Unveiling the Interplay: Capital Expenditures, Capital Stock, Racial Composition, and Educational Attainment in U.S. Schools

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Abstract

This paper examines the impacts of capital expenditures and stock on educational attainment using multi-state data from 2011 to 2019. This broader dataset offers an opportunity to filter out unknown confounders or fixed effects, thereby enhancing the causal inference on the impacts of capital expenditures or stock on educational attainment. This study reveals significant interaction effects of racial composition on educational outcomes. Construction expenditures negatively affect math and Reading/Language Arts scores initially, but these impacts turn positive with higher percentages of white students, suggesting that wealthier districts mitigate disruption effects usually found during construction of new facilities. High school graduation rates show a similar pattern. More emphatically, newly constructed and purchased structures or land initially negatively impact proficiency scores, reversing with increased white student percentages. Conversely, these capital stock variables generally boost graduation rates, with diminishing returns as white student percentages increase. These findings highlight the complex interplay between race, wealth, and educational infrastructure.

Key words: racial disparity in infrastructure impacts, capital spending on educational outcomes, multi-state data for causal inference

JEL Codes: I22, I24, I28, H52, H75

1. Introduction

This paper assesses the impacts of specific educational inputs—capital expenditures and stock—on educational attainment, using multi-state data sets over an extended period. This approach enhances causal findings by filtering out unknown confounders that previous literature suggests weaken causal inference, and by narrowing down the identification of causal links specifically to capital expenditures and stock.

One enduring question in educational policy is whether school spending affects educational attainment. The 1966 Coleman Report indicated a weak relationship between school spending and student outcomes (Handel & Hanushek, 2023; Jackson, 2018; Jackson & Mackevicius, 2024). Similarly, Hanushek (2003) reviewed 163 studies conducted before 1995 and concluded that there is little association between resources and student outcomes. Conversely, Hedges et al. (1994) found a strong association through a formal meta-analysis of much of the same data used by Hanushek (2003). Jackson (2018) notes that the older literature is not sufficiently causal.

In contrast, the new literature on school spending aims to enhance causal inference. It analyzes exogenous variations in school spending, such as those induced by School Finance Reforms (SFRs), to disentangle the effects of school spending from other confounding factors like family background (Jackson, 2018). Additionally, recent studies have employed advanced estimation methods such as Regression Discontinuity Design (RDD), Event Studies, Instrumental Variables (IV) approaches, or a combination of these techniques (Jackson & Mackevicius, 2024).

Jackson & Mackevicius (2024) conducted a meta-analysis of 31 studies from 1995 to 2020, which are causally enhanced. They found that a $1,000 increase in per-pupil spending sustained over four years increases test scores by about 4.4 percent of a standard deviation of test scores. Similarly, Handel & Hanushek (2023) conducted a meta-analysis of 43 studies from 1999 to 2022. Jackson & Persico (2023) converted their findings to be comparable to those in Jackson & Mackevicius (2024), revealing that a $1,000 increase in per-pupil spending boosts student test scores by about 4.7 percent of a standard deviation.

Although these recent findings are more causally credible, Handel & Hanushek (2023) raise concerns about unidentified confounders. For instance, these studies cannot fully account for "the impact of the institutional and regulatory structure and the policies and decision-maker actions that come into play in the implementation of any increased resources" (Handel & Hanushek, 2023, p. 34). A potential approach to addressing this issue is to focus on the role of specific inputs, such as capital spending (Handel & Hanushek, 2023).

Recent empirical studies have assessed the impacts of capital expenditures on student outcomes. Some studies report that capital expenditures following bond referenda do not significantly increase educational attainment, such as math and reading proficiency scores or attendance rates (Hong, 2017; Martorell et al., 2016; Rush et al., 2022). Other studies show that capital expenditures and stock exert significant impacts on educational attainment. Conlin & Thompson (2017) and Goncalves (2015) indicate that capital expenditures generally have negative impacts on educational attainment due to the disruption effects of construction on student performance. In contrast, once construction is complete, capital stock generally boosts student test scores. Lafortune & Schönholzer (2022) report similar findings, noting that new school facilities significantly improve math and English Language Arts test scores. Cellini et al. (2010) find that bond referenda for capital expenditures overall boost math and reading test scores. Kogan et al. (2017) show that bond referendum failures, which might cause decreases in capital expenditures, tend to lower student performance.

The above studies provide more credible causal findings on the impacts of capital expenditures or stock on student outcomes by focusing on specific inputs, thereby making the identification of causal links more robust. However, these studies analyze the impacts for a single state, rendering them vulnerable to confounders linked to institutional features or implementation processes associated with capital expenditures. Handel & Hanushek (2023) indicate that institutional issues are often most heterogeneous across states. Thus, multi-state studies have the possibility of not only generalizing program impacts to other circumstances but also enhancing causality in estimating program impacts by controlling for unknown fixed effects. In contrast to single-state studies, this paper uses data from multiple local school districts in 45 states from 2010 to 2019. This broader dataset offers an opportunity to filter out unknown confounders and fixed effects, thereby enhancing the causal inference on the impacts of capital expenditures or stock on educational attainment.

Findings in this paper reveal hidden dimensions in the impacts of capital expenditures and stock on educational attainment, specifically significant interaction effects of racial composition. Annual and two-year lagged construction expenditures negatively affect math and Reading/Language Arts (RLA) scores, but as the percentage of white students increases, these impacts turn positive. This pattern suggests that wealthier districts, which typically have higher percentages of white students, proactively mitigate the disruption effects that literature indicates emerge during construction. Similarly, high school graduation rates improve with increased percentages of white students despite the initial negative impacts of construction expenditures.

The interaction effects are more salient in two capital stock variables: newly constructed structures and newly purchased structures or land. Initially, their impacts on proficiency scores are negative, but these effects reverse with higher percentages of white students. Newly purchased equipment shows weaker but similar patterns. Conversely, while these three capital stock variables generally boost graduation rates, these benefits diminish as the percentage of white students increases. This paradox may stem from wealthier students' lesser attraction to new facilities that are similar to existing ones, highlighting the complex dynamics between race, wealth, and educational infrastructure.

Section 2 explains the construction of cumulative measures of capital stock after applying appropriate depreciation methods. Section 3 outlines the data sources, methods for creating capital expenditures and stock variables from multiple sources, and the models used to estimate their impacts on educational attainment. Section 4.1 reports the statistical results, while Section 4.2 presents key summary findings and discussions, followed by conclusions.

2. Capital Expenditures and Measures of Capital Stock

Investment expenditures denote any additions to net stocks of fixed structures or equipment types (Boddy & Gort, 1973; U. S. Department of Commerce, 2003). There are approximately three approaches to converting periodic investment expenditures into cumulative net stock measures: current-cost, real-cost, and historical-cost valuations. Both current-cost and real-cost valuations of net stocks begin with valuations in constant dollars. These valuations then undergo complex adjustment procedures, especially in the case of real-cost valuation. In contrast, historical-cost valuation starts with the book values of assets, which are typically equal to their acquisition costs that are obtained from published data sources. The useful lives of assets required for this study are mostly provided for both historical-cost and current-cost valuations (U. S. Department of Commerce, 2003). Therefore, this paper employs historical-cost valuation because the analysis in this paper needs the information on useful lives of capital assets, data for which are publicly available.

Boddy & Gort (1973) provide succinct formulas to convert annual investment expenditures into cumulative net stocks by accounting for periodic depreciation. The net capital stock for asset category *j* at time *t* is defined as:

$$K_{j(t)} = \sum_{v=t-\theta_j+1}^{t} \omega_{j(t-v)} I_{j(v)} \quad (1)$$

, where *v* is the vintage of investment expenditures for asset category *j*, θ_j is the useful life of the asset category, $\omega_{j(t-v)}$ is the weight to compute net values of investment expenditures at time *t*, and $I_{j(v)}$ is the investment expenditures made in vintage year, *v*.

