Analyzing the Effects of School Spending on Student Achievement

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1.0 Abstract

This paper focuses on the impact that school spending has on student achievement. This is done by using expenditure per pupil as a proxy for school spending and standardized test results as a proxy for student achievement. This paper looks at district specific spending and student achievement in Connecticut, Ohio and South Dakota from 2007-2017 as these states give a broad overview of the US educational system. The main takeaway is that school spending has no effect on student achievement in these states challenging the current schools of thought.

1.1 Introduction

School and educational quality has been a hotly debated topic for centuries—especially in the United States. Education is seen a resource that can push societies forward and drive progress over time. The most formative aspect of education is secondary education, as the teenage years is a key turning point in a child's development. Over the last 40 years, secondary education has been an incredibly politicized issue as the US spends the most per pupil of any first world country but is slipping in terms of student achievement[1] (OECD 2012). There is growing concern that educational gap between wealthier and poorer districts is the cause for millions of children to be left behind—leading to worse career and life outcomes[2] (Pfeffer 2016).

There have been many major initiatives in the last 15 years to rectify the problems outlined above. One of the most famous initiatives is the No Child Left Behind (NCLB) law—signed into law by President Bush in 2002. The primary goal of NCLB was to significantly increase the role of the federal government in holding schools responsible in academic outcomes

[1] Programme for International Students Assessment." *OECD*

[2] Pfeffer, Fabian. "Growing Wealth Gaps in Education." *National Poverty Center Working Paper Series*

of their students. However, considerable aspects of the NCLB law were problematic including lack effectiveness in achieving student success, relying too heavily on standardized tests, lack of funding, and narrowing the curriculum[3] (Klein 2017). Another famous initiative is the Common Core State Standard Initiative—a massive program that was focused on creating a set of unified expectations for primary and secondary education across the country. The goal of the Common Core was to build upon NCLB and allow for clear comparisons of student outcomes between different states and explicitly track student academic progress[4] (NPR 2014). Like NCLB there has been strong backlash against Common Core including making it harder for students to advance and graduate, cutting away weeks of class time for test preparation rather than student learning, and taking away from the fun and joy of school itself[5] (Krip 2014).

These initiatives, among many others, caused a huge spike in educational spending. However, despite this spike in spending—there has been no significant increase in student achievement—whether it be graduation rates, standardized test scores, or future wages. Figure 1 is a graph that shows from 1970-2006 there is a massive increase in the inflation-adjusted federal expenditure per pupil but stagnant growth in math, reading, and science scores.

Research Hypothesis

From all the analysis of above, the paper will explore the central reasons for why educational spending has dramatically spiked while student achievement scores have stayed relatively constant. The high level question this paper will be exploring is "*what effect does school spending have on student achievement."* What this means at a broad level is

[3] Klein, Alyson. "No Child Left Behind Overview: Definitions, Requirements, Criticisms, and More." *Education Week*
[4] "The Common Core FAQ." *NPR*
[5] Kirp, David L. "Rage Against the Common Core." *The New York Times*

two-fold—does school spending even have an effect on their students and if so to what degree. In terms of school spending, the focus will be on *total expenditure per pupil* at a district level. Total expenditure is a conglomeration of different spending patterns for a school. In terms of student achievement, the focus will be specifically on student performance on *state administered graduation tests* in a variety different categories including mathematical and reading comprehension performance. This paper in particular will look at expenditures at district level in three different states and what effect it has on the student proficiency levels for the various high school graduation test results.

Sharpening the question above, *"what effect does public school district expenditure per pupil have on the percent of students that pass the high school graduation tests."* Based on the data, the regressions run will better understand the causal relationship and quantify the impact of school expenditure on high school student outcomes. From all of this, the research hypothesis would be "*schools that spend more on education will produce a larger percentage of students that pass high school graduation tests than schools that spend less."*

Overview of Data, Model and Central Findings

The data this paper will be using for the explanatory and dependent variables are specific to statewide educational levels—specifically in three major states: Connecticut, Ohio, and South Dakota. The main reason these states were chosen is based on their current spending patterns per pupil—states that spend well above average (Connecticut), states that spend roughly average (Ohio), and states that spend well below average (South Dakota) as shown in Figure 2 below. For each state, the data used for both the explanatory variable and the dependent variable are organized via district level. This way it is very easy to match the effect that district level spending has on district level outcomes.

