardon and Kalogrides (2017) for a full discussion of how these measures are constructed.

3.1.5 Other State and District Controls

Other data used in my analysis include median household income and additional measures used in school finance formulas. The median household income for each school district comes from the 2000 Census and the American Community Survey (ACS) 5-year estimates. These sources provide an estimate of district income for 1999 and then 2009 onward. To account for district-level changes in income, particularly during the great recession, I impute values linearly between the district value in 1999 and the value in 2009. This captures the potential drop in incomes in areas most deeply affected by the recession. Some school finance formulas include a measure of the cost of living to adjust for within state differences in the cost of teacher salaries.[17]

3.2 Creating a Balanced Panel of School Districts

Over time, new school districts are formed, old districts are absorbed into existing districts, and some local districts are consolidated into regional districts that serve a larger geographic area. This regional consolidation is especially apparent in the Midwest, where small, rural districts have been combining with greater frequency (Gordon and Knight, 2009). To create a balanced panel of school districts, I combine all districts that are ever associated with each other. For example, Figure A1 shows the boundaries of two school districts in Minnesota, Brewster and Round Lake. These two districts consolidated into Brewster-Round Lake Public Schools in 2014. Therefore, I treat these two school districts as a single district across the entire analysis period. I sum the property values and student counts in these two districts and average the median income and test scores.

I aggregate school districts for two additional reasons: regional district overlap and availability of property value data. Some states have municipality-level elementary districts and regional high school districts that serve multiple municipalities. Even if I have the property values for each municipality, it is not possible to distinguish how the change in

[17] These additional variables are outlined in Online Appendix B.

property values for a municipality affects each district separately. Figure A2 illustrates this issue with three municipalities in New Jersey. Bellmawr, Runnemede, and Gloucester municipalities each provide for their own elementary services, and Black Horse Regional High provides secondary services for all three. In both situations, I combine school districts to the lowest level for which I have data and use the aggregated school district in my analysis. While most property value data is reported at the school district level, in some states the data are at the municipality or county level and it is not possible to perfectly map property values to school districts. In these cases, I aggregate districts to the level at which property values are available.

The number of school districts in my sample of 24 states starts at 8,061 in 1999 and falls to 7,649 by 2014 due to actual consolidations. After making my additional district consolidations due to data limitations, my balanced panel consists of 6,500 districts.[18] I also make several exclusions to reduce noise and volatility in my per-pupil measures, which are similar to the exclusions in Lafortune, Rothstein, and Schanzenbach (2018). Specifically, I remove districts with fewer than 100 students at any time and district-year observations with enrollment: more than double the district's mean enrollment, more than 15 percent different from enrollment in either adjacent year, or more than 10 percentage points above or below the district's average growth in enrollment. I also remove district-year observations with per pupil expenditure or simulated revenue more than 5 times larger or smaller than the state average. Together, these restrictions affect roughly 19.5% of district-year observations, but many of these districts are also dropped due to other missing data. My main conclusions are not sensitive to these restrictions.[19]

[18] I perform additional analyses to show my results are robust to dropping all consolidated districts. These results are available in Appendix Table A20.

[19] Estimates without these sample restrictions are available in Appendix Table A20.

3.3 Summary Statistics

Summary statistics for my main estimation samples for graduation rates or SEDA test scores are presented in Table 1. The table highlights the fact that each outcome is available for distinct subsets of the data. The first two columns present means and standard deviations for the graduation rate sample, where spending information is either available for at least 1 year prior to cohort graduation and for at least 4 years prior. The last column reports statistics for the sample with SEDA test scores. The graduation rate samples cover just under 3,000 school districts, while the test score sample has just under 6,000 school districts. The average graduation rate is about 80 percent for the 10th grade cohort.

My sample consists of districts from 24 states. Table 2 compares the characteristics of districts in states including in my sample and those that are not included, to speak to the external validity of my estimates. These differences are calculated as of 2009. The first column shows statistics for the districts in states in my sample, column (2) provides statistics for districts in states not in my sample, column (3) displays the p-value of the difference between column (1) and (2), and the final column is statistics for all districts. The 24 states in my sample account for 55 percent of all students and 56 percent of districts. Districts are similar in their average number of students and teachers, and in income. There are some differences in property tax revenue per student and fractions of students eligible for free or reduced price lunch, in special education or who are a racial minority. However, these differences are small and provide suggestive evidence that my estimates for the relationship between spending and student outcomes would generalize to other states not in my sample.

4 Method

The central challenge in estimating the causal effect of total spending on student achievement is endogeneity between expenditures and student outcomes. For example, districts with a higher number or percentage of children who come from low-income families receive addition funding through programs such as Title I. This negatively biases cross-sectional estimates. On the other hand, districts with a higher fraction of parents that are high income or are more engaged in education also receive additional resources through a higher willingness to pay taxes for education and potentially donations to the district. This situation instead causes a positive bias in a cross-section. These are just two examples of the bias that comes from factors related to both educational outcomes and levels of spending. It is unclear which type of bias dominates in any given sample, so cross-sectional OLS estimates are difficult to interpret in a causal manner. Controlling for fixed differences between districts accounts for many of these cross-sectional biases, but changes in student or family characteristics also introduce bias.

4.1 Simulated Instrument

To address these endogeneity concerns, I construct an instrument that captures the mechanical response in revenue to changes in property values through fixed school funding formulas. States regularly change the funding level per student to address student needs and changing costs of education. Districts also frequently change their tax rates based on their budgetary needs and the current level of property wealth. Both of these policy decisions are likely to be endogenously related to changes in student performance. In my instrument, I fix both state funding formulas and district property tax rates in a base year. The only determinant of funding left to vary is property wealth. With fixed tax rules, increased property wealth leads to increased property tax revenue and, often, decreased state transfers.

Specifically, I start with a district's base year effective tax rate, which is given by

$$ETR_0^d = \frac{\text{Property Tax Revenue}_0^d}{W_0^d}, \tag{19}$$

where Property Tax Revenue$_0^d$ is the total revenue from property taxes in the base year and

W_0^d is the total market value of property in the base year.[20] Previous research finds that property values are determined, in part, by the quality of schools in the area (Oates, 1969; Black, 1999; Bayer, Ferreira, and McMillan, 2007; Ries and Somerville, 2010). Thus, student achievement may directly affect property values in the district. To avoid this simultaneity issue, I calculate simulated property wealth in year t as

$$\tilde{W}_t^d = \frac{W_t^s - W_0^s}{W_0^s} \times W_0^d, \tag{20}$$

where W_t^s and W_0^s are state-level property wealth in year t and the base year, respectively. I use state-level changes that omit the focal district to remove any potential impact of district-level changes on the aggregate. This can also be done at other levels of aggregation (e.g. CBSA or national). The higher the level of aggregation, the less concern about characteristics of the district impacting property values.[21] My measure of simulated property wealth is a Bartik-style shift-share measure, where the share is the baseline level of property wealth and the shift is changes at the state-level (Bartik, 1991).

Simulated local revenue, $\tilde{L}_t^d$ is then the base year effective tax rate times simulated wealth, or

$$\tilde{L}_t^d = ETR_0^d \times \tilde{W}_t^d. \tag{21}$$

The effective tax rate absorbs most of the L_t^d function by accounting for assessment rates, delinquency rates, and exemptions. Simulated state revenue, $\tilde{S}_t^d$, is calculated by substituting a combination of the base year statutory tax rate, τ_0^d, base year effective tax rate, ETR_0^d, base year student counts, and current year simulated property wealth into the base year

[20]Due to data limitations, I am unable to recover market values from assessed values for all districts. The instrument exhibits the same variation for districts with assessed, rather than market, values but the magnitude of the first stage will be scaled by the portion of ℓ_t^d for which I am not able to account.

[21]I perform additional analyses with simulated revenue calculated using national changes in wealth. These analyses are available in Table A20 and provide similar results to my leave-one-out measure for graduation rates, but the first stage becomes weak for the test score samples.

state funding formula. That is,

$$\tilde{S}_t^d = S_0(\tau_0^d, \tilde{W}_t^d, wADM_0^d, \tilde{L}_t^d). \tag{22}$$

Here, S_0 captures important characteristics of funding formulas in the base year that determine the response in state revenue to changes in property values. The set of variables included in simulated state revenue depend on the particular state funding formula. To explain how I construct simulated state revenue, consider the examples of New Mexico and Georgia. In New Mexico, the foundation amount was \$2,344.09 per weighted pupil in 1999 and the only other variables state funding depends on are student counts and property wealth. Thus, simulated state revenue for New Mexico is calculated as

$$\tilde{S}_t^d = \$2,344.09 \times wADM_0^d - \ell_t^d \times 0.0005 \times \tilde{W}_t^d, \tag{23}$$

and it follows that simulated revenue is:

$$\tilde{R}_t^d = \$2,344.09 \times wADM_0^d + (ETR_0^d - \ell_0^d \times 0.0005) \times \tilde{W}_t^d. \tag{24}$$

For Georgia, the foundation amount in 1999 was \$2,038.74 per weighted pupil, so simulated state revenue is

$$\begin{aligned}\tilde{S}_t^d &= \$2,039 \times wADM_0^d - \ell_0^d \times 0.005 \times \tilde{W}_t^d \\ &+ \ell_t^d \times \min\left\{\frac{3.25}{1000}, \tau_0^d - 0.005\right\} \times \max\{0, \tilde{W}_t^{90} - \tilde{W}_t^d\}\end{aligned} \tag{25}$$

and simulated revenue is

$$\begin{aligned}\tilde{R}_t^d &= \$2,039 \times wADM_0^d + (ETR_0^d - \ell_0^d \times 0.005) \times \tilde{W}_t^d \\ &+ \ell_0^d \times \min\left\{\frac{3.25}{1000}, \tau_0^d - 0.005\right\} \times \max\{0, \tilde{W}_t^{90} - \tilde{W}_t^d\}.\end{aligned} \tag{26}$$

This same procedure is carried out for each district in my sample.

4.2 Empirical Strategy

I estimate two-stage least squares (2SLS) models relating student achievement to per pupil spending, using simulated revenue per pupil as an instrument for actual per pupil spending. The first stage equation for per-pupil spending is:

$$\text{Spending}_{d,t-\tau} = \alpha_0 + \alpha_1 \tilde{R}_{d,t-\tau} + \alpha_2 W_{d,t} + \boldsymbol{X}_{d,t}\boldsymbol{\alpha}_3 + \gamma_d + \gamma_{s,t} + \eta_{d,t} \tag{27}$$

where $\text{Spending}_{d,t-\tau}$ is observed log spending in district d in the τ years before calendar year t. This can either be the values of simulated revenue and spending τ years ago or the average over the past τ years. $W_{d,t}$ is the value of property in the district, $\mathbf{X}_{d,t}$ is a vector of district characteristics including log number of students, median household income, fraction of students with an IEP, fraction of student eligible for free or reduced price lunch, fraction of black student, and fraction of Hispanic students. District fixed effects are given by γ_d and state-by-year fixed effects are given by $\gamma_{s,t}$, where s indicates the state in which district d is located.

The second stage is:

$$A_{d,t} = \beta_0 + \beta_1 \widehat{\text{Spending}}_{d,t-\tau} + \beta_2 W_{d,t} + \boldsymbol{X}_{d,t}\boldsymbol{\beta}_3 + \delta_d + \delta_{s,t} + \varepsilon_{d,t}, \tag{28}$$

where $A_{d,t}$ is district-level student achievement, $\widehat{\text{Spending}}_{d,t-\tau}$ is predicted spending over the past τ years from the first stage, and other measures are as described in the first stage. In both equations, standard errors are clustered at the district level.

Education is a cumulative process, so even if student achievement responds directly to education spending, it is unlikely to do so in the same year. Instead of measuring the immediate effect of spending on contemporaneous test scores, I consider current and lagged district spending individually and on average. Ideally, I would examine the effect of spending over the past four years on fourth grade test scores and spending over the past eight years on eighth grade test scores. In practice, my instrument is stronger nearer to the base year, so I restrict my attention to the lags with a strong first stage. Since graduation rates are available in earlier years (1999-2010) my first stage is strong in closer relative years, lower values of τ. Thus, for models of the graduation rate I focus on spending between the current year ($\tau = 0$) and four years prior ($\tau = 4$). Test score measures are only available for later years (2009-2013) and therefore have a strong first stage with longer lags, higher values of τ. For test score outcomes I focus on spending in the five to eight years prior to the year the outcomes are measured. These are due to my empirical approach and do not necessarily reflect an underlying aspect of the education production function.

4.3 Identification

Including the observed district property values in my regressions makes clear that my model is not identified by within-district variation in property wealth. Instead, identifying variation comes from the interaction of property wealth and the fixed tax rules. In this case, the exclusion restriction is that simulated revenue is only related to student achievement through its affect on spending. Since the simulated instrument is determined only by base-year tax rules and adjustments to base-year property wealth, the exclusion restriction is violated if changes in unobserved factors related to changes in student outcomes (such as demographic shifts) are also related to the interaction of base-year tax rates and base-year property wealth. Thus, simulated revenue should not be related to large changes in demographics. The exclusion restriction would also be violated if demographic trends were determined by the combination of initial tax rates and property wealth.

In order to assess the validity of my empirical strategy, I propose several exercises that show whether the data is consistent with the assumptions necessary for my estimates to reflect a causal effect. First, in Figure 8, I explore whether the data support the exclusion restriction by plotting trends in district characteristics separately for four subgroups. The subgroups are created by splitting the sample by districts above and below the median for initial property wealth and effective tax price. The exclusion restriction would be violated if changes in district characteristics related to student achievement are related to baseline tax rates and property wealth. To provide context, the top two figures show the trends in property values and simulated revenue per pupil across the four subgroups. Property values exhibit the same upward trend for each group until 2009, when values in districts with high initial wealth decreased and values in districts with low initial property wealth stopped increasing. The trends in simulated revenue are similar until about 2003 when districts with low initial wealth have the largest increases. These lines are expected to diverge to the extent that there is variation in baseline tax rates and property wealth that are relevant for differences in revenue. The fraction of students eligible for free or reduced-price lunch trends up similarly for all four subgroups, which suggests no differential trends in district poverty. Finally, the fraction of students who are black increases in districts with high initial property wealth and remains relatively stable for districts with low initial property wealth. This suggests that my estimates may be attenuated because the districts with the largest growth in fraction black are also the districts with the largest increase in simulated revenue per student. Taken together, these provide evidence that my estimates are not being driven by trends in student characteristics.

In the next section I show two additional checks for the validity of my research design. First, I estimate the effect of simulated revenue on various measures of student composition. A strong relationship between student composition and simulated revenue could mean my estimates are biased. I will show that effects are small and the relationships that are significant would work in the opposite direct of the results I find. Second, I do a placebo test of whether future future simulated revenue is related to current outcomes. If my estimates are driven by endogeneity between my measure of revenue and student outcomes then the order of spending and outcomes would not matter. I will show that current and past spending matter, but future spending does not, which provides further evidence in support of my identification strategy.

5 Results

I show the individual-lag first stage effect of log simulated revenue on log total expenditures for the graduation rate samples and SEDA test score samples in figures, with corresponding tables available in the appendix. The y-axis of the figures are the estimated first-stage coefficient given a 10 percent increase in spending and the x-axis is number of years relative to when the cohort is set to graduate. Coefficients are shown as dots, 95% confidence intervals are shown as whiskers, and F statistics for each estimate are in brackets. Each column of the table correspond to one of the relative years on the x-axis and each panel is one of the samples.

First-stage estimates for the graduation rate samples are shown in Figure 4, with corresponding results in Table A4. The coefficients are mostly between 0.01 and 0.02, which means that a 10 percent increase in simulated revenue increases spending by 1 to 2 percent. This suggests that school districts and state governments respond to the mechanical change in revenue from changes in property values, but not enough to fully counteract the increase in revenue. However, as I previously mentioned, the scaling of simulated revenue makes these an underestimate of the true magnitude. The figures also show a pattern wherein estimates with a short lag (4 years or less) have a strong first stage, while estimates with a longer lag have smaller coefficients that either are not statistically different from zero or have F statistics less than 10. This is consistent with there being a strong first stage near the base year of 1999 that becomes weaker the further away the measure is from the base year.

Similar estimates for the SEDA test score samples are reported in Figure 5 and Table A5. The coefficients are centered around 0.02 for the later lags and decline to be around 0.01 for the earlier lags. These effects are similar to the magnitude of those in the graduation rate samples, but show a pattern that is opposite of the graduation rate samples, with stronger estimates for the longer lags and estimates that are attenuated and have F statistics below 10 for lags fewer than 3 years.

Simulated revenue is a strong instrument near the base year of 1999, but becomes weak farther away from the base year. This pattern is not due to actual heterogeneity in the lag structure, but is driven by the calculation of the instrument. Graduation rates are measured from the base year until 2010, but test scores are measured from 2009 to 2013. Thus, the short lags in the graduation sample and the long lags in the SEDA test score sample are strong because they come from the years in which the simulated instrument is strong. Since my 2SLS results are only reliable when the first stage is strong, I focus on spending in the 1 and 4 years before graduation rates are measured and spending 5 to 8 years prior to when test scores are measured.

Table 3 reports estimates with various averages of the prior years of simulated revenue and spending. Column (1) is the average of the current year and the previous year, column (2) is the average of the current year and the previous 4 years, estimates with the average of this year and the past 8 years are shown in column (3), and the last column has estimates averaged from 5 to 8 years prior to when the outcome is measured. Panels A through D present estimates for the graduation rate samples and panel E shows results for the SEDA test score sample. The estimates using average lags are consistent with the individual lags in the pattern of first-stage strength. The first stage is strong for averages of 1, 4, and 8 lags for graduation sample, but not for the average of 5 to 8 years prior. The SEDA test score sample has a strong first stage for the 8-year lag and the 5-8 year average, but not for the 1 and 4 year lags.

The results of my 2SLS analysis are reported in individual lags as both figures and tables and average lags in a table similar to the first stage results. Instead of showing all the individual lags, I only report the results for the lags that have a strong first stage. Figure 6 shows the individual lag results for graduation rates, with corresponding estimates in Table

A4.[22] The coefficients are positive and significant in the year of and before graduation, but smaller and not statistically significant 2 to 4 year prior. The estimates in Table 4 suggest that the average effect of a 10 percent increase in spending on graduation rates ranges from 2.1 to 4.4 percentage points. These results suggest that increased spending is most effective at improving graduation rates for those near graduation.

Figure 7 and Table A7 report the 2SLS results of spending on SEDA test scores. The coefficients are generally positive, significant, and around 0.1 standard deviations in magnitude. The exception is for 8th grade math scores, which are similar in magnitude but vary from a point estimate near zero for 8 years prior up to 0.2 for 4 years prior. The average lag results in Table 5 suggest that increasing spending by 10 percent in the 5 to 8 years prior to the test increase 4th grade math scores by 0.078 standard deviations, 4th grade reading scores by 0.088 standard deviations, 8th grade math scores by 0.048 standard deviations, and 8th grade reading scores by 0.093 standard deviations. It is important to note that increased spending has a lasting impact on test scores, and improvements made before students enter school have a significant effect several years later.

These estimates are consistent with the most recent, well-identified estimates for the effect of spending on test scores. In particular, Lafortune, Rothstein, and Schanzenbach (2018) find that after 10 years of increased spending by $1,000 per pupil, due to school finance reforms, test scores increased between 0.12 and 0.24 standard deviations. Other studies find positive effects of spending on test scores in single-state case studies (Guryan, 2001; Papke, 2005). My estimates suggest that a thousand dollar increase in spending per pupil results in a 0.051 to 0.066 standard deviation increase in test scores (In my sample, average spending per pupil is $13,719.24, so $1,000 is a 7.29 percent increase. Scaling my estimates by 0.729 gives $0.09 \times 0.729 = 0.066$ for 4th grade test scores and $0.07 \times 0.729 = 0.051$ for 8th grade reading scores.), which is smaller than Lafortune, Rothstein, and Schanzenbach (2018). However, the parameter I estimate is the effect of increased spending 5 to 8 years

[22] The coefficients for other individual lags with a weak first stage are imprecisely estimated and generally not informative, but are available upon request.

before the test is taken, while Lafortune, Rothstein, and Schanzenbach (2018) report the effect of a persistent increase in spending over the previous 10 years. If there is a cumulative effect of being in a district with more resources, then scaling my estimates to 10 years rather than 4 years provides effect sizes consistent with their study.

5.1 Validity Checks

If my measure of spending is correlated with changes in the types of students in the district, then the estimates could reflect changes in student composition rather than changes in student achievement. I explore whether this is the case in Table 6, which shows the effect of spending in the current and previous year in the graduation rate sample in the first 5 columns and average spending 5 to 8 years prior in the test score sample in the last 5 columns. The first column shows estimates for the log number of students and columns (2) through (5) show estimates for the fraction of students in different categories including fraction black, fraction Hispanic, fraction with an IEP (special education), and fraction eligible for free or reduced price lunch. A 10 percent increase in spending increases the number of students by 232 in the graduation rate sample and 210 in the test score sample, which amounts to a 4.5 percent increase. In the graduation rate sample, the fraction of students who are black increased by 0.22 percentage points, fraction Hispanic increased by 1.28 percentage points, fraction of students with an IEP increased by 0.23 percentage points, and fraction of students eligible for free or reduced-price lunch decreased by 0.64 percentage points. However, the decrease in free or reduced-price lunch eligibility is not statistically significant. The SEDA test score sample shows a similar increase in the fraction Hispanic, but the estimates for fraction black, fraction with an IEP, and fraction eligible for free or reduced price lunch are smaller in magnitude and not statistically different from zero. While several of these coefficients are statistically significant, they are relatively small in magnitude and rule out large changes in student composition driving my results. In fact, the small changes are generally in the direction that would work against finding an effect if they were true shifts in the district population. These changes are also consistent with retaining more students that are most in danger of dropping out.

As a falsification test, I also estimate the effect of spending over several following years on outcomes in the current year. Table 7 shows the relationship between average spending over the following four years on graduation rates in the current year. The first stage is strong, but the 2SLS estimate is small, negative, and not statistically significant, which provides additional evidence that my estimates reflect a causal effect of spending on student achievement. I am unable to do a similar falsification test for test scores because I do not have a strong first stage for spending in any years following a test-score measure.

5.2 Exploring Mechanisms and Heterogeneity

Although my instrument only allows me to estimate the causal effect of total resources, it is instructive to examine the categories in which districts choose to spend their extra funds. Table 8 shows 2SLS estimates for the relationship between expenditures and local, state, and federal revenue. All measures are in thousands of real 2013 dollars per pupil. The first three columns show results for the 10th grade cohort graduation sample with average lags over the current and 1 previous year, while the last three columns present estimates for the SEDA test score sample with average lags 5 to 8 years prior to the test. The majority of increased revenue comes through local sources. State aid also increases, but the estimate for the SEDA test score sample is negative and less precisely estimated. Table 9 and Table 10 report 2SLS estimates of total expenditures on mutually exclusive and collectively exhaustive subcategories of spending for the graduate rate sample and test score sample, respectively. These estimates suggest that the majority of increased spending was devoted to current expenditures, capital outlay, and payments to other organizations. The larger than average payments to the state, other schools, and private schools are consistent with districts bearing a portion of the responsibility of students who would otherwise attend but are attending other schools. Table 11 breaks up current expenditure into instructional, support service, and other categories. This shows that the majority of current expenditures are instructional expenditures, but support services also receive a significant portion of the funds.[23] The difference between the samples in the fraction of each dollar going to current expenditures is driven by less support service spending in the test score sample.

I also explore heterogeneity in the effect of spending on graduation rates. In Table 12 I show results for models fully interacted with an indicator that equals 1 in periods that simulated revenue decreased from the previous period in panel A. The coefficients on log spending represent the effect of increased spending and the coefficient on loss interacted with log spending shows how much larger or smaller the effect of spending is when spending decreases. In these models I instrument for the two spending variables with simulated revenue and simulated revenue interacted with the indicator for a loss. Because I have more than one instrument, I report an F statistic suggested by Kleibergen and Paap (2006) as a test for the strength of the instruments and find they are reasonably strong.[24] The coefficients on log spending for graduation rates are similar in magnitude to the non-interacted coefficients in Table 4 and the coefficients on the interaction term are small and only statistically different from zero for the 11th grade graduation cohort. This estimate suggests that a 10 percent increase in spending increases the number of diplomas per 11th-graders (1 year ago) 0.31 percentage more when spending decreases than when spending increases. That represents is a 15.7 percent larger magnitude effect when budgets are cut than when they expand. I consider this merely suggestive because gains are only significantly different from losses for the 11th grade cohort measure, and the direction of the effect is not consistent nor significantly different from zero for test scores.

Panel B shows the results of similar analyses with models fully interacted with an indicator equal to 1 if the district has median household income below the median in their state. The estimates for graduation rates are larger in magnitude for high-income districts

[23]Additional tables with estimates for each subcategory of spending are available in Online Appendix A.

[24]The Kleibergin-Paap statistic is a generalization of the statistic suggested by Cragg and Donald (1993) for cases with non-i.i.d. standard errors.

than the average across all districts from the baseline model in Table 4. My estimates suggest that increasing spending by 10 percent increases graduation rates by 4.32 to 7.1 percentage points in high income districts and 0.3 to 1.45 percentage points in low income districts. The difference between high and low income districts is statistically significant for all cohorts.

6 Conclusion

This paper addresses the question of whether money spent on education affects graduation rates and test scores using the interaction of market changes in property values with fixed school finance rules as an instrument for spending. I find that a 10 percent increase in spending increases graduation rates by 2.1 to 4.4 percentage points. A 10 percent increase in spending also increases 4th and 8th grade math and reading scores by between 0.05 and 0.09 standard deviations. Increased spending primarily goes to current expenditures, new construction, and payments to other organizations such as the state government and local private schools. The improvement in graduation rates is observed almost entirely in high-income districts. Spending has lasting effects on test scores, so that students benefit from investments made before they even begin school.

In sum, the answer to the question of whether money matters in education is yes. Further understanding the way in which money matters will also help shape efficient policies. For example, the reduced form relationship I find between property values and student outcomes is important to consider when crafting school finance plans. If formulas provide additional funding to districts with low levels of property wealth, but reinforce this relationship, it could increase spending volatility enough to offset the benefits of increased funds. Another implication of my finding is that we have not yet reached the flat of the curve and marginal increases in spending still result in meaningful improvements in the quality and quantity of education. Also, because I find that increased spending before a student even enters school significantly improves their test scores, estimates that relate contemporaneous expenditures and test scores will likely miss the true impact of the spending.

The relationship between property values and local revenue is not unique to school finance. Thus, my approach can be applied directly to other locally-financed public programs. This is especially useful in other cases where it is difficult to measure the effect of resources on outcomes because of the relationship between the outcome and the level of investment, such as the number of police officers and the level of crime. While other contexts do not have the same type of equalization schemes as seen in school finance, other state-level limitations on local taxing behavior provide between-state variation in wealth prices.

