Capital Expenditure by School Districts:
Driven by Enrollment, or Administrative Convenience?

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Abstract

This paper empirically explores capital spending by independent school districts in the US. Capital spending is interesting because financing for capital is much more flexible than for current expenditures. Thus, we might expect that school districts are able to much more closely follow their desires than with current spending, where there are many more institutional constraints. We therefore examine whether capital spending is motivated by enrollments, or by other issues. The motivation for our examination is to get a sense of whether it is likely that capital is optimized with respect to enrollment. If so, it would make sense to estimate the rate of return to capital. If not, then it is not possible to estimate the rate of return to capital. Our examination empirically finds that both income per capita and population influence capital spending. Further, we do not find that school districts appear to adjust capital over time, creating significant disparities in capital per student for different cohorts. Finally, we find that capital spending is also related to parts of the administrative structure, such as the frequency of borrowing. The importance of these finding are that school districts appear unlikely to be on their production possibilities frontier in terms of learning, which suggests estimation of the rate of return to capital spending is unlikely to be successful.

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I. Introduction[1]

This is an exploratory study of capital investment by public school districts responsible for providing K-12 education. Recent studies have found mixed results for the effect of capital spending on test scores- a presumed measure of output. Biasi, LaFortune, and Schonholzer (2024) find positive productivity results, while Cellini, Ferreira and Rothstein (2010) find no effects on children's outcomes. Jackson and Mackevicius (2024) find that overall, capital spending and current spending have about equal returns. Our goal is to provide some perspective by which the effects of public capital can be studied. Specifically, if school districts are not on their production possibility frontier with capital, then it will not be possible, or useful, to measure the productivity of additional capital. Schools will not be on their productivity frontier if they have other objectives than those in the presumed output of the specified production function, which generally have been student test scores. Thus, we assemble evidence on the two primary choices facing school districts; one is the level of investment to reach the preferred level of capital stock, and the other is the method to finance the desired investment. We therefore subject data on school financing to five tests, with implications for evidence on potential objectives. First, we frame two tests over the smoothing of capital expenses over time and the business cycle, with a view towards equity of cohorts over time. We construct two additional tests by estimating an Error Correction Model (ECM), and investigating the relative importance of enrollment compared to income per capita and population. A final test estimates the ECM for two groups, school

[1] We thank seminar participants at the University of Houston, the Southern Economic Association Meeting, and the International Western Economics meets (Melbourne) for useful comments. We received excellent research assistance from Hanieh Nasrollahi, Ali Nourozi and Alexis Oatchade.

districts that borrow frequently and those that seldom borrow. The administrative structure exists so that variation in the frequency of borrowing should be irrelevant. On the other hand, if there are administrative elements that impact borrowing frequency, the level of capital stock may estimates but segments by the frequency of borrowing. looks to the relative importance of administrative criteria by specifying the capital stock as a function of the frequency of borrowing.

Our empirical tests combine a careful look at the data describing capital financing and expenditure by school district, as well as regression analysis using an Error Correction Model as indicated by our statistical tests. We look at school districts only in the large US metropolitan regions, so that the competitive environment in which districts find themselves is relatively similar. Further, our data focuses exclusively on independent school districts, which are those that have some ability to set their own tax rates and level of debt. Our data thus consists of a square panel containing financing and enrollment information from 827 school districts from 58 MSAs, composed of 194 counties in 32 states.

School districts presumably will choose the level of capital appropriate to achieving their objectives. The objective of school districts is not obviously clear. Were the objective to maximize the standardized test scores for students, then presumably the marginal impact of capital for new buildings, building maintenance, educational technology, plumbing, air conditioning, and even school buses should be equal per dollar of expenditure. On the other hand, were districts to have different attributes in their objective functions, factors outside the education production function might also be important. Simply as an example, if the goal of the district were to have as large as capital stock possible (a variant of budget maximization), then capital spending might be maximized given access to debt. Alternatively, if labor is disproportionately influential in the decision process, capital might have a lower or higher shadow price than labor in the production function. Our empirical examination provides evidence that other factors besides students are important to decisions concerning capital spending.

School districts have a much broader array of vehicles by which capital expenditures can be financed than for current expenditures. Unlike current spending, capital expenditure may be financed by debt.[2] One potential impact of debt is to make it administratively easier to smooth capital expenditures over time. Intertemporal equity across cohorts has recently been shown to be a relatively neglected topic in schools (Belosi, Craig, Dhar, and Sorensen, 2022), a surprising condition given the attention that equity in education resources has garnered cross-sectionally. Capital spending can be smoothed over time not only because additional debt can be taken during periods of resource shortfalls, but school districts also have special saving funds, called bond funds, that can be accessed over time solely for capital spending. In contrast, current expenditures are subject to the balanced budget constraints where expenditures cannot exceed current revenues.

While capital expenditures can be undertaken with debt, districts also have the choice of paying for capital out of current resources. The data available from Census sources does not distinguish the source of financing for capital. We construct a measure of current financing of capital by subtracting from total capital expenditure changes in various aspects of the debt picture, and arrive at an estimate of about 67% of capital being financed out of current resources. The practice may have advantages for smoothing expenditures over time, to the extent that capital

[2] In theory, this might even be more efficient because the cost of capital will be spread over the users through debt service.

expenditures formerly financed currently can be switched to debt financing in low resource periods, with debt picking up the displaced capital expenditures.

To this time our first two tests about smoothing and alternative school district objectives constitute solely a look at the data. We show that there is a wide variety of debt behavior by school districts. Further, we find that the economic health of the economy as seen by recessionary periods does not appear to be motivating to changes in the financing structure. We do not find that there is an increase in debt during or just after recessions, when debt substitution out of current expenditures might be expected. We expect to be much more explicit about these issues in the next version of our paper.

The second pair of statistical tests for the presence of alternative objectives arises out of estimates of an Error Correction Model (ECM). We empirically analyze the importance of enrollment compared to variables that determine the tax base. While enrollment will change the costs facing a school district, income and population affect the tax base, as well as potentially demand, without changing the actual cost constraint. Thus we test whether income and population impact capital, and we test for the speed of adjustment of the capital stock when either enrollment, or the tax base, changes.

Our final test is of whether administrative criteria changes debt behavior. Specifically, school districts have the option of deciding how often to borrow money, either from banks or the bond market (Ivanhov and Zimmerman, 2024). Because school districts have the option of the bond fund accounts in which they can keep borrowed funds for subsequent years, the frequency with which districts borrow should have no impact on the level of capital, since it should have no impact on the available resources. In fact, however, we find that districts that borrow more frequently have larger capital stocks.

Section II of our paper presents the data on independent school districts and the institutional environment. Section III presents the data means and analysis of the ECM to illustrate the relative importance of enrollment compared to other elements that influence the level of capital in each school district. A final section concludes that the level of capital stock appears to be influenced by a large number of different elements, leading us to believe that estimates of the marginal productivity of capital investment will not be useful until we achieve a full understanding of the objectives of school districts. Section V concludes with speculation that the plethora of influences on capital in education might be reason to consider alternative institutional structures.