At a high level, the data for the explanatory variable is the public district expenditure per pupil data. This encompasses various aspects of school expenditures including teacher salaries, building expenses, transportation fees, staff support spending, administrative pay and various financial support expenditures. The data for the dependent variable is the high school graduation test results for all public districts in each state. In the United States, in order to graduate high school and obtain a GED (General Equivalency Diploma), each state requires students to take and pass tests in mathematics and english language arts (some states require more). Connecticut, Ohio, and South Dakota all administer different graduation tests but with the same objective of earning a high school diploma and ensuring students are ready for the real world. This paper includes multiple years from 2007-2017 to create a panel data set, with the most recent graduation test administered in 2017 and the corresponding data from FY 2016-2017.

The model used is panel data analysis with fixed effects—with a combination of time, district, and state fixed effects. This confirms that the regression analysis holds the average effect of each district, each year, and each state constant. This way effects that are exogenous and unrelated to the research such as parental income, district taxation, cost of living and time specific factors will be fixed and not affect the analysis. The panel constructed will be estimating the graduation test performance for a given district and a given year from that district's total expenditure per pupil in that year.

Multiple models were constructed and analyzed when trying to discern what effect expenditure per public school district has on academic outcomes of high school students. The major takeaway is that total expenditure per pupil at a district level does not have any significant effect on the percent of students that pass the high school graduation tests as shown in Tables 4-6 below. The paper explores changing the different explanatory and dependent variables, changing regression types and models, factoring in confidence intervals but the outcome stays constant—expenditure has no effect on student achievement.

The rest of this paper is split into multiple parts. First discussing where the research fits into the current academic research landscape, then going into depth about the data, methods and empirical strategy, walking through pre-trends and background information about Connecticut, Ohio and South Dakota, exploring the results from an aggregate level and state granular level and finally discussing the implications of the results.

1.2 Literature Review

Over the past 30 years, there has been extensive literature written about different factors that affect student performance including educational spending. The academic research over this time period is all over the place with most studies focused on answering interesting questions rather than building on each other.

Starting in the 1981, Eric Hanushek conducted a study between school expenditures and the achievement of students—mainly focused on primary education. His conclusion is very similar to the conclusion this paper makes that there is no distinct relationship between expenditure and achievement of students. He even takes it a step further by saying reducing class sizes or hiring better teachers will have no effect on student achievement as well (Hanushek, 1981)[6]. In 1989, Hanushek wrote another paper that focused on the variation in school

[6] Hanushek, Eric A. "Throwing Money at Schools." *Journal of Policy Analysis and Management*

expenditure and its effect on student performance. Similar to his first paper, he also finds no effect and even finds no relationship between teacher skill and educational backgrounds or experience (Hanushek 1989)[7]. Both papers conclude that schools need to focus on performance incentives to ensure the teaching quality and growth in student outcomes.

In the 1990s, David Card and Alan Krueger published a series of papers focused on returns to education and how people perform differently based on educational systems. In the paper they co-wrote in 1992, they find that the men that were educated in states with higher quality schools (better student/teacher ratio, relative teacher pay etc.) had a higher return to additional years of schooling[8] (Card and Krueger, 1992). Building on that research, in 1996 they co-wrote another paper that was focused on how school resources affected student earnings particularly focused on race. Their conclusion in this paper is that schools resources did indeed affect student eventual earnings and that predominantly white schools with more resources had better achieving students than predominantly black schools (Card and Krueger, 1996)[9]. These two papers directly rebukes Hanushek's findings during the 1980s that articulated the lack of effect between spending/change in spending on students' performance and future earnings.

In 1999, Krueger wrote another paper that further contradicted Hanushek's findings. In this paper, Krueger analyzed data of over 11,000 students who were randomly assigned to different class sizes from K-3. The paper's findings include that, on average, performance on standardized tests increased by 4 percentile points the first year students attended smaller class and the test score advantage of smaller classes increased by ~1 percentile point per year every

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[7] Hanushek, Eric A. "The Impact of Differential Expenditures on School Performance."*Educational Researcher*
[8] Card, David, and Alan Krueger. "Does School Quality Matter? Returns to Education and the Characteristics of Public Schools in the United States." *The Journal of Political Economy*
[9] Card, David, and Alan Krueger. "School Resources and Student Outcomes: An Overview of the Literature and New Evidence from North and South Carolina." *The Journal of Economic Perspectives*

year after[10] (Krueger 1999). Joshua Angrist and Victor Lavy conducted a similar study with Israel public schools that follow Maimonides rule of having 40 students maximum per classroom. They find that smaller classroom rule lead to a substantial increase in test scores for 4th and 5th grade students[11] (Angrist and Lavy, 1999). Finally in 2014 Peter Fredriksson et. al wrote a paper focused on the long terms effect of class size in primary schools and concluded that smaller classes had a positive effect on future ability as well as better future wages and earnings[12] (Fredriksson et. al, 2013) All three of these paper rebuke Hanushek's (1981) second claim that classroom size has no effect on student achievement. This inconsistency is clear example that the literature in the educational spending space is by no means uniform.