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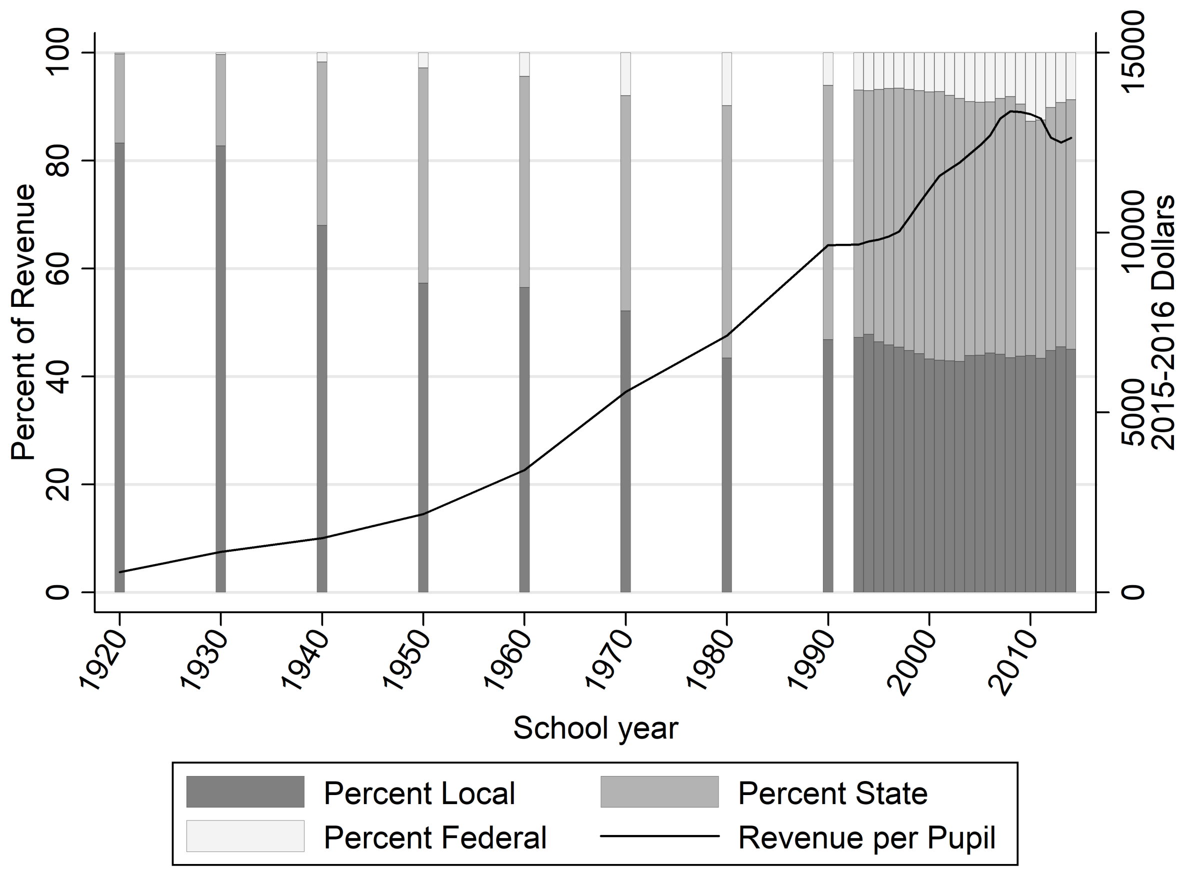
Figures & Tables

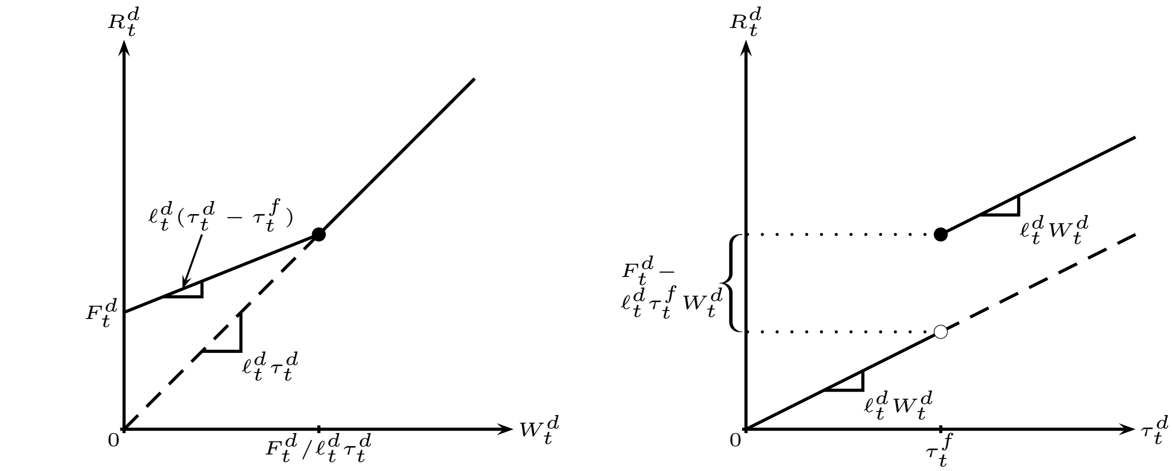
Figure 1: Historical Sources of School District Revenue



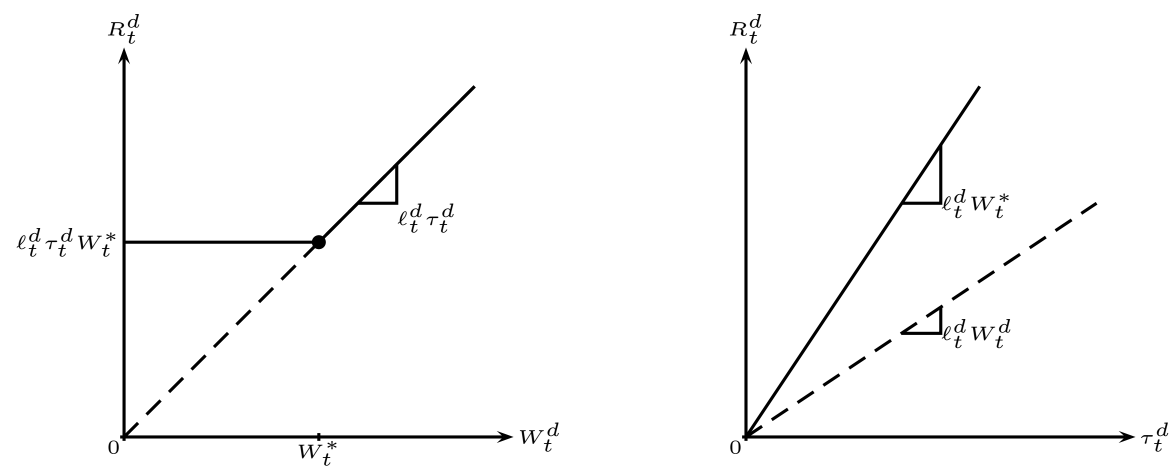
Notes: Data from U.S. Department of Education, National Center for Education Statistics, Biennial Survey of Education in the United States, 1919-20 through 1949-50; Statistics of State School Systems, 1959-60 and 1969-70; Revenues and Expenditures for Public Elementary and Secondary Education, 1979-80; and Common Core of Data (CCD), "National Public Education Financial Survey," 1989-90 through 2013-14.

Figure 2: Relationship between revenue and wealth/tax rate for general school finance plans

A. Foundation

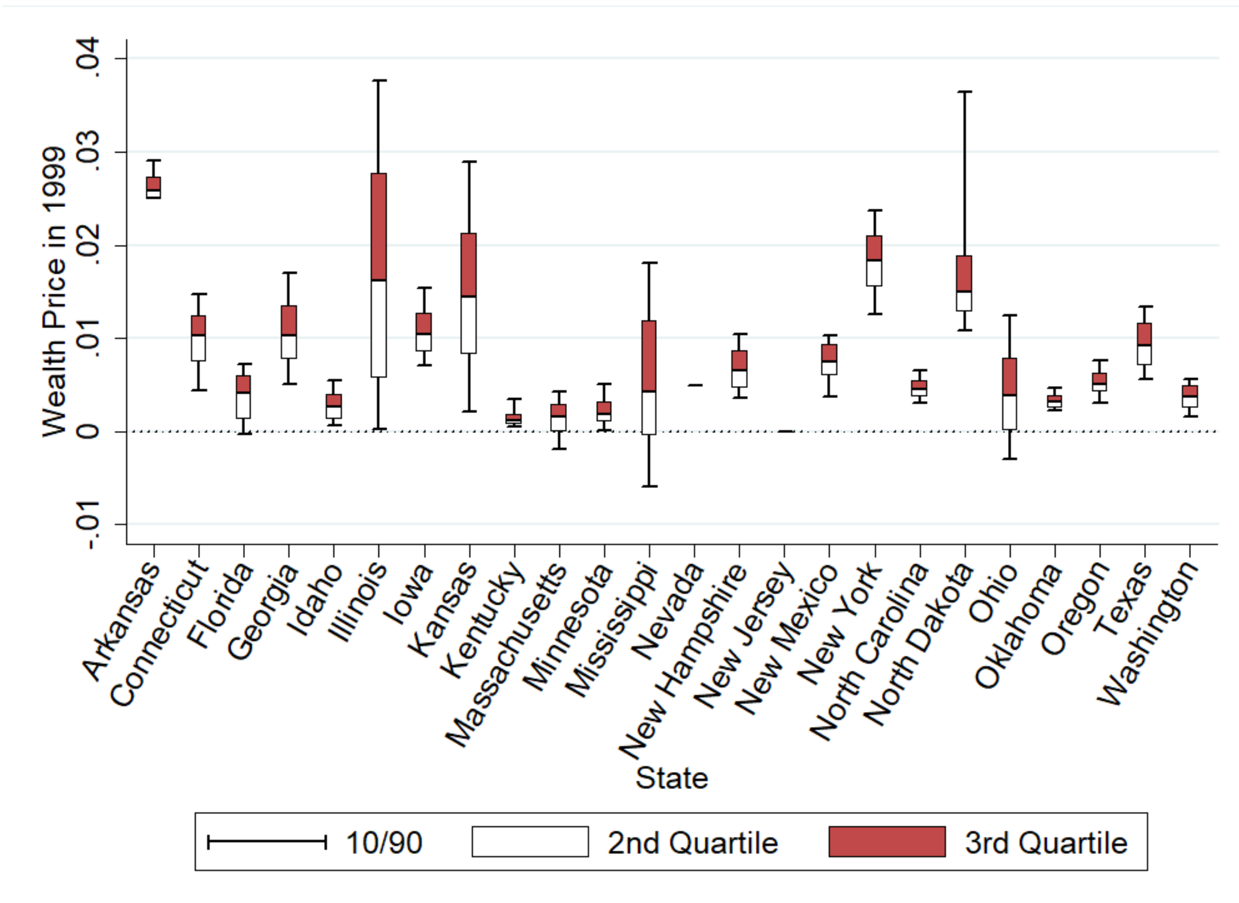


B. District Power Equalization



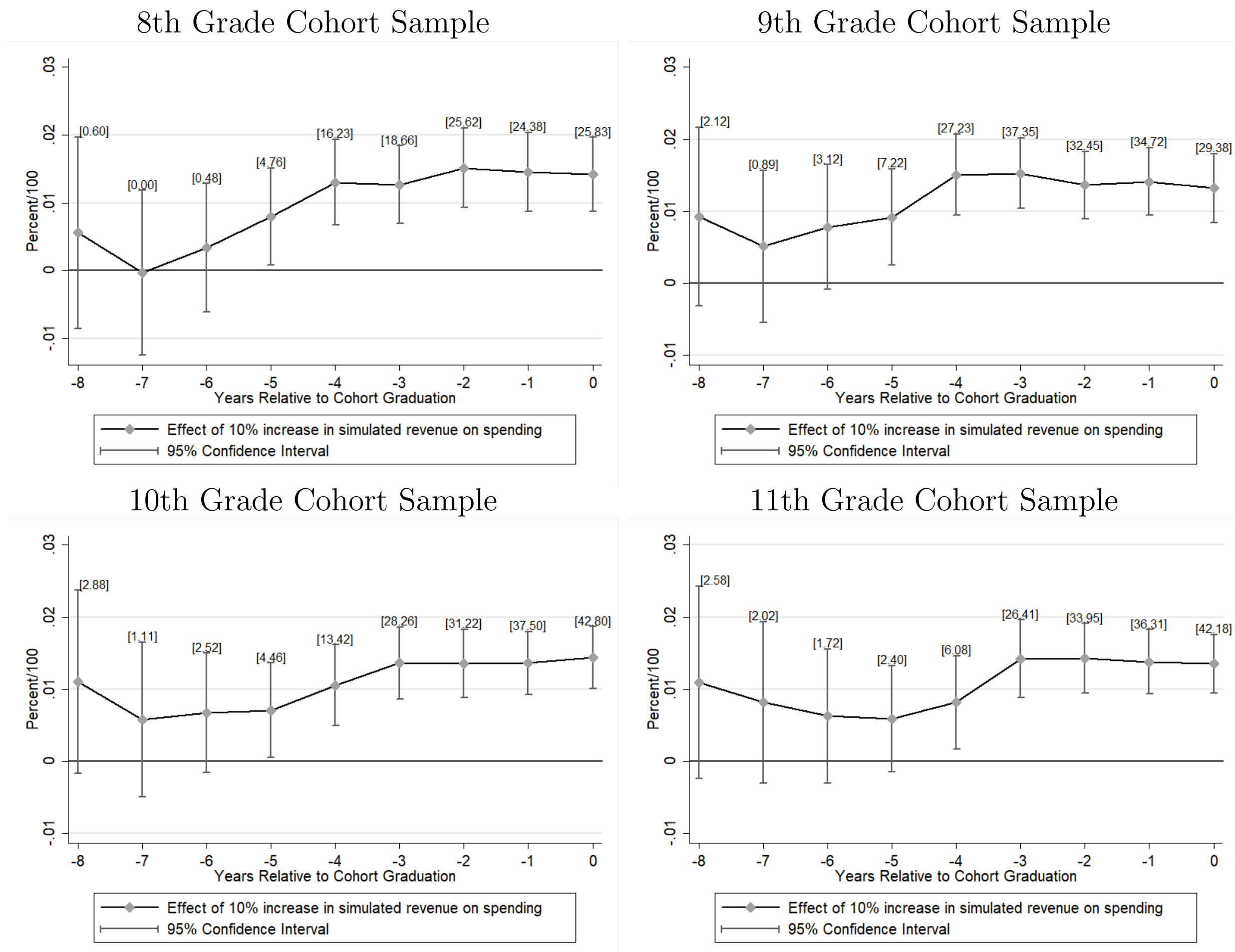
Notes: Panel A shows the relationship between revenue and property wealth (left) and revenue and the tax rate (right) for a foundation plan with foundation tax rate τ_t^f and guaranteed foundation amount F_t^d. Panel B shows the relationship between revenue and property wealth (left) and revenue and the tax rate (right) for a district power equalization plan with guaranteed yield of W_t^*. Dotted lines represent local revenue with no state aid.

Figure 3: Distribution of estimated wealth price in 1999



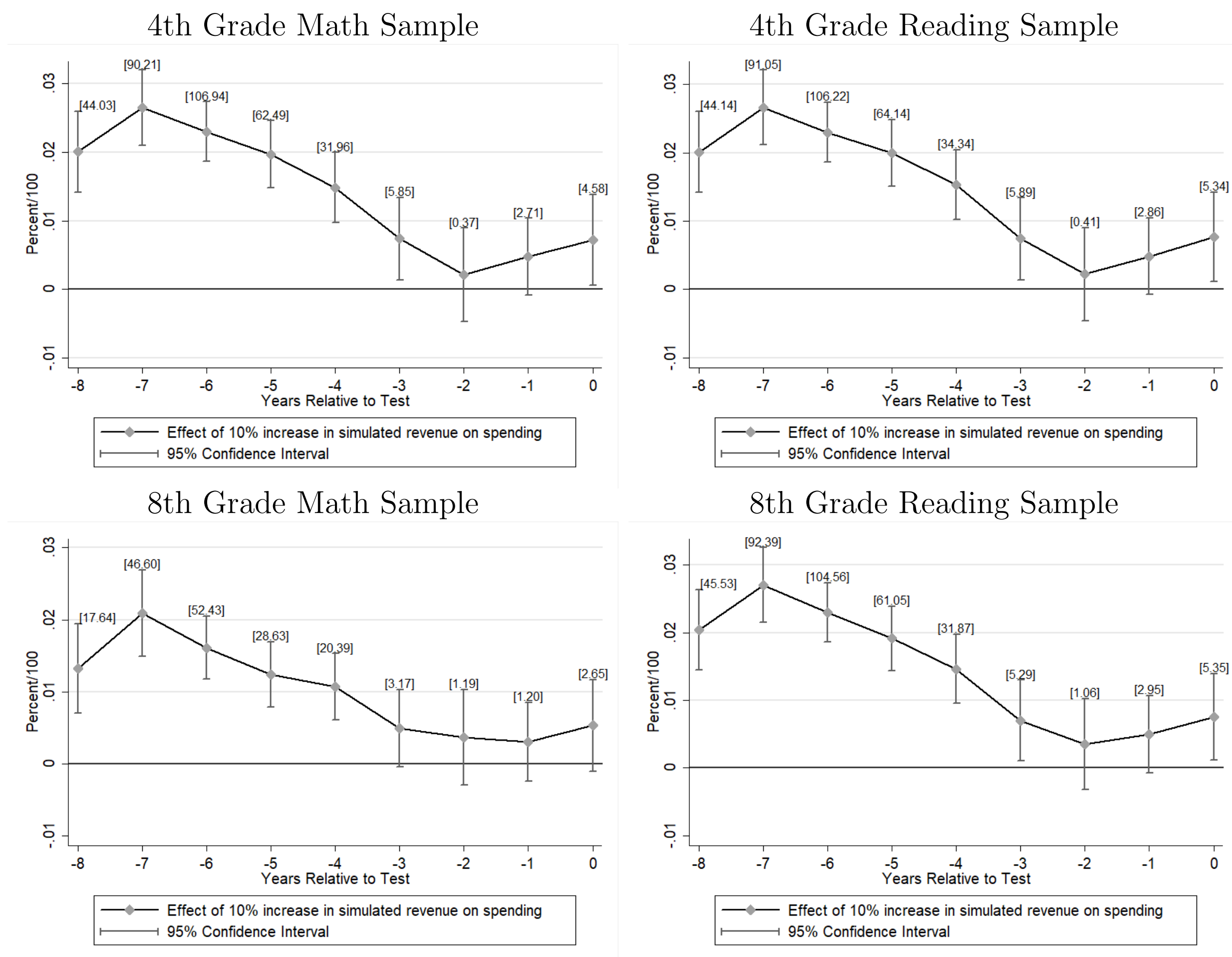
Notes: The wealth price is the fraction of each additional dollar of property wealth that districts take in as revenue. Calculations of the wealth price based on policies in 1999 can be found in Online Appendix B.

Figure 4: First-stage effect of a 10% increase in simulated revenue on total expenditure for graduate rate samples – individual year lags



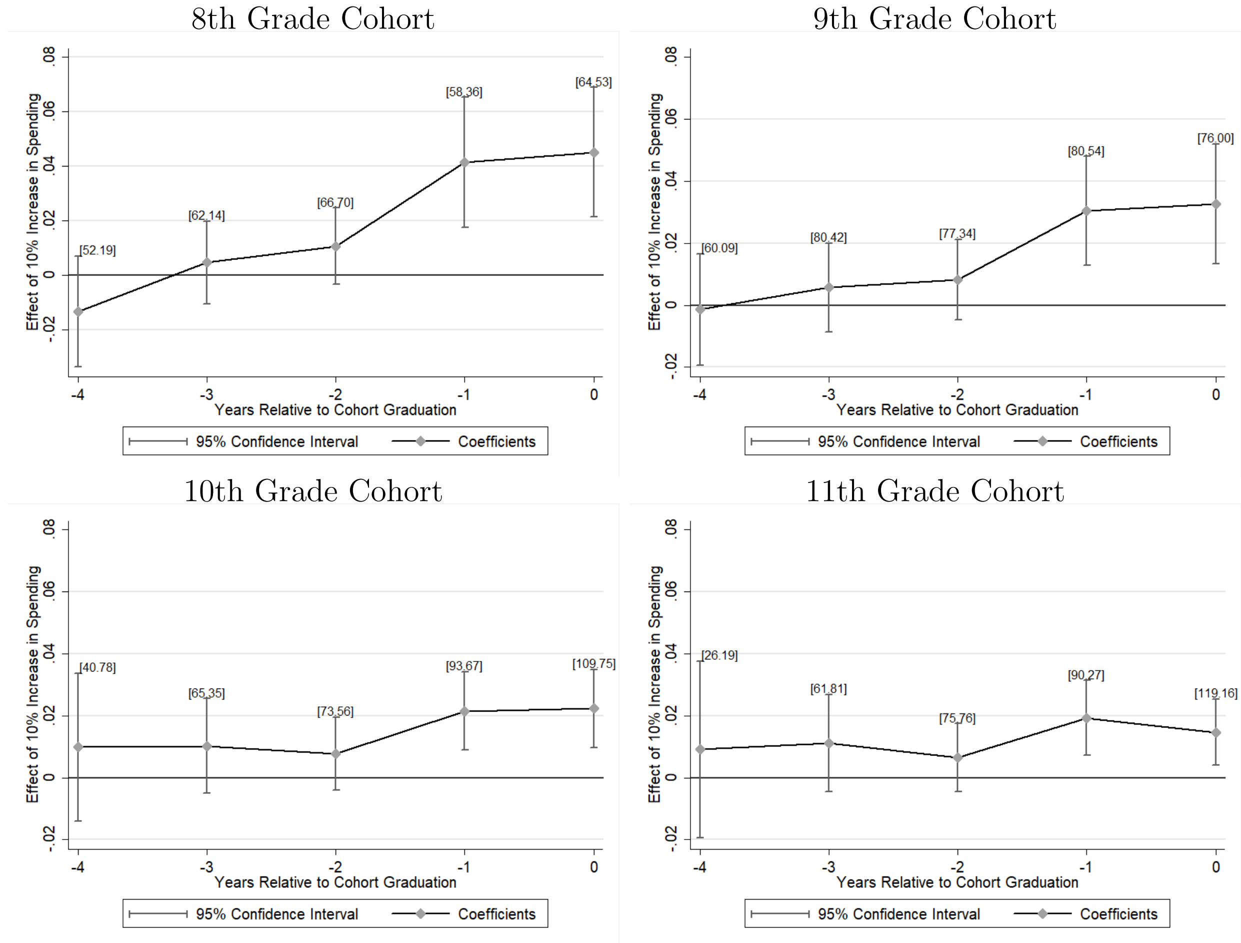
Notes: Figure 4 presents point estimates (divided by 10), 95 percent confidence intervals, and F statistics in brackets, from individual regressions of lagged total expenditures on simulated revenue with the same lag for samples with non-missing graduation rates. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level.

Figure 5: First-stage effect of a 10% increase in simulated revenue on log expenditure for SEDA test score samples – individual year lags



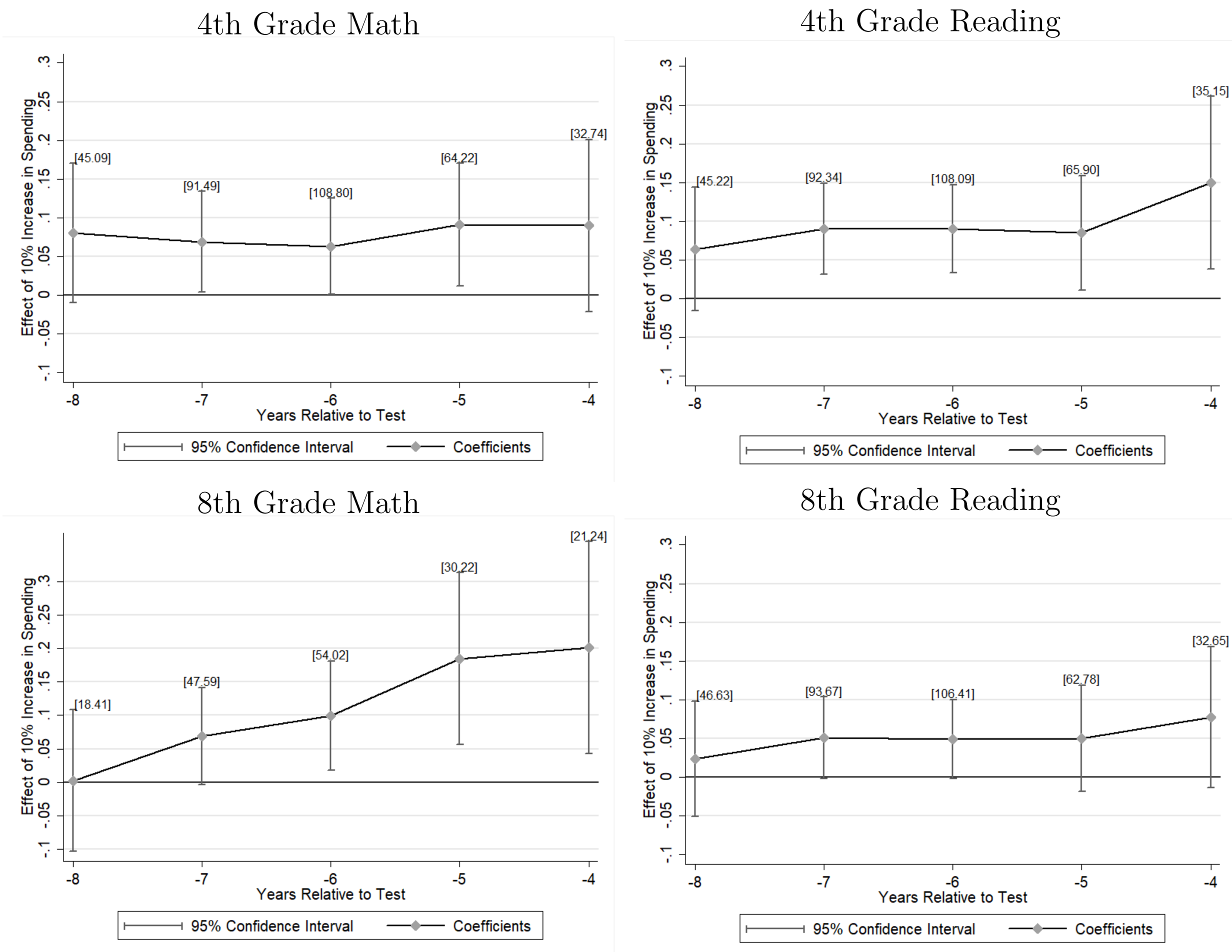
Notes: Figure 5 presents point estimates (divided by 10) and 95 percent confidence intervals, and F statistics in brackets, from individual regressions of lagged total expenditures on simulated revenue with the same lag for samples with non-missing test scores. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level.