II. Data and Institutional Detail

Our empirical approach to sorting out the possible motivation for school districts is to examine how the level of capital investment varies with respect to a number of potential influences. School districts in the US are often single purpose special districts with their own set of rules, and with their own political boundaries. The creation of school districts is a function of each US state, thus there is a set of fifty different rules regarding school district institutional form. For example, political boundaries are generally drawn without regard to other local governments. These independent school districts are also able to choose their own tax rates and debt levels- subject to constraints imposed by the state governments. The other broad institutional structure is that school districts can be part of the responsibilities for a general purpose local government. For administrative similarity we exclude the school districts that are part of a general purpose local government, and focus on independent school districts- the predominant form in the US.

The other criterion we impose on our data is we select independent school districts in large metropolitan areas. The spatial dependence of school districts is likely to occur due to potential mobility of taxpayers, and indeed there are literally thousands of papers on the Tiebout model of inter-governmental competition and sorting by parents.[3] By restricting our observations to large metropolitan areas, the competitive environment for all school districts in our sample is similar, since families have a wide choice in tax rates, quality of education provision, and debt levels.[4]

We therefore use all the independent school districts in the largest 60 metropolitan areas in the US.[5] Because we omit schools that are part of general purpose governments, we end up with data from 58 metropolitan areas. We form a panel by using annual data from 1980 to 2017. All metropolitan areas have multiple school districts, so after excluding districts with less than 100 students we end up with 827 school districts, covering 32 states. The metropolitan areas are defined by county, and the 58 metro areas have 194 counties. The means of the resulting data set are shown in the following table:

Table 1: Descriptive Statistics

Variable		Mean	Std. dev.	Min.	Max.	Observations
Rurul or Urban Overall		1.007282	0.994	0.000	3.000	N = 104,360
	Between		0.994	0.000	3.000	n = 2609

[3] See Inman (1978) for one of early works modelling taxes as the price citizens pay for entry into local schools, and the resulting behavioral implications for governments that seek to attract population and tax base.

[4] That is, we assume the large urban areas are in a Tiebout equilibrium, so that any one school district has essentially an infinite number of competitors.

[5] We use the 1990 Census definition of metropolitan areas, although these definitions change every decade.

	Within		0.000	1.007	1.007	T = 40
Population growth rate	Overall	0.0086006	0.014	-0.069	0.151	N = 104,360
	Between		0.011	-0.011	0.071	n = 2609
	Within		0.009	-0.075	0.118	T = 40
Enrollment growth rate	Overall	0.0023329	0.100	-5.787	24.938	N = 104,360
	Between		0.022	-0.182	0.653	n = 2609
	Within		0.097	-5.603	24.287	T = 40
Income growth rate	Overall	0.0120914	0.027	-0.273	0.715	N = 104,360
	Between		0.004	-0.001	0.027	n = 2609
	Within		0.027	-0.280	0.709	T = 40
Total Revenue	Overall	11281.9	4,775.5	0.0	96,280.8	N = 104,360
	Between		3,583.4	6,159.4	33,475.3	n = 2609
	Within		3,157.5	n/a	86,541.7	T = 40
Total State IG Revenue (%)	Overall	0.4974453	0.200	0.000	2.824	N = 104,360
	Between		0.173	0.076	0.911	n = 2609
	Within		0.101	-0.284	2.958	T = 40
Total Property Tax revenue (%)	Overall	0.4021564	0.200	0.000	3.536	N = 104,360
	Between		0.175	0.000	0.880	n = 2609
	Within		0.097	-0.339	3.392	T = 40

Notes: The table presents the variation, mean, standard deviation, min, and max for each variable across different dimensions. "Overall" refers to the total variation, "Between" refers to the variation between panel, and "Within" refers to the variation over time.

The data source is the Census in the Annual Survey of State and Local Government Finance. We use only consolidated school districts, which means they cover all of grades K-12. The data has financial variables for every school district in every year. We append enrollment data from the Digest of Education Statistics.

The Census data, while relatively complete for financial flow data, does not contain data on the capital stock, nor detail on what is purchased with the reported capital expenditures. Given our interest in understanding the capital decisions of school districts, we construct an estimate of the capital stock using data on annual investment with a perpetual inventory model.

Specifically, we minimize the following objective function:

$$\min \{ \frac{1}{T-1} \sum_{t=1980}^{2017} \frac{K_{t+1} - K_t}{K_t} - \frac{1}{T-1} \sum_{t=1980}^{2017} \frac{S_{t+1} - S_t}{S_t} \ ]^2$$

Subject to $K_{t+1} = I_t + (1 - \delta)K_t$

$\delta = 0.041,$ and T = 38

where K is the capital stock and S are current expenditures. The initial value of capital, K_0, is set to a value such that the average growth rate of capital equals the average growth rate of current expenditure S. The depreciation rate is calculated so that debt to total capital to GDP is about constant.[6]

Table 3 shows the financial data pertaining to capital investment. We see on average that school districts borrow money about 1/3 of the years, although there is wide variation (some districts never borrow, some borrow every year). Total Debt Issued is new debt, which at $1,105 per student is about equal to the stock of assets in the bond funds at $1,081. This suggests there is not much smoothing in capital expenditure, since there is not a stock of previously borrowed funds greater than the money newly borrowed. The Sinking Fund account is the stock of money from which debt is retired, this mean is very small relative to the debt outstanding. Significant

[6] The depreciation rate is actually rather unimportant, since it is just a constant after logs in regressions with delta K.

heterogeneity in the management of debt is indicated in the minimums, which are generally zero. That is, about 1/6 of school districts never issue debt. Interest expense is 4.6% of the stock of debt.

Table 3: Financial Variables Supporting the Capital Stock

Variable		Mean	Std. dev.	Min.	Max.		Observations
FINANCING VARIABLELS							
Debt Issued (share of years issued)	Overall	33.78%	0.20	0.00	1.00	N =	104,360
	Between		0.20	0.00	1.00	n =	2,609
	Within		n/a	0.34	0.34	T =	40
Total Debt Issued	Overall	1,105	2,987.79	0.00	84,963.29	N =	104,360
Real $ per capita	Between		817.70	0.00	5,835.26	n =	2,609
	Within		2,873.76		80,670.31	T =	40
Total Debt Outstanding	Overall	7,100	7,779.68	0.00	259,982.90	N =	104,360
Real $ per capita	Between		4,416.69	0.00	33,047.33	n =	2,609
	Within		6,404.96		245,330.60	T =	40
Bond Funds	Overall	1,081	2,789.00	0.00	96,646.74	N =	104,360
Real $ per capita	Between		893.59	0.00	8,113.49	n =	2,609
	Within		2,642.03		94,503.92	T =	40
Sinking Funds	Overall	282	766.33	0.00	29,903.09	N =	104,360
Real $ per capita	Between		371.20	0.00	4,159.35	n =	2,609
	Within		670.46		29,194.92	T =	40
Interest Expense	Overall	327	355.54	0.00	17,328.43	N =	104,360
Real $ per capita	Between		205.05	0.00	1,465.59	n =	2,609
	Within		290.49		16,303.76	T =	40

Notes: The table presents the variation, mean, standard deviation, min, and max for each variable across different dimensions. "Overall" refers to the total variation, "Between" refers to the variation between the yearly averaged over school districts, and "Within" refers to the yearly average within each school district, averaged over districts.

The level of capital stock that results from our perpetual inventory method is illustrated below in Figure 1, where the financial values are in 2015 dollars, and we have divided by the number of students in each school district. The Figure shows that after fifteen years of being relatively constant, the capital stock per student started to rise in the late 1990s, and has continued its rise through the end of our data. The Figure also has national recessions highlighted, and there is no cyclicality apparent in the data.