Post 2000s, the literature began to focus on teaching quality as well as school expenditures. A paper written by Hanushek as well as Steve Rivkin and John Kain, analyzed the impact that schools and teachers had on influencing achievement and they concluded that the "effects of a costly ten student reduction in class size are smaller than benefit of moving up 1 standard deviation in the teacher quality distribution"[13] (Haunshek et. al, 2005). This is consistent with Hanushek's earlier papers that articulate the importance of teacher quality over everything else. A paper written by Jackson et. al, finds that 10% increase in per pupil spending on student born between 1955 and 1985 leads to a small increase completed years of education, higher wages, and reduction in poverty. The paper finds that the effects are even greater on children that

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[10] Krueger, Alan B. "Experimental Estimates of Education Production Functions." *Quarterly Journal of Economics*
[11] Angrist, J. D., and V. Lavy. "Using Maimonides' Rule to Estimate the Effect of Class Size on Scholastic Achievement." *The Quarterly Journal of Economics*
[12] Peter, Fredriksson, et al. "Long-Term Effects of Class Size *The Quarterly Journal of Economics*
[13] Hanushek, Eric, et al. "Teachers, Schools, and Academic Achievement."*Econometrica*

were from low income families[14] (Jackson et. al, 2015). This paper again rebuke the earlier findings that spending doesn't affect achievement determined by Hanushek in 1991.

This lack of consistency and conclusion in literature despite certain trends over the years is where this paper will come in play. This paper focuses on an important issue at hand—should the government create policies that affect school spending and does that directly and/or indirectly affect student success. Right now a large amount of the literature is focused on either national or local spending patterns, this paper focuses on statewide educational spending patterns. In addition, this paper's goal is to resolve the inconsistencies of the literature by clearly articulating the effect school expenditure has on student academic achievement when it comes to performance on standardized testing—an easily quantifiable dependent variable. This paper will address that new aspect by regressing the overall expenditure on standardized tests results and explore the true source of educational inequity. This paper adds to the existing literature by providing a unique take on a very common question and can get glimpse into how school spending directly affect student potential and success.

1.3 Models, Methods, and Data

Explanation of Data

As mentioned above, the goal of the paper is to learn more about *"what effect does public school district expenditure per pupil have on the academic outcomes of high school students."* This is to understand how spending in schools affects students performance and guide policymakers to understand the importance of school financing on educational development. Just to reiterate, the explanatory variable is the public district per pupil data from 2007-2017 and the

[14] Jackson, C. Kirabo, et al. "The Effects of School Spending on Educational and Economic Outcomes: Evidence from School Finance Reforms."*NBER*

dependent variable are the percent of students that pass the graduation tests for all public districts in each of the three states from the same time period. The most recent graduation test of March 2017 and the corresponding data from FY 2017 match with each other and so on.

As stated above, this paper focuses on three key states: Connecticut, Ohio, and South Dakota. These states were chosen based on their current spending patterns per pupil. According to research conducted by the United States census bureau, these three states vary dramatically in average total expenditure per pupil. In FY 2013, Connecticut spent (on average) $14,702.42 per pupil, Ohio spent (on average) $9,968 per pupil, South Dakota spent (on average) $7,217 per pupil while the United States spent (on average) $10,700 per pupil as shown in Figure 2[15] and Table 1.

From this research, the paper breaks these three states into three distinct segments—states that spend well above average (Connecticut), states that spend roughly average (Ohio), and states that spend well below average (South Dakota). For each state, the data found for both the explanatory variable and the dependent variable are organized via district level. This way it is very easy match to the effect of district level spending on district level student outcomes for each particular state. Table 1 below gives an overview of the spending patterns of the three states from 2007-2017 recorded during the time span. Connecticut has consistently higher numbers each year than either Ohio and South Dakota. Table 2-3 give an overview of the percent of students that pass the state sanctioned graduation test for both math and reading respectively. Ohio has slightly better numbers than Connecticut despite spending less per student. That being said, South Dakota is significantly worse than either state and spends significantly less than both.