Figure 6: Two-stage least squares estimates of log spending on graduation rates



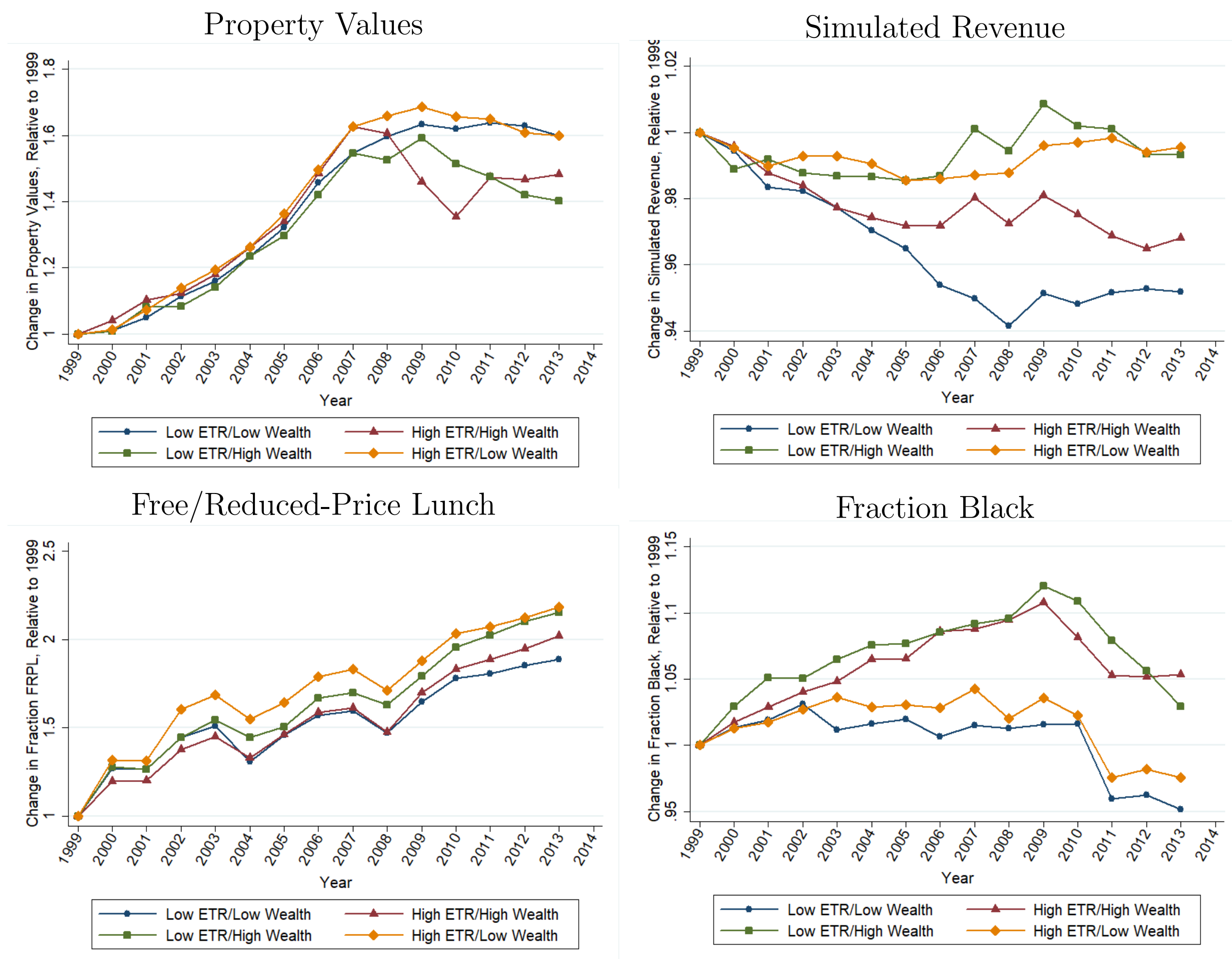
Notes: Figure 6 presents point estimates (divided by 10), 95 percent confidence intervals, and F statistics in brackets, from individual 2SLS regressions of graduation rates on lagged log total expenditures instrumented by lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level.

Figure 7: Two-stage least squares estimates of log spending on SEDA test scores



Notes: Figure 7 presents point estimates (divided by 10), 95 percent confidence intervals, and F statistics in brackets, from individual 2SLS regressions of test scores on lagged log total expenditures instrumented by lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level.

Figure 8: Change in district characteristics relative to 1999, by base-year wealth and effective tax rate



Notes: Figure 8 plots the mean change in property values, simulated revenue per pupil, fraction of students eligible for free or reduced price lunch, and fraction of students who are black, relative to 1999, for 4 groups: (1) districts with below median effective tax rate and below median property wealth, (2) districts with above median effective tax rate and above median property wealth, (3) districts with below median effective tax rate and above median property wealth, and (4) districts with above median effective tax rate and below median property wealth. Effective tax rates and property wealth are calculated as of 1999 and medians are calculated at the state level.

Table 1: Summary statistics for main estimation samples

	(1)	(2)	(3)
	10th Grade Cohort		SEDA Test
	1-year	4-year Lag	Score Sample
Graduation Rate	0.81	0.81	
	(0.17)	(0.19)	
Average Lagged Spending ($1,000 PP)	12.57	12.37	12.63
	(4.29)	(3.94)	(4.32)
Average Lagged Simulated Revenue ($1,000 PP)	7.22	7.08	7.05
	(3.91)	(3.70)	(3.83)
Fraction Special Education	0.13	0.13	0.14
	(0.05)	(0.05)	(0.04)
Fraction Black	0.11	0.10	0.08
	(0.18)	(0.18)	(0.16)
Fraction Hispanic	0.11	0.12	0.13
	(0.18)	(0.19)	(0.20)
Fraction Free-Reduced Price Lunch	0.38	0.39	0.43
	(0.23)	(0.23)	(0.22)
Number of Students	5,265	5,330	4,493
	(24,308)	(22,954)	(24,533)
Median Household Income	56,495	55,852	57,034
	(21,955)	(21,470)	(22,895)
Property Wealth ($100,000s)	22,588	24,630	20,729
	(127,459)	(133,268)	(112,742)
Districts	2,825	2,824	5,857
N	23,082	18,061	27,160

Notes: Means are reported with standard deviations in parentheses. Statistics are calculated for three estimation samples. The 10th grade cohort graduation rates with 1 lag are available from 2000-2010 and with 4 lags are available from 2003-2010. SEDA test scores are available for 2009-2013 so the spending variables lagged 5 to 8 years cover years 2001-2008. All monetary variables are in real 2013 dollars.

Table 2: Summary statistics for characteristics of districts in and out of the sample

	(1) In Sample	(2) Not In Sample	(3) P-value of (2)-(1) or Fraction	(4) All
	I. District-level Averages			
Number of Students	3,703	3,754	0.848	3,725
Number of Teachers	255	220	0.042	239
Student-Teacher Ratio	13.5	14.8	0.000	14.1
Spending Per Student	15,169	14,719	0.481	14,970
Property Tax Revenue Per Student	5,742	4,925	0.002	5,381
Median Household Income	56,328	53,546	0.000	55,111
Fraction with an IEP	0.131	0.136	0.000	0.133
Fraction FRPL Eligible	0.405	0.407	0.632	0.406
Fraction Black	0.077	0.063	0.000	0.071
Fraction Hispanic	0.116	0.105	0.001	0.111
Fraction White	0.743	0.751	0.092	0.747
	II. Observation Counts			
Students	26,592,100	21,418,996	0.55	48,011,096
Districts	7,182	5,706	0.56	12,888
States	24	26	0.48	50

Notes: Panel I displays averages for the variables indicated and panel II displays counts. Columns (1), (2), and (4) report averages of the indicated variables. Column (3) reports the p-value of the difference between column (2) and column (1) for panel I and the fraction in the sample for panel II. Values are based on 2009.

Table 3: First stage estimates of log simulated revenue on log spending – average lags

	(1) 1 year	(2) 1-4 years	(3) 1-8 years	(4) 5-8 years
	A. 8th Grade Graduation Cohort Sample			
Log Sim. Rev.	0.157**	0.175**	0.188**	0.041
	(0.029)	(0.027)	(0.030)	(0.047)
F	29.63	43.02	39.61	0.77
Districts	2,724	2,720	2,667	2,668
N	17,467	15,676	9,146	9,147
	B. 9th Grade Graduation Cohort Sample			
Log Sim. Rev.	0.145**	0.188**	0.214**	0.106**
	(0.024)	(0.024)	(0.027)	(0.042)
F	35.82	60.26	65.31	6.36
Districts	2,825	2,825	2,815	2,816
N	22,130	18,641	10,009	10,011
	C. 10th Grade Graduation Cohort Sample			
Log Sim. Rev.	0.147**	0.180**	0.206**	0.105**
	(0.022)	(0.025)	(0.027)	(0.042)
F	44.42	51.74	60.09	6.21
Districts	2,825	2,824	2,816	2,817
N	23,082	18,061	9,967	9,969
	D. 11th Grade Graduation Cohort Sample			
Log Sim. Rev.	0.150**	0.179**	0.216**	0.118**
	(0.023)	(0.027)	(0.026)	(0.042)
F	44.62	42.54	66.31	7.82
Districts	2,823	2,815	2,797	2,798
N	20,606	15,355	9,538	9,540
	E. SEDA Test Score Sample			
Log Sim. Rev.	0.057+	0.037	0.221**	0.213**
	(0.032)	(0.025)	(0.018)	(0.022)
F	3.19	2.29	144.38	92.76
Districts	5,649	5,648	5,644	5,650
N	24,116	24,102	24,087	24,114

Notes: This table reports the results of first stage regressions of total expenditures on simulated revenue with average lags for samples with non-missing graduation rates. Column (1) is the average of the current and previous year, column (2) is the average of the current and the past 4 years, column (3) is the average over the past 8 years, and column (4) is the average from 5 to 8 years prior to the measured outcome. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 4: Two-stage least squares estimates of log spending on graduation rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	8th Grade Cohort		9th Grade Cohort		10th Grade Cohort		11th Grade Cohort	
	1 year	1-4 years	1 year	1-4 years	1 year	1-4 years	1 year	1-4 years
Log Spending	0.437**	0.265**	0.331**	0.307**	0.246**	0.384**	0.211**	0.382**
	(0.118)	(0.102)	(0.094)	(0.097)	(0.069)	(0.098)	(0.066)	(0.114)
Dep. Var. Mean	0.79	0.79	0.76	0.76	0.81	0.81	0.85	0.85
First-stage F	71.92	101.64	86.32	113.12	97.83	101.85	96.56	92.90
Districts	2,676	2,660	2,823	2,817	2,824	2,821	2,819	2,802
N	17,419	15,616	22,128	18,633	23,081	18,058	20,602	15,342

Notes: This table reports results from two-stage least squares regressions of graduation rates on average lagged log total expenditures instrumented with average lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 5: Two-stage least squares estimates of log spending on test scores

	(1)	(2)	(3)	(4)
	4th Grade		8th Grade	
	Math	Reading	Math	Reading
Log Spending, 5-8 years prior	0.775*	0.879**	0.929*	0.477+
	(0.338)	(0.304)	(0.401)	(0.277)
First-stage F	183.01	184.92	98.73	180.67
Districts	5,662	5,659	5,640	5,671
N	26,371	26,380	24,582	26,457

Notes: This table reports results from two-stage least squares regressions of test scores on average lagged log total expenditures instrumented with average lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 6: Two-stage least squares estimates of log spending on student composition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Graduate Rates					SEDA Test Scores				
	Total	Black	Hispanic	IEP	FRPL	Total	Black	Hispanic	IEP	FRPL
Log Spending	2323.970**	0.022*	0.128**	0.023**	-0.064	2095.343**	0.009	0.159**	0.001	0.007
	(424.656)	(0.010)	(0.015)	(0.008)	(0.040)	(621.043)	(0.008)	(0.019)	(0.014)	(0.040)
Dep. Var. Mean	5265.24	0.11	0.11	0.13	0.38	4613.16	0.08	0.12	0.14	0.42
First-stage F	195.99	195.99	195.99	195.99	195.99	124.47	124.47	124.47	124.47	124.47
Districts	2,824	2,824	2,824	2,824	2,824	5,524	5,524	5,524	5,524	5,524
N	23,081	23,081	23,081	23,081	23,081	23,988	23,988	23,988	23,988	23,988

Notes: This table reports results from two-stage least squares regressions of student composition outcomes on average lagged log total expenditures instrumented with average lagged log simulated revenue. The outcome for the first column is total number of students, while the outcome for columns (2) through (5) are the fraction of students in the given category. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 7: Two-stage least squares estimates of future log spending on graduation rates

	(1)
Average Log Spending, Next 4 Years	-0.003
	(0.059)
F	95.06
Districts	2,824
N	23,438

Notes: This table reports results from two-stage least squares regressions of graduation rates on average log total expenditures over the next four years instrumented with log simulated revenue averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 8: Two-stage least squares estimates of spending on source of revenue

	(1)	(2)	(3)	(4)	(5)	(6)
	Graduation Rate			SEDA Test Score		
	Local	State	Federal	Local	State	Federal
Spending ($1,000s PP)	0.707**	0.103**	0.005	1.314**	-0.119	-0.080**
	(0.068)	(0.042)	(0.011)	(0.253)	(0.083)	(0.023)
Dependent Variable Mean ($1,000s PP)	5.57	5.93	0.94	5.95	5.88	0.87
Baseline Fraction	0.42	0.50	0.09	0.45	0.47	0.09
F	83.60	83.60	83.60	21.42	21.42	21.42
Districts	2,824	2,824	2,824	5,527	5,527	5,527
N	23,081	23,081	23,081	24,006	24,006	24,006

Notes: This table reports results from two-stage least squares regressions of various sources of revenue on average lagged log total expenditures instrumented with log simulated revenue averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 9: Two-stage least squares estimates of spending on total expenditure sub-categories – graduation rate sample, 10th grade cohort, one-year lag

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Current	Non-Elementary	Capital		Payments to:			Interest
	Expenditure	or Secondary	Outlay	State	Other Schools	Private	Charter	Payments
Spending ($1,000s PP)	0.515**	0.045**	0.259**	0.122**	0.012*	0.016**	0.002	0.036**
	(0.051)	(0.009)	(0.061)	(0.028)	(0.006)	(0.005)	(0.006)	(0.009)
Dep. Var. Mean	10.67	0.07	1.24	0.06	0.12	0.064	0.021	0.24
Baseline Fraction	0.87	0.01	0.09	0.004	0.01	0.004	0.002	0.02
First-stage F	83.60	83.60	83.60	83.60	83.60	83.60	83.60	83.60
Districts	2,824	2,824	2,824	2,824	2,824	2,824	2,824	2,824
N	23,081	23,081	23,081	23,081	23,081	23,081	23,081	23,081

Notes: This table reports results from two-stage least squares regressions of various expenditure categories on average lagged log total expenditures instrumented with log simulated revenue averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 10: Two-stage least squares estimates of log spending on total expenditure sub-categories – SEDA sample, five to eight year lag

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Current	Non-Elementary	Capital		Payments to:			Interest
	Expenditure	or Secondary	Outlay	State	Other Schools	Private	Charter	Payments
Spending ($1,000s PP)	0.571**	-0.005	0.229+	0.083**	0.093**	0.020**	-0.011*	0.041**
	(0.118)	(0.005)	(0.121)	(0.024)	(0.028)	(0.008)	(0.005)	(0.013)
Dep. Var. Mean	10.75	0.06	1.26	0.05	0.24	0.067	0.018	0.24
Baseline Fraction	0.86	0.00	0.08	0.004	0.02	0.005	0.003	0.02
First-stage F	21.42	21.42	21.42	21.42	21.42	21.42	21.42	21.42
Districts	5,527	5,527	5,527	5,527	5,527	5,527	5,527	5,527
N	24,006	24,006	24,006	24,006	24,006	24,006	24,006	24,006

Notes: This table reports results from two-stage least squares regressions of various expenditure categories on average lagged log total expenditures instrumented with log simulated revenue averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 11: Two-stage least squares estimates of log spending on current expenditure subcategories

	(1)	(2)	(3)	(4)	(5)	(6)
		Graduate Rates			SEDA Test Score	
	Instructional	Support Services	Other	Instructional	Support Services	Other
Spending ($1,000s PP)	0.292**	0.215**	0.007**	0.420**	0.159**	-0.008+
	(0.032)	(0.024)	(0.003	(0.086)	(0.042)	(0.004
Dep. Var. Mean	6.55	3.69	0.44	6.57	3.74	0.44
Baseline Fraction	0.53	0.30	0.04	0.52	0.30	0.04
First-stage F	83.60	83.60	83.60	21.42	21.42	21.42
Districts	2,824	2,824	2,824	5,527	5,527	5,527
N	23,081	23,081	23,081	24,006	24,006	24,006

Notes: This table reports results from two-stage least squares regressions of various current expenditure categories on average lagged log total expenditures instrumented with log simulated revenue averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table 12: Two-stage least squares estimates of log spending on graduation rates

A. Gains versus Losses

	(1) 8th Grade	(2) 9th Grade	(3) 10th Grade	(4) 11th Grade
Log Spending	0.413**	0.308**	0.225**	0.198**
	(0.110)	(0.088)	(0.065)	(0.063
Loss*Log Spending	-0.006	0.009	0.009	0.031**
	(0.013)	(0.011)	(0.010)	(0.011)
Dep. Var. Mean	0.79	0.76	0.81	0.85
Kleibergen-Paap F	38.67	44.33	48.64	45.76
Districts	2,676	2,823	2,824	2,819
N	17,419	22,128	23,081	20,602

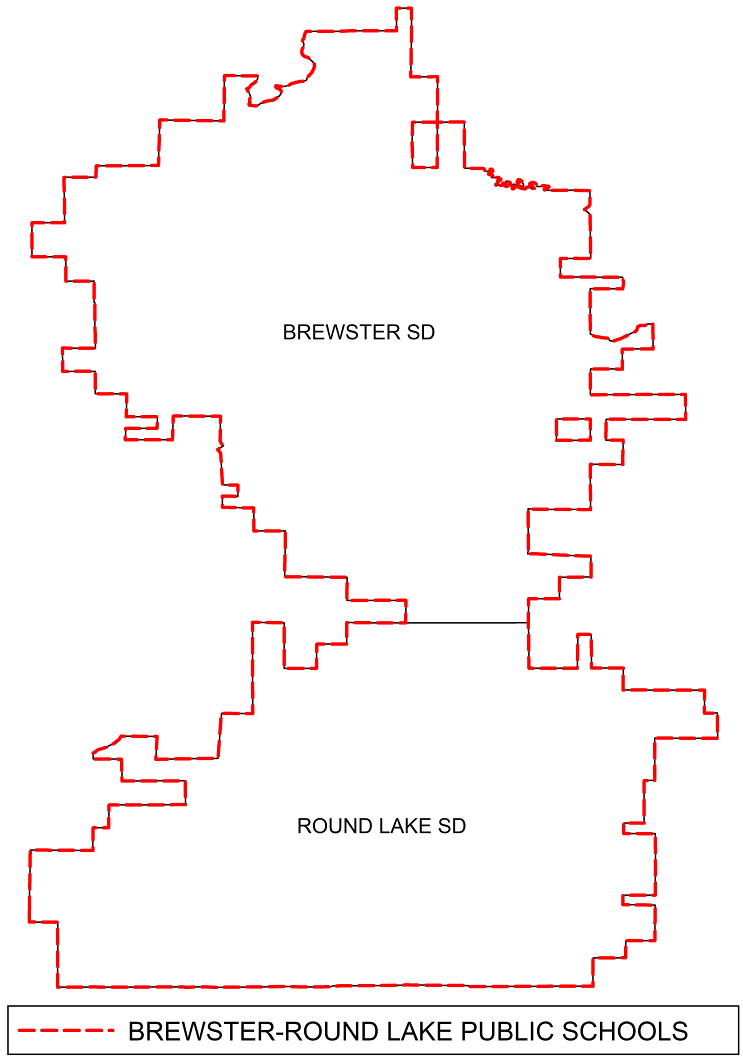
B. High- versus Low-Income Districts

	(1) 8th Grade	(2) 9th Grade	(3) 10th Grade	(4) 11th Grade
Log Spending	0.706**	0.594**	0.431**	0.432**
	(0.255)	(0.215)	(0.148)	(0.145
Low Income*Log Spending	-0.561*	-0.557**	-0.370*	-0.401**
	(0.270)	(0.229)	(0.159)	(0.155)
Dep. Var. Mean	0.79	0.76	0.81	0.85
Kleibergen-Paap F	12.06	12.87	15.55	15.14
Districts	2,676	2,823	2,824	2,819
N	17,419	22,128	23,081	20,602

Notes: This table reports results from two-stage least squares regressions of graduation rates (panel A) and test scores (panel B) on average lagged log total expenditures instrumented with log simulated revenue, averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. All covariates are interacted with an indicator equal to 1 if the change in simulated revenue from the previous year is negative. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

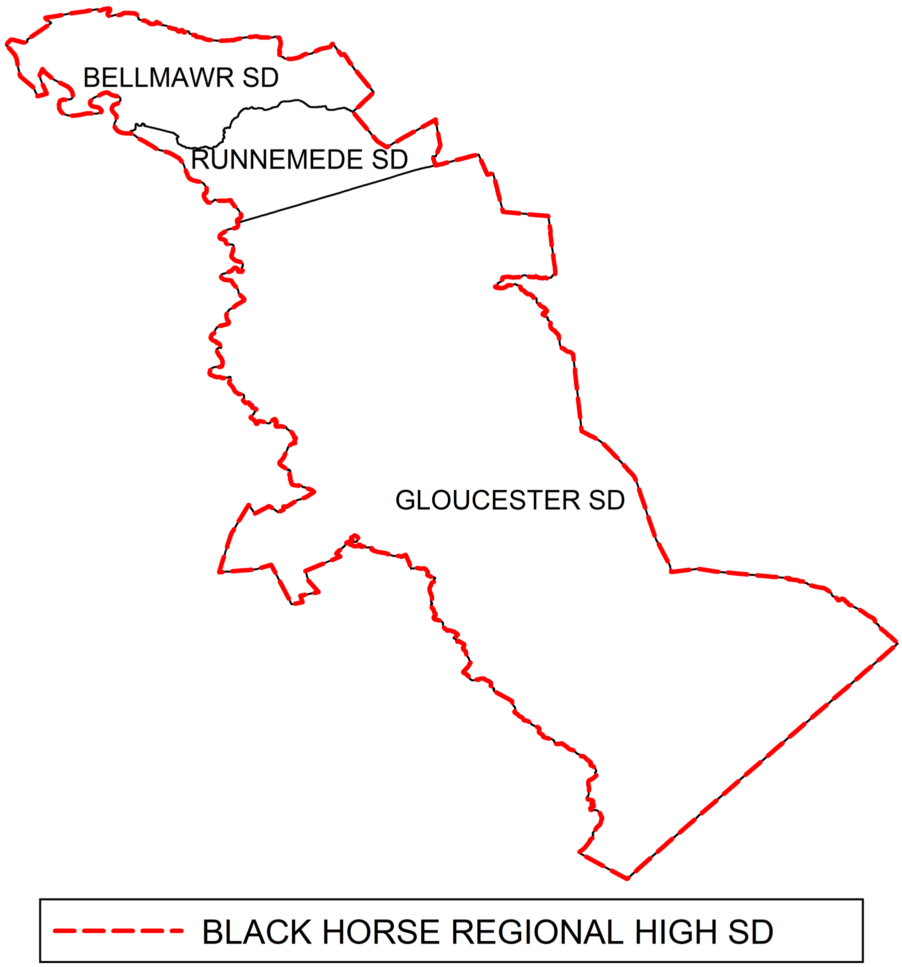
A Online Appendix - Additional Figures and Tables

Figure A1: Example of District Consolidation - Minnesota



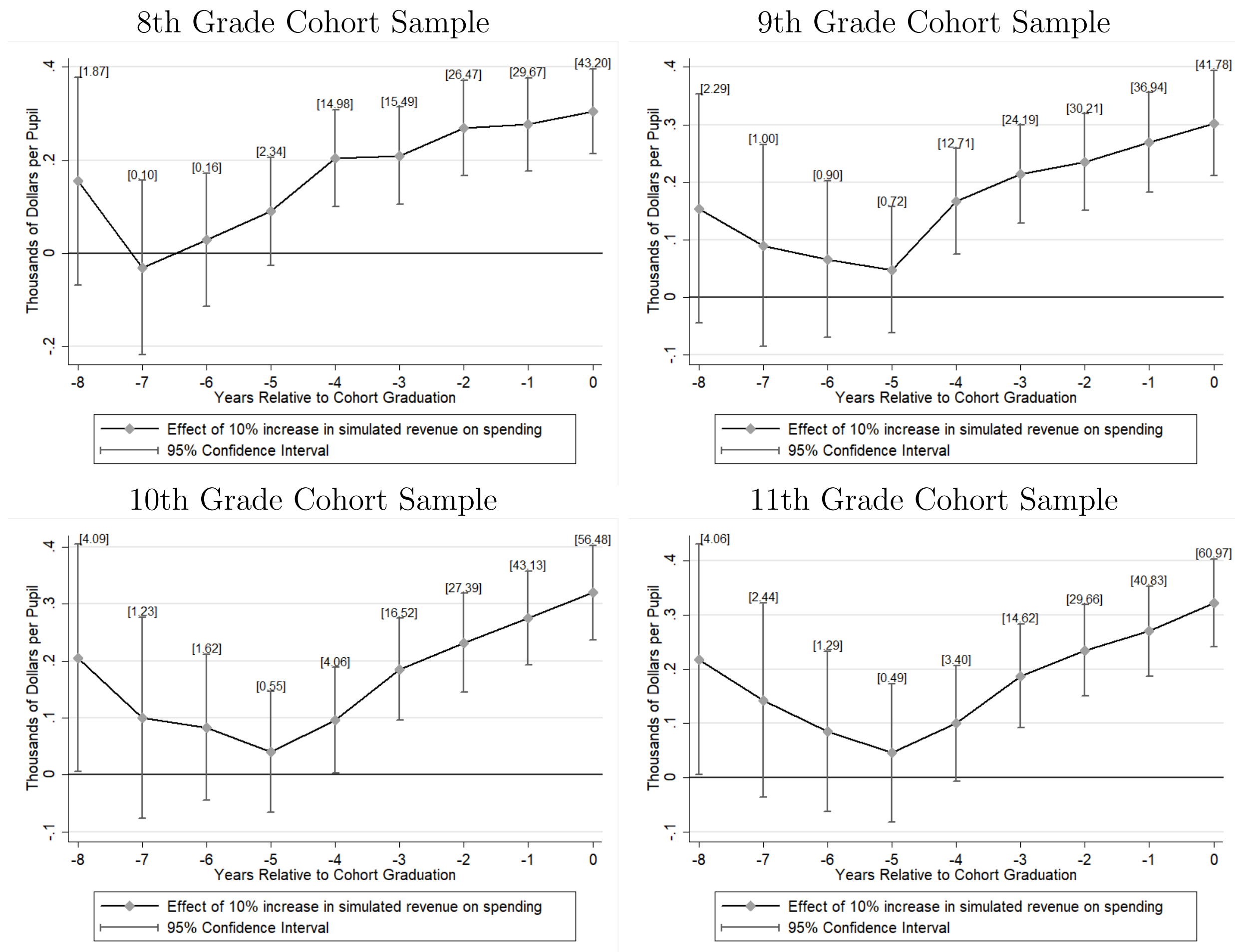
Notes: Boundaries shown for 2 school districts (Brewster and Round Lake) in Minnesota, which consolidated into a single school district (Brewster-Round Lake) in 2014.