For net stocks with straight line depreciation, applying only half a year's depreciation to the most recent investment expenditures, the weight is defined as:

$$\omega_{j(t-v)} = 1 - \frac{1}{2\theta_j} - \frac{t-v}{\theta_j} \quad (2)$$

For net stocks with double declining balance depreciation, again applying only half a year's depreciation to the most recent investment expenditures, the weight is defined as:

$$\omega_{j(t-v)} = (1 - \frac{1}{\theta_j})(1 - \frac{2}{\theta_j})^{t-v} \quad (3)$$

The double declining balance depreciation is directly comparable to the perpetual inventory method with geometric depreciation (U. S. Department of Commerce, 2003). The annual geometric rate of depreciation for asset category *j* is defined as:

$$\delta_j = \frac{R_j}{\theta_j} \quad (4)$$

, where R_j is the declining-balance rate for asset category *j*, which is the multiples of the comparable depreciation rate that would be computed for the first period of the asset's useful life based on straight-line depreciation. We can compute the net capital stock for asset category *j* at time *t* as in Equation (1) by using the weight, again applying only half a year's depreciation to the most recent investment expenditures (U. S. Department of Commerce, 2003):

$$\omega_{j(t-v)} = (1 - \frac{\delta_j}{2})(1 - \delta_j)^{t-v} \quad (5)$$

It is straightforward to see that Equation (5) is identical to Equation (3), if we replace R_j in Equation (4) with 2 that is referred to as a double-declining balance rate. If we set R_j equal to 1, a single-declining balance rate, Equation (5) becomes identical to geometric depreciation with a single-declining balance rate. However, the latter is not employed in this paper because it returns relatively much higher net stock values than what the straight-line depreciation method and the double declining depreciation method generate. For instance, assume that $110 was invested in vintage year 1 and new investment expenditures, which increased by $10 each year, were made up to year 10. The net capital stock value in year 10 is $857.5 if we use the straight-line depreciation, $691 if we apply the double-declining balance depreciation, but $1011.9 if we apply the geometric depreciation with a single-declining balance rate.

This paper applies Equations (2) and (3) because we need to choose both depreciation rates and useful lives of asset categories if we opt for geometric depreciation methods. Equations (2) and (3) are more convenient for constructing net stock measures and simulations because we only need to choose useful lives of asset categories. Some asset types such as equipment depreciate faster than other fixed structures like buildings (Boddy & Gort, 1973; U. S. Department of Commerce, 2003). Thus, the double-declining balance depreciation is applied to equipment while the straight-line depreciation method is applied to fixed structures or facilities.

3. Data and Model

3.1. Data

De Witte & López-Torres (2017) conducted a review of 223 journal articles on the factors affecting educational outcomes. Handel & Hanushek (2023) also identified what factors affect educational outcomes. Their models define educational outcomes as a function of educational resources or inputs, student characteristics, family-related factors, features of educational institutions, community/environmental factors, etc.

Educational outcomes are proficiency scores from math and reading/language arts (RLA) assessments, along with high school graduation rates for local school districts in the U. S. states. Proficiency scores represent the percentage of students scoring at or above proficient levels on these standardized tests. Fourteen proficiency scores, covering grades 3 through 8 and high school, are analyzed for each subject (math and RLA), resulting in a total of fifteen outcome measures, along with high school graduation rates. Data originate from ED*Facts* Data Files provided by the U.S. Department of Education. Due to the COVID-19 pandemic, proficiency scores for SY 2019-20 are unavailable, and scores from SY 2020-21 are not comparable to previous years due to ongoing disruptions.[1] Appendix A provides additional details on how proficiency scores were constructed.

To ensure consistency in high school graduation rate calculations, this paper focuses on data collected using the new cohort method mandated by the U.S. Department of Education in 2008 for Title I, Part A of the Elementary and Secondary Education Act (ESEA). The new method was implemented beginning from SY 2010-11 (U. S. Department of Education, 2023). While ED*Facts* data include graduation rates through SY 2020-21, we exclude data for SY 2019-20 and SY 2020-21 due to potential COVID-related disruptions. Similarly, although proficiency scores are available from SY 2009-10, we utilize data from SY 2010-11 onwards to maintain a consistent nine-year timeframe (SY 2010-11 to SY 2018-19) for all educational outcome measures. In Table 1, Math_Grade03 through RLA_High_School are fourteen proficiency scores and High_School_Graduation_Rate is the high school graduation rates based on the new cohort method.

Data for capital expenditures are obtained from the Common Core of Data provided by the National Center for Educational Statistics (NCES). The data are available from the school year SY 1989-90, but some years prior to SY 1994-95 are incomplete. Therefore, this paper uses fiscal data from SY 1994-95 to SY 2018-19. As detailed in Appendix A, regression models use five capital expenditures and stock variables as examples of educational resources and inputs, which are also the main variables of interest in this paper. In Table 1, Construction_Expenditures

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[1] Data are obtained from: https://www2.ed.gov/about/inits/ed/edfacts/data-files/index.html [accessed September 3, 2023]

are annual expenditures mostly on constructing fixed structures. As noted in Appendix A, two-year lagged construction expenditures, Lagged_Construction_Expenditures, and Construction_Expenditures are likely to measure disruption effects during building construction (Conlin & Thompson, 2017; Goncalves, 2015). Construction_Stock is the stock value of fixed structures. Land_Building_Stock is the stock value of land and pre-existing buildings. Equipment_Stock is the stock value of various types of equipment. All fiscal variables in this study, including the above five variables, are converted to 2019 constant dollars using the State and Local Government Price Deflator. Additionally, all fiscal variables are measured on a per-pupil basis. The number of students in school districts came from the Common Core of Data.

Five additional variables, obtained from the Common Core of Data, are used as examples of educational resources and inputs or environmental factors. Local_Revenue_Share denotes the share of locally raised revenues out of total revenues. Federal_Revenue_Share indicates the share of federal funds. Instruction_Salary refers to per pupil salary for instruction, while Support_Services_Salary represents per pupil salary for support services. Property_Tax_Revenue represents per pupil property tax revenue as an environmental factor. Sample I in Table 1 comprises 40130 non-missing observations for all the aforementioned variables, covering 45 states from SY 2010-11 to SY 2018-19. The number of school districts ranges from 4,721 in SY 2010-11 to 4,225 in SY 2017-18.[2]

The Common Core of Data provides additional information on student characteristics and features of educational institutions. Percent_White measures the share of white students in school districts. School_Administrators represents the per pupil number of school administrators.

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[2] The five missing states are: Alaska, Hawaii, Maryland, North Carolina, and Virginia.

Teachers denotes the per pupil number of teachers. Student_Support_Staff indicates the per pupil number of school staff providing student support. Unfortunately, data for these variables are missing in six additional states.[3] Given their potential to improve the explanatory power of regression models, however, this paper also analyzes a subset (Sample II in Table 1), which includes these variables despite having fewer observations (34104).

3.2. Model

The regression models in this paper use data from SY 2010-11 to SY 2018-19, encompassing approximately 4,500 school districts in up to 45 states. The models control for two-way fixed effects across states and years. Although three-way fixed effects models could potentially be more effective, preliminary analyses indicated strong collinearity among school district fixed effects. Consequently, two-way fixed effects models are used. To address the collinearity, standard errors are clustered by state-year interactions. Additionally, the models utilize Driscoll & Kraay (1998) standard errors to adjust for cross-sectional dependence, accounting for temporal correlation between the errors of the previous year and the current year.

Lafortune & Schönholzer (2022) demonstrate strong capitalization effects of test scores on property valuations in school districts. The educational outcomes in this paper likely affect property valuations, which in turn might influence capital expenditures and stock measures. To control for potential endogeneity, two-stage least squares regression (2SLS) models are employed. The instruments for endogenous variables are their lagged values expressed as ranks (Kroszner & Stratmann, 1998, 2000). These lagged variables are divided into thirds, with a rank

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[3] The six states are: Alabama, Arizona, Arkansas, California, Colorado, and Connecticut.

of one assigned to the lowest third, a rank of two to the middle third, and a rank of three to the upper third. By construction, the rank variables are positively correlated with the endogenous variables. If changes in the levels of the endogenous variables do not alter ranks, then ranks are independent of error terms in the second stage regression because small changes in the continuous variables are less likely to move an observation from one category to another. This stability means that minor variations or errors in the data do not significantly affect the rank assignment. Only observations near the crossover points between ranks are likely to violate this condition. Therefore, choosing a small number of ranks, such as three, reduces the likelihood of such correlations.[4] To strengthen the instruments, the 2SLS estimation includes additional instruments. Capital expenditures and stock measures from SY 2005-06, adjusted only for inflation, are utilized. These measures likely reflect changes in market property valuations while filtering out the capitalized effects of test scores on property valuations (Eom et al., 2014).