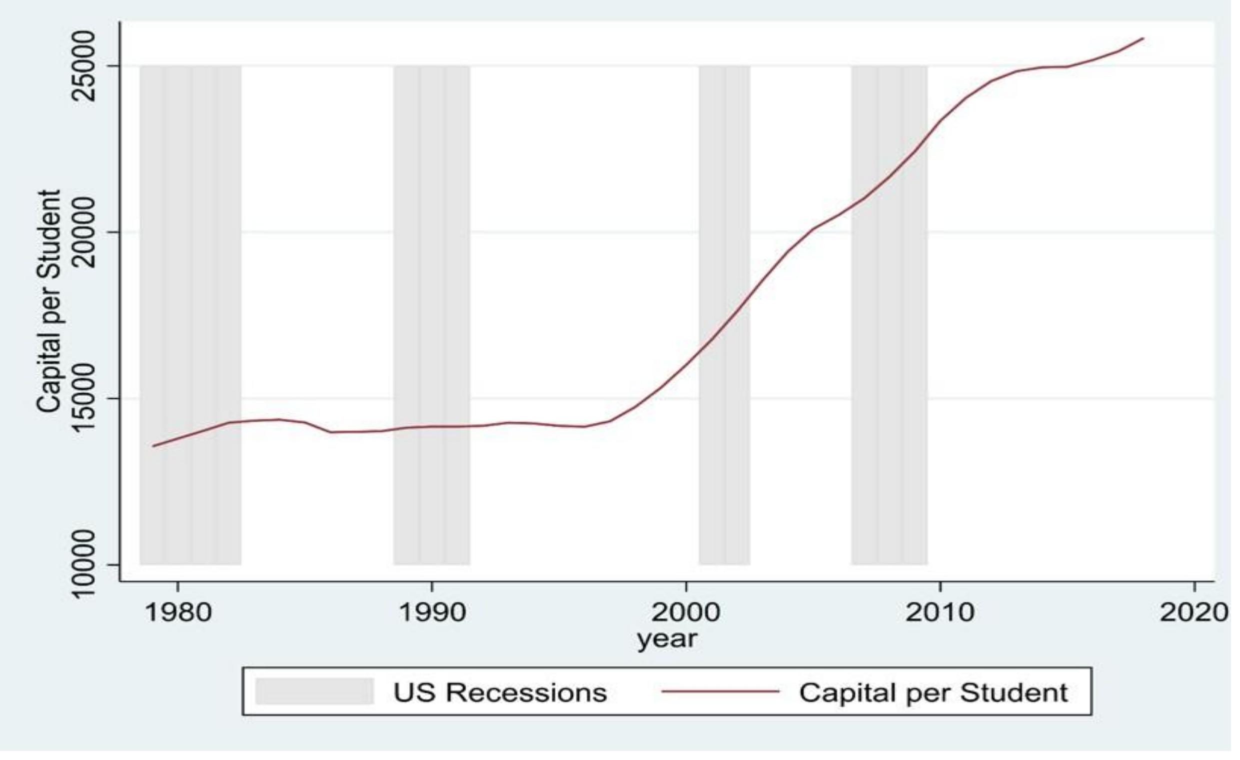


Figure 1: Capital Stock Over Time

An interesting feature of the school district data is that it appears that not all capital is financed by debt. It is, instead, financed out of current resources. We don't yet have an estimate for the empirical magnitude, although a preliminary estimate is that 2/3 of capital is financed out of sources other than debt. One way to examine the issue, however, is to look at the debt to capital ratio.

Figure 2: Debt/Capital Ratio

This graph is interesting because it shows that debt rises quite quickly, even relative to capital, during the capital growth spurt starting in the late 1990s. There seems to be no response to the recessions of the early 1980s, or the beginning of the 21rst century. The data also shows that the financial disruptions from the Great Recession of 2008 limited the use of debt, although the ratio did not come close to falling to the levels of the 1980s.

One issue that requires more careful analysis is that the issuance of debt by school districts is erratic. Some districts borrow frequently, and others almost never borrow. There is not data on whether school districts are borrowing from banks, or from creating bonds. The number of school districts that borrow in any one year, however, has increased along with the increase in total debt as shown below:

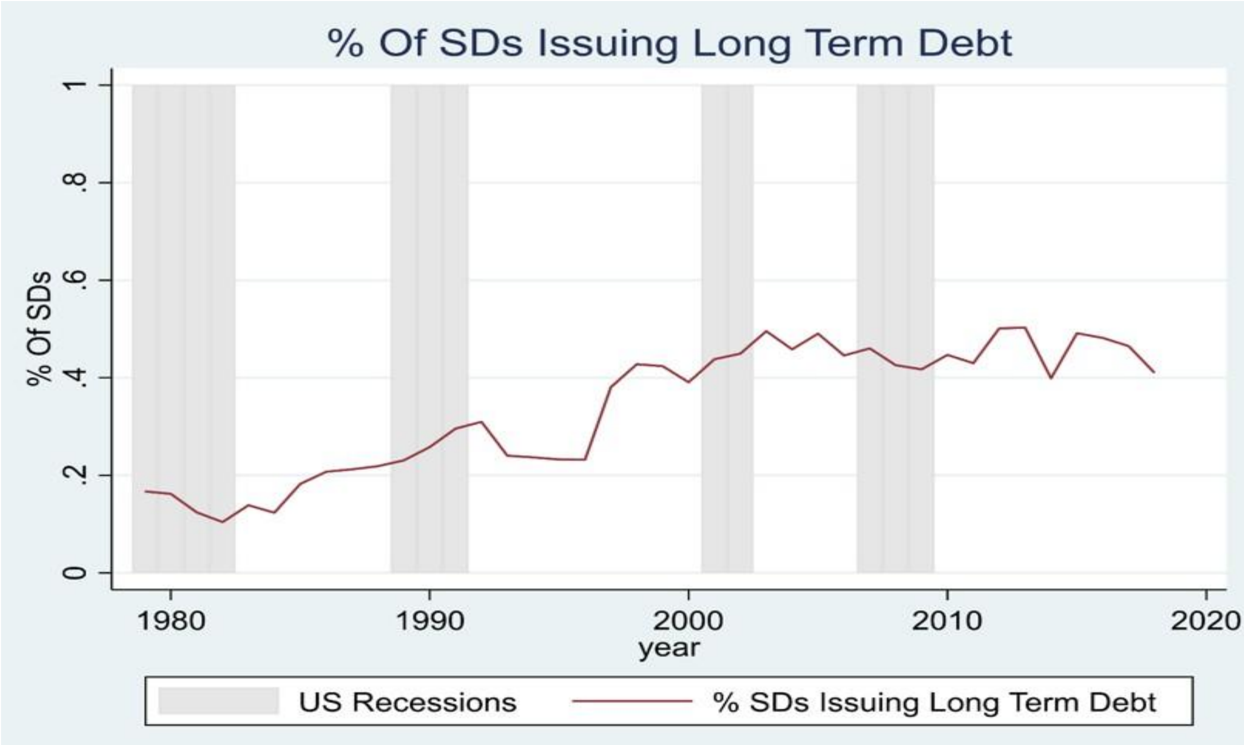


Figure 3: Long Term Debt Issuance by School Districts

A. Behavioral Implications in Raw Data

Despite the more flexible administrative environment for intertemporal concerns offered by capital compared to current expenditures, however, school districts face a set of additional obstacles for debt financing. An important constraint is that public referenda on debt is required in some circumstances. Further, there are additional fixed costs in creating bonds, one instrument by which school districts access borrowed funds. Alternatively, districts can form a financial relationship including debt with a bank (Ivanov and Zimmerman, 2024), with maybe different shadow constraints. Debt as well impacts the current budget through debt service; bond interest is paid periodically to bondholders (generally quarterly), while principal is paid into a required sinking fund that is disbursed at maturity. [7]