Figure A2: Example of Overlapping/Nested Districts - New Jersey



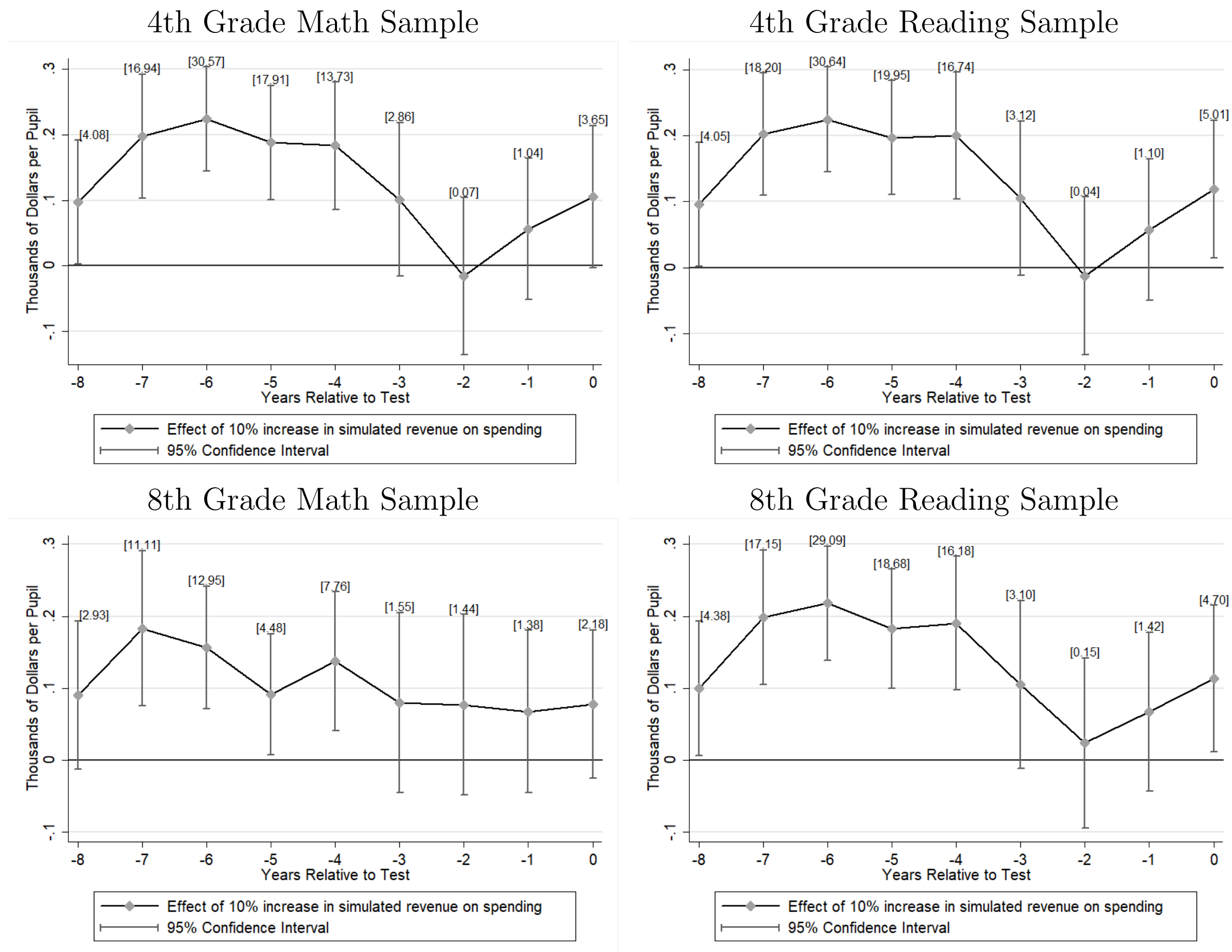
Notes: Boundaries for 4 school districts in New Jersey are shown. Bellmawr, Runnemede, and Gloucester are K-8 districts and Black Horse is a regional 9-12 district.

Figure A3: First-stage effect of simulated revenue ($1,000 per pupil) on total expenditure ($1,000 per pupil) in graduation rate samples – individual year lags



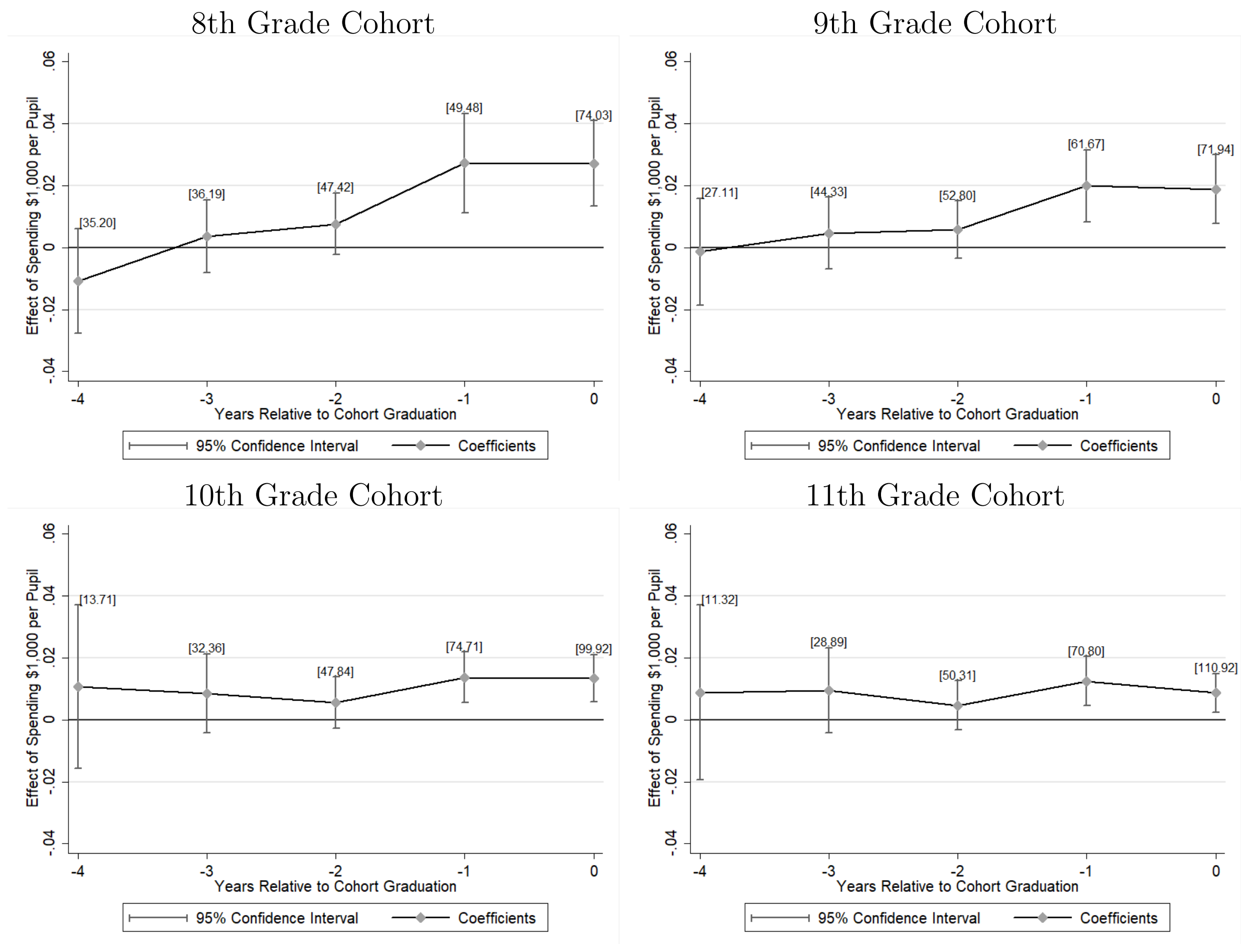
Notes: Figure A3 presents point estimates, 95% confidence intervals, and F statistics in brackets, from individual regressions of lagged per-pupil total expenditures on log simulated revenue with the same lag for samples with non-missing graduation rates. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level. Corresponding estimates are presented in Table A8.

Figure A4: First-stage effect of simulated revenue ($1,000 per pupil) on total expenditure ($1,000 per pupil) for SEDA test score samples – individual year lags



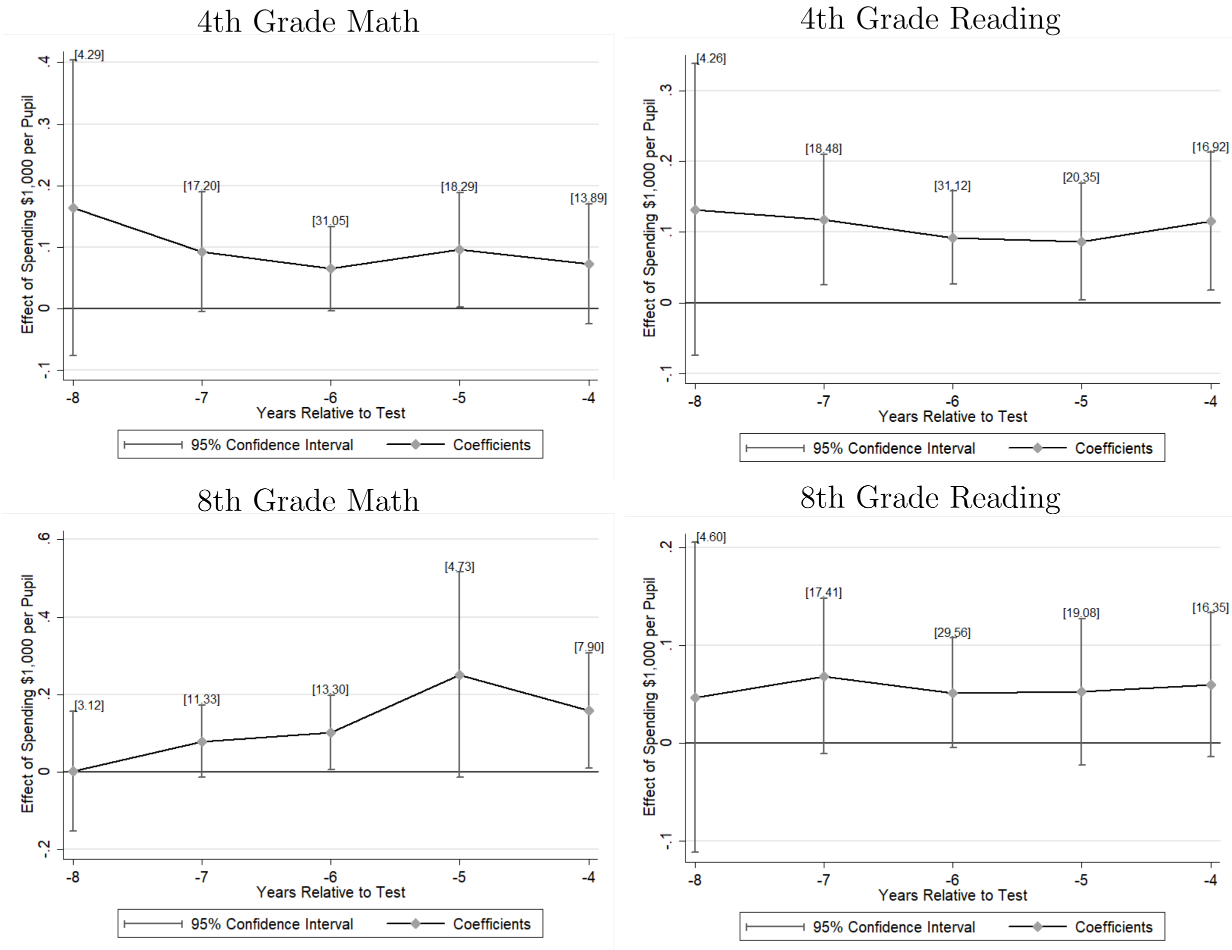
Notes: Figure A4 presents point estimates, 95% confidence intervals, and F statistics in brackets, from individual regressions of lagged per-pupil total expenditures on log simulated revenue with the same lag for samples with non-missing graduation rates. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level. Corresponding estimates are presented in Table A9.

Figure A5: Two-stage least squares estimates of per-pupil spending on graduation rates



Notes: Figure A5 presents 2SLS estimates and 95% confidence intervals for the effect of per-pupil spending instrumented with log simulated revenue. Numbers in brackets are first-stage F statistics. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level. Corresponding estimates are presented in Table A11.

Figure A6: Two-stage least squares estimates of per-pupil spending on SEDA test scores



Notes: Figure A6 presents 2SLS estimates and 95% confidence intervals for the effect of per-pupil spending instrumented with log simulated revenue. Numbers in brackets are first-stage F statistics. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level. Corresponding estimates are presented in Table A13.

Table A1: School Finance Formula Type for Each State

State	Foundation	District Power Equalization	Combination/ Tiered
Alabama	X		
Alaska	X		
Arizona	X		
Arkansas	X		
California	X		
Colorado	X		
Connecticut	X		
Delaware	X		
Florida	X		
Georgia			X
Idaho	X		
Illinois			X
Indiana	X		
Iowa	X		
Kansas	X		
Kentucky			X
Louisiana	X		
Maine	X		
Maryland	X		
Massachusetts	X		
Michigan	X		
Minnesota	X		
Mississippi	X		
Missouri	X		
Montana			X
Nebraska	X		
Nevada	X		
New Hampshire	X		
New Jersey	X		
New Mexico	X		
New York	X		
North Dakota	X		
Ohio	X		
Oklahoma	X		
Oregon	X		
Pennsylvania	X		
Rhode Island		X	
South Carolina	X		
South Dakota	X		
Tennessee	X		
Texas			X
Utah	X		
Vermont		X	
Virginia	X		
Washington	X		
West Virginia	X		
Wisconsin		X	
Wyoming	X		
Total	40	3	5

Notes: Adapted from Verstegen and Jordan (2009). Not included: Hawaii and North Carolina. Hawaii's single school district is fully funded by the state. North Carolina uses a flat grant system.

Table A2: States with Tax and Expenditure Limits

State	Description
Arkansas	Income limited to 5% for homesteads and 10% for non-homesteads
California	Increase in assessed value limited to $\min\{0.02, CPI\}$
Illinois	29 of 102 counties opted into the PTELL program by 1999. This limits the increase in property tax revenue to $\min\{0.05, CPI\}$
Indiana	The maximum levy is the maximum levy from the previous year adjusted by the assessed value growth quotient (AVGQ)
Iowa	Increase in property values limited to 3% annually
Maryland	10% limit in annual increase in property values with a 3-year phase in for all increases
Massachusetts	Annual increase in property tax revenue limited to 2.5%
Michigan	Annual increase in property values limited to $\min\{0.05, CPI\}$
Nebraska	Annual increase in spending limited by an amount determined by the legislature
Nevada	Annual increase in property tax revenue limited to 6%
New Jersey	Annual increase in spending limited to $\min\{0.03, CPI\}$
New Mexico	Annual increase in property values limited to 3%
Ohio	Tax rates automatically adjust as assessments increase to keep revenue generated from a tax levy fixed. 3-year phase in of value increases
Oklahoma	Annual increase in property values limited to 5%
Oregon	Annual increase in property values limited to 3%
Texas	Annual increase in property values limited to 10%
Washington	Annual increase in revenue limited to 6% above the highest level in the last three years
West Virginia	Annual increase in revenue limited to 1% per year (tax rates decreased if assessments raise more than 1%)
Wisconsin	Annual increase in revenue per pupil cannot exceed $208.88 in 1998-1999, and adjusted for inflation in future years

Notes: States with no dynamic limits (as of FY1999): Alabama, Alaska, Arizona, Colorado. Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maine, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New York, North Carolina, North Dakota, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Virginia, and Wyoming.

Table A3: State Summary Statistics

	(1)	(2)	(3)	(4)	(5)
		Balanced Panel School Districts			
States	Raw Districts	All	SEDA Test Scores	SEDA Test Score Gaps	CCD Cohort Graduation Rate
Arkansas	245	238	237	49	234
Connecticut	167	138	135	27	106
Florida	67	67	67	57	67
Georgia	180	180	178	131	177
Idaho	115	112	84	2	97
Illinois	871	848	667	87	425
Iowa	364	319	283	16	273
Kansas	297	284	207	16	236
Kentucky	174	173	164	25	165
Massachusetts	408	235	225	29	210
Minnesota	337	329	289	32	290
Mississippi	149	79	79	58	79
Nevada	17	17	15	2	16
New Hampshire	162	120	89	0	68
New Jersey	573	339	321	89	211
New Mexico	89	89	66	6	78
New York	725	668	618	89	592
North Carolina	115	115	115	84	115
North Dakota	192	176	54	2	104
Ohio	612	608	602	76	573
Oklahoma	539	513	322	21	357
Oregon	195	194	138	10	161
Texas	1,031	1,025	804	187	866
Washington	295	295	211	34	229
Total	7,919	7,161	5,970	1,129	5,729

Notes: The number of districts per state in my sample are shown. The first column reports the raw number of traditional public school districts reported in the CCD and column (2) is the number of districts in my balanced panel. Columns (3) through (5) are the number of districts with nonmissing values in the balanced panel for the variables indicated.

Table A4: First stage estimates of log simulated revenue on log spending for graduation rate samples – individual year lags

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
				A. 8th Grade Cohort Graduation Rate					
Log Sim. Rev.	0.142**	0.146**	0.151**	0.127**	0.130**	0.079*	0.033	-0.003	0.056
	(0.028)	(0.029)	(0.030)	(0.029)	(0.032)	(0.036)	(0.048)	(0.062)	(0.072)
F	25.83	24.38	25.62	18.66	16.23	4.76	0.48	0.00	0.60
Districts	2,724	2,724	2,722	2,721	2,720	2,716	2,708	2,688	2,668
N	17,467	17,467	17,275	16,967	15,677	14,640	13,203	11,510	9,147
				B. 9th Grade Cohort Graduation Rate					
Log Sim. Rev.	0.132**	0.141**	0.136**	0.153**	0.151**	0.092**	0.078+	0.051	0.092
	(0.024)	(0.024)	(0.024)	(0.025)	(0.029)	(0.034)	(0.044)	(0.054)	(0.063)
F	29.38	34.72	32.45	37.35	27.23	7.22	3.12	0.89	2.12
Districts	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,821	2,816
N	22,342	22,130	21,751	20,108	18,643	16,918	14,885	12,683	10,011
				C. 10th Grade Cohort Graduation Rate					
Log Sim. Rev.	0.144**	0.136**	0.135**	0.136**	0.105**	0.071*	0.067	0.058	0.110+
	(0.022)	(0.022)	(0.024)	(0.026)	(0.029)	(0.033)	(0.042)	(0.055)	(0.065)
F	42.80	37.50	31.22	28.26	13.42	4.46	2.52	1.11	2.88
Districts	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,822	2,817
N	23,457	23,082	21,468	19,863	18,063	16,449	14,593	12,633	9,969
				D. 11th Grade Cohort Graduation Rate					
Log Sim. Rev.	0.135**	0.138**	0.143**	0.142**	0.082**	0.058	0.062	0.081	0.109
	(0.021)	(0.023)	(0.024)	(0.028)	(0.033)	(0.038)	(0.047)	(0.057)	(0.068)
F	42.18	36.31	33.95	26.41	6.08	2.40	1.72	2.02	2.58
Districts	2,823	2,823	2,823	2,820	2,815	2,815	2,813	2,812	2,798
N	22,227	20,606	19,049	17,194	15,357	14,431	13,327	12,089	9,540

Notes: This table reports the results of individual first stage regressions of log total expenditures on log simulated revenue with the same lag for samples with non-missing graduation rates. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A5: First stage estimates of log simulated revenue on log spending for test score samples – individual year lags

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
				A. SEDA 4th Grade Math Scores					
Log Sim. Rev.	0.072*	0.047+	0.021	0.074**	0.148**	0.197**	0.230**	0.265**	0.201**
	(0.034)	(0.029)	(0.035)	(0.031)	(0.026)	(0.025)	(0.022)	(0.028)	(0.030)
F	4.58	2.71	0.37	5.85	31.96	62.49	106.94	90.21	44.03
Districts	5,780	5,780	5,781	5,781	5,781	5,781	5,781	5,781	5,781
N	26,501	26,492	26,495	26,496	26,500	26,502	26,502	26,501	26,502
				B. SEDA 4th Grade Reading Scores					
Log Sim. Rev.	0.077*	0.049+	0.022	0.074**	0.153**	0.199**	0.230**	0.266**	0.201**
	(0.033)	(0.029)	(0.035)	(0.031)	(0.026)	(0.025)	(0.022)	(0.028)	(0.030)
F	5.34	2.86	0.41	5.89	34.34	64.14	106.22	91.05	44.14
Districts	5,778	5,778	5,779	5,779	5,779	5,779	5,779	5,779	5,779
N	26,511	26,502	26,505	26,506	26,510	26,512	26,512	26,511	26,512
				C. SEDA 8th Grade Math Scores					
Log Sim. Rev.	0.053	0.031	0.037	0.049+	0.107**	0.124**	0.161**	0.209**	0.133**
	(0.032)	(0.028)	(0.034)	(0.028)	(0.024)	(0.023)	(0.022)	(0.031)	(0.032)
F	2.65	1.20	1.19	3.17	20.39	28.63	52.43	46.60	17.64
Districts	5,787	5,787	5,787	5,788	5,788	5,788	5,788	5,788	5,788
N	24,741	24,732	24,734	24,736	24,740	24,742	24,741	24,740	24,741
				D. SEDA 8th Grade Reading Scores					
Log Sim. Rev.	0.076*	0.050+	0.035	0.070*	0.147**	0.191**	0.230**	0.270**	0.204**
	(0.033)	(0.029)	(0.034)	(0.030)	(0.026)	(0.024)	(0.022)	(0.028)	(0.030)
F	5.35	2.95	1.06	5.29	31.87	61.05	104.56	92.39	45.53
Districts	5,801	5,801	5,801	5,802	5,802	5,802	5,802	5,802	5,802
N	26,599	26,590	26,592	26,594	26,598	26,600	26,600	26,599	26,600

Notes: This table reports the results of individual first stage regressions of log total expenditures on log simulated revenue with the same lag for samples with non-missing test scores. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A6: Two-stage least squares estimates of log spending on graduation rates

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
				A. 8th Grade Cohort Graduation Rate					
Log Spending	0.452**	0.414**	0.107	0.046	-0.134	0.001	-0.193	-0.318	-0.337
	(0.121)	(0.122)	(0.071)	(0.078)	(0.104)	(0.151)	(0.250)	(0.465)	(0.397)
Dep. Var. Mean	0.79	0.79	0.79	0.78	0.79	0.78	0.78	0.78	0.79
First-stage F	64.53	58.36	66.70	62.14	52.19	24.83	8.05	1.74	2.89
Districts	2,676	2,676	2,675	2,669	2,660	2,656	2,636	2,608	2,535
N	17,419	17,419	17,228	16,915	15,617	14,580	13,131	11,430	9,014
				B. 9th Grade Cohort Graduation Rate					
Log Spending	0.327**	0.304**	0.082	0.057	-0.014	-0.054	-0.284+	-0.475	-0.473
	(0.098)	(0.090)	(0.066)	(0.073)	(0.092)	(0.129)	(0.172)	(0.297)	(0.300)
Dep. Var. Mean	0.76	0.76	0.76	0.76	0.76	0.75	0.75	0.75	0.75
First-stage F	76.00	80.54	77.34	80.42	60.09	25.46	12.85	4.46	5.09
Districts	2,823	2,823	2,823	2,823	2,818	2,815	2,808	2,802	2,758
N	22,340	22,128	21,749	20,106	18,636	16,908	14,868	12,664	9,953
				C. 10th Grade Cohort Graduation Rate					
Log Spending	0.223**	0.215**	0.077	0.103	0.098	0.143	-0.121	-0.389	-0.201
	(0.064)	(0.064)	(0.060)	(0.078)	(0.122)	(0.158)	(0.196)	(0.261)	(0.202)
Dep. Var. Mean	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.80	0.81
First-stage F	109.75	93.67	73.56	65.35	40.78	19.81	11.11	4.80	6.35
Districts	2,824	2,824	2,824	2,824	2,822	2,822	2,818	2,804	2,773
N	23,456	23,081	21,467	19,862	18,060	16,446	14,586	12,615	9,925
				D. 11th Grade Cohort Graduation Rate					
Log Spending	0.147**	0.193**	0.064	0.112	0.091	0.102	-0.099	-0.411+	-0.360
	(0.054)	(0.062)	(0.056)	(0.080)	(0.146)	(0.178)	(0.209)	(0.229)	(0.239)
Dep. Var. Mean	0.85	0.85	0.85	0.85	0.85	0.84	0.85	0.86	0.86
First-stage F	119.16	90.27	75.76	61.81	26.19	13.51	8.77	6.33	5.77
Districts	2,820	2,819	2,815	2,810	2,803	2,794	2,786	2,773	2,722
N	22,224	20,602	19,041	17,184	15,345	14,410	13,300	12,050	9,464

Notes: This table reports results from individual two-stage least squares regressions of graduation rates on lagged log total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A7: Two-stage least squares estimates of log spending on SEDA test scores

	No Lag	1 Lag	2 Lags	3 Lags	4 Lags	5 Lags	6 Lags	7 Lags	8 Lags
				A. 4th Grade Math					
Log Spending	-2.474	-1.003	5.189	0.851	-2.474	0.910*	0.631*	0.690*	0.803
	(1.786)	(1.770)	(10.711)	(1.331)	(1.786)	(0.404)	(0.315)	(0.331)	(0.459)
First-stage F	6.91	4.94	0.36	6.15	6.91	64.22	108.80	91.49	45.09
Districts	5,663	5,662	5,662	5,663	5,663	5,664	5,664	5,664	5,664
N	26,384	26,374	26,376	26,378	26,384	26,385	26,385	26,384	26,385
				B. 4th Grade Reading					
Log Spending	-1.054	-2.209	6.814	1.139	-1.054	0.849*	0.899**	0.900**	0.641
	(1.362)	(1.832)	(12.045)	(1.321)	(1.362)	(0.377)	(0.291)	(0.301)	(0.408)
First-stage F	7.87	5.14	0.40	6.20	7.87	65.90	108.09	92.34	45.22
Districts	5,660	5,659	5,659	5,660	5,660	5,661	5,661	5,661	5,661
N	26,393	26,383	26,385	26,387	26,393	26,394	26,394	26,393	26,394
				C. 8th Grade Math					
Log Spending	-0.222	1.832	3.956	4.795	-0.222	1.846**	0.993**	0.691	0.023
	(1.737)	(2.307)	(4.747)	(3.074)	(1.737)	(0.656)	(0.418)	(0.370)	(0.540)
First-stage F	4.73	3.02	1.17	3.49	4.73	30.22	54.02	47.59	18.41
Districts	5,642	5,641	5,641	5,642	5,642	5,643	5,643	5,643	5,643
N	24,596	24,586	24,588	24,590	24,596	24,597	24,596	24,595	24,596
				D. 8th Grade Reading					
Log Spending	0.854	1.502	-1.588	0.424	0.854	0.502	0.490	0.506	0.236
	(1.353)	(1.726)	(3.297)	(1.168)	(1.353)	(0.350)	(0.260)	(0.270)	(0.381)
First-stage F	7.88	5.23	1.05	5.58	7.88	62.78	106.41	93.67	46.63
Districts	5,673	5,672	5,672	5,673	5,673	5,674	5,674	5,674	5,674
N	26,471	26,461	26,463	26,465	26,471	26,472	26,472	26,471	26,472