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[15] "Public Education Finances: 2013". *United Census Bureau*

The data found for the explanatory variable is from a variety of sources each pulled from the three different states. The data for school funding in Connecticut is from the *Connecticut Public School District Spending per Student Reports*[16]. This data is strictly expenditure focused that contains a conglomeration of different aspects such as total expenditure, instructional, operational, and student support expenditures. The data for district funding for Ohio is from the *Ohio District Profile Reports*[17]. This data includes school demographic data, faculty and staff personnel data, property valuation and tax data, expenditure data, revenue data and financial status for all districts. Finally, the explanatory district spending data for South Dakota is from the *South Dakota Annual Finance Report.*[18] The annual finance report has total expenditure per district as well the general fund balance, impact aid, capital outlay fund balance, and special educational spending for each South Dakota school district. Since these three data sources have a number of different factors and inputs, when combining into one aggregate data source—the only input that was consistent and considered for final analysis was total expenditure per pupil. The analysis conducted below will only look at total expenditure per pupil per district in all 3 states.

The data found for the dependent variable is a collection of the different graduation test results and is organized via district. The data for Connecticut comes from the *Connecticut Academic Performance Test.* For each year, the dataset states the percent of 10th graders that pass four different standardized tests—reading, mathematics, writing, and science[19]. The data for Ohio comes from the *Ohio Graduation Test (OGT)* results. For each given year, the dataset states

[16] "Connecticut Public School District Spending Per Student". *Connecticut School Finance Project*
[17] "District Profile Reports (Cupp Report)." *Ohio Department of Education*
[18] "School Finance." *Fund Balances - SD Department of Education*
[19] "State by District/School Report." *CAPT Data Interaction (Public)*

the percent of 10th graders that pass five different standardized tests—reading, mathematics, writing, science, and social studies.[20] Finally, the data for South Dakota comes from the *South Dakota School Performance Index.* The school performance index details the performance of 11th graders on mathematics, reading (english language arts) graduation tests as well other high school statistics. The dataset doesn't explicitly mention the percentage of students that pass the mathematics and english language arts graduation tests but it can be calculated using their district assessment methodology[21]. Because of this, the analysis conducted below only looks at the percent of students that pass the math and reading graduation tests per district in all 3 states.

The dataset used to conduct the analysis is a combination of the total expenditure data for all the districts in each of the three states as well as the total percent of students that pass the reading and math graduation tests per district in these states. There are a variety of different shortcomings of data outlined above. The most pressing shortcoming is the lack of reliability of the data. This is due to the fact that for each state there are separate data sources for spending and student performance. Furthermore the data sources between states are inconsistent and not standardized for either expenditure or achievement. Finally, the South Dakota data is inconsistent as the testing methodology changed from 2013-2015 as the data collected was scored and procured differently. This doesn't have a large effect on the primary analysis of this paper but does impact the South Dakota specific regressions mentioned below.

Empirical Strategy

As mentioned above, the empirical strategy and primary model this paper will be using is panel data analysis with fixed effects. In order to eliminate the effects of district, state, and

[20] "Ohio Graduation Tests (OGT) Assessment Results." *Ohio Department of Education*
[21] "Accountability: School Performance Index." *SD Department of Education*

time—the paper will be using district fixed effects, time fixed effects, as well as state fixed effects. Since using state fixed effects would be redundant with district fixed effects (no two districts overlap in multiple states), the paper multiplies the different state dummy variables with the year. This gets the different state specific trends over time and removes it from our regression coefficient. The first set of dummy variables will be for each district which will amount to around 800 district specific dummy variables, $Dist_d$. The second set of dummy variables, $Time_t$, will be for each time period will amount to 11 time specific variables from 2007-2017. The third set of dummy variables, $State_s$, will amount to 3 different state specific variables for each of the three states. Again, in order for this dummy variable to provide value, this paper multiplies it by the year giving the state specific effects over time. Finally, this paper will use log transformation of the expenditure data per pupil. This is for consistency with the dependent variable which is measured in percentage (percent of students that pass the math/reading graduation tests). Please see the primary model equation below:

$$\boldsymbol{Student\_Achievement_{dst} = \beta_0 + \beta_1 \ln(Total\_Expenditures_{dst}) + \Theta_d(Dist_d) + \ldots + \gamma_t(Time_t) + \ldots + \lambda_s(State_s) \times Year + \ldots + u_{dst}}$$

The primary model equation above estimates the percent of students that pass a graduation test (either math or reading) in a specific district d, specific state s, and a specific time t. The β_1 coefficient is the key coefficient in question. When total expenditure per pupil increases by one percent, the percent of students that pass that particular graduation test increases by β_1 percent. Below is a complete key of the other components of the regression.