4. Findings

For fifteen regression models corresponding to fifteen educational outcome variables, each of the capital expenditures and stock variables is tested for endogeneity. Some variables exhibited similar patterns of endogeneity. For example, in Appendix B – Table 1, only Construction_Expenditures and Lagged_Construction_Expenditures were endogenous in the 2SLS models for Math_High_School and RLA_High_School. The Wu-Hausman test confirmed the presence of endogeneity. To strengthen the instruments, one more instrument was used. The

[4] When one-year lagged rank-based instruments fail to pass relevant tests, five-year lagged rank-based instruments are used as shown in Appendix B.

Sargan test indicated no overidentification, and the first-stage F statistics were in the thousands and statistically significant at p = 0.0000, although these statistics are not reported in the table.

Staiger & Stock (1997) suggested using a first-stage F statistic threshold of 10 to prevent over-rejecting null hypotheses for second-stage regression coefficients when instruments are not sufficiently strong. Lee et al. (2022) indicated that this threshold is often unreliable because t-test statistics may have a non-normal distribution, even in large samples, leading to biased conventional t-ratio inferences. Instead, they proposed adjusting the t statistics of second-stage regression coefficients based on first-stage F statistics, known as the tF procedure. They recommend an F statistic of 104.67 for an alpha value of 0.05. Similarly, Keane & Neal (2024) emphasized that the critical first-stage F statistic should be at least 50 to ensure that instrumental variable (IV) estimates outperform OLS estimates.

The F statistics for the two variables mentioned above were in the thousands that are much larger than critical values of 104.67 or 50. However, caution is needed when applying the critical values, as these were suggested for one endogenous variable with one instrument. For multiple endogenous variables, we can use the Cragg-Donald (C-D) statistic (Cragg & Donald, 1993). Stock & Yogo (2005) provided critical values for the minimum eigenvalues of the C-D statistic. However, Sanderson & Windmeijer (2016) noted that the limiting distributions in Stock & Yogo (2005) are conservative, often rejecting the null hypothesis of weak instruments too infrequently. They proposed asymptotic methods for models with multiple endogenous variables, “where reduced form parameters are not local to zero, but the reduced form parameter matrix is local to a rank reduction of one” (Sanderson & Windmeijer, 2016, p. 212).

Thus, Appendix B – Table 1 also reports the conditional F statistics proposed by Sanderson & Windmeijer (2016), in addition to the C-D statistics. The 2SLS model for Math_High_School included two endogenous variables with three instruments, yielding a conditional F statistic of 1140.0 with p = 0.0000. According to the critical values suggested by Stock & Yogo (2005), the critical first-stage F statistic for a tolerable relative bias level of 0.1 at a significance level of 0.05 is 13.43. The F statistic in Appendix B – Table 1 far exceeds this critical value, indicating strong instruments. All remaining test results exhibited similar patterns of strong instruments.

Sections 4.1 and 4.2 present the overall patterns in the statistically significant (at $p < 0.1$ at the minimum but mostly at $p < 0.01$) impacts of capital expenditures and stock on educational attainment. Section 4.3 provides a summary of the numerical estimations of these impacts and compares them with findings reported in the literature. Section 4.4 presents findings on control variables.

4.1. Sample I

Tables 2 and 3 report empirical findings with Sample I. Consistent with the literature, Construction_Expenditures disrupts educational attainment. Annual and two-year lagged expenditures on construction, Lagged_Construction_Expenditures, negatively affect high school graduation rates. Additionally, two-year lagged expenditures on construction decrease math scores for most lower-grade students (e.g., between 3rd and 8th grade). Interestingly, these expenditures increase math scores for 4th graders and Reading/Language Arts (RLA) scores for high school students. This unexpected finding warrants further analysis with a different data sample, as shown in Section 4.2.

In line with existing research, capital stock variables—Construction_Stock, Land_Building_Stock, and Equipment_Stock—generally improve math and RLA scores for lower-grade students. Both Construction_Stock and Equipment_Stock enhance high school graduation rates, suggesting that fixed buildings, facilities, or equipment boost educational attainment. However, Construction_Stock and Land_Building_Stock detract from RLA scores for high school students, and Land_Building_Stock negatively affects their math scores. This could indicate that fixed buildings or facilities might hinder the individualized study settings that are beneficial for older students. In contrast, Equipment_Stock, which likely supports individualized study environments, improves both RLA and math scores for high school students. A possible explanation for why Construction_Stock boosts high school graduation rates, not proficiency scores, is that more buildings or facilities may provide more classes required for graduation.

The next section investigates what happens to the above findings if we use the sample with extra control variables but drop the missing cases in them.

4.2. Sample II with Extra Covariates

Tables 4 and 5 report empirical findings with Sample II with extra covariates. It identifies the interaction effects of racial composition on educational attainment. The somewhat ambiguous disruption effects of annual and two-year lagged construction expenditures are mostly mitigated when Percent_White (the percentage of white students in school districts) is interacted with these expenditures. The impacts of some proficiency scores, such as math scores for 3rd and 5th graders and RLA scores for high school students, remain, but most other categories do not show any meaningful patterns. However, math scores for 7th graders and RLA scores for 6th graders reveal significant interaction effects of race. The disruption effect from annual construction expenditures negatively affects these scores, but as the percentage of white students increases, the impacts turn positive. It is likely that wealthier districts, which white students are more likely to attend, proactively took extra steps to mitigate potential disruption effects.

A similar pattern emerges for high school graduation rates. Both annual and two-year lagged construction expenditures negatively affect graduation rates. However, as Percent_White increases, these expenditures actually boost graduation rates. Wealthier districts might have taken further steps, such as arranging required classes in other pre-existing facilities, prior to or during new construction.

The interaction effects of race are much stronger and more salient with the three capital stock variables. Construction_Stock negatively affects math and RLA scores for students in several lower grades and high schools. As Percent_White increases, however, these proficiency scores turn positive. Land_Building_Stock negatively affects math scores for 7th graders and high school students, as well as RLA scores for students in all grades, including high schools. However, as Percent_White increases, these same proficiency scores, along with math scores for 3rd and 6th graders, turn positive. The interaction effects of race with respect to Equipment_Stock are slightly weaker but still present. Equipment_Stock negatively affects RLA scores for 6th graders and high school students but positively affects them with increasing percentages of white students although some other proficiency scores show somewhat bifurcated patterns. Wealthier districts might have integrated new facilities with their pre-existing ones, leveraging their resources to make them functional.

Opposite interaction effects of race emerge for high school graduation rates. All three measures of capital stock positively affect graduation rates. However, as Percent_White increases, these capital stock variables decrease graduation rates. At first glance, this pattern is puzzling, but Lafortune & Schönholzer (2022) provide some clues. They analyze whether and how newly constructed school facilities affect educational attainment in the Los Angeles Unified School District from 2002 to 2012. Among their findings, some results are particularly illuminating. New school facilities increase attendance rates by 4 to 5 percent. Specifically, students switching from schools with poor facility conditions are more likely to attend newly constructed schools. Similarly for this paper, schools with relatively lower percentages of white students and possibly poorer students might have induced their students to attend schools with newly added facilities. In contrast, students in wealthier schools might not have been attracted to new capital that may provide more classes required for graduation but is not distinguishable from pre-existing facilities.

In sum, the analysis of Sample II with extra covariates reveals significant interaction effects of racial composition on educational attainment. Annual and two-year lagged construction expenditures negatively affect math and RLA scores, but as the percentage of white students increases, these impacts turn positive. This pattern suggests wealthier districts, which are more likely to have higher percentages of white students, proactively mitigate disruption effects. Similarly, high school graduation rates improve with increased Percent_White despite initial negative impacts from construction expenditures. The interaction effects are also evident in capital stock variables: Construction_Stock and Land_Building_Stock negatively affect proficiency scores, but these effects reverse with higher Percent_White. Equipment_Stock shows weaker yet similar patterns. Conversely, while capital stock generally boosts graduation rates, these benefits diminish as Percent_White increases. This paradox may stem from wealthier students' lesser attraction to new facilities that are similar to existing ones, highlighting complex dynamics between race, wealth, and educational infrastructure.

4.3. Numerical Summary and Comparison of Main Findings

A meta-analysis by Jackson and Mackevicius (2024), introduced in Section 1, reported that a $1,000 increase in per-pupil capital spending sustained over four years boosts test scores by approximately 3.4 percent of a standard deviation. Although the disruption effects from capital projects may decrease test scores by about 1.2 percent of a standard deviation in the first few years, this finding was not statistically significant. Additionally, the meta-analysis found that such spending increases high school graduation rates by about 16.3 percent of a standard deviation.