Notes: This table reports results from individual two-stage least squares regressions of test scores on lagged log total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A8: First stage estimates of simulated revenue ($1,000 per pupil) on total expenditure ($1,000 per pupil) for graduation rate samples – individual year lags

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
A. 8th Grade Cohort Graduation Rate									
Per-pupil Sim. Rev.	3.053**	2.768**	2.694**	2.099**	2.052**	0.905	0.289	-0.299	1.556
	(0.464)	(0.508)	(0.524)	(0.533)	(0.530)	(0.592)	(0.730)	(0.954)	(1.137)
F	43.20	29.67	26.47	15.49	14.98	2.34	0.16	0.10	1.87
Districts	2,724	2,724	2,722	2,721	2,720	2,716	2,708	2,688	2,668
N	17,467	17,467	17,275	16,967	15,677	14,640	13,203	11,510	9,147
B. 9th Grade Cohort Graduation Rate									
Per-pupil Sim. Rev.	3.025**	2.687**	2.350**	2.139**	1.667**	0.476	0.658	0.896	1.537
	(0.468)	(0.442)	(0.428)	(0.435)	(0.468)	(0.559)	(0.695)	(0.898)	(1.016)
F	41.78	36.94	30.21	24.19	12.71	0.72	0.90	1.00	2.29
Districts	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,821	2,816
N	22,342	22,130	21,751	20,108	18,643	16,918	14,885	12,683	10,011
C. 10th Grade Cohort Graduation Rate									
Per-pupil Sim. Rev.	3.198**	2.753**	2.318**	1.853**	0.956*	0.400	0.834	1.000	2.055*
	(0.426)	(0.419)	(0.443)	(0.456)	(0.475)	(0.541)	(0.656)	(0.901)	(1.016)
F	56.48	43.13	27.39	16.52	4.06	0.55	1.62	1.23	4.09
Districts	2,825	2,825	2,825	2,825	2,825	2,825	2,825	2,822	2,817
N	23,457	23,082	21,468	19,863	18,063	16,449	14,593	12,633	9,969
D. 11th Grade Cohort Graduation Rate									
Per-pupil Sim. Rev.	3.224**	2.704**	2.346**	1.876**	1.000+	0.456	0.857	1.430	2.181*
	(0.413)	(0.423)	(0.431)	(0.491)	(0.542)	(0.650)	(0.755)	(0.915)	(1.082)
F	60.97	40.83	29.66	14.62	3.40	0.49	1.29	2.44	4.06
Districts	2,823	2,823	2,823	2,820	2,815	2,815	2,813	2,812	2,798
N	22,227	20,606	19,049	17,194	15,357	14,431	13,327	12,089	9,540

Notes: This table reports the results of individual first stage regressions of per-pupil total expenditures on log simulated revenue with the same lag for samples with non-missing graduation rates. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A9: First stage estimates of simulated revenue ($1,000 per pupil) on total expenditure ($1,000 per pupil) for test score samples – individual year lags

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
A. SEDA 4th Grade Math Scores									
Per-pupil Sim. Rev.	1.053+	0.561	-0.157	1.010+	1.830**	1.877**	2.235**	1.977**	0.970*
	(0.552)	(0.549)	(0.609)	(0.597)	(0.494)	(0.444)	(0.404)	(0.480)	(0.480)
F	3.65	1.04	0.07	2.86	13.73	17.91	30.57	16.94	4.08
Districts	5,780	5,780	5,781	5,781	5,781	5,781	5,781	5,781	5,781
N	26,501	26,501	26,502	26,503	26,504	26,505	26,506	26,506	26,506
B. SEDA 4th Grade Reading Scores									
Per-pupil Sim. Rev.	1.190*	0.575	-0.125	1.053+	2.001**	1.970**	2.245**	2.020**	0.964*
	(0.531)	(0.548)	(0.610)	(0.596)	(0.489)	(0.441)	(0.406)	(0.473)	(0.479)
F	5.01	1.10	0.04	3.12	16.74	19.95	30.64	18.20	4.05
Districts	5,778	5,778	5,779	5,779	5,779	5,779	5,779	5,779	5,779
N	26,511	26,511	26,512	26,513	26,514	26,515	26,516	26,516	26,516
C. SEDA 8th Grade Math Scores									
Per-pupil Sim. Rev.	0.776	0.675	0.768	0.797	1.372**	0.912*	1.567**	1.832**	0.900+
	(0.526)	(0.574)	(0.640)	(0.640)	(0.493)	(0.431)	(0.435)	(0.550)	(0.526)
F	2.18	1.38	1.44	1.55	7.76	4.48	12.95	11.11	2.93
Districts	5,787	5,787	5,788	5,788	5,788	5,788	5,788	5,788	5,788
N	24,741	24,741	24,742	24,743	24,744	24,745	24,745	24,745	24,745
D. SEDA 8th Grade Reading Scores									
Per-pupil Sim. Rev.	1.129*	0.672	0.236	1.048+	1.906**	1.827**	2.182**	1.985**	0.996*
	(0.520)	(0.564)	(0.605)	(0.596)	(0.474)	(0.423)	(0.405)	(0.479)	(0.476)
F	4.70	1.42	0.15	3.10	16.18	18.68	29.09	17.15	4.38
Districts	5,801	5,801	5,802	5,802	5,802	5,802	5,802	5,802	5,802
N	26,599	26,599	26,600	26,601	26,602	26,603	26,604	26,604	26,604

Notes: This table reports the results of individual first stage regressions of per-pupil total expenditures on log simulated revenue with the same lag for samples with non-missing test scores. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A10: First stage estimates of simulated revenue ($1,000 per pupil) on total expenditure ($1,000 per pupil) – average lags

	(1) 1 year	(2) 1-4 years	(3) 1-8 years	(4) 5-8 years
	A. 8th Grade Graduation Cohort Sample			
Per-pupil Sim. Rev.	0.010**	0.008+	0.003	-0.004
	(0.004)	(0.004)	(0.004)	(0.008)
F	5.87	3.43	0.90	0.26
Districts	2,885	2,881	2,820	2,821
N	18,610	16,570	9,552	9,553
	B. 9th Grade Graduation Cohort Sample			
Per-pupil Sim. Rev.	0.008*	0.009*	0.004	-0.002
	(0.004)	(0.004)	(0.004)	(0.008)
F	5.23	4.64	1.12	0.05
Districts	2,988	2,988	2,977	2,978
N	23,567	19,655	10,468	10,470
	C. 10th Grade Graduation Cohort Sample			
Per-pupil Sim. Rev.	0.009**	0.009*	0.002	-0.005
	(0.004)	(0.004)	(0.003)	(0.008)
F	5.80	4.54	0.26	0.41
Districts	2,988	2,987	2,979	2,980
N	24,538	19,082	10,440	10,442
	D. 11th Grade Graduation Cohort Sample			
Per-pupil Sim. Rev.	0.008**	0.007+	0.002	-0.007
	(0.004)	(0.004)	(0.004)	(0.008)
F	5.80	2.72	0.44	0.75
Districts	2,986	2,978	2,960	2,961
N	22,005	16,337	10,004	10,006
	E. SEDA Test Score Sample			
Per-pupil Sim. Rev.	0.001	-0.004	-0.003	-0.001
	(0.009)	(0.006)	(0.004)	(0.004)
F	0.00	0.48	0.61	0.02
Districts	5,951	5,951	5,951	5,952
N	25,534	25,534	25,534	25,538

Notes: This table reports the results of first stage regressions of total expenditures on simulated revenue with average lags. Column (1) is the average of the current and previous year, column (2) is the average of the current and the past 4 years, column (3) is the average over the past 8 years, and column (4) is the average from 5 to 8 years prior to the measured outcome. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A11: Two-stage least squares estimates of per-pupil spending on graduation rates

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
A. 8th Grade Cohort Graduation Rate									
Spending ($1,000s PP)	0.027**	0.027**	0.008	0.004	-0.011	0.000	-0.021	-0.048	-0.018
	(0.007)	(0.008)	(0.005)	(0.006)	(0.009)	(0.015)	(0.028)	(0.102)	(0.021)
Dep. Var. Mean	0.79	0.79	0.79	0.78	0.79	0.78	0.78	0.78	0.79
First-stage F	74.03	49.48	47.42	36.19	35.20	11.19	3.25	0.33	3.98
Districts	2,676	2,676	2,675	2,669	2,660	2,656	2,636	2,608	2,535
N	17,419	17,419	17,228	16,915	15,617	14,580	13,131	11,430	9,014
B. 9th Grade Cohort Graduation Rate									
Spending ($1,000s PP)	0.019**	0.020**	0.006	0.005	-0.001	-0.007	-0.031	-0.036	-0.033
	(0.006)	(0.006)	(0.005)	(0.006)	(0.009)	(0.018)	(0.022)	(0.026)	(0.022)
Dep. Var. Mean	0.76	0.76	0.76	0.76	0.76	0.75	0.75	0.75	0.75
First-stage F	71.94	61.67	52.80	44.33	27.11	5.46	4.43	2.89	4.17
Districts	2,823	2,823	2,823	2,823	2,818	2,815	2,808	2,802	2,758
N	22,340	22,128	21,749	20,106	18,636	16,908	14,868	12,664	9,953
C. 10th Grade Cohort Graduation Rate									
Spending ($1,000s PP)	0.013**	0.014**	0.005	0.009	0.011	0.018	-0.011	-0.029	-0.013
	(0.004)	(0.004)	(0.004)	(0.006)	(0.013)	(0.021)	(0.018)	(0.021)	(0.013)
Dep. Var. Mean	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.80	0.81
First-stage F	99.92	74.71	47.84	32.36	13.71	4.97	5.70	3.26	6.63
Districts	2,824	2,824	2,824	2,824	2,822	2,822	2,818	2,804	2,773
N	23,456	23,081	21,467	19,862	18,060	16,446	14,586	12,615	9,925
D. 11th Grade Cohort Graduation Rate									
Spending ($1,000s PP)	0.009**	0.013**	0.005	0.010	0.009	0.012	-0.009	-0.029*	-0.022
	(0.003)	(0.004)	(0.004)	(0.007)	(0.014)	(0.022)	(0.019)	(0.017)	(0.014)
Dep. Var. Mean	0.85	0.85	0.85	0.85	0.85	0.84	0.85	0.86	0.86
First-stage F	110.92	70.80	50.31	28.89	11.32	3.51	4.48	5.03	6.43
Districts	2,820	2,819	2,815	2,810	2,803	2,794	2,786	2,773	2,722
N	22,224	20,602	19,041	17,184	15,345	14,410	13,300	12,050	9,464

Notes: This table reports results from individual two-stage least squares regressions of graduation rates on individually lagged per-pupil total expenditures instrumented with individually lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A12: Two-stage least squares estimates of per-pupil spending on graduation rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	8th Grade Cohort		9th Grade Cohort		10th Grade Cohort		11th Grade Cohort	
	1 year	1-4 years	1 year	1-4 years	1 year	1-4 years	1 year	1-4 years
Spending ($1,000s per pupil)	0.028**	0.018**	0.020**	0.021**	0.015**	0.026**	0.013**	0.027**
	(0.007)	(0.007)	(0.006)	(0.007)	(0.004)	(0.007)	(0.004)	(0.008)
Dep. Var. Mean	0.79	0.79	0.76	0.76	0.81	0.81	0.85	0.85
First-stage F	70.42	85.94	72.96	79.86	83.60	67.40	80.64	55.29
Districts	2,676	2,660	2,823	2,817	2,824	2,821	2,819	2,802
N	17,419	15,616	22,128	18,633	23,081	18,058	20,602	15,342

Notes: This table reports results from individual two-stage least squares regressions of graduation rates on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A13: Two-stage least squares estimates of per-pupil spending on test scores

	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$	$\tau = 6$	$\tau = 7$	$\tau = 8$
				A. SEDA 4th Grade Math Scores					
Spending ($1,000s PP)	-0.176	-0.081	-0.675	0.064	0.073	0.096*	0.065+	0.093+	0.164
	(0.133)	(0.148)	(2.695)	(0.103)	(0.050)	(0.047)	(0.035)	(0.050)	(0.122)
Dep. Var. Mean	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
First-stage F	5.09	2.13	0.07	2.98	13.89	18.29	31.05	17.20	4.29
Districts	5,663	5,663	5,663	5,664	5,664	5,664	5,664	5,664	5,664
N	26,384	26,384	26,384	26,386	26,387	26,388	26,389	26,389	26,389
				B. SEDA 4th Grade Reading Scores					
Spending ($1,000s PP)	-0.071	-0.182	-1.179	0.083	0.115*	0.087*	0.092**	0.118**	0.132
	(0.092)	(0.170)	(5.704)	(0.101)	(0.050)	(0.042)	(0.034)	(0.047)	(0.105)
Dep. Var. Mean	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
First-stage F	6.75	2.21	0.04	3.24	16.92	20.35	31.12	18.48	4.26
Districts	5,660	5,660	5,660	5,661	5,661	5,661	5,661	5,661	5,661
N	26,393	26,393	26,393	26,395	26,396	26,397	26,398	26,398	26,398
				C. SEDA 8th Grade Math Scores					
Spending ($1,000s PP)	-0.016	0.100	0.190	0.297	0.158*	0.251+	0.102*	0.079+	0.003
	(0.125)	(0.125)	(0.219)	(0.255)	(0.076)	(0.135)	(0.049)	(0.048)	(0.079)
Dep. Var. Mean	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
First-stage F	3.49	2.63	1.44	1.65	7.90	4.73	13.30	11.33	3.12
Districts	5,642	5,642	5,642	5,643	5,643	5,643	5,643	5,643	5,643
N	24,596	24,596	24,596	24,598	24,599	24,600	24,600	24,600	24,600
				D. SEDA 8th Grade Reading Scores					
Spending ($1,000s PP)	0.060	0.122	-0.245	0.026	0.060	0.053	0.052+	0.069+	0.047
	(0.095)	(0.141)	(0.761)	(0.079)	(0.037)	(0.038)	(0.029)	(0.041)	(0.081)
Dep. Var. Mean	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
First-stage F	6.40	2.60	0.15	3.22	16.35	19.08	29.56	17.41	4.60
Districts	5,673	5,673	5,673	5,674	5,674	5,674	5,674	5,674	5,674
N	26,471	26,471	26,471	26,473	26,474	26,475	26,476	26,476	26,476

Notes: This table reports results from individual two-stage least squares regressions of SEDA test scores on individually lagged per-pupil total expenditures instrumented with individually lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A14: Two-stage least squares estimates of per-pupil spending on test scores

	(1)	(2)	(3)	(4)
	4th Grade		8th Grade	
	Math	Reading	Math	Reading
	A. SEDA Test Scores			
Spending ($1,000s PP)	0.091*	0.101**	0.110*	0.057+
	(0.042)	(0.038)	(0.052)	(0.034
First-stage F	46.12	49.28	21.80	45.64
Districts	5,664	5,661	5,643	5,674
N	26,388	26,397	24,600	26,475

Notes: This table reports results from individual two-stage least squares regressions of SEDA test scores on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A15: Two-stage least squares estimates of log spending on instructional expenditure sub-categories – Graduation Rate sample, one-year lag

A. 10th Grade Cohort Graduation Rate Sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Instructional	Teacher Salaries				Instructional
	Salaries	Regular	Special	Vocational	Other	Benefits
Spending ($1,000s PP)	0.277**	0.559**	0.095**	0.023**	0.041**	0.126**
	(0.030)	(0.063)	(0.013)	(0.004)	(0.006)	(0.014)
Dep. Var. Mean	3.92	1.49	0.29	0.05	0.07	1.174
Baseline Fraction	0.32	0.12	0.02	0.00	0.01	0.094
First-stage F	83.60	83.60	83.60	83.60	83.60	83.60
Districts	2,824	2,824	2,824	2,824	2,824	2,824
N	23,081	23,081	23,081	23,081	23,081	23,081

B. SEDA Test Score Sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Instructional	Teacher Salaries				Instructional
	Salaries	Regular	Special	Vocational	Other	Benefits
Spending ($1,000s PP)	0.415**	0.941**	0.206**	-0.028**	0.044**	0.166**
	(0.086)	(0.202)	(0.046)	(0.007)	(0.011)	(0.034)
Dep. Var. Mean	3.88	1.69	0.32	0.05	0.07	1.155
Baseline Fraction	0.34	0.16	0.03	0.01	0.01	0.117
First-stage F	21.42	21.42	21.42	21.42	21.42	21.42
Districts	5,527	5,527	5,527	5,527	5,527	5,527
N	24,006	24,006	24,006	24,006	24,006	24,006

Notes: This table reports results from individual two-stage least squares regressions of per-pupil instructional expenditure sub-categories on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A16: Two-stage least squares estimates of per-pupil spending on support service expenditure sub-categories

A. 10th Grade Cohort Graduation Rate Sample

	(1) Pupil Support	(2) Staff Support	(3) General Admin.	(4) School Admin.	(5) Operations & Maintenance	(6) Transportation	(7) Other
Spending ($1,000s PP)	0.058**	0.068**	0.009*	0.039**	0.087**	0.031**	0.030**
	(0.007)	(0.009)	(0.004)	(0.005)	(0.011)	(0.005)	(0.005)
Dep. Var. Mean	0.49	0.38	0.24	0.49	0.87	0.426	0.246
Baseline Fraction	0.04	0.03	0.02	0.04	0.07	0.034	0.020
First-stage F	83.60	83.60	83.60	83.60	83.60	83.60	83.60
Districts	2,824	2,824	2,824	2,824	2,824	2,824	2,824
N	23,081	23,081	23,081	23,081	23,081	23,081	23,081

B. SEDA Test Score Sample

	(1) Pupil Support	(2) Staff Support	(3) General Admin.	(4) School Admin.	(5) Operations & Maintenance	(6) Transportation	(7) Other
Spending ($1,000s PP)	0.074**	0.039**	0.031**	0.047**	0.070**	0.020**	0.029**
	(0.017)	(0.012)	(0.013)	(0.011)	(0.018)	(0.008)	(0.008)
Dep. Var. Mean	0.46	0.36	0.30	0.48	0.87	0.444	0.234
Baseline Fraction	0.04	0.03	0.03	0.04	0.08	0.041	0.024
First-stage F	21.42	21.42	21.42	21.42	21.42	21.42	21.42
Districts	5,527	5,527	5,527	5,527	5,527	5,527	5,527
N	24,006	24,006	24,006	24,006	24,006	24,006	24,006

Notes: This table reports results from individual two-stage least squares regressions of per-pupil support service expenditure sub-categories on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A17: Two-stage least squares estimates of per-pupil spending on capital expenditure sub-categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Graduate Rates					SEDA Test Scores				
	New Construction	Land	Instructional Equipment	Other Equipment	Nonspecified Equipment	New Construction	Land	Instructional Equipment	Other Equipment	Nonspecified Equipment
Spending ($1,000s PP)	0.234**	0.012	0.006*	0.004	0.0000	0.251**	-0.024	0.013**	-0.006	0.0016
	(0.049)	(0.015)	(0.003)	(0.007)	(0.001)	(0.087)	(0.031)	(0.004)	(0.011)	(0.005)
Dep. Var. Mean	0.79	0.063	0.057	0.13	0.011	0.79	0.056	0.058	0.13	0.011
Baseline Fraction	0.05	0.004	0.005	0.01	0.001	0.05	0.004	0.005	0.01	0.001
First-stage F	83.60	83.60	83.60	83.60	83.60	21.42	21.42	21.42	21.42	21.42
Districts	2,824	2,824	2,824	2,824	2,824	5,527	5,527	5,527	5,527	5,527
N	23,081	23,081	23,081	23,081	23,081	24,006	24,006	24,006	24,006	24,006

Notes: This table reports results from individual two-stage least squares regressions of per-pupil capital expenditure sub-categories on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A18: Two-stage least squares estimates of per-pupil spending on other current expenditure sub-categories

A. 10th Grade Cohort Graduation Rate Sample

	(1) Food Services	(2) Enterprise Operations	(3) Other Elem/Sec	(4) Community Services	(5) Adult Education	(6) Other Non-Elem/Sec
Spending ($1,000s PP)	0.012**	0.000	0.001	0.003	-0.002	0.042**
	(0.003)	(0.001)	(0.001)	(0.003)	(0.002)	(0.008)
Dep. Var. Mean	0.35	0.021	0.0026	0.031	0.017	0.010
Baseline Fraction	0.03	0.002	0.0002	0.003	0.001	0.001
First-stage F	83.60	83.60	83.60	83.60	83.60	83.60
Districts	2,824	2,824	2,824	2,824	2,824	2,824
N	23,081	23,081	23,081	23,081	23,081	23,081

B. SEDA Test Score Sample

	(1) Food Services	(2) Enterprise Operations	(3) Other Elem/Sec	(4) Community Services	(5) Adult Education	(6) Other Non-Elem/Sec
Spending ($1,000s PP)	-0.019**	0.002*	0.002	0.003	-0.005+	0.001
	(0.005)	(0.001)	(0.002)	(0.004)	(0.002)	(0.001)
Dep. Var. Mean	0.34	0.025	0.0028	0.029	0.015	0.005
Baseline Fraction	0.03	0.002	0.0001	0.002	0.001	0.001
First-stage F	21.42	21.42	21.42	21.42	21.42	21.42
Districts	5,527	5,527	5,527	5,527	5,527	5,527
N	24,006	24,006	24,006	24,006	24,006	24,006

Notes: This table reports results from individual two-stage least squares regressions of per-pupil other current expenditure sub-categories on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A19: Two-stage least squares estimates of spending on teacher counts

A. 10th Grade Cohort Graduation Rate Sample

	(1) Total Teachers	(2) Teacher Aides	(3) Total Counselors	(4) Library Specialists	(5) District Admin.	(6) School Admin.	(7) Student Support
Spending ($1,000s PP)	-15.715**	-2.259	-1.334**	-0.054	-0.152	-2.033**	-1.223
	(6.687)	(1.718)	(0.509)	(0.103)	(0.223)	(0.776)	(1.284)
Dep. Var. Mean	337.38	70.186	11.6710	6.304	6.519	18.041	21.469
Baseline Fraction	28.29	6.01	0.99	0.54	0.56	1.56	1.84
First-stage F	83.60	83.60	83.60	83.60	83.60	83.60	83.60
Districts	2,824	2,824	2,824	2,824	2,824	2,824	2,824
N	23,081	23,081	23,081	23,081	23,081	23,081	23,081

B. SEDA Test Score Sample

Notes: This table reports results from individual two-stage least squares regressions of teacher counts on lagged per-pupil total expenditures instrumented with lagged log simulated revenue. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

Table A20: Two-stage least squares estimates of log spending on graduation rates and test scores – robustness checks

A. National Trends

	(1)	(2)	(3)	(4)	(5)
	10th Grade Graduation Rate	Test Scores: 5 to 8 Year Lag			
	1-Year Lag	G4 Math	G4 Reading	G8 Math	G4 Reading
Log Spending	0.250**	-4.973	-4.117	-11.836	-1.552
	(0.077)	(9.799)	(8.195)	(34.710)	(5.915)
F	65.85	0.45	0.48	0.14	0.50
Districts	5,447	5,662	5,659	5,640	5,671
N	35,442	26,372	26,381	24,582	26,458

B. No Combined Districts

	(1)	(2)	(3)	(4)	(5)
	10th Grade Graduation Rate	Test Scores: 5 to 8 Year Lag			
	1-Year Lag	G4 Math	G4 Reading	G8 Math	G4 Reading
Log Spending	0.270**	0.636+	0.706*	1.002**	0.593*
	(0.080)	(0.345)	(0.309)	(0.411)	(0.281)
F	76.60	176.59	178.50	95.19	173.59
Districts	2,628	5,224	5,221	5,197	5,229
N	21,444	24,428	24,437	22,647	24,475

C. No Combined Districts + No Sample Restrictions

	(1)	(2)	(3)	(4)	(5)
	10th Grade Graduation Rate	Test Scores: 5 to 8 Year Lag			
	1-Year Lag	G4 Math	G4 Reading	G8 Math	G4 Reading
Log Spending	0.290**	0.475	0.253	0.005	0.085
	(0.085)	(0.301)	(0.240)	(0.479)	(0.220)
F	72.38	132.47	138.79	45.83	142.72
Districts	2,655	5,470	5,474	5,431	5,471
N	21,829	29,881	30,086	26,770	29,556

Notes: This table reports results from two-stage least squares regressions of graduation rates and test scores on average lagged log total expenditures instrumented with log simulated revenue, averaged over the same years. Models also include controls for district property wealth, median household income, fraction of students who are black, fraction Hispanic, fraction special education, fraction eligible for free or reduced price lunch, district fixed effects, and state-by-year fixed effects. All covariates are interacted with an indicator equal to 1 if the fraction of students in the district eligible for free or reduced-price lunch is in the top quartile for their state. Standard errors are clustered at the district level: * $p < 0.05$, ** $p < 0.01$.

B Online Appendix - State Administrative Data

This section outlines the data sources for property values from each state.

B.1 Arkansas

Tables with assessed valuation, tax rate, and taxes levied by class of property for counties, cities, and school districts are available from the Arkansas Assessment Coordination Department.[25] School district-level values are available from 1995-2010, but they have not compiled school district-level values since 2010. The assessment rate for real property in Arkansas is 0.2, so my measure of market values is the assessed value multiplied by 5.

B.2 Connecticut

The Connecticut Office of Policy and Management (OPM) publishes excel sheets of the grand list by town on their website. The description from the website reads: "The Office of Policy and Management annually develops the full-value estimate of all taxable property within the 169 towns and cities. A ratio of assessment to market value is calculated from real estate sales occurring within each town and city. A separate ratio and full-value estimate is listed for four property types: residential, apartment, commercial/industrial/public utility and vacant land." Thus, the net grand list is the value determined by the assessors and the net equalized grant list corrects any inconsistencies in the assessment process to arrive at their best estimate of the market value in that town or city. The net equalized grand list subtracts out exemptions, so the full market value is the gross equalized grand list. This is readily available in the Total Grand List files, which are available for 1995-2012 because they also report the equalized value of exemptions. I only require the accurate levels of property values in the base year, so I use the 2013 and 2014 data to calculate the state-level changes in property wealth from the net equalized grand list to supplement the information from the gross equalized grand list in prior years.

The towns and cities perfectly map into school district boundaries, with each school district covering a set of towns and cities. Thus, I aggregate the city-level file from the OPM to the school district level. Real property must be reevaluated once every decade, and at that time, it is assessed at 70% of fair market value (FMV). Personal property is also assessed at 70% of FMV, but this FMV is adjusted annually. Property values are limited to changes of 5% between any two years.