- ***Student_Achievement$_{dst}$*: *Estimating achievement in district d state s at time t***
- ***β_0* : *intercept term***
- ***β_1*: *effect that school expenditure for district d in state s at time t***

- ***ln(Total_Expenditures$_{dst}$) :*** *natural log of the expenditure per pupil in district d in state s at time t*
- ***Θ_d :*** *effect of dummy variable for district d in state s at time t [need one for all districts]*
- ***Dist$_d$:*** *dummy variable for district d in state s at time t [need one for all districts]*
- ***γ_t :*** *effect of dummy variable for time t [need one for all years]*
- ***Time$_t$:*** *dummy variable for time t [need one for all years]*
- ***λ_s:*** *effect of dummy variable for state s [need one for all states]*
- ***State$_s$:****dummy variable for state s [need one for all years]*
- ***Year :*** *year in question from 2007 - 2017 [not a dummy variable]*
- ***u_{dst}:*** *error term*
- ***[…] :*** *need a dummy variable for every district time,and state * year when doing analysis*

This methodology above makes sure that there is a comprehensive answer to the question of how does total expenditure per pupil affect student achievement without other confounding variables and factors.

To ensure that there is strong indicator data, this paper also goes through multiple modified version of the primary model outlined above—namely estimating the student achievement on the log total expenditure per pupil only using time and district fixed effects. In addition, the above regressions are run again on total expenditures per pupil not log transformed. This adds more color to the analysis and allows for more variability in the district and time components respectively. See the equations below for time fixed effects and district fixed effects respectively:

1. $Student\_Achievement_{dst} = \beta_0 + \beta_1 \ln(Total\_Expenditures_{dst}) + \Theta_d(Dist_d) + \ldots + \gamma_t(Time_t) + \ldots + u_{dst}$
2. $Student\_Achievement_{dst} = \beta_0 + \beta_1 (Total\_Expenditures_{dst}) + \Theta_d(Dist_d) + \ldots + \gamma_t(Time_t) + \ldots + \lambda_s(State_s) \times Year + \ldots + u_{dst}$
3. $Student\_Achievement_{dst} = \beta_0 + \beta_1 (Total\_Expenditures_{dst}) + \Theta_d(Dist_d) + \ldots + \gamma_t(Time_t) + \ldots + u_{dst}$

In addition, the paper will be playing around with a different type of model called the first differences model. The first difference model regresses the yearly change in student achievement (aka passing rate) for a given district on the yearly change in total expenditure per pupil for that particular district. This model is another way to better understand the effects that public expenditure at a district level has on passing rate of students. This paper explores two variants of the first differences model in order to assure complete robustness of the data. The first variant is the model with no fixed effects, and the second variant has the state only fixed effects to remove the state specific trends. The equations for the two variants are below respectively:

1. $\Delta Student\_Achievement_{dst} = \beta_0 + \beta_1 \Delta(Total\_Expenditures_{dst}) + u_{dst}$
2. $\Delta Student\_Achievement_{dst} = \beta_0 + \beta_1 \Delta(Total\_Expenditures_{dst}) + \lambda_s(State_s) + u_{dst}$

The goal of this paper is to understand how school expenditure affects student achievements which is why it iterates through a wide array of combinations. The control variables are the different fixed effects for both time and district. By setting up the research design in this format, it best ensures that the results are causal rather than correlation based as the threat of omitted variable bias is removed. Potential weaknesses in the identification strategy include the fact that there are myriad of factors that affect school spending and student outcomes such as overall wealth of district residents, tax revenue spent on school development, property valuation around the area, and quality of teaching. These components can cause the conclusions read from the data to be not as strong as one would like.

1.4 Background Information and Pre-Trends

In addition to these three states being in different spending categories, these states are on very different educational trajectories. Before presenting the overall analysis, this paper will be going through background information for Connecticut, Ohio, and South Dakota. This will include going through the key issues each state faced in education.

During the 2000s, Connecticut was one of the strongest performing states in education but among the worst in the achievement gap. In 2007, ⅔ of the students in elementary schools met the state goals for the Connecticut Mastery test. However, when looking into the data, only ⅓ of black, hispanic, and low-income students met the state goals. This shows that the gap between minorities and the white middle class was significant as a majority of the students falling behind in student achievement were minorities. This gap was exacerbated in middle school where middle class white students outperformed their low income minorities twice as much as they did in elementary school. Although Connecticut was leading the nation in student performance, there is clear achievement gap between poor and non-poor. During this decade—Connecticut ranked dead last in the United States in the achievement gap between poor and non-poor students[22].