There are three interesting pieces of data in Table 2 that pertain to school district behavior. One is that expenditures per student is at least equal to revenue, so that on average there is no savings in the school system. Second, the difference between total expenditures and current expenditures is $1,645, considerably greater than annual investment of $1,064. We are uncertain at the moment, however, about how debt service is accounted. Third, and relevant for considering whether school districts are able to smooth their expenditures when revenues fluctuate, we see that the time series variation in expenditures on average within each school district is $2,555 per student. This level is significantly smaller than the time variation in revenue, $3,158. An institutional detail that may account for the amount of smoothing is state aid, which because it is progressive in nature, serves to partially smooth expenditures except when the entire state faces a downturn (Biolsi, Craig, Dhar, and Sorensen, 2022).

Were learning the only objective of the school districts, it would be expected that enrollment might be the single variable that would explain the level of capital expenditures. On the other hand, the level of local property might impact capital spending to the extent that capital expenditures have an element of consumption. Further, some state aid to school districts seems to be directed toward capital, and may also be related to per capita income. Finally, although on the surface orthogonal to learning, the population size may be related to capital expenditure

[7] There are IRS restrictions on the maturity length, to limit arbitrage possibilities between borrowing at the income tax-free rate and investing at the taxable rate.

because, holding per capita income and enrollment constant, population will indicate the size of the property tax base.

III. Error Correction Model and the Speed of Adjustment

An alternative methodology by which we examine potential sources of influence over the pattern of capital spending is to estimate an Error Correction Model (ECM). Specifically, capital spending targeted to student outcomes would be expected to be driven by enrollment, based on the production function of education. On the other hand, if school districts are motivated to spend by the level of available resources, both income per capita and population might influence capital spending. Both variables would impact the budget constraint— higher income per capita means the same property tax rate will yield more income. Similarly, higher population with enrollment constant may indicate higher potential tax revenue. The final issue for which we have insufficient data is that some state aid is targeted for capital expenditures, it is not only directed at current spending. We do have, however, data on actual annual investment. So if state aid has at least a partial effect on expenditure smoothing over time we will observe the smooth spending, even if it is difficult to identify the actual cause.

We therefore set up estimation of the ECM to account for all three potential factors, enrollment, income per capita, and population per school district. There are 2,609 total school districts spanning 40 years each, for a total of 104,360 observations. The ECM therefore consists of the variables in the following table. In addition to the means, we present the standard deviation

Table 5?: Error Correction Model Variables

Variable		Mean	Std. dev.	Min	Max	ervations	
Capital Stock	Overall	17,895	9,978	222	181,825	N =	104,360
real $ per capita	Between		7,638	1,091	116,447	n =	2609
	Within		6,422		107,231	T =	40
Total Current Expenditures	Overall	9,782	4,216	328	67,968	N =	104,360
real $ per capita	Between		3,354	5,518	28,144	n =	2,609
	Within		2,555		65,607	T =	40
School District Income	Overall	39,825	11,132	18,367	128,431	N =	104,360
real $ per capita	Between		8,819	24,695	82,417	n =	2,609
	Within		6,796	6,794	95,305	T =	40
Enrollment per District	Overall	6,098	18,625	106	747,009	N =	104,360
	Between		18,380	137	644,061	n =	2,609
	Within		3,032		187,356	T =	40
Population in each District	Overall	652,860	1,252,184	4,743	10,100,000	N =	104,360
	Between		1,241,916	5,616	9,182,608	n =	2,609
	Within		161,820		2,141,589	T =	40

Notes: The Table presents summary statistics across different dimensions. Overall is for the panel data as a whole. Between refers to the mean over time for each district, averaged across all districts, while Within refers to the average across all districts taken for each year.

over not only the entire variable, but over the two dimensions of the panel data, between school districts, and over time. An important issue before estimation is to ascertain the dynamic attributes of the data. We thus first test whether these four variables, annual capital investment per capita, per capita income, school enrollment, and population, are non-stationary. We also find that the four variables are co-integrated. These tests therefore indicate an Error Correction Model (ECM) is appropriate for describing annual investments in school district capital.

The Co-integrating equation we use for our test is:

$Capital_{i,t} = \alpha + \beta_1 . Income_{i,t} + \beta_2 . Enrollment_{i,t} + \beta_3 . Population_{i,t} + \nu_{i,t}$

Table 4: Results for Harris-Tzavalis unit-root test

Variable	Statistic	z
Capital stock	0.9664	26.34
Total Current Oper	0.9373	6.98
Per Capita Income (county level)	0.9872	40.17
Enrollment	0.9700	28.70
County Population	0.9852	38.86

Totes: The null hypothesis is that panels contain unit roots.

Table 5: Cointegration Test

	Pedroni test statistics
Group rho	34.810
Group t PP	17.811
Group t ADF	29.502

The ECM equation is therefore:

$$\Delta K_{i,t} = \delta_0 +$$

Δ Capital i,t = δ0 + λ . ˆν i, t−1 + 4Σj = 1 τ j . Δ Capital i , t−j +

4Σp = 0 ζ p . Δ Income i , t−p + 4Σp = 0 ψ p . Δ Enrollment i , t−p +

4Σp = 0 γ p . Δ Population i , t−p + ε i, A related use of the ECM estimates is to examine the speed of adjustment back to equilibrium for each of the three forces. The impulse response functions we construct to illustrate the speed of adjustment show two attributes of school district behavior. First, a shock to enrollment has a rapid impact on capital investment, since it is the denominator of investment per student. Population and income have more modest initial impacts, since part of their impact works through tax revenues, and property tax revenues have been found to respond quite slowly to external economic changes. Second, however, we find that investment levels never return to their initial values. That is, even after multiple decades, the initial value of investment per student is not restored. Not only does this finding indicate that investment is impacted by income per capita and population, but that the actual level of capital stock is also not solely a function of enrollment. These results may be about the objectives of the school district. A more complex possibility, however, is that the capital stock is not solely an "investment" good by the residents through the agency of the school district. It is also possible there are elements of consumption in education, in which case elements that change the tax base may be expected to change the capital stock. Nonetheless, an element of consumption would suggest that estimating the return to capital as if it were an investment good alone is an important omission.

Once the capital relationships are established, we test for stability in these relationships with respect to the administrative environment. An empirically important but surprising finding is that the optimal level of capital stock for school districts is found to be higher for districts that borrow frequently compared to those that borrow less often. This finding holds both within states as well as between states—an important distinction since state governments control the administrative environment for local school districts. The seemingly empirical importance of the frequency of borrowing is quite puzzling given the administrative structure that strongly suggests the frequency of borrowing should be unrelated to issues affecting the level of capital. That is, school districts can put their unspent borrowed money in a bond fund and spend out of the bond fund when needed.

Table 6 presents the parameter estimates for the ECM for capital using the full sample. The coefficients in the first three rows show that student enrollment is the smallest of the influences on investment per student, and the enrollment coefficient is negative.   It is natural for capital per student to fall with an influx of students since capital may adjust slowly over time. We explore this issue below.