B.3 Florida

The Florida Department of Revenue provides property tax data going back several decades (historical data is available on their website: ftp://sdrftp03.dor.state.fl.us/DataBooks). The data is part of the "Florida Ad Valorem Valuations and Tax Data" series. Table 4 reports "just values" (their term for full market values) for real, personal, and centrally assessed property combined. I use these just values as the total property wealth in the

[25] http://www.arkansas.gov/acd/statewide_values_rates_assessed_values.html

county. School districts are coterminous with counties so the county-level information is matched directly to school districts.

B.4 Georgia

The Local Government Services Division of the Georgia Department of Revenue is charged with ensuring that property taxes are assessed uniformly and administered properly by each of the county tax officials. They provide a digest of property tax values on their website.[26] These digests include values for each class of property for each county and independent school district.

B.5 Idaho

The Idaho State Department of Education has a report in their archives[27] about school district property taxes back to 1999. These reports include the market value of property by school district, tax rates by purpose by school district, taxes levied by purpose by school district. I match this market value of property directly to school districts.

B.6 Illinois

The Illinois Department of Revenue publishes a report called "Illinois Property Tax Statistics", which is available on their website[28] back to 1976. This report includes the total equalized assessed value for each taxing district in Table 28. I apply the inverse of the assessment rate to the assessed value to retrieve the total market value in each district. This file includes information for every taxing district including school districts, which are then matched to the school district information from the CCD.

B.7 Iowa

The Iowa Department of Management has information about school property taxes back to 2003 on their website.[29] The data includes net valuations by school district (2001-2016), tax rates by purpose by school district (2001-2016), total levies by school district (2003-2016), instructional support levies by school district (2003-2016), physical plant and equipment levies by school district (2003-2016), tax rates and revenue by county (2002-2016).

B.8 Kansas

The Kansas Department of Revenue produces an annual statistical report, which it makes available on its website back to 2004. These reports include a summary report of assessed property values by school district, compiled by the Division of Property Valuation. These reports are available from 2001 to 2015, but the information reported is from the previous

[26] https://dor.georgia.gov/digest-consolidated-summaries
[27] http://www.sde.idaho.gov/finance/archives.html
[28] http://tax.illinois.gov/AboutIdor/TaxStats/PropertyTaxStats/PreviousYears/
[29] http://www.dom.state.ia.us/local/schools/archive.html

year so corresponds to values from 2000-2014. Kansas has three separate assessment rates for five classes of property. Residential property is assessed at 11.5 percent of market value. Commercial real estate, motor vehicles, and agricultural property are each assessed at 30 percent of market value. Commercial equipment and machinery is assessed at 20 percent of market value. The majority of property assessed is real property so I use the residential assessment rate to convert the assessed values into approximate market values.

B.9 Kentucky

The Kentucky Revenue Cabinet releases state-level statistics on property tax revenues annually. The Kentucky Department of Revenue Office of Property Valuation has an archive of tax rates of each county by purpose (including education) and class, and tax rates for each school district by class on their website[30] back to 1999. On the individual county information pages there is valuation information by county for the whole state from 2005-2015, which was supplemented with years 1999-2004 by contacting the department directly.

B.10 Massachusetts

The Massachusetts Department of Revenue publishes an annual report available on their website[31] back to 2003. This report includes statewide summaries of revenues collected. The Division of Local Services has oversight of property taxation and municipal finance. Their website[32] also has a Municipal Databank with taxable values by municipality (back to 1981), assessed values by class by municipality (back to 1981), taxes levied by class by municipality (back to 1986), school versus total expenditure (back to 1986), and tax rate by class by municipality (back to 1981).

B.11 Minnesota

Each year, the Department of Revenue reports to the Legislature on property tax values and assessment practices in Minnesota. Posted on their website[33], these reports analyze market trends, the effects of property tax laws and changes to them, and how property values are assessed throughout the state. These reports were mandated by the Legislature in 2001, and the first one was issued in 2003. These reports have county by county market values by class and the last decade of changes to market value compared to the statewide average.

B.12 Mississippi

The Mississippi State Tax Commission was restructured in 2010 to become the Department of Revenue. The DOR presents an annual report of financial and statistical data pertaining

[30] http://revenue.ky.gov/NR/exeres/ADD5DAC1-5E46-4DCD-B3C0-E54DBA6D8E05,frameless.htm?NRMODE=Published

[31] http://www.mass.gov/dor/tax-professionals/news-and-reports/annual-reports/

[32] http://www.mass.gov/dor/local-officials/municipal-databank-and-local-aid-unit/databank-reports-new.html

[33] http://www.revenue.state.mn.us/propertytax/Pages/apreport.aspx

to tax collections in the state of Mississippi for the fiscal year (July–June). The Department of Archives and History has electronic (PDF) reports from 2003. These reports include the assessment of property by class by county (back to 2002). Millage rate reports by county are available here back to 2010.

B.13 Nevada

The Nevada Department of Taxation publishes an annual report available on their website[34] back to 2005 (state archive[35] has reports back to 1998). These reports include assessed value after exemptions by county (taxable value). There is an additional report on Property Tax Rates available on the website[36] back to 1971. These reports include assessed values and total property tax rates by taxing unit, combined property tax rates by component by taxing unit (taxing units include counties, municipalities, and school districts).

B.14 New Hampshire

The New Hampshire Department of Revenue Administration is statutorily required to issue an Annual Report, which is available on their website[37] back to 2002.

B.15 New Jersey

The State of New Jersey Department of Community Affairs has data available on its website[38] for 1998-2015. The property tax tables include taxable value, taxes levied by purpose, and tax rates by purpose all by municipality. The Property Value Classification tables include additional valuation details including residential values and the percentage of total value from residential property.

B.16 New Mexico

The New Mexico Taxation and Revenue Department releases "Property Tax Facts", which are available on their website[39] back to 2004 (Economic and Statistical Information/Property Tax Reports). These fact sheets include residential taxable values and obligations by county (Table 1), property taxes by purpose by county (Table 4).

B.17 New York

The overall full-value tax rates are available by county on their website . The New York State Department of Taxation and Finance has several annually published reports regarding

[34] http://tax.nv.gov/Publications/Annual_Report/

[35] http://www.nsladigitalcollections.org/browse/taxationstateofnevada#search/facet_1:Annual%20Reports/

[36] http://tax.nv.gov/LocalGovt/PolicyPub/ArchiveFiles/Redbook/

[37] http://revenue.nh.gov/publications/reports/index.htm

[38] http://www.state.nj.us/dca/divisions/dlgs/resources/property_tax.html

[39] http://www.tax.newmexico.gov/forms-publications.aspx

property taxes on their website.[40] One of these reports is titled "Exemptions from Real Property Taxation in New York State" and includes detailed exemption data by county and municipality (back to 2000) including total equalized value (Table B1).

data.ny.gov also provides access to useful data including real property tax levy data (back to 2004).

B.18 North Carolina

The North Carolina Department of Revenue makes several tables of statistics available on their website . These reports include effective tax rates for counties and municipalities (back to 2002-2003 here), real property valuations by class by county (back to 2003-2004 here), property valuations by real, personal, and public service by county (back to 1998-1999 here). The North Carolina Department of State Treasurer also has reports on their website . These include assessed valuation, tax rate, assessment ratio, effective tax rate by county and municipality back to 2000.

B.19 North Dakota

The North Dakota Office of State Tax Commissioner produces several major publications available on their website . These include the State and Local Taxes Guide (biennially back to 1998) with general property taxes levied by county. Another report titled Property Valuations and Property Taxes Levied in North Dakota/The Property tax Statistical Report includes taxable valuation by class by county (Table 1), general and special property taxes levied by county by political subdivision (Table 3 – includes school districts), property taxes levied by tax code by county (Table 4), taxes levied on classes of property by county (Table 5), and millage rates by tax code by county (Table 7).

North Dakota has a 9 percent assessment rate on property. I use this to convert the assessed values reported in the financial facts document to approximate market values.

B.20 Ohio

The Ohio Department of Taxation makes data available on their website . These data include taxable property values, taxes levied, and tax rates by school district (SD1, back to 1986); millage rates by school district (DTE27, back to 1994); assessed value and taxes levied by county (PD 30, back to 1987); and taxable value of real property by class by county (PD31, back to 1985).

B.21 Oklahoma

Oklahoma uses a range of assessment rates for multiple classes of property. The assessment rate for real property varies between 11 percent and 13.5 percent. Personal property is assessed between 10 and 15 percent of market value. Public service property is assessed at a fixed rate of 22.85 percent. I do not have information on which assessment rate is used in

[40] https://www.tax.ny.gov/pubs_and_bulls/orpts/publications/property_pubs_prior.htm

each district. Thus, I use the lower bound of the ranges of assessment rates when converting assessed values into approximate market values.

B.22 Oregon

The Oregon Department of Revenue publishes an annual report titled Oregon Property Tax Statistics, which is available on their website back to FY 1997-1998. These reports include market and assessed value, taxes levied, and average tax rate by county (all property, Table A.2); market value and assessed value by type (real, personal, etc.) by county (Table A.4); assessed value by class by county (Table B.4); tax rates by type of taxing district by city (Table H); and tax rates by type of tax by taxing district (including school districts, Appendix A).

B.23 Tennessee

The Tennessee State Board of Equalization publishes the annual Tax Aggregate Report of Tennessee, which is available on their website back to 2000. This report includes assessments for counties and municipalities (Table I), tax rates for counties and municipalities (Table VI). The Tennessee Comptroller of the Treasury Division of Property Assessments also has tax rates by county for 1997-2015. Tennessee school districts do not have the power to tax.

B.24 Texas

The Texas Comptroller of Public Accounts Property Tax Division publishes an Annual Property Tax Report, which is available on their website back to 2003. These reports have several tables of information including appraised values by category by appraisal district (Appendix A); appraised values by category, millage rates, and taxes levied by school district (Appendix B, I somehow have Appendix B for 2002 as well); appraised values by category, millage rates by purpose and associated taxes levied by county (Appendix C). The key data comes from the School District Self-Reports.

B.25 Virginia

School districts in Virginia do not have taxing authority. The Annual Report published by the Virginia Department of Taxation reports individual and corporate income tax, sales and use tax, local property tax, and other state tax data. Reports are available back to FY 1999 and beginning with the FY 2006 report, both the Adobe PDF and Excel spreadsheet versions are available for download in their website . These reports include market values, taxable values, and tax levies by county (Table 5.2). They also conduct an annual Assessment/Sales Ratio Study, available on their website back to 1998, which includes total fair market value by county and by city (Table 1), the nominal and effective tax rate by county and by city (Table 3), true value of real estate versus public service corporation by county and by city (Table 4). Lastly there is a report with tax rates by class by county back to tax year 1999 available here .

B.26 Washington

The Washington State Department of Revenue releases an annual Tax Statistics report, which is archived on their website back to 1997. These are available as full pdf reports back to 2006 and excel files of the tables are available from 2001-2015. There is also a Property Tax Statistical Report available here back to 1998, with a table of taxable value and levies due by school district (Part 3/Appendix C).

C Online Appendix - School Finance Formulas

This section outlines the school finance formulas for each state in my sample and summarizes them as the tax price and wealth price as of 1999. It is helpful to establish some notation used throughout this section. Here I will call ℓ_t^d the district markup, which is a multiplicative factor that encompasses statewide assessment ratios and district-specific factors that determines the amount of revenue given property wealth and the tax rate (e.g. fraction of homes receiving a homestead exemption, rates of delinquent property tax payments, etc.) such that $\tau_t^d \times \ell_t^d W_t^d = L_t^d(\tau_t^d \times W_t^d)$.

C.1 Arkansas

Arkansas has a foundation program, which is distributed as State Equalization Funding per Student (SEFPS) and Additional Base Funding (ABF) (Ark. Stat. Ann. §6-20-303). Every school district must tax itself 25 mills for Maintenance and Operation and half the revenue from each additional mill above 25 is captured by the state.

State Equalization Funding per Student (SEFPS) for each district is calculated by subtracting each district's local revenue per student (LRPS) from the basic local revenue per student (BLRPS), which gives

$$SEFPS_t^d = \frac{0.98\times(0.025\times\ell_t^s W_t^s)+0.75\times\text{Misc.}_t^s}{ADM_t^s} - \frac{0.98\times(0.025\times\ell_t^d W_t^d)+0.75\times\text{Misc.}_t^d}{ADM_t^d},$$

where W_t^s is the aggregate property assessment for the state, Misc._t^s is the aggregate miscellaneous and other funds from state sources, and ADM_t^s is the aggregate average daily membership for the state, and corresponding variables with a d superscript are the same measures but at the district level.

Additional Base Funding (ABF) combines revenue sources on an ADM basis and brings all school districts up to a minimum level of revenue per ADM. The revenues included in the calculation of ABF are: Total Local M&O Revenue Available, State Equalization Funding, General Facilities Funding, Student Growth Funding, and Revenue Loss Funding. These revenue sources are totaled and divided by the ADM of the district. Once the total state and local revenue per ADM is calculated, all of the school districts are ranked from most revenue per ADM to the least revenue per ADM. The revenue per ADM for the school district at the 95th percentile is multiplied by 80% to arrive at the Minimum State and Local Revenue per ADM (MSLR). Any school district whose revenue per ADM is less than the MSLR receives ABF in the amount per ADM equal to the difference between the district's revenue per ADM and MSLR. Revenue per ADM_t^d is

$$\frac{R_t^d}{ADM_t^d} = \frac{\left(\frac{\tau_t^d-0.025}{2}+0.025\right)\times\ell_t^d W_t^d+\text{Misc.}_t^d}{ADM_t^d}+SEFPS_t^d$$

where here Misc._t^d includes General Facilities Funding, Student Growth Funding, and Revenue Loss Funding. The Minimum State and Local Revenue per ADM is

$$MSLR_t^d = 0.80 \times P_{95}\left(\frac{R_t^d}{ADM_t^d}\right)$$

where $P_{95}\left(\frac{R_t^d}{ADM_t^d}\right)$ is the 95th percentile of $\frac{R_t^d}{ADM_t^d}$ for all $d \in D$. Using these definitions, the Additional Base Funding is

$$ABF_t^d = \max\left(0, MSLR_t^d - \frac{R_t^d}{ADM_t^d}\right)$$

For my revenue functions, I omit miscellaneous revenues since they are unrelated to property wealth and so will not effect the wealth price. Thus, local revenue is

$$L_t^d = \begin{cases} \tau_t^d \times \ell_t^d W_t^d, & \text{if } \tau_t^d < 0.025 \\ (0.5(\tau_t^d - 0.025) + 0.025) \times \ell_t^d W_t^d, & \text{if } \tau_t^d \geq 0.025 \end{cases}$$

state revenue is

$$S_t^d = (ABF_t^d + SEFPS_t^d) \times ADM_t^d$$

and total revenue is

$$R_t^d = (0.5(\tau_t^d - 0.025) + 0.025) \times \ell_t^d W_t^d + (ABF_t^d + SEFPS_t^d) \times ADM_t^d$$

The wealth price is then given by

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.025) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} 0 & \text{if } \frac{R_t^d}{ADM_t^d} < 0.8 P_{95}\left(\frac{R_t^d}{ADM_t^d}\right) \\ 0.5 \ell_t^d W_t^d & \text{if } \frac{R_t^d}{ADM_t^d} \geq 0.8 P_{95}\left(\frac{R_t^d}{ADM_t^d}\right). \end{cases}$$

C.2 Connecticut

School districts in Connecticut are financed by their townships instead of being independent taxing authorities. Thus, their finance system is quite simple. The state determines how much money per weighted student the district should get, then decides how much they will pay and how much needs to be covered by the town. Townships set a single millage rate for all their local revenue, including for school districts, so it's impossible to tell the effect of marginally increasing property tax rates. Connecticut's Education Cost Sharing (ECS) is a foundation-based equalization formula that distributes aid based on the extent to which local town wealth falls short of a statutorily set State Guaranteed Wealth Level (SGWL).

The unit of allocation of the ECS is "need students" Student counts are weighted as follows to arrive at total need students. The resident student count of each town (ADM) is the number of children educated at the expense of the town in public schools or in other placements prescribed and paid for by the town. A full-time equivalent count (FTE) is added to the resident student count if a district operates either a system-wide calendar in excess of 180 days (the legal minimum) or a free summer school program or both. Additional weights include 25% for students in families eligible for TANF, 10% for students with limited English proficiency (LEP), and 25% for students at remedial education levels (Remedial). Need students can then be defined as

$$NS_t^d = ADM_t^d + FTE_t^d + 0.25 \times TANF_t^d + 0.1 \times LEP_t^d + 0.25 \times Remedial_t^d.$$

Local fiscal capacity is determined by town wealth per student. The ECS definition of town wealth begins with each town's Equalized Net Grand List (ENGL). ENGL per pupil is then adjusted based on the average ratio of each town's per capita income (PCI) and median household income (MHI) to the highest town's PCI and MHI. Income-adjusted property wealth is given by:

$$AdjW_t^d = \frac{1}{2} \times \left(\frac{PCI_t^d}{\max_{i \in D}\{PCI_t^i\}} + \frac{MHI_t^d}{\max_{i \in D}\{MHI_t^i\}} \right) \times W_t^d$$

$AdjW_t^d$ is then divided by need students and by populations and the average of these two is the town's unit value of equalized taxable property wealth. Equalized wealth is given by the average of adjusted wealth divided by need students and adjusted wealth divided by population. That is,

$$EW_t^d = \frac{1}{2} \times \left(\frac{AdjW_t^d}{NS_t^d} + \frac{AdjW_t^d}{Pop_t^d} \right)$$

Each town's equalized wealth is compared to 1.55 times the median town's wealth, which is called the state guaranteed wealth level (SGWL). Specifically,

$$SGWL_t = 1.55 \times \text{median}_{i \in D}\{EW_t^i\}$$

A town's ability to pay is reflected by its wealth as a fraction of the SGWL. Towns with local resources equal to or above the SGWL receive a base aid percentage of zero. All others receive the difference between 100% and the percentage they are able to fund based on the fraction described above. This percentage is then multiplied times the town's total foundation which is the product of the foundation and the total need students of the town. The local share of this town's total basic foundation is

$$\frac{EW_t^d}{SGWL_t^d} \times NS_t^d \times Foundation_t$$

The foundation for 1998-99 is set by statute at \$5,775 per need student. This makes the local revenue function

$$L_t^d = \ell_t^d \tau_t^d W_t^d$$

the state revenue function is

$$S_t^d = \left(1 - \frac{EW_t^d}{SGWL_t^d}\right) \times NS_t^d \times 5775$$

and total revenue is

$$R_t^d = ETR_t^d \times W_t^d + \left(1 - \frac{EW_t^d}{SGWL_t^d}\right) \times NS_t^d \times 5775.$$

The wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = ETR_t^d - \frac{1}{4} \times \left(\frac{PCI_t^d}{\max_{i \in D}\{PCI_t^i\}} + \frac{MHI_t^d}{\max_{i \in D}\{MHI_t^i\}}\right) \times \left(1 + \frac{NS_t^d}{Pop_t^d}\right) \times \frac{1}{SGWL_t^d} \times 5775$$

and the tax price is unclear because there is no separate tax rate for education.

C.3 Florida

The Florida Education Finance Program (FEFP) is a highly-modified foundation plan laid out in Florida Statute §236.081. Funds are distributed based on weighted full time equivalents (WFTE) multiplied by the foundation amount (called the base student allocation or BSA) and the District Cost Differential (DCD). A number of other funds are included such as the Declining Enrollment Supplement, the Sparsity Supplement, Discretionary Tax Equalization, the Safe Schools Allocation, the Remediation Reduction Incentive, the Dropout Prevention Incentive, the Disparity Compression Adjustment, and the Hold Harmless Adjustment. Only the Sparsity Supplement and Discretionary Tax Equalization interact with W_t^d so I omit the other items.

The foundation tax rate is called Required Local Effort Millage (RLE Millage$_t^d$) and is set at 6.509 mills, then adjusted by an equalization factor for each district. This equalization factor is based on the relative amount of property wealth in the district compared to the rest of the state.

WFTE is calculated using the program cost factors outlined in Table C1. Using these cost factors WFTE is

$$\begin{aligned} WFTE_t^d = {} & 1.057 \times FTE_t^{k-3} + FTE_t^{4-8} + 1.138 \times FTE^{9-12} + 1.201 \times ESOL_t \\ & + 1.240 \times VOC_t + 1.341 \times SL1_t + 2.072 \times SL2_t + 3.287 \times SL3_t + 4.101 \times SL4_t \\ & + 6.860 \times SL5_t \end{aligned}$$

The district cost differential (DCD) adjusts the foundation level based on an average of the previous three years of the Florida Price Level Index (FPLI) as follows:

$$DCD_t^d = 0.008 \times \frac{FPLI_t^d + FPLI_{t-1}^d + FPLI_{t-2}^d}{3} + 0.2.$$

In 1998-99, DCD_t^d ranged from .9103 to 1.0751.

Table C1: Florida Pupil Weights

Group	Weight
Basic Programs	
Kindergarten and Grades 1, 2, and 3	1.057
Grades 4, 5, 6, 7, and 8	1.000
Grades 9, 10, 11, and 12	1.138
Programs for At-Risk Students	
Dropout Prevention and Teenage Parent	1.399
Educational Alternatives, Grades 9–12	1.138
Intensive English/ESOL	1.201
Exceptional Student Programs	
Support Level 1	1.341
Support Level 2	2.072
Support Level 3	3.287
Support Level 4	4.101
Support Level 5	6.860
Vocational Education, Grades 6–12	1.240

Districts may levy up to 0.76 mills above the foundation tax rate (0.51 mills of discretionary current operation millage and 0.25 under the discretionary tax equalization program). The Discretionary Tax Equalization (DTE) portion of the funding formula provides the difference between \$50 per $WFTE_t^d$ and what the district generates with the last 0.25 mills. Thus, DTE is given by

$$DTE_t^d = \max\left\{0, 50 \times WFTE_t^d - .00025 \times \ell_t^d W_t^d\right\}.$$

Districts with fewer than three high schools, an unweighted FTE of 20,000 or less, and unweighted FTE per high school ($SI_t^d = \max\left\{1000, \frac{FTE_t^d}{\#\text{ of HS}_t^d}\right\}$) less than 7,308, are eligible for the Sparsity Supplement (SS_t^d). If the district's maximum discretionary levy (revenue generated by applying the maximum discretionary millage rate to the taxable value in the district) is above the state average, then SS_t^d is reduced by the amount by it exceeds the state average multiplied by FTE_t^d. This gives

$$SS_t^d = BSA_t \times WFTE_t^d \times \left(\frac{1101.8978}{2700+SI_t^d} - 0.01101\right) - FTE_t^d \times 0.00076 \times \max\left\{0, \frac{\ell_t^d W_t^d}{FTE_t^d} - \frac{\ell_t^s W_t^s}{FTE_t^s}\right\}.$$

In 1998-1999 the base student allocation (foundation level) was set at \$3,214.20. Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$3214.20 \times WFTE_t^d \times DCD_t^d + SS_t^d + DTE_t^d - \frac{\text{RLE Millage}_t^d}{1000} \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$3214.20 \times WFTE_t^d \times DCD_t^d + SS_t^d + DTE_t^d + \left(\tau_t^d - \frac{\text{RLE Millage}_t^d}{1000}\right) \times \ell_t^d W_t^d$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} \left(\tau_t^d - 0.000076 - \frac{\text{RLE Millage}_t^d}{1000}\right) \times \ell_t^d & \text{if } \frac{\ell_t^d W_t^d}{FTE_t^d} > \frac{\ell_t^s W_t^s}{FTE_t^s} \\ \left(\tau_t^d - \frac{\text{RLE Millage}_t^d}{1000}\right) \times \ell_t^d & \text{if } \frac{\ell_t^d W_t^d}{FTE_t^d} \leq \frac{\ell_t^s W_t^s}{FTE_t^s} \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.4 Georgia

The Quality Basic Education Act (QBE) program is a foundation program with a guaranteed yield equalization component established in GA. CODE §20-2-160. The foundation level was set at \$2,038.74 per weighted student. The local share is determined by the foundation tax rate of 5 mills or the equivalent amount of revenue. Funds are assigned based on weighted full time equivalent ($wFTE$) pupils, which are calculated by applying the weights from Table C2 to student counts.[41] Using these weights gives

$$wFTE_t^d = 1.3286 \times FTE_t^K + 1.2432 \times FTE_t^{1-3} + 1.0197 \times FTE_t^{4-5} + 1.0242 \times FTE_t^{6-8} + FTE_t^{9-12}.$$

There are also additional program weights for students attending programs for which I do not have data, so I leave them out of my calculations.

Table C2: Georgia Pupil Weights

Program	Weight
Kindergarten program	1.3286
Primary grades program (1-3)	1.2432
Upper elementary grades program (4-5)	1.0197
Middle grades program (6-8)	1.0242
High school general education program (9-12)	1.000
High school non-vocational laboratory program (9-12)	1.2428
Vocational laboratory program (9-12)	1.3557
Program for the handicapped:	
Category I	2.3419
Category II	2.7204
Category III	3.4579

[41] These weights were put in place in 1995-1996 and I am unable to find a record of them being changed before 1998-1999. Even if they were changed, the changes are likely to be minor.

In addition to foundation aid, the state provides guaranteed yield funding (GY) which equalizes up to 3.25 mills that are levied above the required five mills. The equalization is based on the difference between what the local district generates by levying the 3.25 mills and what is generated by the local district at the 90th percentile in property wealth per pupil (W^{90}, including the district markup)

$$GY_t^d = \min\left\{0.00325, \max\left\{0, \tau_t^d - 0.005\right\}\right\} \times \left(\max\left\{\ell_t^d W_t^d, W_t^{90}\right\} - \ell_t^d W_t^d\right)$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$\begin{aligned} S_t^d &= \$2,038.74 \times wFTE_t^d - 0.005 \times \ell_t^d W_t^d \\ &+ \begin{cases} 0.00325 \times \left(W_t^{90} - \ell_t^d W_t^d\right) & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \tau_t^d > \frac{8.25}{1000} \\ \left(\tau_t^d - 0.005\right) \times \left(W_t^{90} - \ell_t^d W_t^d\right) & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \frac{5}{1000} \leq \tau_t^d \leq \frac{8.25}{1000} \\ 0 & \text{if } \ell_t^d W_t^d \geq W_t^{90} \end{cases}, \end{aligned}$$

and total revenue is

$$\begin{aligned} R_t^d &= \$2,038.74 \times wFTE_t^d + \left(\tau_t^d - 0.005\right) \times \ell_t^d W_t^d \\ &+ \begin{cases} 0.00325 \times \left(W_t^{90} - \ell_t^d W_t^d\right) & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \tau_t^d > \frac{8.25}{1000} \\ \left(\tau_t^d - 0.005\right) \times \left(W_t^{90} - \ell_t^d W_t^d\right) & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \frac{5}{1000} \leq \tau_t^d \leq \frac{8.25}{1000} \\ 0 & \text{if } \ell_t^d W_t^d \geq W_t^{90}. \end{cases} \end{aligned}$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} \left(\tau_t^d - 0.00825\right) \times \ell_t^d & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \tau_t^d > \frac{8.25}{1000} \\ 0 & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \frac{5}{1000} \leq \tau_t^d \leq \frac{8.25}{1000} \\ \left(\tau_t^d - 0.005\right) \times \ell_t^d & \text{if } \ell_t^d W_t^d \geq W_t^{90} \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \ell_t^d W_t^d & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \tau_t^d > \frac{8.25}{1000} \\ \ell_t^d W_t^d + \left(W_t^{90} - \ell_t^d W_t^d\right) & \text{if } \ell_t^d W_t^d < W_t^{90} \text{ and } \frac{5}{1000} \leq \tau_t^d \leq \frac{8.25}{1000} \\ \ell_t^d W_t^d & \text{if } \ell_t^d W_t^d \geq W_t^{90}. \end{cases}$$

C.5 Idaho

The Idaho Public School Foundation Program (PSFP) assures each district an equal dollar amount per "support unit" made up of state and local funds. Support units are a weighted student count that is intended to measure the number of teachers required to teach the population of students in the district. The distribution factor is the amount guaranteed per support unit and was $20,758.63 in 1998-1999. The local share is the amount of property tax revenue generated by 3 mills.