Ohio, on the other hand, was going through comprehensive overhaul of its education system during the 2000s. In 2006, Ted Strickland (D) was elected governor—the first time in 12 years a democrat won. One of Strickland's biggest priorities was to fix school funding and student achievement in Ohio schools. In June of 2009, the Ohio legislature passes his comprehensive education reform bill including mandating staffing inputs at building level, the introduction of new academic standards and state testing, changing the licensing rules for state appointed teachers, funding based on inputs, lowering student teacher ratio, all day kindergarten, and revising academic standards[23]. In 2010, Ohio adopted the federally produced Common Core standards—revamping its educational system for the second time in three years. These two

[22] "The State of Connecticut Public Education". *Great Schools for All ConnCAN*
[23] "Buckeye Education in Review: 1999 to 2009." *The Thomas B. Fordham Institute*

initiatives were the culmination of a decade long revamp of the Ohio educational system to make it more competitive with the elite coastal schools.

Finally, South Dakota was spiraling in the opposite direction of Connecticut and Ohio during this decade. Shown in the Figure 3, South Dakota invested 37% of their general fund into state aid for K-12 education and by 2014 it had plummeted to 27%. This 10% drop was a result of the "no real-growth" funding formula introduced in the 1990s. This formula caused the level of investment in K-12 education to stagnate at the same inflation adjusted level for over 15 years. Because school funding in South Dakota failed to keep up with the rest of the United States, South Dakota students suffered. In 2003, South Dakota 4th graders scored above the nation's average in reading and by 2013 only 32% of 4th graders were even proficient in reading[24] (Smolnisky 2015). Now, South Dakota's expenditure per pupil is towards the bottom in the United States with no brighter future in sight.

1.5 Aggregate Results and Discussion

Overview of Results

As mentioned above when trying to understand the results, multiple different models were run trying to determine what effect and correlation expenditure per pupil had on the educational outcomes of high school students at a district level. The different models analyzed include multiple fixed effects, dual fixed effects, singular fixed effects, log transformed explanatory total expenditure per pupil, first differences, and first differences with fixed effects. The reason multiple models were run was to truly certify that the results were consistent and correct. The takeaway from the different models is that school expenditure has no effect on the

[24] Smolnisky, Joy. "Portion of SD State Taxes Dedicated to K-12 Education Drops by 25% in Last 10 Years". *South Dakota Budget & Policy Institute*

percent of students that pass the graduation tests. No matter the model, the results seem to be consistent that there is no effect. See Table 4-6 below for more information about the results.

Model 1: ***Estimating percent pass via log expenditure w/ fixed effects for district, time, state/year***

In this paper's primary model, the paper is regressing the percent of students that pass the math and reading tests on the log transformation of the total expenditure per pupil of each district. The fixed effects for this regression include time, district, and state * year. The goal of this model is to tell what effect a one percent increase in spending has on the percent increase in both the math and reading scores. This model is the basis of the empirical strategy for the paper and removes the exogenous effects that are specific to the given year, district, and state. Model 1 gives the most robust and comprehensive answer to the paper's research question of the effect spending has on student outcomes.

As shown in Table 4, the model shows that expenditure has an extremely small effect on both the percent of students that pass either the math or reading graduation tests. For the math graduation tests, there is a 0.135% increase in the percent of students that pass the tests for every one percent increase in total expenditure per pupil. For the reading graduation tests, there is a -0.3273% decrease in the percent of students that pass. The result, despite being slightly negative, is the same as the effect on the math graduation tests where expenditure has an extremely small negative effect.

Together, these two regressions distinctly portray how little correlation total expenditure per pupil has on students passing the graduation tests especially when removing the effects that are unique to the year, district, and state. Even when looking at the 95% confidence interval, the results are still within a 2-3% magnitude. This outcome is surprising as conventional wisdom would think that spending more would be better performance but for these districts in this time period—that is not the case.

Model 2: ***Estimating percent pass via log expenditure w/ fixed effects for district, time***

In the second model, the paper is again regressing the percent of students that pass the math and reading tests on the log transformation of the total expenditure per pupil. The fixed effects for this regression, however, are only time and district. This model is very similar to the first model but takes out state specific effects as it can be argued that the district fixed effects absorbs those effects.