Table 6 provides a comparable estimation by measuring percentage increases in educational outcomes per $1,000 increase in per-pupil spending in relevant categories. Regression coefficients are multiplied by 1,000, and the resulting estimates are presented as percentages of the standard deviations of the relevant variables in Table 1. The disruption effects from capital spending reported by Jackson and Mackevicius (2024) are comparable to the overall impacts summarized in Table 6.

The impacts of Construction_Expenditures for the base effects with Sample II range from -9.84 percent to 4.99 percent of standard deviations for school districts with non-white students. The impacts of the three capital stock variables range from approximately -0.34 percent to 2.55 percent of standard deviations in test scores for Sample I, without interaction effects. However, the impacts range from about -5.01 percent to 28.33 percent of standard deviations when the percent of white students increases by 100 percent (or by a unit, 1), as shown in Sample II with interaction effects.

These ranges cannot be directly compared to the 3.4 percent of a standard deviation resulting from four years of sustained capital spending reported by Jackson and Mackevicius (2024), as the three capital stock variables in this paper represent accumulated capital spending over 15 to 25 years, which is measured for a single year. Nonetheless, the 3.4 percent of a standard deviation falls within the overall ranges presented in Table 6. Additionally, the 16.3 percent of a standard deviation for high school graduation rates reported by Jackson and Mackevicius (2024) lies within the range of about 2.24 percent to 44.75 percent of standard deviations for school districts with non-white students (the base effects for Sample II).

4.4. Findings on Control Variables

Control variables affect educational outcomes as expected from the literature, especially when focusing on the regression models that include interaction effects. Property_Tax_Revenue, intended to measure school district wealth, is anticipated to enhance educational outcomes. However, it negatively affects the outcomes. Since the regression models also control for various spending measures, Property_Tax_Revenue likely reflects the fiscal pressures experienced by school districts. This is because spending has a positive impact on educational outcomes, while revenues in this context measure the fiscal burden that detracts from educational outcomes.

In contrast, Local_Revenue_Share, which represents the share of locally raised revenue rather than per-pupil dollar amounts, is more likely to indicate the fiscal flexibility of school districts, thus enhancing educational outcomes. Federal_Revenue_Share likely reflects a shortage of fiscal resources in school districts, as substantial federal aid, such as Title I fund, is directed towards poorer districts. Consequently, it is not surprising to observe negative signs for Federal_Revenue_Share.

Both Instruction_Salary and Support_Services_Salary enhance educational outcomes. Similarly, the number of teachers also improves outcomes. In contrast, Student_Support_Staff and School_Administrators have negative impacts, suggesting that the quality, rather than the quantity, of school administrative staff is more crucial for educational outcomes. Additionally, the sign for Percent_White is positive: as the percentage of white students in school districts increases, educational outcomes tend to improve.

5. Conclusions

This paper contributes to the understanding of how specific educational inputs, namely capital expenditures and capital stock, impact educational attainment by utilizing multi-state data sets from 2010 to 2019. By focusing on a broader dataset that spans multiple states, this study filters out unknown confounders and fixed effects, thereby enhancing causal inference. Unlike earlier literature, which often indicated weak relationships between school spending and student outcomes, recent studies, including those analyzed here, provide more causally credible findings by employing advanced estimation methods. The results reveal that while annual and two-year lagged construction expenditures initially negatively affect math and Reading/Language Arts (RLA) scores, these impacts turn positive as the percentage of white students increases. This suggests that wealthier districts, typically with higher percentages of white students, can effectively mitigate the disruption effects associated with construction. Similarly, high school graduation rates improve with higher percentages of white students, despite the initial negative impacts of construction expenditures.

The interaction effects of racial composition are more salient in the impacts of capital stock variables on educational attainment. Newly constructed structures and newly purchased structures or land initially negatively impact proficiency scores, but these effects become positive with higher percentages of white students. Newly purchased equipment shows similar but weaker patterns. In contrast, these capital stock variables generally boost graduation rates but the benefits diminish as the percentage of white students increases, possibly due to wealthier students' lesser attraction to new facilities similar to existing ones. These findings underscore the complex dynamics between race, wealth, and educational infrastructure, highlighting the need for nuanced policy approaches that consider the varying impacts of capital investments across different demographic groups. By focusing on specific educational inputs and utilizing a comprehensive multi-state dataset, this study provides robust evidence of the significant and multifaceted impacts of capital expenditures and stock on educational outcomes.

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Appendix A: Additional Details on Data Construction

Proficiency scores:

To protect privacy in schools with few students, proficiency scores are reported in ranges, typically five or ten percentage points wide. For example, a school with 31-60 students might have a reported score of "40-49%," while a slightly larger school might be shown as "30-34%" (U. S. Department of Education, 2020). In these cases, the midpoint (e.g., 44.5% for "40-49%" or 32% for "30-34%") is used for analysis. Scores with wider ranges exceeding ten points (e.g., "greater than 50%") are excluded. Schools with over 300 students receive individual percentage scores and don't require adjustment.

Capital expenditures and stock:

Three fiscal measures necessary for constructing measures of capital expenditures and stock include construction expenditures, expenditures for land and buildings, and equipment expenditures (U. S. Departmenet of Education, 2020). Construction expenditures (referred to as Construction_Expenditures in Table 1) are the costs incurred from producing fixed structures, additions, replacements, and major alterations. Conlin & Thompson (2017) and Goncalves (2015) found disruption effects during the construction of new facilities or buildings. Lafortune & Schönholzer (2022) indicated that, on average, it takes 2.12 years from the start of construction to completion. Thus, the regression models in this paper also control for lagged construction expenditures. However, a strong correlation was detected between Construction_Expenditures and one-year lagged construction expenditures. Therefore, regression models included two-year lagged construction expenditures, Lagged_Construction_Expenditures, only. Accumulated construction expenditures are converted to construction capital stock (referred to as Construction_Stock in Table 1) based on the weight specified in Equation (2). A useful life of 50 years is suggested for educational buildings for state and local governments (U. S. Department of Commerce, 2003). Therefore, θ_j in Equation (2) is set at 50. Since this category includes some provision for equipment, the actual useful life might be shorter than 50 years. Preliminary analyses were conducted with a useful life set at 40 years, which yielded almost similar results.

This paper considers expenditures for land and buildings, encompassing costs associated with land acquisition, improvements, and existing structures (U. S. Departmenet of Education, 2020). While land has an infinite useful life, public school buildings in the 2012-13 school year averaged approximately 44 years old (21st Century School Fund et al., 2016). Newly acquired existing buildings may therefore have a remaining useful life of around six years on average. Selecting an appropriate useful life for this category presents a challenge. As a result, this paper also uses 50 years for this category, which are used for Construction_Stock. Expenditures for land and buildings are converted to their stock measures, Land_Building_Stock, based on Equation (2). Main results were almost unchanged even when the useful life for this category was set at 40.

Equipment expenditures were incurred from purchasing apparatus, furnishings, motor vehicles, and office machines. These expenditures are converted to their stock measures, referred to as Equipment_Stock, based on Equation (3). Useful lives for various types of equipment for state and local governments are suggested to range from 7 to 33 years (U. S. Department of Commerce, 2003). This paper uses 15 years as the overall useful life for these capital stock categories. Given that motor vehicles and office machines tend to have shorter useful lives, preliminary analyses were conducted using a 10-year useful life. The main findings remained almost unchanged.