Support units are determined by counts of students in kindergarten, elementary, secondary, "exceptional" education, and alternative schools. I lack data on exceptional education and alternative school counts so I omit those counts from my calculations. The divisors for converting student counts into support units are given in Table C3. Using these values gives

$$\begin{aligned}\text{Support Units}_t^d = &\min\{U_t^K, ADA_t^K \times D_t^K\} \\ &+ \min\{U_t^{1-6}, ADA_t^{1-6} \times D_t^{1-6}\} \\ &+ \min\{U_t^{7-12}, ADA_t^{7-12} \times D_t^{7-12}\}\end{aligned}$$

where D_t^j is the divisor for group j and U_t^j are the maximum units allowed, as given in the table.

Table C3: Idaho Support Unit Weights

ADA	Attendance Divisor	Maximum Units Allowed
	K Support Units	
41 or more	40	1 or more as computed
31 to 40.99	-	1
26 to 30.99	-	0.85
21 to 25.99	-	0.75
16 to 20.99	-	0.6
8 to 15.99	-	0.5
1 to 7.99	-	count as elementary
	Elementary Support Units	
300 or more	23 (Grades 4, 5, 6) 20 (Grades 1, 2, 3)	15
160 to 299.99	20	8.4
110 to 159.99	19	6.8
71.1 to 109.99	16	4.7
51.7 to 71.0	15	4.0
33.6 to 51.6	13	2.8
16.6 to 33.5	12	1.4
1.0 to 16.5	N/A	1.0
	Secondary Support Units	
750 or more	18.5	47
400 to 749.99	16	28
300 to 399.99	14.5	22
200 to 299.99	13.5	17
100 to 199.99	12	9
99.99 or fewer		
Grades 7-12	-	8
Grades 9-12	-	6
Grades 7-9	-	1 per 14 ADA
Grades 7-8	-	1 per 16 ADA

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$20,758.63 \times \text{Support Units}_t^d - 0.003 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$20,758.63 \times \text{Support Units}_t^d + (\tau_t^d - 0.003) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.003) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.6 Illinois

General State Aid (Illinois Compiled Statutes 5/18-8.05) is distributed under one of three formulas: Foundation, Alternate Method, and Flat Grant. The formula that applies to a given school district is determined by its property wealth. The state aid formula compares the district equalized assessed value (EAV) per pupil to a "state guaranteed wealth per pupil." The state guaranteed level (GL) also varies by the type of school district. For 1998-1999 the state guaranteed wealth per ADA pupil was:

- \$188,478 for elementary districts
- \$361,250 for secondary districts
- \$144,500 for unit (k-12) districts

Districts qualify for one of three formulas determined by EAV per pupil as follows:

Group Label	EAV Group	Formula
WG^1	$\frac{\ell_t^d W_t^d}{ADA_t^d} < 0.93 \times GL$	Foundation
WG^2	$0.93 \times GL < \frac{\ell_t^d W_t^d}{ADA_t^d} < 1.75 \times GL$	Alternate
WG^3	$1.75 \times GL < \frac{\ell_t^d W_t^d}{ADA_t^d}$	Flat Grant

The foundation level in 1998-1999 was \$4,225 per pupil. The local share is revenue generated by the foundation tax rate, which depends on the type of school district. The foundation tax rate is 2.3 mills for elementary districts, 1.2 mills for secondary districts, and 3 mills for unit districts. The alternative plan also uses the foundation level and local share as defined in the foundation plan, but under the following formula:

$$\$4,225 \times ADA_t^d \times \left(0.07 - \left(\frac{\text{Local Share}_t^d}{\$4,225 \times ADA_t^d} - 0.93\right) \times \frac{0.02}{0.82}\right).$$

The flat grant formula only depends on student counts as follows:

$$218 \times ADA_t^d.$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \begin{cases} \$4,225 \times ADA_t^d - (I_{\{e\}} \times 0.023 + I_{\{s\}} \times 0.012 + I_{\{u\}} \times 0.03) \times \ell_t^d W_t^d & \text{if } WG^1 \\ \$4,225 \times ADA_t^d \times \left(0.07 - \left(\frac{\text{Local Share}_t^d}{\$4{,}225 \times ADA_t^d} - 0.93\right) \times \frac{0.02}{0.82}\right) & \text{if } WG^2 \\ \$218 \times ADA_t^d & \text{if } WG^3 \end{cases},$$

where $I_{\{e\}}$ indicates elementary district, $I_{\{s\}}$ indicates secondary district, $I_{\{u\}}$ indicates unit district, and $GL^d = I_{\{e\}} \times \$188,478 + I_{\{s\}} \times \$361,250 + I_{\{u\}} \times \$144,500$. Total revenue is

$$R_t^d = \begin{cases} \$4,225 \times ADA_t^d + (\tau_t^d - (I_{\{e\}} \times 0.023 + I_{\{s\}} \times 0.012 + I_{\{u\}} \times 0.03)) \times \ell_t^d W_t^d & \text{if } WG^1 \\ \$4,225 \times ADA_t^d \times \left(0.07 - \left(\frac{\text{Local Share}_t^d}{\$4{,}225 \times ADA_t^d} - 0.93\right) \times \frac{0.02}{0.82}\right) + \tau_t^d \times \ell_t^d W_t^d & \text{if } WG^2 \\ \$218 \times ADA_t^d + \tau_t^d \times \ell_t^d W_t^d & \text{if } WG^3 \end{cases}.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} (\tau_t^d - (I_{\{e\}} \times 0.023 + I_{\{s\}} \times 0.012 + I_{\{u\}} \times 0.03)) \times \ell_t^d & \text{if } WG^1 \\ (\tau_t^d - (I_{\{e\}} \times 0.023 + I_{\{s\}} \times 0.012 + I_{\{u\}} \times 0.03) \times \frac{0.02}{0.82}) \times \ell_t^d & \text{if } WG^2 \\ \tau_t^d \times \ell_t^d & \text{if } WG^3 \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.7 Iowa

Iowa has a foundation plan with an additional discretionary tier with state matching defined in statute as the School Foundation Program (1999 Code of Iowa Ch. 257). The foundation tax rate is 5.4 mills. Spending is dictated by the district cost per pupil (DCPP) and state cost per pupil (SCPP). The foundation level is 87.5 percent of the state cost per pupil, which increases by a predetermined rate each year. The district cost per pupil is a district-specific measure that also grows at the same rate per year. Districts are also guaranteed \$300 per student in state aid, regardless of their local share dictated by the foundation tax rate.

Funds are dispersed based on weighted enrollment, which is a weighted sum of students in various programs and categories. The data for counts of students in these programs is not available historically so I use a measure of total enrollment.

Under the second tier, districts may increase their budgets by up to 10% through an "instructional support" levy. The instructional support levy is a percentage equalizing plan with the state participation at 25% for an average wealth district. Second tier funding is thus given by

$$\text{Second Tier}_t^d = \begin{cases} 0.1 \times DCPP_t^d \times ADM_t^d & \text{if } \tau_t^d > 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} \\ 0.25 \times (\tau_t^d - 0.0054) \times \ell_t^d W_t^d & \text{if } 0.0054 < \tau_t^d < 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} \end{cases}.$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \max\{300 \times ADM_t^d, 0.875 \times SCPP_t \times ADM_t^d - 0.0054 \times \ell_t^d W_t^d + \text{Second Tier}_t^d\},$$

and total revenue is

$$R_t^d = \max\{300 \times ADM_t^d, 0.875 \times SCPP_t \times ADM_t^d + \text{Second Tier}_t^d + (\tau_t^d - 0.0054) \times \ell_t^d W_t^d\}.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} 1.25 \times (\tau_t^d - 0.0054) \times \ell_t^d & \text{if } 0.0054 < \tau_t^d < 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} \\ (\tau_t^d - 0.0054) \times \ell_t^d & \text{if } 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} < \tau_t^d \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} 1.25 \times \ell_t^d W_t^d & \text{if } 0.0054 < \tau_t^d < 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} \\ \ell_t^d W_t^d & \text{if } 0.0054 + \frac{0.4 \times DCPP_t^d \times ADM_t^d}{\ell_t^d W_t^d} < \tau_t^d. \end{cases}$$

C.8 Kansas

Kansas has a foundation program that includes weights for certain programs and low enrollments as well as a discretionary tier called the local option budget (LOB) (K.S.A. §72-64, 1998). There are also additional categorical funds that I do not include in my calculations. Funds are distributed based on full time equivalent (FTE) student counts. The 1998-1999 foundation level was \$3,720 per weighted FTE. Student counts are adjusted by various factors to create Weighted FTE (wFTE). The only factor for which data is available is students eligible for free or reduced price lunch, which get an additional weight of 0.08, thus I define wFTE as

$$wFTE_t^d = FTE_t^d + 0.08 \times FTE_t^{FRPL}.$$

Local effort is determined by the revenue from the foundation tax rate of 20 mills and other revenues.

The local option budget is comprised of funds raised above 20 mill foundation tax rate and state matching funds based on assessed values per pupil. LOB can be up to 25 percent of the foundation level. The state share is given by

$$\text{State Share}_t^d = \left(1 - \frac{\ell_t^d W_t^d / FTE_t^d}{P_{75}(\ell_t^d W_t^d / FTE_t^d)}\right) \times LOB_t^d$$

where $P_{75}(\ell_t^d W_t^d / FTE_t^d)$ is the 75th percentile of assessed value per pupil across districts in the state.

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$3,720 \times wFTE_t^d - 0.02 \times \ell_t^d W_t^d + \text{State Share}_t^d \times \max\{0, \tau_t^d - 0.02\} \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$3,720 \times wFTE_t^d + (\tau_t^d - 0.02) \times \ell_t^d W_t^d + \text{State Share}_t^d \times \max\{0, \tau_t^d - 0.02\} \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = 2 \times \left(1 - \frac{\ell_t^d W_t^d / FTE_t^d}{P_{75}(\ell_t^d W_t^d / FTE_t^d)}\right) \times (\tau_t^d - 0.02) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d \times \left(2 - \frac{W_t^d / FTE_t^d}{P_{75}(\ell_t^d W_t^d / FTE_t^d)}\right).$$

C.9 Kentucky

The Support Education Excellence in Kentucky (SEEK) funding program is a modified foundation program that includes an additional equalization component. The foundation tax rate is 3 mills and the foundation level is $2,839 per pupil in weighted average daily attendance from the previous year.[42] The equalization component allows districts to generate additional revenue up to 15% of the foundation guarantee. Local effort is equalized at 150% of the state-wide average of assessed property value per pupil. The final tier allows districts to generate up to 30% above the combination of foundation guarantee and equalized funds and is not equalized.

Funding is based on the prior year ($t-1$) number of students in weighted average daily attendance ($wADA_t^d$). Using the weights in Table C4 gives

$$wADA_t^d = ADA_{t-1}^d + 0.15 \times ADM_{t-1}^{FRPL} + 2.35 \times ADM_{t-1}^{\text{Severe}} + 1.17 \times ADM_{t-1}^{\text{Moderate}} + 0.24 \times ADM_{t-1}^{\text{Speech}} + ADM_{t-1}^{HH}.$$

[42] $2,839 in 1998-99 amounts to $3,979.09 in 2013 dollars.

Table C4: Kentucky Pupil Weighted Factors

Group	Notation	Weight
At-Risk (FRPL-Eligible)	ADM_t^{FRPL}	0.15
Severe Handicap	ADM_t^{Severe}	2.35
Moderate Handicap	ADM_t^{Moderate}	1.17
Speech Therapy	ADM_t^{Speech}	0.24
Home & Hospital	ADM_t^{HH}	1.00

State equalizing funds are given by

$$\begin{aligned}\text{Tier }1_t^d &= wADA_t^d \\ &\times \begin{cases} 0.15 \times \$3,979.09 & \text{if } 0.003 < \tau_t^d < 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}} \\ (\tau_t^d - 0.003) \times (\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}) & \text{if } \tau_t^d \geq 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}}. \end{cases}\end{aligned}$$

Local revenue is given by

$$\tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$3,979.09 \times wADA_t^d + \text{Tier }1_t^d - 0.003 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$3,979.09 \times wADA_t^d + \text{Tier }1_t^d + (\tau_t^d - 0.003) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} (\tau_t^d - 0.003) \times \ell_t^d & \text{if } 0.003 < \tau_t^d < 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}} \\ (\tau_t^d - 0.003) \times \left(\ell_t^d + \frac{1.5\ell_t^s}{ADA_t^s} - \frac{\ell_t^d}{ADA_t^d}\right) & \text{if } \tau_t^d \geq 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}}, \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \ell_t^d W_t^d & \text{if } 0.003 < \tau_t^d < 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}} \\ \ell_t^d W_t^d + (\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}) & \text{if } \tau_t^d \geq 0.003 + \frac{0.15\times\$3,979.09}{\frac{1.5\times\ell_t^s W_t^s}{ADA_t^s} - \frac{\ell_t^d W_t^d}{ADA_t^d}}. \end{cases}$$

C.10 Massachusetts

Massachusetts has a foundation program referred to as Chapter 70 state aid, which was created by the Education Reform Act of 1993. The foundation amount for 1998-1999 was set at \$6,442 per pupil. A complicated formula with over 35 variables determines how this foundation amount should be adjusted based on student characteristics and the amount of required local contribution. For now, I assign the same foundation level for each district and assign a foundation tax rate of 9.4 mills.

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$6,442 \times ADM_t^d - 0.0094 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$6,442 \times ADM_t^d + (\tau_t^d - 0.0094) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.0094) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.11 Minnesota

Minnesota has a foundation program, known as the General Education Revenue program (Minnesota Statue 126C)[43]. Funds are allocated based on pupil units, which is a measure of weighted student counts. This weighted student count is

$$wADM_t^d = 0.53 \times ADM_t^K + 1.06 \times ADM_t^{1-6} + 1.3 \times ADM_t^{7-12} + ADM^D$$

where ADM_t^K is the number of kindergarten students without an IEP, ADM_t^{1-6} is the number of students in 1st through 6th grade, ADM_t^{7-12} is the number of students in 7th through 12th grade, and ADM_t^D is the number of pre-k and kindergarten students with a disability.

The majority of formula-based revenue is assigned through Basic Revenue, which is

$$\text{Basic Revenue}_t^d = \$3,530 \times wADM_t^d.$$

The remaining components of general education revenue are either categorical grants or based solely on student counts in particular programs. Because basic revenue accounts for about 77.7% of formula-based revenue, I estimate total General Education Revenue by dividing basic revenue by 0.777. The foundation tax rate for 1998-1999 was 0.369. If a district raises more local revenue than what is guaranteed by general education revenue, then the general education tax rate is reduced to the rate that generates exactly the guarantee. Districts can raise more than the foundation level and receive state funds to guarantee \$9,039 per weighted pupil on the first \$315 per weighted pupil above the foundation level.

[43]Full statutes are available at https://www.revisor.mn.gov/statutes/?id=126C&year=1998.

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \begin{cases} \frac{\$3{,}530 \times wADM_t^d}{0.777} - 0.369 \times \ell_t^d W_t^d + (\tau_t^d - 0.369) \times \max\left\{0, 9039 - \frac{\ell_t^d W_t^d}{wADM_t^d}\right\} & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d \leq 315 \times wADM_t^d \\ \frac{\$3{,}530 \times wADM_t^d}{0.777} - 0.369 \times \ell_t^d W_t^d & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d > 315 \times wADM_t^d \end{cases}$$

and total revenue is

$$R_t^d = \begin{cases} \frac{\$3{,}530 \times wADM_t^d}{0.777} + (\tau_t^d - 0.369) \times \left(\ell_t^d W_t^d + \max\left\{0, 9039 - \frac{\ell_t^d W_t^d}{wADM_t^d}\right\}\right) & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d \leq 315 \times wADM_t^d \\ \frac{\$3{,}530 \times wADM_t^d}{0.777} + (\tau_t^d - 0.369) \times \ell_t^d W_t^d & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d > 315 \times wADM_t^d \end{cases}$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} (\tau_t^d - 0.369) \times \left(\ell_t^d - \frac{\ell_t^d}{wADM_t^d}\right) & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d \leq 315 \times wADM_t^d \\ (\tau_t^d - 0.369) \times \ell_t^d & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d > 315 \times wADM_t^d \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \left(\ell_t^d W_t^d + \max\left\{0, 9039 - \frac{\ell_t^d W_t^d}{wADM_t^d}\right\}\right) & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d \leq 315 \times wADM_t^d \\ \ell_t^d W_t^d & \text{if } (\tau_t^d - 0.369) \times \ell_t^d W_t^d > 315 \times wADM_t^d \end{cases}.$$

C.12 Mississippi

State aid to school districts in Mississippi is described by the Mississippi Adequate Education Program (Miss. Stat. §37-151-7) operates like a guaranteed yield plan. The Base Student Cost (BSC) is calculated based on the funding of schools with an adequate proficiency rating as a baseline. In 1998-1999, the BSC was \$2,787. The guaranteed funding for each district, known as the Adequate Education Program Cost (AEPC), is

$$AEPC_t^d = BSC_t \times (ADM_t^d + 0.05 \times \text{Free-Lunch}_t^d) + \text{Add-ons}_t^d$$

where Free-Lunch_t^d is the number of students participating in the Free Lunch Program and Add-ons_t^d is the sum of 8 categorical grants for transportation, vocational/technical education, special education, gifted education, alternative school programs, extended school year programs, university-based programs, and bus drive training programs. To participate in the MAEP and receive state aid, districts must provide revenue from levying 28 mills of local property tax or 27 percent of the $AEPC_t^d$, whichever is less.

The add-on grants are unrelated to district wealth and tax rates, so I do not include them in my formulas. Local revenue is

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$2,787 \times (ADM_t^d + 0.05 \times \text{Free-Lunch}_t^d) - \min\left\{0.028 \times \ell_t^d W_t^d, 0.27 \times \$2,787 \times ADM_t^d\right\},$$

and total revenue is

$$R_t^d = \tau_t^d \times \ell_t^d W_t^d + \$2,787 \times (ADM_t^d + 0.05 \times \text{Free-Lunch}_t^d) - \min\left\{0.028 \times \ell_t^d W_t^d, 0.27 \times \$2,787 \times ADM_t^d\right\}.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.028) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.13 Nevada

The Nevada Plan is a minimum foundation program that provides guaranteed funding per weighted pupil (NEV. REV. STATE. § 387.121). The amount of the guarantee, called the basic support guarantee, is adjusted for each district based on a number of factors. The average basic support guarantee was $3,802 in 1999-2000 (the earliest year available). State financial aid to school districts equals the difference between school district basic support guarantee and local available funds produced by mandatory taxes. Nevada has a 2.25% local sales tax that funds about half of the total guarantee. I treat this as additional state revenue transferred to districts. The local share of property tax accounts for less than 10 percent of the guarantee, but districts raise twice as much money as that local share as part of the mandatory 0.0075 levy.

The state also provides a set amount of special education funding each year. For example, in 1998-1999, 2,088 units were funded by the Legislature at $28,248 per unit for a total appropriation of $58,981,824. These per-unit funds are not enough to cover the full cost of the special education program unit and there may be more units in the state than the total appropriation. Districts are required to have one special education program unit per 16 students with an IEP.

Local revenue is given by

$$L_t^d = 0.0075 \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$3,802 \times \left(0.6 \times ADM_t^k + ADM_t^{1-12}\right) + \$28,248 \times \frac{IEP_t^d}{16} - 0.0025 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$3,802 \times \left(0.6 \times ADM_t^k + ADM_t^{1-12}\right) + \$28,248 \times \frac{IEP_t^d}{16} + 0.005 \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = 0.005 \times \ell_t^d$$

and the tax price does not apply in this situation because districts are not allowed to increase their tax rate.

C.14 New Hampshire

The New Hampshire legislature adopted a new school funding formula, called the Adequate Education Funding Plan (AEFP), for the 1999-2000 school year in response to court challenges to their current system, which primarily relied on local funding for education. The AEFP provides \$4,220 per pupil in funding, about half of which is generated by a 6.6 mill statewide property tax. Funds are assigned based on the weighted number of pupils, such that

$$wADM_t^d = ADM_t^{k-6} + 1.2 \times ADM_t^{7-12} + ADM_t^{IEP} + \begin{cases} 0 & \text{if } \frac{FRPL_t^d}{ADM_t^d} < 0.12 \\ 0.5 \times FRPL_t^d & \text{if } 0.12 \leq \frac{FRPL_t^d}{ADM_t^d} \leq 0.24 \\ FRPL_t^d & \text{if } 0.24 < \frac{FRPL_t^d}{ADM_t^d} \end{cases}$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$4,220 \times wADM_t^d - 0.066 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$4,220 \times wADM_t^d + (\tau_t^d - 0.066) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.066) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.15 New Jersey

The school finance plan in New Jersey as of 1998-1999 was established by the "Comprehensive Educational Improvement and Financing Act of 1996," (CEIFA) (N.J. STAT. ANN. §18a: 1–1 et seq. CEIFA). Due to a New Jersey Supreme Court decision, Abbott v. Burke 575 A.2d 359 (N.J. 1990), CEIFA requires the state make funding in 28 low-income, urban school districts equivalent to spending the most affluent districts. CEIFA is a minimum foundation grant program with 24 additional aid programs.

The foundation amount per pupil is called the T&E (Thorough & Efficient) amount and the total foundation budget is called the T&E budget. The T&E budget is the level of spending determined by the state to be necessary to support a quality education. The T&E budget is a district's weighted enrollment times the T&E amount. That is,

$$\text{T\&E Budget}_t^d = \text{Weighted Pupils}_t^d \times \text{T\&E Amount}_t$$

Each year the T&E amount is increased by an amount equal to the annual percentage increase in the Consumer Price Index (CPI). For the 1998-1999 school year, the T&E amount is

\$6,899. There is an additional "T&E flexible amount," which give a range around the T&E amount that is also considered acceptable. The T&E flexible amount was \$336 for 1997-1998, so adjusted by the CPI makes it $336 * (1 + .0220859) \approx 343.42$ for 1998-1999.

Table C5: Per Pupil Weighting Factors

	Weight	T&E Amount	T&E Range
Kindergarten	.50	\$3,450	\$3,278-\$3,623
Elementary School	1.0	\$6,899	\$6,544-\$7,244
Middle School	1.12	\$7,727	\$7,341-\$8,113
High School	1.2	\$8,279	\$7,865-\$8,693

Using the numbers from Table C5, we get

$$\text{Weighted Pupils}_t^d = 0.5 \times ADM_t^k + ADM_t^{1-5} + 1.12 \times ADM_t^{6-8} + 1.2 \times ADM_t^{9-12}$$

The local share is determined by three factors: (a) the total amount of aid to be allocated through the CCSA formula statewide; (b) the district's income; and, (3) the district's property wealth. Specifically,

$$\text{Local Share}_t^d = \text{T\&E Budget}_t^d \times \left(\frac{WRT_t \times W_t^d + IRT_t \times I_t^d}{2} \right)$$

where WRT is the wealth ratio and IRT is the income ratio. The wealth ratio is given by

$$WRT_t = \frac{\text{T\&E Budget}_t^d}{W_t^s},$$

and in 2008-2009, the WRT was 0.0092690802. The income ratio is based on

$$IRT_t = \frac{\text{T\&E Budget}_t^d}{I_t^s},$$

which was 0.04546684 in 2008-2009.

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \text{Weighted Pupils}_t^d \times \text{T\&E Amount}_t \times (1 - WRT_t \times \ell_t W_t^d),$$

and total revenue is

$$R_t^d = \tau_t^d \times \ell_t^d W_t^d + \text{Weighted Pupils}_t^d \times \text{T\&E Amount}_t \times (1 - WRT_t \times \ell_t W_t^d).$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \ell_t^d(\tau_t^d - WRT_t \times \text{T\&E Amount}_t)$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.16 New Mexico

School funding in New Mexico is a foundation plan determined by the New Mexico Public School Finance Act of 1974. Funds are distributed based on weighted student counts called program units. Total program units are given by

$$\begin{aligned}\text{Total Program Units}_t^d = 1.44 \times FTE_t^k + 1.2 \times FTE_t^1 + 1.18 \times FTE_t^{2-3} + 1.045 \times FTE_t^{4-6} \\ + 1.25 \times FTE_t^{7-12} + SpecEd_t^d + Bilingual_t^d.\end{aligned}$$

There is not enough data available to calculate the $SpecEd_t^d$ and $Bilingual_t^d$ portions separately so, I omit them in my simulated funding.

The foundation level in 1998-1999 was \$2,344.09 per weighted student. The required minimum local levy is 0.5 mills.