As shown in Table 4, the model shows a small effect that expenditure has on the percent of student passing either the math or reading graduation tests—albeit a greater effect than Model 1. For the math graduation tests, there is a 1.461% increase in the percent of students that pass for every one percent increase in spending. For the reading tests, there is a 0.077% increase in the percent of students that pass.

Similar to Model 1, the regressions run yield a surprising result that total expenditure per pupil has little to no effect on the percent of students passing the graduation tests despite removing the state fixed effects. Here the 95% confidence interval is actually slightly larger than Model 1 with a 3-5% magnitude—still a very small interval. This conclusion, similar to Model 1s, goes against the thought that spending more means more success.

Model 3 & 4: ***Estimating percent pass via expenditure w/ fixed effects***

In the third and fourth model, the paper now regresses the percent of students that pass the math and reading tests on the discrete value of the total expenditure per pupil of each district as the log transformation of the explanatory variable could be skewing results. Model 3 has fixed effects for time, district, and state * year while Model 4 has fixed effects for time and district only. These models are very similar to Model 1 and 2 respectively but instead of regressing on the log transformation of expenditure, the models regress on the discrete expenditure value. That means for the results, the coefficients explain the effect that spending $1 has on the percent of students that pass the graduation tests.

As shown in Table 5, Model 3 and 4 show an even smaller effect that spending has on the percent of student passing. For Model 3, there is a 0.00003% increase in the percent of students that pass the math graduation tests for every $1 increase while for Model 4, there is a 0.0003% increase. The results are no different on the percent of student passing the reading graduation tests. For Model 3, there is a -0.00003% decrease while for Model 4 there is a 0.00003% increase.

These results are even more striking than results found in Models 1 and 2 as the coefficients are as close to zero as possible with 95% confidence interval ranging from zero to zero. This precision despite having over 4000 data points being run in the regressions means that the results are truly zero and these models further proves the outcome that the expenditure does not have an effect on student achievement.

Model 5 & 6: ***First Differences—Estimating change percent pass via change expenditure***

To ensure the results are consistent with the first four models, the paper uses a different model type called the first differences for Models 5 and 6. The first difference model regresses the yearly change in the percent of students that pass a given graduation test on the yearly change in total expenditure per pupil for that district. Model 5 has no fixed effects while Model 6 has state specific fixed effects. That means for the results, the coefficients explain the effect of increasing the yearly change in spending by $1 has on the percent change of students that pass the graduation tests.

As shown in Table 6, Model 5 and 6 also show a minimal effect that increasing the yearly change in spending by one unit has on the yearly percent change of student passing the math graduation tests. For Model 5, there is a 0.00004% increase in the percent of students that pass the math graduation tests and for Model 6, there is a -0.0006% decrease in the percent of students that pass the math graduation tests. There is no difference for the reading graduation tests. For Model 5, there is a 0.0006% increase while for Model 6, there is a 0.005% increase in the percent.

Despite the setup of Model 5 and 6 being vastly different—the outcome is the same. There appears to be no correlation that expenditure has on student achievement and the performance of students on the different graduation tests—both math or reading. Even when taking into account the 95% confidence interval, the yearly change in spending has no correlation with yearly change of percent of students passing. This result is consistent with the other models but also achieve the surprising result of no correlation.

Robustness Checks

The biggest potential problems critics can pose is that the data is too nuanced and that the models above aren't comprehensive enough and don't include multiple other factors. To check for robustness and combat this critique, the paper explores a variety of different regressions outlined below. The robustness checks give the same results as the regressions above—expenditure has no effect on student achievements. The different robustness checks ran are below:

1. Regressing the percent of students that pass the graduation tests on log transformed total expenditure per pupil
   - Using district and year & state fixed effects
   - Using time and year & state fixed effects
   - Using year only fixed effects
   - Using district only fixed effects
   - Using no fixed effects

2. Regressing the percent of students that pass the graduation tests on discrete total expenditure per pupil
   - Using district and year & state fixed effects
   - Using time and year & state fixed effects
   - Using year only fixed effects
   - Using district only fixed effects
   - Using no fixed effects

Discussion

The results suggest that school expenditure has no effect on student achievement. No matter how the model is constructed via multiple, dual, singular fixed effects, log transformation of expenditure or first differences—the outcome is the same. Again, this analysis is limited to the effect of how much a school spends per pupil on student achievement outcomes from 2007-2017 in Connecticut, Ohio and South Dakota public school districts. This result is surprising, as the common sentiment and literature all believes that schools that spend more have students that perform better. However, education is complex and standardized tests are hotly debated if they are best indicator of success. There are variety of drawbacks to these tests including catering a certain student type, irrelevant material and not a comprehensive enough success metric. Student achievement can be affected by a variety of other factors such as graduation rate, college matriculation rate, average income after graduation, etc. In addition, the school spending metrics could be a bit flawed as they don't tell the whole story of school quality. Other school quality factors include teaching quality, school environment, parental influence & pressure, classroom technology & size and overall internal student motivation. Because of these limitations and drawbacks, the conclusions drawn above must be taken with a grain of salt and researched further.