The coefficients also show the per capita capital stock responds more to shocks to per capita income than to an increase in population. While an increase in population leads to an increase in the total tax base, an increase in income per capita possibly leads in addition to an increase in demand for capital by residents. Even so, it is interesting that

Table 6: Estimates of Error correction model (ECM) for Capital: Full Sample

Notes: Dependent variable is in per student 2015 dollars.

	Log of Capital	Log of Capital
lnincomccnty	1.126***	
	(0.006)	
lncnrollrncnt	-0.233***	
	(0.004)	
lnpop	0.306***	
	(0.007)	
L.R.csiduals		-0.011***
		(0.000)
D.lnincomccnty		-0.064***
		(0.010)
LD.lnincomccnty		-0.051***
		(0.010)
L2D.lnincomccnty		0.001
		(0.010)
L3D.lnincomccnty		0.041***
		(0.010)
L4D.lnincomccnty		0.064***
		(0.010)
LD.lncapital		0.460***
		(0.003)
L2D.lncapital		-0.114***
		(0.004)
L3D.lncapital		0.005
		(0.004)
L4D.lncapital		-0.022***
		(0.003)
D.lncnrollmcnt		-0.924***
		(0.006)
LD.lncnrollmcnt		0.528***
		(0.006)
L2D.lncnrollmcnt		-0.038***
		(0.006)
L3D.lncnrollrncnt		0.079***
		(0.006)
L4D.lncnrollrncnt		0.043***
		(0.006)
D.lnpop		-0.081*
		(0.044)
LD.lnpop		0.004
		(0.055)
L2D.lnpop		0.226***
		(0.053)
L3D.lnpop		0.16 ***
		(0.051)
L4D.lnpop		-0.023
		(0.039)
School Districts	2609	
Observations	104,360	91,315

even the total tax base, as indicated by population, stimulates growth in capital per student. This school district response suggests there is at least an element of budget maximization in school district investment decisions, since the increase in population is holding enrollment constant.

A. Impulse Response Functions

Based on the estimates shown above, we construct impulse response functions for each of the variables. Figure 1 illustrates the impulse response function assuming a 10% positive shock to income per capita. Because the coefficient β_1 is relatively low at 0.104, the figure shows that capital responds to the income increase quite slowly. After two decades capital only covers about 28% of the distance to its optimal long run level (shown by the dotted line towards the top of the

Figure 4:

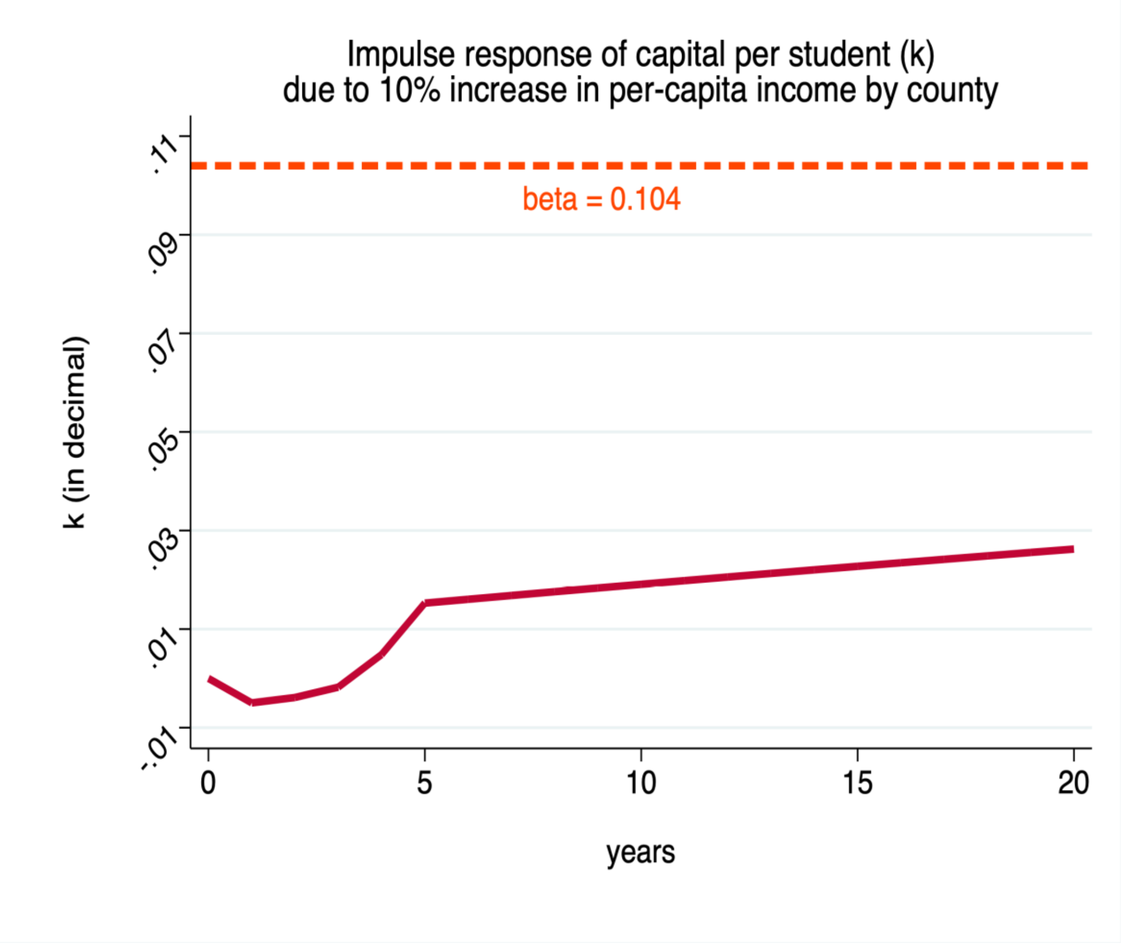
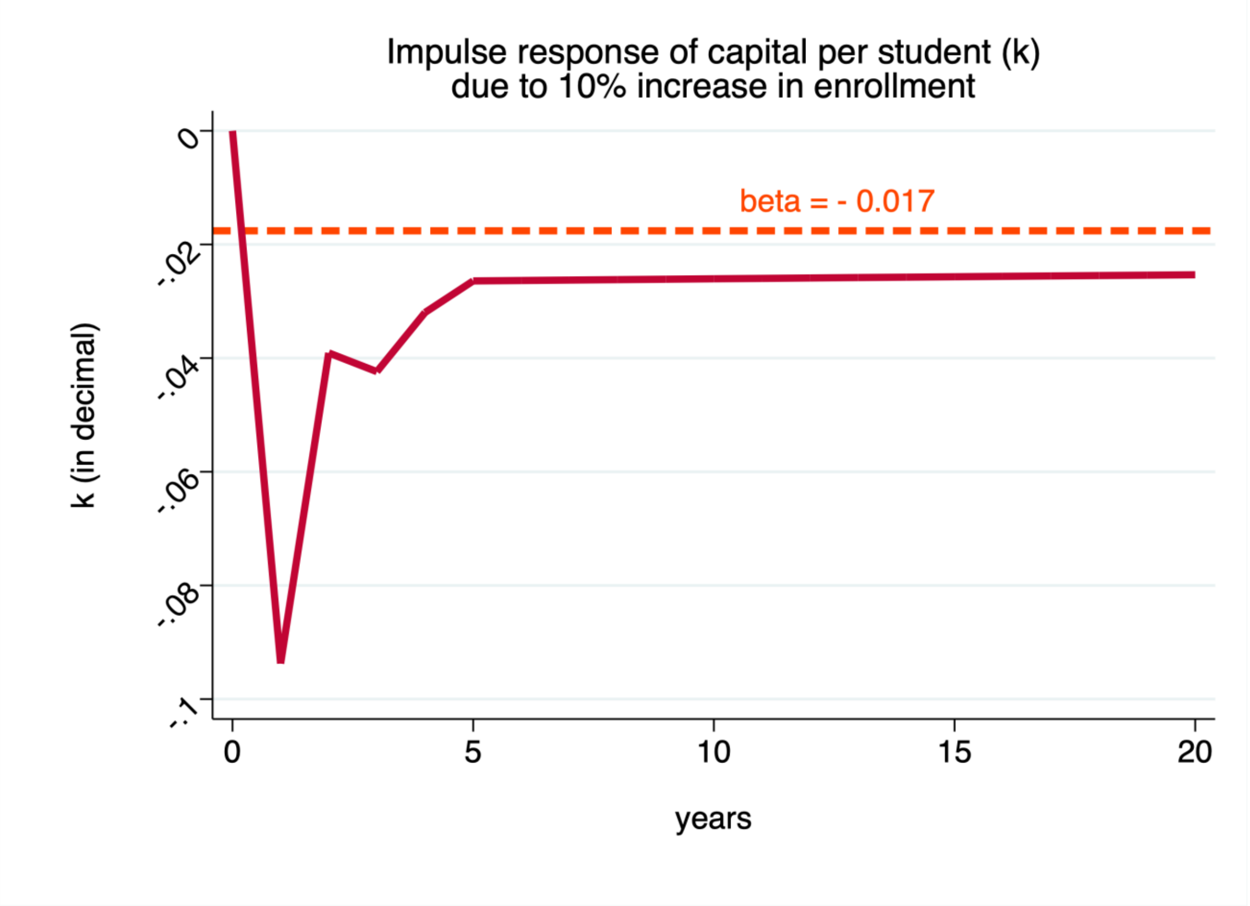