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$2,344.09 \times \text{Total Program Units}_t^d - 0.0005 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$2,344.09 \times \text{Total Program Units}_t^d + (\tau_t^d - 0.0005) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.0005) \times \ell_t^d$$

and the tax price is

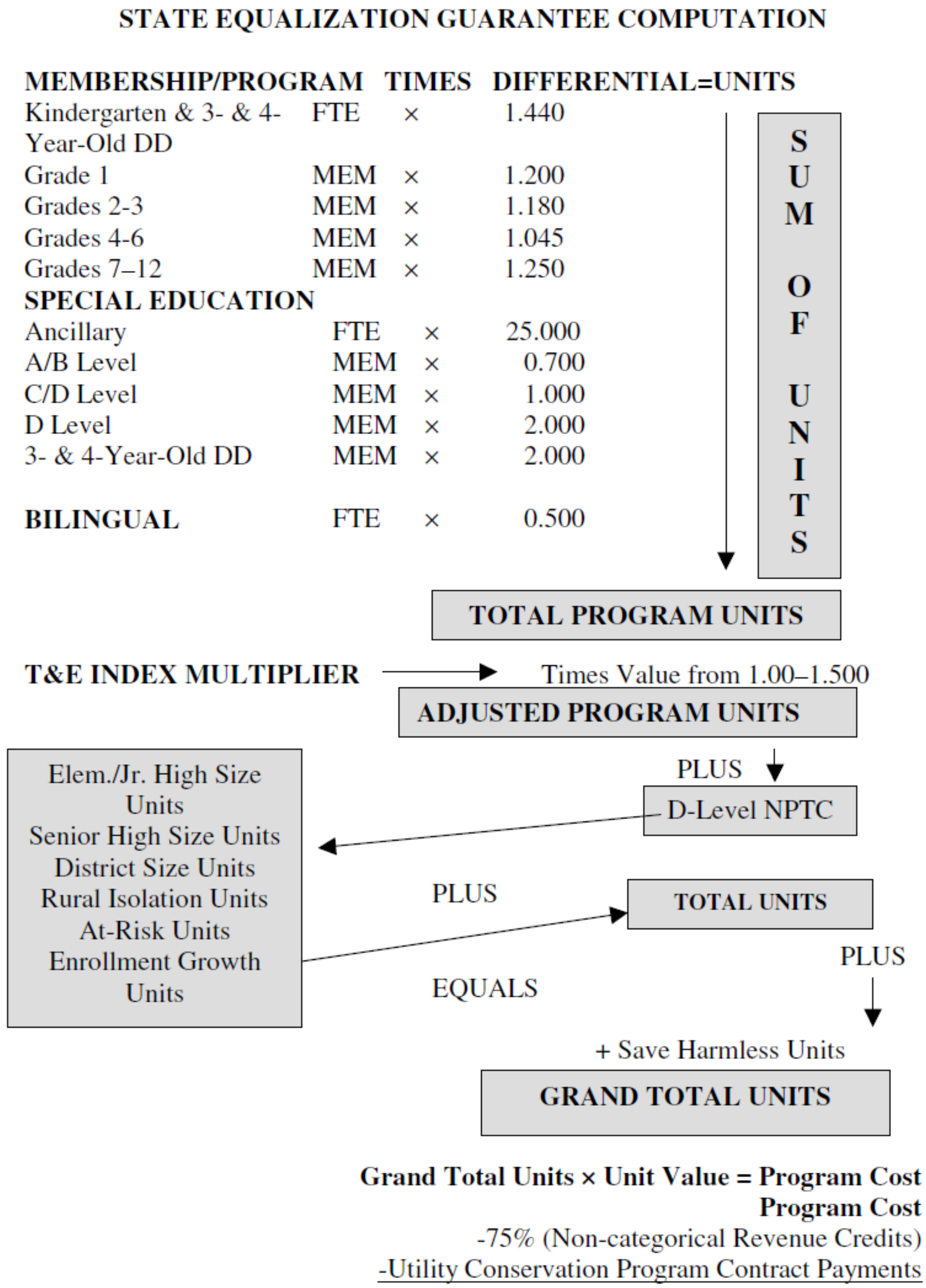
$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.17 New York

State aid for education in New York is distributed as Basic Operating Aid (BOA), Extraordinary Needs Aid, Growth Aid, Tax Effort Aid, Tax Equalization Aid, and Transition Adjustment (N.Y. CODE §3602 (12)). BOA accounts for about half of state funding and most funds are equalized.

Funds are assigned based on weighted pupils, called Total Aidable Pupil Units (TAPU).

Figure C1: New Mexico Funding Formula



Source: U.S. Department of Education National Center for Education Statistics (2001)

The weights depend on the number of students in certain grades and programs as described in Table C6. Data is unavailable for summer school and dual enrollment, so I calculate TAPU as

$$TAPU_t^d = 0.5 \times ADM_t^{k-halfday} + ADM_t^{k-6} + 1.25 \times ADM_t^{7-12} + 0.25 \times ADM_t^{IEP}$$

Table C6: Pupil Weights for Calculating TAPU

Grade	Weight
1/2 Day K	0.50
Full Day K-6 (excluding Special Education)	1.00
Full Day K-6 Special Education	1.25
7-12 (excluding Special Education)	1.25
7-12 Special Education	1.50
Summer School	0.12
Dual Enrollment	fraction of day in public school programs

The primary source of state funds comes in the form of Basic Operating Aid (BOA), which is

$$BOA_t^d = \begin{cases} TAPU_t^d \times 400 & \text{if Aid Per Pupil}_t^d \leq 400 \\ TAPU_t^d \times \text{Aid Per Pupil}_t^d & \text{if Aid Per Pupil}_t^d > 400 \end{cases}$$

Aid Per Pupil$_t^d$ is the result of applying a number of district-level adjustment factors to the basic foundation level, called the Approved Operating Expenses (AOE) which are established by the legislature each year. Specifically,

$$\text{Aid Per Pupil}_t^d = OAR_t^d \times (\$3,900 + \text{Ceiling Adjustment}_t^d)$$

where

$$OAR_t^d = \begin{cases} \min\left\{0.9, 1.37 - (1.23 - CWR_t^d)\right\} & \text{if } CWR_t^d < 0.627 \\ 1.00 - (0.64 \times CWR_t^d) & \text{if } 0.627 \leq CWR_t^d < 0.8 \\ 0.80 - (0.39 \times CWR_t^d) & \text{if } 0.8 \leq CWR_t^d < 1.706 \\ \max\left\{0.0, 0.51 - (0.22 \times CWR_t^d)\right\} & \text{if } CWR_t^d \geq 1.706 \end{cases}$$

and

$$\text{Ceiling Adjustment}_t^d = \frac{0.075}{CWR_t^d} \times \min\left\{\$8,000, \frac{AOE_{t-2}^d}{TAPU_{t-2}^d} - \$3,900\right\}.$$

CWR is the Combined Wealth Ratio and adjusts for the district's property wealth and aggregate income.[44]

There are other grants for state aid but most do not vary with property wealth and are irrelevant for the variation in my instrument. An exception is Tax Equalization Aid, which

[44] Specifically, $CWR_t^d = 0.5\left(\frac{W_{t-3}^d}{W_{t-3}^s}\frac{TAPU_{t-2}^s}{TAPU_{t-2}^d} + \frac{IPP_t^d}{IPP_t^s}\right)$ where $IPP_t^d = \frac{\text{Income}_{t-3}^d}{TAPU_{t-2}^d}$.

is the primary foundation adjustment. Specifically,

$$\text{Tax Equalization}_t^d = \left(\min\left\{8000, \frac{AOE_t^d - BOA_t^d}{TAPU_t^d}\right\} - 0.0195 \times \frac{\ell_t^d W_t^d}{TAPU_t^d}\right) \times TAPU_t^d,$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = BOA_t^d + \text{Tax Equalization}_t^d,$$

and total revenue is

$$R_t^d = \tau_t^d \times \ell_t^d W_t^d + BOA_t^d + \text{Tax Equalization}_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.0195) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.18 North Carolina

School funding in North Carolina is unique among the states. The state provides a level of funds to each district based on weighted student counts, which they use to determine the cost of the number of teachers needed to teach those students. Districts can choose to levy additional property taxes to increase spending, but are under no obligation to do so and local levies have no impact on state aid.

The state funds PSAT testing in the amount of 2.69 for each 8th and 9th grade student; instructional materials, supplies, instructional equipment, and testing support at \$40.29 per student; and textbooks at the rate of \$46.77 per student. The base teacher allotment is a

Table C7: Number of Students per Alloted Teacher

Grades	Number of Students
K-2	20
3	22.23
4-6	22
7-8	21
9	24.5
10-12	26.64

weighted number of students based on the weights in Table C7 and rounded to the nearest one-half position. This results in a teacher allotment of

$$\text{Teacher Allotment}_t^d = \frac{ADM_t^{k-2}}{20} + \frac{ADM_t^3}{22.23} + \frac{ADM_t^{4-6}}{22} + \frac{ADM_t^{7-8}}{21} + \frac{ADM_t^9}{24.5} + \frac{ADM_t^{10-12}}{26.64}$$

Each county is given one additional teacher allotment for a math/science/computer teacher regardless of student counts. School districts are also allotted one position per 200.10 ADM for instructional support. Teacher assistants are allotted at $749.64 per ADM in grades K-3. One principal is allowed per school and assistant principals are allowed as 1 month per 76.12 ADM.

The total salary allocation for each district is the number of teachers times the salary allocated to each type of teacher. Base teacher pay is $38,065 plus $3,307 in benefits, instructional support positions receive $45,973 including benefits, principals receive $46,940, and assistant principals receive $46,125. This gives a total salary allocation of

$$\begin{aligned}\text{Salaries}_t^d = {} & 41,372 \times (\text{Teacher Allotment}_t^d + 1) + 45,973 \times \frac{ADM_t^d}{200.1} \\ & + 46,940 \times \text{Number of Schools}_t^d + 46,125 \times \frac{ADM_t^d}{76.12}\frac{1}{12}\end{aligned}$$

There are two additional grants to cover retirement and social security benefits that is an additional 11.07% of the salary allocation, or $\text{Additional Benefits}_t^d = 0.1107 \times \text{Salaries}_t^d$.

Combining the above information gives local revenue as

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$2.69 \times ADM_t^{8-9} + \$40.29 \times ADM_t^d + \$46.77 \times ADM_t^d + \$749.64 \times ADM_t^{k-3} + 1.1107 \times Salaries_t^d,$$

and total revenue is

$$R_t^d = \tau_t^d \times \ell_t^d W_t^d + \$2.69 \times ADM_t^{8-9} + \$87.06 \times ADM_t^d + \$749.64 \times ADM_t^{k-3} + 1.1107 \times Salaries_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \tau_t^d \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.19 North Dakota

North Dakota has an equalized foundation formula (N.D. CENT. CODE §15-40.1), which is distributed based on weighted student counts, called weighted pupil units (WPU). In 1998-1999, the foundation level was $2,032 per WPU and the foundation tax levy was 32 mills. There is no recapture provision so state aid is the maximum of the formula calculation and zero.

Table C8: Weights for Calculating Weighted Pupil Units

Category (Grade level & size)	Statutory Weighting	Weighting Factor Applied in 1998-1999
Approved preschool	1.010	1.2924
Kindergarten (all districts)	0.500	0.5720
Rural elementary (1-8)	1.280	1.3198
Grades 1-6 (<100 ADM)	1.090	1.2012
Grades 1-6 (100-999)	0.905	0.9477
Grades 1-6 (1,000+)	0.950	0.9706
Grades 7-8 (all districts)	1.010	0.9832
Grades 9-12 (<75 ADM)	1.625	1.4905
Grades 9-12 (75-149)	1.335	1.1981
Grades 9-12 (150-549)	1.240	1.0917
Grades 9-12 (550+)	1.140	1.0473

Source: U.S. Department of Education National Center for Education Statistics (2001)

Applying the student weights described in Table C8 gives

$$\begin{aligned}
WPU_t^d &= 1.2924 \times ADM_t^{pk} + 0.572 \times ADM_t^k \\
&+ (I_{<100} \times 1.2012 + I_{100 \text{ to } 999} \times 0.9477 + I_{\geq 1000} \times 0.9706) \times ADM_t^{1-6} \\
&+ 0.9832 \times ADM_t^{7-8} \\
&+ (I_{<75} \times 1.4905 + I_{75 \text{ to } 149} \times 1.1981 + I_{150 \text{ to } 549} \times 1.0917 + I_{>550} \times 1.0473) \times ADM_t^{9-12}
\end{aligned}$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$2.302 \times WPU_t^d - 0.032 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$2.302 \times WPU_t^d + (\tau_t^d - 0.032) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \tau_t^d W_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.20 Ohio

The main school funding program in Ohio is called the School Foundation Funding Program (Ohio Revised Code §3317) and provides a foundation level funded by state and local revenue, and additional categorical grants from the state to school districts. The foundation amount was \$3,851 in 1998-1999, which is further adjusted by a Cost of Doing Business (CODB) factor that captures regional differences in the cost of living. The foundation tax rate is 23 mills. Foundation funds are distributed based on weighted student counts with the following weights: 0.5 for kindergarten; 1.0 for grades 1-12; 0.25 for vocational education pupils who receive services from other educational units; and three major categories of special education weighting: The mildest category gives an additional .22 weighting, the next category gets an additional 3.01 weighting, and the most severe category gets an additional 3.01 weighting but allows for the additional state aid to subsidize more expensive individual educational program costs. I do not have counts of vocational education pupils or the severity of conditions for students with an IEP in the data so I do not include the vocational education weighting and assign each student with an IEP the minimum weight of 0.22. Using these weighting factors gives a weighted average daily membership (wADM) of

$$wADM_t^d = 0.5 \times ADM_t^k + ADM_t^{1-12} + 0.22 \times ADM_t^{IEP}.$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$3,851 \times CODB_t^d \times wADM_t^d - 0.023 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \$3,851 \times CODB_t^d \times wADM_t^d + (\tau_t^d - 0.023) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.023) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.21 Oklahoma

Oklahoma has a two-tiered funding program with a foundation amount as well as a guaranteed yield portion. The foundation tax rate is established in the Oklahoma State Constitution to be 15 mills (Oklahoma Constitution Article X §9(c)). Districts also have a responsibility for 75% of the revenue collected by a countywide tax of 4 mills I use 18 mills as the foundation tax rate, although the additional 3 mills from the countywide tax will be weighted based on the fraction of county property wealth that is in the school district, which I will not be capturing. The base foundation amount was set at \$1,239 per weighted pupil. Weights

Table C9: Oklahoma Pupil Weights

Group	Weight
Half-day early childhood programs	0.7
Full-day early childhood programs	1.3
Kindergarten	1.3
First and second grade	1.351
Third grade	1.051
Fourth through sixth grade	1.0
Seventh through twelfth grade	1.2
Out-of-home placement	1.5

Source: Oklahoma Statute Title 70 §18-201.1

for calculating weighted average daily membership are given in Table C9. Data for half-day early childhood programs and out-of-home placements are unavailable so I calculate weighted students as

$$wADM_t^d = 1.3ADM_t^k + 1.351ADM_t^{1-2} + 1.051ADM_t^3 + ADM_t^{4-6} + 1.2ADM_t^{7-12}.$$

The second tier of state aid is a guaranteed yield program called Salary Incentive Aid. As of 1998-1999, the state guaranteed districts \$59.93 per weighted student for every mill levied above the 18 mill minimum requirement. There is a constitutional cap of a maximum of 20 mills above the minimum requirement. The Salary Incentive Aid can thus be written as

$$\text{Salary Incentive Aid}_t^d = \max\{0, 59.93 \times wADM_t^d - (\tau_t^d - 0.018) \times \ell_t^d W_t^d\}$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \$1,239 \times wADM_t^d - 0.018 \times \ell_t^d W_t^d + \text{Salary Incentive Aid}_t^d,$$

and total revenue is

$$R_t^d = \$1,239 \times wADM_t^d + (\tau_t^d - 0.018) \times \ell_t^d W_t^d + \text{Salary Incentive Aid}_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} 0 & \text{if } W_t^d \leq \frac{59.93 \times wADM_t^d}{(\tau_t^d - 0.018) \times \ell_t^d} \\ (\tau_t^d - 0.018) \times \ell_t^d & \text{if } W_t^d > \frac{59.93 \times wADM_t^d}{(\tau_t^d - 0.018) \times \ell_t^d} \end{cases}$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \$59.93 & \text{if } \tau_t^d \leq \frac{59.93 \times wADM_t^d}{\ell_t^d W_t^d} + 0.018 \\ \ell_t^d W_t^d & \text{if } \tau_t^d > \frac{59.93 \times wADM_t^d}{\ell_t^d W_t^d} + 0.018. \end{cases}$$

C.22 Oregon

Oregon uses a foundation program called the State School Fund (OR Rev. Stat. Ch. 327). In 1998-1999, the foundation level was \$4,500 per weighted pupil and the foundation tax rate was 5 mills. The foundation amount is adjusted by the relative experience level of teachers in the district, compared to the rest of the state. The earliest information available for teacher experience is for the 2005-2006 school year and I assign these values for each year. Specifically the foundation level for each district is

$$\text{Foundation}_t^d = \$4,500 + 25 \times \text{Teacher Experience Adjustment}_t^d$$

where Teacher Experience Adjustment$_t^d$ = Teacher Experience$_t^d$−Teacher Experience$_t^s$. Each pupil receives a weight of 1 and students receive additional weights: 1 for each student in special education; 0.5 for student with English as a second language; 0.2 for students attending a union high school district; -0.1 for students in an elementary school district; and 0.25 for students in poverty, students in foster homes, and students in state facilities. Data is only available for the number of students in each grade, in special education, or eligible for free/reduced-price lunch. Thus, leaving out the weights based on unavailable information, weighted pupils are given by

$$wADM_t^d = ADM_t^d + ADM_t^{SpecEd} + 0.25ADM_t^{FRPL}.$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \text{Foundation}_t^d \times wADM_t^d - 0.005 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \text{Foundation}_t^d \times wADM_t^d + (\tau_t^d - 0.005) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.005) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$

C.23 Texas

School funding in Texas is given by a two-tiered scheme called the Foundation School Program (Texas Education Code §42). The first tier is a foundation program with a 8.6 mill foundation tax rate and a base foundation level of $2,396. The second tier guaranteed $21 in revenue per weighted pupil per 0.1 mills from 8.6 to 15 mills.

The base foundation level is adjusted by several district-specific measures that account for differences in the cost of living and costs associated with educating students in small or rural school districts. The basic allotment (BA_t^d) was $2,396 in 1998-1999. The adjusted basic allotment (ABA_t^d) takes into account the Cost of Education Index (CEI_t^d) as follows:

$$ABA_t^d = \$2,396 \times (((CEI_t^d - 1) \times 0.71) + 1).$$

The small district adjustment (SDA_t^d) applies to districts with fewer than 1,600 students and is given by

$$SDA_t^d = \begin{cases} (1 + (1600 - ADM_t^d) \times 0.00025) \times ABA_t^d & \text{if Square Miles}_t^d < 300 \\ (1 + (1600 - ADM_t^d) \times 0.0004) \times ABA_t^d & \text{if Square Miles}_t^d > 300. \end{cases}$$

The mid-sized district adjustment (MDA_t^d) applies to districts with fewer than 5,000 students and is given by

$$MDA_t^d = (1 + (5000 - ADM_t^d) \times 0.000025) \times ABA_t^d.$$

The adjusted allotment (AA_t^d) is then defined as the maximum of the adjusted basic allotment, small district adjustment, and mid-sized district adjustment.

Table C10 gives the weights used for each program. The non-special education elements can be summarized as

$$\begin{aligned} \text{Foundation}_t^d = AA_t^d \times (&ADM_t^d + 1.35 \times ADM_t^{CATE} + 0.12 \times ADM_t^{GT} \\ &+ 0.1 \times (ADM_t^{ESL} + ADM_t^{PEG}) + 0.2 \times ADM_t^{CE} + 2.41 \times ADM_t^{P}) \end{aligned}$$

and the special education elements as

$$\begin{aligned} \text{SpecEd}_t^d = (&5 \times (ADM_t^{C0} + \times ADM_t^{C1}) + 3 \times (ADM_t^{C2} + ADM_t^{C41,C42} + ADM_t^{SMM}) \\ &+ 2.7 \times ADM_t^{C91-C98} + 2.3 \times ADM_t^{C8} + 2.8 \times ADM_t^{C30} + 1.7 \times ADM_t^{NPC} \\ &+ 4 \times ADM_t^{C81-C89}) \times AA_t^d. \end{aligned}$$

There are two additional categorical grants for New Instructional Facilities, given by $NIF_t^d = \$250 \times ADM_t^{NIF}$, and Transportation, given by T_t^d. Total Tier I funding is then given by

$$\text{Tier I}_t^d = \text{Foundation}_t^d + \text{SpecEd}_t^d + NIF_t^d + T_t^d.$$

Tier 2 funding provides a guaranteed return to each unit of property tax regardless of district property wealth. The guaranteed return is based on Weighted Average Daily

Table C10: Tier I Program Weights

Program	Weight
Regular Block Grant (RBG)	1.00
Career & Technology Allotment (CATE)	1.35
Gifted & Talented Allotment (GT)	0.12
Bilingual/ESL Allotment (ESL)	0.1
Public Education Grant (PEG)	0.1
Compensatory Education Allotment (CE)	0.2
Self-contained, Pregnant (P)	2.41
Special Education	
Homebound (Code 01)	5
Hospital Class (Code 02)	3
Speech Therapy (Code 00)	5
Resource Room (Codes 41 & 42)	3
Self-Contained Severe/Moderate/Mild (SMM)	3
Off-Home Campus (Code 91-98)	2.7
Vocational Adjustment Class (Code 08)	2.3
State Schools (Code 30)	2.8
Non-Pubic Contracts (NPC)	1.7
Residential Care and Treatment (Codes 81-89)	4

Source: U.S. Department of Education National Center for Education Statistics (2001)

Attendance ($WADA_t^d$), which is given by

$$WADA_t^d = \frac{\text{Tier } 1_t^d - T_t^d - 0.5(ABA_t^d - \$2,396)}{\$2,396}.$$

Specifically, districts are guaranteed revenue as if they had \$210,000 per $WADA_t^d$ in property wealth on any millage between 8.6 and 15. Additionally, if the district has more than \$280,000 per $WADA_t^d$ in property wealth, then the state recaptures the amount above \$280,000 per $WADA_t^d$ on those mills. Thus, Tier 2_t^d funding is given by

$$\text{Tier } 2_t^d = \begin{cases} \min\{0.015, \tau_t^d - 0.0086\} \times \left(\$210,000 - \frac{\ell_t^d W_t^d}{WADA_t^d}\right), & \text{if } W_t^d \leq \frac{1}{\ell_t^d}\$210,000 \times WADA_t^d \\ \min\{0.015, \tau_t^d - 0.0086\} \times \left(\$280,000 - \frac{\ell_t^d W_t^d}{WADA_t^d}\right), & \text{if } W_t^d \geq \frac{1}{\ell_t^d}\$280,000 \times WADA_t^d \\ 0, & \text{otherwise} \end{cases}$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = \text{Tier } 1_t^d + \text{Tier } 2_t^d - 0.0086 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = \text{Tier } 1_t^d + \text{Tier } 2_t^d + (\tau_t^d - 0.0086) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = \begin{cases} (\tau_t^d - 0.0086) \times \ell_t^d (1 - \frac{1}{WADA_t^d}), & \tau_t^d < 0.015 \\ (\tau_t^d - 0.0086) \times \ell_t^d - \frac{0.0064 \ell_t^d}{WADA_t^d}, & \tau_t^d > 0.015 \end{cases}$$

other than the group whose property wealth is $\frac{1}{\ell_t^d}\$210,000 \times WADA_t^d \leq W_t^d \leq \frac{1}{\ell_t^d}\$280,000 \times WADA_t^d$, whose wealth price is simply $(\tau_t^d - 0.0086) \times \ell_t^d$. The tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \begin{cases} \$210,000 + \ell_t^d W_t^d (1 - \frac{1}{WADA_t^d}), & \text{if } W_t^d \leq \frac{1}{\ell_t^d}\$210,000 \times WADA_t^d \\ \$280,000 + \ell_t^d W_t^d (1 - \frac{1}{WADA_t^d}), & \text{if } W_t^d \geq \frac{1}{\ell_t^d}\$280,000 \times WADA_t^d \\ \ell_t^d W_t^d, & \text{otherwise.} \end{cases}$$

C.24 Washington

Washington state provides full funding for basic education (Washington Revised Code §§28A.150 and 28A.510). Funds are assigned based on the number of teachers deemed necessary to provide education for the particular makeup of the school district. The makeup of the school district is determined by the full-time equivalent (FTE) counts of students in different grades and programs. There are a number of different allocations for types of teachers based on weighted enrollment and an allocation per teacher unit.

The number of basic education certificated instructional staff formula units (CISFUs) generated per 1,000 FTE students depends on grade level and program. For the grade 4-12 regular education program, districts get 1 staff unit per 21.74 students. For grades K-3, districts get funding based on their actual staff to student ratio, with a maximum of 1 staff unit per 18.42 students (for simplicity, I assign all districts the maximum). School districts get 1 staff per 19.5 students in secondary vocational programs and 1 staff units per 18.2 FTE students enrolled in skill center programs.

Certified instructional staff formula units are given by

$$CISFU_t^d = \frac{FTE_t^{4-12}}{21.74} + \frac{FTE_t^{k-3}}{18.42},$$

Certified administrative staff formula units

$$CASFU_t^d = \frac{FTE_t^d}{250},$$

and classified staff formula units are given by

$$CSFU_t^d = \frac{16.67}{1000} \times FTE_t^d.$$

These three formula unit measures are then multiplied by a factor that takes into account the salary for each teacher unit. This requires data on the education level and tenure of all teachers in the data, which I do not have access to for 1999. Instead, I use the average salary for teachers in Washington in 1999, which is \$54,231.43 in 2013 dollars (38,693 in 1999 dollars). Thus, the salary support for the basic education program would be

$$\text{Salaries}_t^d = \$54,231.43 \times (CISFU_t^d + CASFU_t^d + CSFU_t^d)$$

Data is unavailable for the number of students in secondary vocational programs and skill center programs. However, I know that, in 1999, combined spending on vocational education and skill center programs was 7.8 percent of basic education, so I add 7.8 percent of my calculation of basic education funding. In fact, there are several other categories (special education, transportation, food services, etc.) that I do not have data to calculate for each district, but I know all these programs (including the 7.8 in vocational/skills) are 54.1 percent the size of basic education, so I add this into the calculation to get in the right ballpark.

In addition to salary support, the state provides:

1. \$5,646.98 (\$4,029 in 1999 dollars) per certificated and classified staff unit for insurance,
2. \$11,286.94 (\$8,053 in 1999 dollars) per basic education certificated staff unit for non-employee related costs (e.g., books, supplies, heat);
3. \$27,716.29 (\$19,775 in 1999 dollars) per secondary vocational staff formula unit for non-employee related costs,
4. \$21,505.88 (\$15,344 in 1999 dollars) per skills center certificated staff formula unit for non-employee related costs; and
5. \$511.97 (\$365.28 in 1999 dollars) per certificated instructional staff formula unit for substitute teachers.

Items 3 and 4 will be accounted for in the additional 54.1 percent of basic aid. The other categories for insurance benefits, non-employee related costs, and substitute teachers will be

$$\begin{aligned} \text{Insurance}_t^d &= \$5,646.98 \times (CISFU_t^d + CASFU_t^d + CSFU_t^d) \\ \text{Non-Employee Costs}_t^d &= \$11,286.94 \times (CISFU_t^d + CASFU_t^d) \\ \text{Subsitutes}_t^d &= \$511.97 \times CISFU_t^d \end{aligned}$$

Local revenue is given by

$$L_t^d = \tau_t^d \times \ell_t^d W_t^d,$$

state revenue is

$$S_t^d = 1.541 \times (\text{Salaries}_t^d + \text{Insurance}_t^d + \text{Non-Employee Costs}_t^d + \text{Subsitutes}_t^d) - 0.01 \times \ell_t^d W_t^d,$$

and total revenue is

$$R_t^d = 1.541 \times (\text{Salaries}_t^d + \text{Insurance}_t^d + \text{Non-Employee Costs}_t^d + \text{Subsitutes}_t^d) + (\tau_t^d - 0.01) \times \ell_t^d W_t^d.$$

Thus, the wealth price is

$$\frac{\partial R_t^d}{\partial W_t^d} = (\tau_t^d - 0.01) \times \ell_t^d$$

and the tax price is

$$\frac{\partial R_t^d}{\partial \tau_t^d} = \ell_t^d W_t^d.$$