Appendix B: Details on 2SLS Models

B-Table 1: Instrumental Variables and Conditional F Tests for Table 2 & Table 3

Dependent Var.	Endogenous Var.	Instrumental Var.	Summary Test Results	Conditional F Test Results
CD = Cragg-Donald Test Stat, WH = Wu-Hausman Test Stat, F = 1st Stage F Stat, S = Sargan Test Stat, & CF = Conditional F Stat				
Math_High_School	Construction_Expenditures (1), Lagged_Construction_Expenditures (2)	Rank-based instruments for 1 &2, Construction_Expenditures_2006	CD = 598.5, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 1140.0 (p = 0.0000) 2: CF = 1088.7 (p = 0.0000)
RLA_High_School			Similar to the above results	
Math_Grade03	Construction_Expenditures (1), Construction_Stock (2), Land_Building_Stock (3), Equipment_Stock (4)	Rank-based instruments for 1, 3, & 4, 5-year lagged rank-based instrument for 2, Construction_Stock_2006	CD = 878.4, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 2254.1 (p = 0.0000) 2: CF = 46675.0 (p = 0.0000) 3: CF = 3599.6 (p = 0.0000) 4: CF = 17287.1 (p = 0.0000)
Math_Grade07			Similar to the above results	
RLA_Grade06			Similar to the above results	
Math_Grade04	Construction_Expenditures (1), Lagged_Construction_Expenditures (2), Construction_Stock (3), Land_Building_Stock (4)	Rank-based instruments for 1, 2 & 4, 5-year lagged rank-based instrument for 2, Construction_Stock_2006	CD = 362.2, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 1004.1 (p = 0.0000) 2: CF = 1154.2 (p = 0.0000) 3: CF = 22056.0 (p = 0.0000) 4: CF = 3635.7 (p = 0.0000)
Math_Grade05			Similar to the above results	
Math_Grade08			Similar to the above results	
RLA_Grade03			Similar to the above results	
RLA_Grade04			Similar to the above results	
RLA_Grade05			Similar to the above results	

RLA_Grade07			Similar to the above results	
RLA_Grade08			Similar to the above results	
Math_Grade06	Construction_Expenditures (1), Construction_Stock (2), Land_Building_Stock (3)	Rank-based instruments for 1, 2 & 3, Log (Construction_Stock_2006)	CD = 1060.8, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 2189.8 (p = 0.0000) 2: CF = 16320.8 (p = 0.0000) 3: CF = 3598.5 (p = 0.0000)
High_School_ Graduation_Rate	Construction_Stock (1), Equipment_Stock (2)	Rank-based instruments for 1, & 2, 5-year lagged rank-based instrument for 2	CD = 6607.2, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 83120.8 (p = 0.0000) 2: CF = 19531.8 (p = 0.0000)

B-Table 2: Instrumental Variables and Conditional F Tests for Table 4 & Table 5

Dependent Var.	**Endogenous Var.**	**Instrumental Var.**	**Summary Test Results**	**Conditional F Test Results**
CD = Cragg-Donald Test Stat, WH = Wu-Hausman Test Stat, F = 1st Stage F Stat, S = Sargan Test Stat, & CF = Conditional F Stat, INT_ denotes that variables are interacted with Percent_White				
Math_High_School	INT_Construction_Expenditures (1), INT_Lagged_Construction_Expenditures (2), Percent_White (3)	Rank-based instruments for 1 ,2 & 3, Construction_Expenditures_2006	CD = 333.2, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 873.8 (p = 0.0000) 2: CF = 766.4 (p = 0.0000) 3: CF = 4981.6 (p = 0.0000)
RLA_High_School			Similar to the above results	
Math_Grade03	Construction_Expenditures (1), Construction_Stock (2), Land_Building_Stock (3), Equipment_Stock (4), INT_Construction_Expenditures (5), INT_Construction_Stock (6), INT_Land_Building_Stock (7), INT_Equipment_Stock (8), Percent_White (9)	Rank-based instruments for 1, 3, 4, 5, 6, 7, 8, & 9, 5-year lagged rank-based instrument for 2, Construction_Stock_2006	CD = 31.4, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 495.1 (p = 0.0000) 2: CF = 955.3 (p = 0.0000) 3: CF = 511.6 (p = 0.0000) 4: CF = 868.7 (p = 0.0000) 5: CF = 489.2 (p = 0.0000)
Math_Grade07			Similar to the above results	
RLA_Grade06			Similar to the above results	

				6: CF = 954.0 (p = 0.0000) 7: CF = 505.0 (p = 0.0000) 8: CF = 837.8 (p = 0.0000) 9 CF = 598.0 (p = 0.0000)
Math_Grade04	Construction_Expenditures (1), Lagged_Construction_Expenditures (2), Construction_Stock (3), Land_Building_Stock (4), INT_Construction_Expenditures (5), INT_Lagged_Construction_Expenditures (6), INT_Construction_Stock (7), INT_Land_Building_Stock (8), Percent_White (9)	Rank-based instruments for all variables, Construction_Stock_2006	CD = 45.5, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 472.2 (p = 0.0000) 2: CF = 384.0 (p = 0.0000) 3: CF = 1579.5 (p = 0.0000) 4: CF = 603.3 (p = 0.0000) 5: CF = 496.1 (p = 0.0000) 6: CF = 389.7 (p = 0.0000) 7: CF = 1681.9 (p = 0.0000) 8: CF = 577.2 (p = 0.0000) 9 CF = 686.1 (p = 0.0000)
Math_Grade05			Similar to the above results	
Math_Grade08			Similar to the above results	
RLA_Grade03			Similar to the above results	
RLA_Grade04			Similar to the above results	
RLA_Grade05			Similar to the above results	
RLA_Grade07			Similar to the above results	
RLA_Grade08			Similar to the above results	
Math_Grade06	Construction_Expenditures (1), Construction_Stock (2), Land_Building_Stock (3), INT_Construction_Expenditures (4), INT_Construction_Stock (5), INT_Land_Building_Stock (6), Percent_White (7)	Rank-based instruments for all variables, Log (Construction_Stock_2006)	CD = 50.6, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 702.6 (p = 0.0000) 2: CF = 1190.9 (p = 0.0000) 3: CF = 632.8 (p = 0.0000) 4: CF = 687.8 (p = 0.0000) 5: CF = 1093.7 (p = 0.0000)

				6: CF = 609.5 (p = 0.0000) 7: CF = 606.9 (p = 0.0000)
High_School_ Graduation_Rate	Construction_Stock (1), Equipment_Stock (2), INT_Construction_Stock (3), INT_Equipment_Stock (4), Percent_White (5)	Rank-based instruments for all variables, 5-year lagged rank-based instrument for 1	CD = 190.1, WH, F (strongly stat. sig.), S (stat. insig.)	1: CF = 1849.5 (p = 0.0000) 2: CF = 1990.5 (p = 0.0000) 3: CF = 1776.7 (p = 0.0000) 4: CF = 1906.4 (p = 0.0000) 5: CF = 1535.9 (p = 0.0000)

Table 1: Descriptive Statistics

	Sample I (Full Sample with No Extra Covariates: n = 40130)					Sample II (Sample with Extra Covariates: n = 34104)				
Variable	**Mean**	**Std Dev**	**Min**	**Max**	**Std Error**	**Mean**	**Std Dev**	**Min**	**Max**	**Std Error**
Math_Grade03	62.813	20.377	2.500	97.500	0.102	62.639	20.054	2.500	97.500	0.109
Math_Grade04	60.865	21.888	2.500	97.500	0.109	60.985	21.616	2.500	97.500	0.117
Math_Grade05	57.809	22.668	2.500	97.500	0.113	57.946	22.315	2.500	97.500	0.121
Math_Grade06	56.535	22.512	2.500	97.500	0.112	56.425	22.267	2.500	97.500	0.121
Math_Grade07	54.784	22.775	2.500	97.500	0.114	55.094	22.607	2.500	97.500	0.122
Math_Grade08	54.762	23.881	2.500	97.500	0.119	55.430	23.801	2.500	97.500	0.129
Math_High_School	56.935	25.887	2.500	97.500	0.129	58.231	25.594	2.500	97.500	0.139
RLA_Grade03	61.375	21.182	2.500	97.500	0.106	61.949	20.685	2.500	97.500	0.112
RLA_Grade04	61.089	20.505	2.500	97.500	0.102	61.474	20.166	2.500	97.500	0.109
RLA_Grade05	60.870	20.570	2.500	97.500	0.103	61.192	20.257	2.500	97.500	0.110
RLA_Grade06	60.032	20.546	2.500	97.500	0.103	60.170	20.321	2.500	97.500	0.110
RLA_Grade07	59.785	20.212	2.500	97.500	0.101	60.061	19.976	2.500	97.500	0.108
RLA_Grade08	61.186	20.883	2.500	97.500	0.104	61.362	20.689	2.500	97.500	0.112
RLA_High_School	66.800	20.857	2.500	97.500	0.104	67.993	20.416	2.500	97.500	0.111
High_School_Graduation_Rate	88.595	8.961	2.500	98.000	0.045	88.761	8.939	2.500	98.000	0.048
Construction_Expenditures	960.719	2296.372	0.000	47207.870	11.463	973.924	2310.110	0.000	47207.870	12.509
Lagged_Construction_Expenditures	1016.676	2514.435	0.000	73809.724	12.564	1037.968	2525.933	0.000	56272.620	13.691
Construction_Stock	13283.862	10069.399	0.000	118706.256	50.265	13746.610	10050.135	0.000	99980.091	54.421
Land_Building_Stock	881.166	2385.654	0.000	66213.217	11.909	833.037	2345.565	0.000	66213.217	12.701
Equipment_Stock	1664.685	1174.437	0.000	23993.491	5.863	1722.998	1165.812	4.321	23993.491	6.313
Property_Tax_Revenue	4881.418	4524.284	0.000	144378.611	22.585	4985.246	4449.661	0.000	78290.266	24.095
Local_Revenue_Share	0.416	0.182	0.009	0.994	0.001	0.413	0.177	0.009	0.973	0.001
Federal_Revenue_Share	0.080	0.059	0.000	0.701	0.000	0.077	0.054	0.000	0.695	0.000
Instruction_Salary	4827.753	1844.017	1.300	105658.834	9.205	4888.492	1804.943	1.300	51969.893	9.774
Support_Services_Salary	453.032	157.682	0.000	9744.050	0.787	449.224	141.650	0.000	2692.003	0.767
Percent_White						0.603	0.172	0.000	0.861	0.001
School_Administrators						0.003	0.002	0.000	0.016	0.000
Teachers						0.051	0.025	0.000	0.471	0.000
Student_Support_Staff						0.005	0.006	0.000	0.136	0.000