figure). Indeed, it take almost five years for the level of the capital stock to begin to even move towards the long run value.

In sharp contrast, capital is considerably more responsive to changes in enrollment as shown in Figure 5 with its impulse response function below. Assuming a 10% shock in the number of enrolled students, we see that capital per student falls almost immediately. Further, it only takes

Figure 5:



six years for capital to be within 5% of its long run value, although the estimates also suggest that the previous long run value will never be reached. If there are economies of scale, this would suggest the new capital stock value after six years is the desired level by the school districts.

The difference in the impulse response function from the tax base shock to the enrollment shock is instructive. It could be there are economies of scale in the use of capital in education shown in Figure 5, as the long run value of capital per student is lower after the assumed positive shock of students. All of the action is in the first six years, which may be because of the lags built into the model. Nonetheless, the impulse response function suggests school districts are responsive to enrollment shocks.

School districts are, at the same time, also responsive to income shocks holding enrollment constant. The results in Figure 4 show that a positive income shock is slowly absorbed by the school district over time. That is, even five years capital per student is higher by about 1%, and continues to rise albeit very slowly (note: this rise is also despite whatever equalization forces are captured in the allocation of state aid for capital). This result suggests one of two results, either there is an element of consumption spending within schools so that higher income leads to higher demand for capital. Alternatively, the positive shock to income triggers a desire by school districts to increase their level of investment spending. Separating the two possibilities at this point is relatively unimportant in terms of evaluating the productive effects of capital. That investment is responsive to per capita income, even holding constant enrollment, strongly suggests processes besides education production are important in the choices of investment and capital stock.

B. Frequency of Borrowing

One striking aspect of the debt data for school districts is that there is a wide variation in the frequency with which districts borrow for their capital expenditures. In theory, the frequency of debt would be expected to have no impact at all on the level of investment in new capital. This is because districts have accounts called bond funds, which provide a mechanism by which borrowed funds can be stored and segmented from current accounts. Districts that borrow with bonds will face larger fixed costs than those using bank financing, so it might be expected that larger districts using bond finance would borrow less frequently than those using bank finance.

The use of bond funds by districts borrowing with bonds would nonetheless allow investment to occur at an identical rate as a district using bank financing.

Some school districts do not borrow to finance their capital expenditures, rather they finance capital out of current resources. Again, borrowing would not be expected to impact the level of capital outside of small wealth effects. Districts that finance capital using current resources would presumably have started building their capital with a lag, but outside of the initial effects current finance of investment would be expected to approximate debt service (principal plus interest), and thus the level of capital should again be independent of the financing source.

Based on the above reasoning, we estimate the ECM by segmenting districts based on the frequency with which they borrow. To investigate whether administrative procedures impact investment in capital, we segment our panel data between districts that borrow more than about 13 times over our 40 year sample, or less.[8] It appears to be true that school districts that borrow more frequently borrow less each time than school districts that borrow infrequently (with a small effect on total debt per capita).

We expect to further cement the administrative definitions of newly issued debt in future versions of this research. If administrative procedures are correlated with capital stock, it would indicate either implicit shadow prices that affect investment, or it would indicate discontinuities in information would permit administrators to pursue different investment paths.

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[8] Future versions of the paper will have to address whether the frequency of borrowers is endogenous, or alternatively institutionally fixed. We note that states have significant influence on the allowable actions by school districts.

The ECM estimates in Table 7 show estimation for how the ln of the Capital Stock varies with school district per capita income, population, and enrollment. Table 8 shows the same specification for school districts that borrow more frequently. Low frequency borrowers tend to have higher enrollments. Despite that, investment per student, debt per student, capital stock per student, and debt newly issued per student are all larger for the districts that borrow frequently. Further, as we see from the estimates below, there are significant differences in the ECM estimates

Table 7: Estimates of Error Correction Model for Capital: Low-Frequency Debt Issued Sample (2015 $ per student)

	Log of Capital	Ln Capital
lnincomccnty	1.179***	
	(0.009)	
lncnrollmcnt	-0.367***	
	(0.007)	
lnpop	0.386***	
	(0.011)	
L.rcsid		-0.007***
		(0.000)
D.lnincomccnty		-0.081***
		(0.015)
LD.lnincomecnty		-0.058***
		(0.015)
L2D.lnincomccnty		-0.037**
		(0.015)
L3D.lnincomccnty		0.040***
		(0.015)
L4D.lnincomecnty		0.065***
		(0.015)
LD.lncapital		0.474***
		(0.005)
L2D.lncapital		-0.107***
		(0.005)
L3D.lncapital		0.003
		(0.005)
L4D.lncapital		-0.022***
		(0.005)
D.lnenrollment		-0.937***
		(0.009)
LD.lnenrollment		0.497***
		(0.010)
L2D.lnenrollmcnt		-0.058***
		(0.010)
L3D.lnenrollmcnt		0.084***
		(0.010)
L4D.Inenrollment		0.062***
		(0.009)
D.lnpop		-0.072
		(0.073)
LD.lnpop		-0.055
		(0.092)
L2D.lnpop		0.116
		(0.091)
L3D.lnpop		0.139
		(0.090)
L4D.lnpop		0.068
		(0.068)
Observations	51160	44765