Table 2: Regression Results for Math Proficiency Scores and High School Graduation Rates (Sample I)

Variable	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Construction_Expenditures	0.00023	0.00028	**0.00056**	**0.00028**	0.00041	0.00029	0.00036	0.00028
Lagged_Construction_Expenditures	**-0.00016**	**0.00005**	-0.00034	0.00022	-0.00027	0.00018	**-0.00015**	**0.00006**
Construction_Stock	**0.00005**	**0.00002**	**0.00005**	**0.00002**	**0.00005**	**0.00001**	0.00002	0.00002
Land_Building_Stock	**0.00021**	**0.00005**	**0.00013**	**0.00007**	0.00006	0.00009	0.00005	0.00006
Equipment_Stock	-0.00011	0.00023	0.00018	0.00010	**0.00029**	**0.00011**	**0.00026**	**0.00011**
Property_Tax_Revenue	**-0.00041**	**0.00006**	**-0.00055**	**0.00010**	**-0.00049**	**0.00010**	**-0.00039**	**0.00010**
Local_Revenue_Share	**16.98336**	**1.70722**	**19.85351**	**2.49853**	**20.87717**	**2.16051**	**18.20960**	**2.16881**
Federal_Revenue_Share	**-72.46817**	**6.47079**	**-77.79534**	**5.50322**	**-78.57705**	**3.00739**	**-80.03853**	**5.20940**
Instruction_Salary	**0.00169**	**0.00032**	**0.00191**	**0.00041**	**0.00209**	**0.00042**	**0.00203**	**0.00041**
Support_Services_Salary	**-0.00330**	**0.00128**	**-0.00375**	**0.00138**	**-0.00497**	**0.00129**	**-0.00644**	**0.00145**
R^2	0.47520		0.49940		0.52150		0.51380	
Adj R^2	0.47440		0.49860		0.52080		0.51310	
Within R^2	0.07910		0.07820		0.08940		0.08850	
n	39880		39880		39880		40050	
AIC	328037.5		331886.9		332861.2		334336.2	
BIC	328578.9		332428.3		333402.6		334877.9	
Log. Lik.	-163955.7		-165880.5		-166367.6		-167105.1	
Dependent Variable	Math_Grade03		Math_Grade04		Math_Grade05		Math_Grade06	
Estimates with p < 0.1 are bolded.								
Construction_Expenditures	0.00038	0.00025	0.00065	0.00039	0.00024	0.00026	**-0.00006**	**0.00003**
Lagged_Construction_Expenditures	**-0.00022**	**0.00006**	**-0.00050**	**0.00024**	0.00018	0.00014	**-0.00010**	**0.00003**
Construction_Stock	**0.00009**	**0.00002**	**0.00006**	**0.00002**	-0.00002	0.00002	**0.00004**	**0.00001**
Land_Building_Stock	-0.00002	0.00007	0.00000	0.00010	**-0.00008**	**0.00003**	-0.00002	0.00002
Equipment_Stock	0.00039	0.00026	0.00005	0.00011	**0.00040**	**0.00007**	**0.00022**	**0.00004**
Property_Tax_Revenue	**-0.00051**	**0.00008**	**-0.00046**	**0.00007**	**-0.00038**	**0.00016**	**-0.00005**	**0.00002**
Local_Revenue_Share	**20.60171**	**1.85323**	**22.04089**	**1.69551**	**15.65306**	**2.83579**	**4.53470**	**0.63524**
Federal_Revenue_Share	**-88.45435**	**4.54007**	**-80.53630**	**2.77449**	**-76.02207**	**3.91631**	**-46.61318**	**1.46613**
Instruction_Salary	**0.00225**	**0.00042**	**0.00224**	**0.00043**	**0.00146**	**0.00038**	**0.00037**	**0.00012**
Support_Services_Salary	**-0.00599**	**0.00159**	**-0.00376**	**0.00147**	**-0.00714**	**0.00151**	**-0.00157**	**0.00029**
R^2	0.53330		0.53340		0.57190		0.33260	
Adj R^2	0.53260		0.53260		0.57120		0.33160	
Within R^2	0.10260		0.08850		0.06140		0.09470	
n	39880		39880		39994		39880	
AIC	332269.2		336041.4		339976.2		272126.6	
BIC	332810.6		336582.8		340517.8		272668.0	
Log. Lik.	-166071.6		-167957.7		-169925.1		-136000.3	
Dependent Variable	Math_Grade07		Math_Grade08		Math_High_School		High_School_Graduation_Rate	

Table 3: Regression Results for RLA Proficiency Scores (Sample I)

Variable	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Construction_Expenditures	0.00016	0.00022	0.00015	0.00022	-0.0001	0.00019	0.00003	0.00015
Lagged_Construction_Expenditures	-0.00004	0.00019	0.00008	0.00013	0.00018	0.00012	**-0.00018**	**0.00006**
Construction_Stock	0.00002	0.00001	**0.00003**	**0.00001**	**0.00002**	**0.00001**	**0.00008**	**0.00002**
Land_Building_Stock	**0.00025**	**0.00012**	**0.0002**	**0.0001**	0.00004	0.00013	-0.00006	0.00009
Equipment_Stock	**0.00014**	**0.00004**	0.00009	0.00007	**0.00018**	**0.00005**	**0.00054**	**0.00021**
Property_Tax_Revenue	**-0.00029**	**0.0001**	**-0.00031**	**0.00011**	**-0.00025**	**0.00009**	**-0.00021**	**0.0001**
Local_Revenue_Share	**15.26804**	**2.7541**	**16.41689**	**2.86939**	**16.64943**	**2.49858**	**13.93593**	**2.96409**
Federal_Revenue_Share	**-77.26938**	**5.43881**	**-81.09593**	**3.83463**	**-82.01203**	**4.43748**	**-82.45774**	**5.55015**
Instruction_Salary	**0.0019**	**0.00041**	**0.00191**	**0.00041**	**0.00191**	**0.00035**	**0.00187**	**0.00044**
Support_Services_Salary	**-0.00425**	**0.00105**	**-0.00521**	**0.0015**	**-0.00483**	**0.00111**	**-0.00697**	**0.00172**
R^2	0.535		0.5324		0.5382		0.5077	
Adj R^2	0.5342		0.5317		0.5375		0.5069	
Within R^2	0.0926		0.1069		0.1148		0.1003	
n	39880		39880		39880		39880	
AIC	326315.0		323956.3		323675.7		326149.2	
BIC	326856.4		324497.7		324217.1		326690.6	
Log. Lik.	-163094.5		-161915.1		-161774.8		-163011.6	
Dependent Variable	RLA_Grade03		RLA_Grade04		RLA_Grade05		RLA_Grade06	
Estimates with p < 0.1 are bolded.								
Construction_Expenditures	0	0.00023	0.00029	0.00022	-0.00006	0.00026		
Lagged_Construction_Expenditures	0.00021	0.00012	-0.00009	0.00015	**0.00062**	**0.00017**		
Construction_Stock	**0.00003**	**0.00001**	**0.00003**	**0.00001**	**-0.00006**	**0.00003**		
Land_Building_Stock	-0.00004	0.0001	0.00006	0.00006	**-0.00011**	**0.00002**		
Equipment_Stock	**0.00015**	**0.00008**	**0.00014**	**0.00006**	**0.00038**	**0.00011**		
Property_Tax_Revenue	**-0.00024**	**0.0001**	-0.00017	0.00013	**-0.00033**	**0.00015**		
Local_Revenue_Share	**16.81329**	**2.05909**	**15.50241**	**2.74506**	**13.66067**	**3.13213**		
Federal_Revenue_Share	**-81.02635**	**3.89669**	**-75.59354**	**2.91789**	**-75.6525**	**5.31247**		
Instruction_Salary	**0.0017**	**0.00041**	**0.00147**	**0.00037**	**0.00112**	**0.00034**		
Support_Services_Salary	**-0.00504**	**0.00133**	**-0.00375**	**0.00154**	**-0.00587**	**0.00167**		
R^2	0.521		0.5269		0.5571			
Adj R^2	0.5202		0.5262		0.5564			
Within R^2	0.1125		0.0973		0.0754			
n	39880		39880		39994			
AIC	323762.6		325861.2		324008.0			
BIC	324304.0		326402.6		324549.6			
Log. Lik.	-161818.3		-162867.6		-161941.0			
Dependent Variable	RLA_Grade07		RLA_Grade08		RLA_High_School			