Table 8 : Estimates of Error Correction Model for Capital: High-Frequency Debt Issued Sample

lnincomccnty	1.052***	
	(0.008)	
lncnrollmcnt	-0.142***	
	(0.005)	
lnpop	0.260***	
	(0.008)	
L.rcsid		-0.018***
		(0.001)
D.lnincomccnty		0.048***
		(0.013)
LD.lnincomccnty		'0.048***
		(0.014)
L2D.lnincomccnty		0.028**
		(0.013)
L3D.lnincomccnty		0.037***
		(0.014)
L4D.lnincomccnty		0.061***
		(0.013)
LD.lncapital		0.444***
		(0.005)
L2D.lncapital		0.120***
		(0.005)
L3D.lncapital		0.005
		(0.005)
L4D.lncapital		0.025***
		(0.005)
D.lncnrollment		0.912***
		(0.007)
LD.lncnrollmcnt		0.537***
		(0.008)
L2D.lncnrollmcnt		'0.027***
		(0.008)
L3D.lncnrollmcnt		0.080***
		(0.008)
L4D.lncnrollmcnt		0.034***
		(0.008)
D.lnpop		-0.060
		(0.055)
LD.lnpop		0.010
		(0.068)
L2D.lnpop		0.274***
		(0.065)
L3D.lnpop		0.192***
		(0.063)
L4D.lnpop		-0.04
		(0.049)
School Districts	1,330	
Observations	53,200	46,550

The response of capital to enrollment, income per capita and population is statistically lower in the high frequency sample than the low frequency of borrowing. This result seems a bit counter-intuitive, although it may reflect that high frequency borrowers are more likely to utilize commercial banks rather than issue bonds.

To fully appreciate the difference in the two samples, however, we show the impulse response functions for an income shock in Figure 6 below:

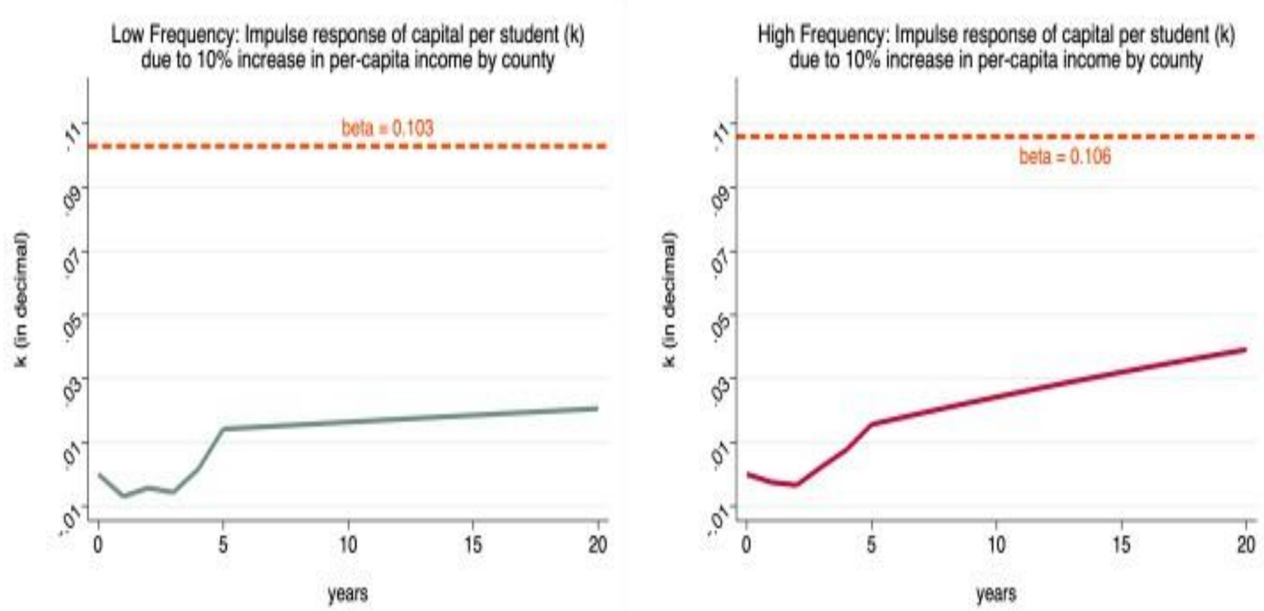

Figure 6: Inpulse Response Functions of capital per student
Due to a 10% Positive Shock to Income

As with the impulse response for the full sample, we see an assumed increase in income of 10% stimulates capital, but only very slowly does the capital stock move towards long run steady state. What is interesting in the sample split, however, is that the high frequency borrowers, while starting at the same place, move much more quickly to steady state than do the low frequency borrowers. This is true despite that the two samples have very similar steady state values, as shown in the dotted line at the top.

Splitting the sample by borrowing frequency is somewhat more consequential in the impulse response functions for enrollment. Figure 7 shows:

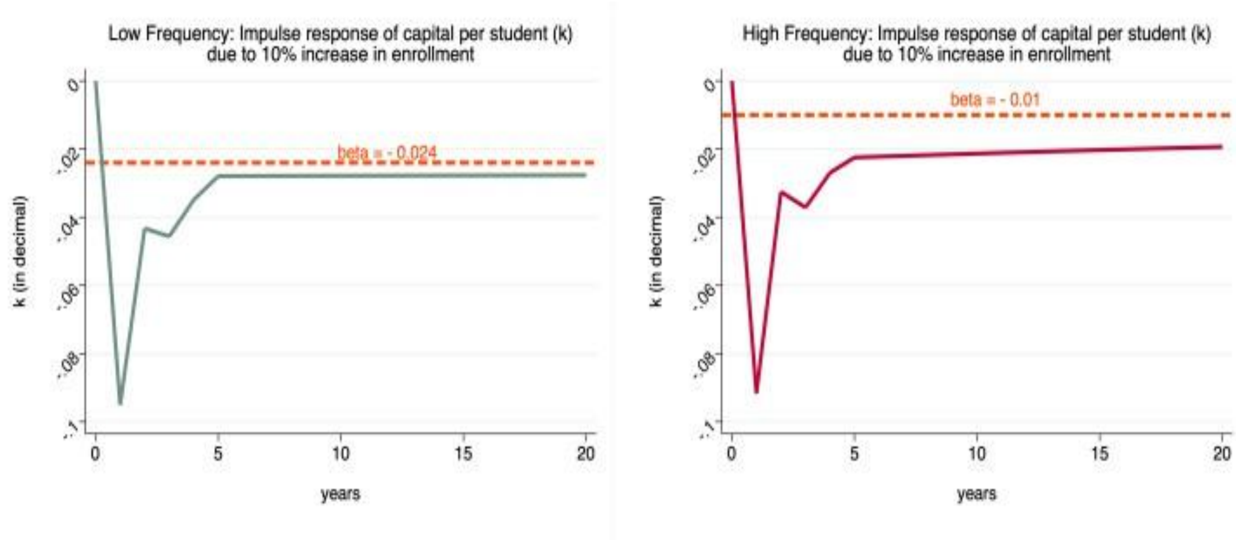

Figure 7: Response of Capital per Student to a 10% increase in Enrollment

Here the steady state value is lower for the Low Frequency sample than the High Frequency sample. Despite that difference, the transition path for both samples is similar. The striking difference, however, is that the Low Frequency sample gets much closer to the steady state than does the High Frequency sample. This result is again despite the similarity in the transition path in the two samples.

IV. Summary and Conclusions

This paper has examined capital expenditures by K-12 school districts, to determine whether they are focused on students, or if there may be other elements that motivate capital spending. The purpose underlying our examination is recent attempts to estimate the rate of return to capital in education (***cite). If school districts are motivated by other criteria that simply students, then estimating the impact of capital on test score (or other student achievement) outputs is problematic, because it is unlikely the school districts will be on their production frontier.

Our examination is over five questions. The first two involve simply the data means. We ask whether there is basic evidence that capital spending is smoothed to a greater extent than is current spending. We do not find even as much evidence as exists for current spending that local governments smooth. This is true looking at the standard deviation of investment over time, and looking at the level of bond funds (borrowed money available to be spent on capital). Additionally, there is a high degree of heterogeneity in how school districts appear to manage their capital financing, suggesting there is not a systematic approach to this important element of school district finances.

The other approach we use to answer the remaining three questions is to estimate an Error Correction Model for annual capital investment. Estimation over our panel data for 827 districts over 33 years finds that enrollment is much less important than two elements describing the tax base; population, and per capita income. This finding is more consistent with a budget maximization model than one where capital spending is motivated by students. We further find that the speed of adjustment is extremely slow, yet faster for the tax base variables than enrollment.

The final test is to segment the data by school districts that frequently borrow compared to rarely borrow. Because school districts have dedicated bond funds, borrowing frequency should be orthogonal to the level of investment, or capital. We find that, however, frequent borrowers have higher capital levels, and somewhat different paths of adjustment than infrequent borrowers.

This preliminary examination has found that it appears unlikely in the extreme that school districts are on the production frontier for capital. Thus, general analyses of capital are unlikely to discover the true shape of the education production function with respect to capital. It also appears that school district officials probably need some general training for how to manage capital expenditures, since heterogeneity appears much larger than suggested by institutional variety.

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Appendix: ECM Estimates for Current Expenditures

Table A1: Estimates of Error correction model (ECM) for Current Expenditure: Full Sample

	Log of Current E;,,.--p.	6. Log of Current E;,,.--p.
lnincomecnty	1.251***	
	(0.003)	
l11enrollment	-0.217***	
	(0.002)	
lnpop	0.222***	
	(0.004)	
L.Residuals		-0.009***
		(0.000)
D.lnincomecnty		0.109***
		(0.007)
LD.Jnincornecnty		0.124***
		(0.007)
L2D.lnincomecnty		0.164***
		(0.007)
L3D.lnincomecnty		0.189***
		(0.007)
L4D.Jnincomecnty		0.000
		(0.007)
LD.Jncapital		0.004*
		(0.002)
L2D.lncapital		-0.010***
		(0.003)
L3D.h1capital		-0.003
		(0.003)
L4D.lncapital		-0.001
		(0.002)
D.lnenrollrnent		-0.770***
		(0.004)
LD.lnenrollrncnt		0.146***

	(0.005)
L2D.lnenrollment	0.098***
	(0.005)
L3D.111enrollmcnt	0.061***
	(0.005)
L4D.lnenrollrncnt	0.011**
	(0.004)
D.lnpop	0.366***
	(0.032)
LD.lnpop	-0.073*
	(0.040)
L2D.lnpop	0.070*
	(0.039)
L3D.lnpop	0.167***
	(0.037)
L4D.!11pop	-0.201***
	(0.029)

2609

School Districts

Observations	104360	91315

Notes: Dependent variable is in per student and dollars of 2015.

Table A2: Estimates of Error Correction Model for Current Expenditure: High-Frequency Debt Issued Sample

	Log of Current Exp.	Δ Log of Current Exp.
lnincomccnty	1.186***	
	(0.005)	
lncnrollmcnt	-0.169***	
	(0.003)	
lnpop	0.205***	
	(0.005)	
L.rcsid		-0.014***
		(0.001)
D.lnincomccnty		0.063***
		(0.009)
LD.lnincomecnty		0.104***
		(0.010)
L2D.lnincomccnty		0.130***
		(0.010)
L3D.lnincomccnty		0.161***
		(0.010)
L4D.lnincomecnty		0.003
		(0.009)
LD.lncapital		0.005
		(0.003)
L2D.lncapital		-0.019***
		(0.004)
L3D.lncapital		-0.004
		(0.004)
L4D.lncapital		-0.006*
		(0.003)
D.lncnrollmcnt		-0.773***
		(0.005)
LD.lncnrollmcnt		0.162***
		(0.006)
L2D.lncnrollmcnt		0.111***
		(0.006)
L3D.lncnrollmcnt		0.062***
		(0.006)
L4D.lncnrollmcnt		0.005
		(0.005)
D.lnpop		0.425***
		(0.039)
LD.lnpop		-0.091*
		(0.049)
L2D.lnpop		0.091*
		(0.047)
L3D.lnpop		0.102**
		(0.045)
L4D.lnpop		-0.210***
		(0.035)

School Districts	1330	
Observations	53200	46550

otes: Dependent variable is in per student and dollars of 2015.

Appendix B: Future Work

To inform the potential importance of aspects of capital financing compared to students, we examine the time pattern of bond fund balances, relative to the frequency of borrowing. If smoothing spending over time is important, we would expect a relatively constant rate of decline in bond funds between newly issued debt. Instead, however, we observe that bond funds tend to be expended quickly, with little evidence of attempts at smoothing capital spending over time.

We further estimate the degree of capital financing out of current resources. We do this by comparing capital expenditure to the potential sources of funds from debt. The debt sources include newly issued debt, as well as the utilization of bond fund holdings. Effort at smoothing current and capital expenditure would be apparent if the share of capital spending out of current resources falls during recessions, and then is re-built after they pass. As with the level of bond funds, we do not observe efforts to smooth either capital or current spending over time using this method.

Table A3: Estimates of Error Correction Model for Current Expenditure: Low-Frequency Debt Issued Sample

	Log of Current Exp.	C:,. Log of Current Exp.
ln.incomecnty	1.301***	
	(0.004)	
lnenrollment	-0.2 6***	
	(0.004)	
lnpop	0.265***	
	(0.006)	
L.rcsid		-0.005***
		(0.001)
D.lnincomecnty		0.161***
		(0.011)
LD.lnincomeenty		0.140***
		(0.011)
12D.lnincomecnty		0.195***
		(0.011)
13D.lnincomecnty		0.214***
		(0.011)
14D.lnincomecnty		-0.007
		(0.011)
LD.lncapital		0.002
		(0.004)
12D.lncapital		-0.001
		(0.004)
13D.lncapital		-0.002
		(0.004)
14D.lncapital		0.004
		(0.004)
D.lnenrollment		-0.758***
		(0.007)
LD.lnenrollment		0.123***
		(0.007)
12D.lnenrollment		0.073***
		(0.008)
13D.lnenrollment		0.063***
		(0.008)
14 D.lnenrollment		0.020***
		(0.007)
D.lnpop		0.323***
		(0.054)
LD.lnpop		-0.013
		(0.069)
12D.lnpop		-0.002
		(0.06)
13D.lnpop		0.241***
		(0.067)
14D.lnpop		-0.177***
		(0.050)
School Districts	1279	
Observations	51160	44765

Notes: Dependent variable i in per student and 2015 dollars.