Table 4: Regression Results for Math Proficiency Scores and High School Graduation Rates (Sample II with Extra Covariates)

Variable	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Construction_Expenditures	**0.00103**	**0.00049**	0.00036	0.00096	0.00014	0.00088	0.00124	0.00134
Lagged_Construction_Expenditures	-0.00032	0.00041	0.00235	0.00143	**0.00222**	**0.00085**	0.00062	0.00047
Construction_Stock	0.00008	0.0002	**-0.00056**	**0.00006**	**-0.00064**	**0.0001**	**-0.00059**	**0.0002**
Land_Building_Stock	-0.0008	0.00046	-0.00078	0.00082	-0.00104	0.00078	-0.0019	0.00105
Equipment_Stock	**-0.00202**	**0.00106**	-0.00039	0.00024	-0.00037	0.00035	-0.00009	0.00052
INT_Construction_Expenditures	-0.00095	0.00073	0.00053	0.00154	0.00066	0.00141	-0.00079	0.00221
INT_Lagged_Construction_Expenditures	0.00038	0.00057	-0.00386	0.00207	**-0.00349**	**0.00127**	-0.00102	0.00066
INT_Construction_Stock	0	0.0003	**0.00096**	**0.00008**	**0.00105**	**0.00015**	**0.00096**	**0.00029**
INT_Land_Building_Stock	**0.00157**	**0.00078**	0.00142	0.00136	0.00168	0.00128	**0.00311**	**0.00162**
INT_Equipment_Stock	0.00223	0.00137	0.00051	0.0004	0.00068	0.00044	-0.00004	0.00076
Property_Tax_Revenue	**-0.00027**	**0.00006**	**-0.0003**	**0.00008**	**-0.00024**	**0.00008**	-0.00009	0.00009
Local_Revenue_Share	**16.12903**	**1.59087**	**17.86895**	**1.34253**	**18.82201**	**0.89765**	**15.99564**	**1.06413**
Federal_Revenue_Share	**-36.06595**	**5.72005**	**-40.81537**	**5.06388**	**-43.34456**	**3.57022**	**-42.61624**	**3.34724**
Instruction_Salary	**0.00204**	**0.00026**	**0.00209**	**0.00038**	**0.00226**	**0.00042**	**0.00214**	**0.00042**
Support_Services_Salary	-0.00064	0.00088	-0.00028	0.00084	-0.00077	0.00107	**-0.00342**	**0.00089**
Percent_White	**24.37022**	**6.47417**	**16.61358**	**2.57489**	**13.26305**	**5.22884**	15.36813	10.23456
School_Administrators	-4.46823	166.42057	50.59846	162.47913	-118.46298	183.08759	6.51971	181.88611
Teachers	-23.33994	20.41942	**-69.36615**	**30.83894**	**-69.30191**	**20.4739**	-15.47813	13.91437
Student_Support_Staff	-54.49682	55.26601	-43.54835	84.91623	-28.93804	69.20324	-108.82653	70.20399
R^2	0.505		0.5285		0.5405		0.5315	
Adj R^2	0.5039		0.5275		0.5396		0.5305	
Within R^2	0.1224		0.1197		0.1265		0.128	
n	30038		30115		30115		30157	
AIC	243440.2		247301.4		248626.0		249158.4	
BIC	243980.3		247841.7		249166.3		249698.8	
Log. Lik.	-121655.1		-123585.7		-124248.0		-124514.2	
Dependent Variable	Math_Grade03		Math_Grade04		Math_Grade05		Math_Grade06	
Estimates with $p < 0.1$ are bolded.								
Construction_Expenditures	**-0.00143**	**0.00051**	0.00043	0.00078			**-0.00079**	**0.00011**
Lagged_Construction_Expenditures	-0.00069	0.00051	0.00144	0.00118			**-0.00114**	**0.00012**
Construction_Stock	0.00031	0.00027	**-0.00054**	**0.00012**	**-0.00022**	**0.00006**	**0.00069**	**0.00005**
Land_Building_Stock	**-0.00279**	**0.00049**	-0.00151	0.00135	**-0.00031**	**0.00013**	**0.00023**	**0.00007**
Equipment_Stock	**-0.00206**	**0.00038**	0.00001	0.00035	0.00001	0.00056	**0.00369**	**0.00066**
INT_Construction_Expenditures	**0.0035**	**0.00077**	0.00087	0.00133	0.00053	0.0004	**0.00121**	**0.00015**
INT_Lagged_Construction_Expenditures	0.00091	0.00072	-0.0027	0.00175	0.00037	0.00025	**0.00167**	**0.00015**
INT_Construction_Stock	-0.00035	0.00041	**0.00091**	**0.00019**	**0.00031**	**0.00008**	**-0.00102**	**0.00008**
INT_Land_Building_Stock	**0.00448**	**0.00085**	0.00244	0.0021	**0.00039**	**0.00018**	**-0.00036**	**0.0001**

INT_Equipment_Stock	**0.00317**	**0.00077**	-0.00051	0.00058	0.00018	0.00097	**-0.00594**	**0.00106**
Property_Tax_Revenue	**-0.0003**	**0.00011**	**-0.00021**	**0.00009**	**-0.00025**	**0.00007**	-0.00001	0.00003
Local_Revenue_Share	**19.07613**	**1.16084**	**19.58708**	**1.08755**	**15.21239**	**1.13921**	**3.7462**	**0.38341**
Federal_Revenue_Share	**-52.34552**	**5.57984**	**-46.57929**	**2.99694**	**-43.42964**	**3.85394**	**-21.31855**	**1.84083**
Instruction_Salary	**0.00273**	**0.00044**	**0.00251**	**0.00043**	**0.00142**	**0.00013**	**0.00072**	**0.00011**
Support_Services_Salary	**-0.00315**	**0.00103**	-0.00029	0.00123	**-0.00465**	**0.00157**	0.00074	0.00052
Percent_White	**21.41069**	**6.87493**	15.14868	9.24985	**18.03552**	**3.34393**	**41.34721**	**2.98497**
School_Administrators	33.941	302.13054	377.98059	389.5062	**-575.75399**	**206.30604**	33.47458	33.74308
Teachers	-41.3648	24.50968	-51.79946	28.97136	**121.57936**	**15.17103**	**-25.73631**	**9.58227**
Student_Support_Staff	-67.00409	71.10045	-93.26766	53.96066	**-351.66582**	**142.71204**	**-38.83122**	**12.25827**
R^2	0.5465		0.555		0.6115		0.333	
Adj R^2	0.5455		0.5541		0.6107		0.3316	
Within R^2	0.1264		0.1153		0.1066		0.0918	
n	30038		30115		30115		30038	
AIC	248031.9		251793.0		253085.3		203191.8	
BIC	248572.1		252333.3		253609.0		203732.0	
Log. Lik.	-123951.0		-125831.5		-126479.6		-101530.9	
Dependent Variable	Math_Grade07		Math_Grade08		Math_High_School		High_School_Graduation_Rate	

Table 5: Regression Results for RLA Proficiency Scores (Sample II with Extra Covariates)

Variable	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
Construction_Expenditures	-0.00043	0.00122	0.00015	0.00084	-0.00016	0.00077	**-0.00191**	**0.00084**
Lagged_Construction_Expenditures	0.00221	0.00144	0.00045	0.00136	0.00111	0.0013	-0.00037	0.00076
Construction_Stock	**-0.00064**	**0.00014**	**-0.0007**	**0.00011**	**-0.0006**	**0.00008**	0.00018	0.00033
Land_Building_Stock	**-0.00132**	**0.00034**	**-0.00276**	**0.00052**	**-0.00212**	**0.00069**	**-0.00339**	**0.00096**
Equipment_Stock	-0.00053	0.00038	**-0.00082**	**0.00036**	-0.00062	0.00036	**-0.0023**	**0.001**
INT_Construction_Expenditures	0.00109	0.00167	0.00017	0.0011	0.00013	0.00099	**0.00352**	**0.00121**
INT_Lagged_Construction_Expenditures	-0.00316	0.00186	-0.00005	0.00193	-0.00082	0.0019	0.00043	0.00114
INT_Construction_Stock	**0.00101**	**0.00017**	**0.00111**	**0.00013**	**0.00091**	**0.00013**	-0.00015	0.0005
INT_Land_Building_Stock	**0.00263**	**0.00064**	**0.00488**	**0.00083**	**0.00363**	**0.00113**	**0.00555**	**0.00159**
INT_Equipment_Stock	0.00048	0.00066	0.00085	0.00052	0.00086	0.00054	**0.00351**	**0.00151**
Property_Tax_Revenue	**-0.00015**	**0.00005**	**-0.00012**	**0.00005**	-0.00011	0.00007	-0.00006	0.00009
Local_Revenue_Share	**16.43185**	**1.90136**	**17.48799**	**1.7731**	**17.61856**	**1.19923**	**14.77363**	**1.60996**
Federal_Revenue_Share	**-40.85985**	**4.72465**	**-44.70781**	**2.77068**	**-43.15356**	**3.35852**	**-39.54346**	**6.10442**
Instruction_Salary	**0.00185**	**0.00029**	**0.00155**	**0.00028**	**0.00181**	**0.00033**	**0.00194**	**0.00036**
Support_Services_Salary	**0.00166**	**0.00064**	0.00085	0.00063	**0.002**	**0.00059**	-0.00106	0.00106
Percent_White	**11.38804**	**3.91227**	4.14262	3.86592	**9.69706**	**3.81178**	15.81799	10.80884
School_Administrators	**-1117.48326**	**283.34762**	**-1270.70253**	**266.19706**	**-1268.31515**	**267.62063**	**-1325.19121**	**381.54362**
Teachers	**48.57692**	**19.18191**	**84.41026**	**26.04681**	1.72373	25.21271	**83.8166**	**13.59433**
Student_Support_Staff	-71.81658	61.27091	-58.96986	61.73362	-19.89807	80.72935	-89.38683	69.77937
R^2	0.5484		0.5431		0.5726		0.5113	
Adj R^2	0.5475		0.5421		0.5717		0.5103	
Within R^2	0.1397		0.1489		0.16		0.1314	
n	30115		30115		30115		30038	
AIC	243193.3		241935.5		240448.0		243759.1	
BIC	243733.6		242475.9		240988.3		244299.3	
Log. Lik.	-121531.7		-120902.8		-120159.0		-121814.6	
Dependent Variable	RLA_Grade03		RLA_Grade04		RLA_Grade05		RLA_Grade06	
Estimates with p < 0.1 are bolded.								
Construction_Expenditures	-0.00039	0.00082	-0.00017					
Lagged_Construction_Expenditures	0.00199	0.00113	0.00158	0.00124				
Construction_Stock	**-0.00072**	**0.00012**	**-0.00072**	**0.00016**	**-0.00034**	**0.00006**		
Land_Building_Stock	**-0.00293**	**0.0005**	**-0.00289**	**0.00069**	**-0.00071**	**0.00011**		
Equipment_Stock	0.00019	0.00014	-0.00007	0.00035	-0.00073	0.00045		
INT_Construction_Expenditures	0.00085	0.00101	0.00115	0.00136	0.00007	0.00042		
INT_Lagged_Construction_Expenditures	-0.00215	0.00174	-0.00205	0.0018	**0.00111**	**0.00017**		
INT_Construction_Stock	**0.00108**	**0.00015**	**0.00113**	**0.00022**	**0.00045**	**0.00007**		
INT_Land_Building_Stock	**0.00495**	**0.00075**	**0.00491**	**0.00103**	**0.00101**	**0.00015**		

INT_Equipment_Stock	**-0.00066**	**0.0003**	-0.00038	0.00057	**0.00145**	**0.00063**		
Property_Tax_Revenue	-0.00008	0.00009	0.00003	0.00006	**-0.00022**	**0.00007**		
Local_Revenue_Share	**17.06406**	**1.07739**	**15.45494**	**1.42259**	**14.61528**	**1.35472**		
Federal_Revenue_Share	**-41.9945**	**2.97035**	**-40.82029**	**3.21805**	**-41.06512**	**4.37889**		
Instruction_Salary	**0.00157**	**0.00038**	**0.00125**	**0.00026**	**0.00105**	**0.00017**		
Support_Services_Salary	**0.00142**	**0.00052**	0.00151	0.00082	-0.00185	0.00129		
Percent_White	**10.22155**	**3.60563**	6.52274	5.70898	**12.07991**	**2.51371**		
School_Administrators	**-991.14989**	**146.93363**	**-773.69785**	**96.20995**	**-861.07653**	**307.64399**		
Teachers	23.60649	24.92551	**63.30742**	**31.47393**	**46.50759**	**22.93402**		
Student_Support_Staff	-30.78316	68.75107	-74.05192	70.94206	-131.75304	88.34895		
R^2	0.5376		0.5219		0.5908			
Adj R^2	0.5366		0.5209		0.59			
Within R^2	0.1437		0.1228		0.1233			
n	30115		30115		30115			
AIC	241928.0		244705.1		240820.9			
BIC	242468.3		245245.4		241344.7			
Log. Lik.	-120899.0		-122287.5		-120347.5			
Dependent Variable	RLA_Grade07		RLA_Grade08		RLA_High_School			

Table 6: Numerical Summary of Main Findings

	Sample I (No interaction effects)		Sample II (Base effects)		Sample II (Interaction effects)	
	category	% of sigma	category	% of sigma	category	% of sigma
			Construction_Expenditures			
lowest			RLA_Grade06	-9.84		
highest	**Math_Grade04**	**2.56**	Math_Grade03	4.99	**Math_Grade07**	**17.69**
	High_School_Graduation_Rate	**-0.67**	High_School_Graduation_Rate	-8.95	High_School_Graduation_Rate	11.19
			Lagged_Construction_Expenditures			
lowest	Math_Grade07	-0.97			**Math_Grade05**	**-15.68**
highest	**RLA_High_School**	**2.97**	**Math_Grade05**	**8.96**	**RLA_High_School**	**4.90**
	High_School_Graduation_Rate	-1.12	High_School_Graduation_Rate	-11.19	High_School_Graduation_Rate	22.37
			Construction_Stock			
lowest	RLA_Grade05	0.10	RLA_Grade08	-3.38	Math_High_School	1.17
highest	Math_Grade07	0.40	Math_High_School	-0.88	Math_Grade07	4.42
	High_School_Graduation_Rate	0.45	High_School_Graduation_Rate	7.83	High_School_Graduation_Rate	-11.19
			Land_Building_Stock			
lowest	Math_High_School	-0.37	Math_High_School	-6.28	RLA_High_School	4.57
highest	RLA_Grade03	1.18	RLA_Grade03	-2.74	RLA_Grade06	28.33
			High_School_Graduation_Rate	2.24	High_School_Graduation_Rate	-4.47
			Equipment_Stock			
lowest	RLA_Grade03	0.68	RLA_Grade03	-8.98	RLA_Grade07	-5.01
highest	RLA_Grade06	2.55	RLA_Grade06	-3.87	RLA_Grade06	18.88
	High_School_Graduation_Rate	2.23	High_School_Graduation_Rate	44.75	High_School_Graduation_Rate	-67.12

Note: Bolded results are the only value or the only two values for a range. When there are multiple findings for the lowest or highest values, one of them is reported.