1.6 State Specific Results and Discussion

State Specific Regressions & Analysis

While there might be no concrete conclusion when looking at the data as an aggregate above, the next step is to examine the results at a state level. By looking at the state level, this paper will better understand if the effects are state specific or county wide. These individual regressions will help solidify the finding that no matter the location—spending has no direct effect on student achievement levels. This paper runs a modified version of Model 2 on each state specifically and the results are below for each state—Connecticut, Ohio, and South Dakota—as shown in Table 7.

In Connecticut, for the math graduation test there is a -5% decrease in the percent of students that pass for every one percent increase in spending. In reading, there is a 0.87% increase for the same metric. Ohio, on the other hand has a -1.1% decrease in the percent of students that pass the math graduation test and a -0.2% decrease in the percent of students that pass the reading graduation test. South Dakota is on the opposite extreme where there is a 12% increase the percent of students that pass the math graduation test for every one percent increase in spending but a -1.5% decrease for the reading graduation test.

This inconsistency in the data for these three state is puzzling and doesn't tell a clear picture of what the effects are. Having strong positive and negative correlations for the same state but different tests is a better indication that the data specifically at the state level is non-robust and incomplete. In addition, despite the large positive number of the South Dakota math graduation test coefficient, the South Dakota data is inconsistent as the testing methodology changed from 2013-2015 as the data collected was scored and procured differently. Therefore the analysis conducted isn't strong enough to tell the complete story of what the true effects of spending on student achievement.

State Specific Trends & Discussion

In addition to performing linear regressions, the paper examines the state data at a high level to discern any trends. The paper looks at the average expenditure over time per state and compares it to the average percent of students that pass the different graduation tests also per state. Since the Connecticut and Ohio datasets have more information about student testing—the paper explores the change in the average percent of students that pass the graduation tests in other subjects such as science, writing, social studies in addition to the math and reading graduation tests used for analysis above.

In Figure 4 below, Connecticut's average total expenditure per pupil has been steadily increasing from 2007 to 2013 going from under $12k per pupil in 2007 to over $14.5k per pupil six years later. However as shown in Figure 5, there is no effect on the results of any of the graduation tests. Each graduation test has both increases and decreases from year to year. For example, the average percent of students that pass the reading graduation tests went up from 2007-2008, fell from 2008-2012, and went up from 2012-2013 despite Connecticut spending more per pupil every year. The same here goes for the other graduation tests as there is no clear correlation between spending more and performing better on the graduation tests.

On the other hand, there is a strange pattern in Ohio's average total expenditure as shown in Figure 6 below. From 2011 to 2012, Ohio's average total expenditure per pupil being roughly constant. Then, in 2013, due to budget constraints, that number dipped by roughly $200 per pupil. In 2014 and 2015, the number spiked to over $10.4k per pupil. While spending was all over the place from 2011-2015, the percent of students that passed the Ohio graduation tests were not. Looking at Figure 7 below, the average percent of students that pass the different graduation tests is roughly constant if not slightly declining despite the erratic nature of the spending data. For example, although the expenditure per pupil jumps by over $600 per pupil from 2013 to 2014—the performance on all five exams only slightly increases and actually decreases in 2015 despite a similar spending amount. The same goes for the individual graduation tests as there seems to be no clear correlation between spending less, more, or the same on the performance on these tests.

Finally, the opposite pattern is occurring South Dakota. As shown in Figure 8 below, South Dakota's average expenditure per pupil increase dramatically from roughly 7k in 2013 to over 8.5k in 2017 (no measurement in 2014). Despite that, as shown in in Figure 9, that the percent of students that passed the math and english graduation tests in this time dropped dramatically. This is surprising as this directly contradicts common sentiment, the research hypothesis that spending more per pupil improves student outcomes and even the state specific regression above. The only reason that this graph isn't strong enough to prove the opposite correlation—spending more per pupil lowers the achievement outcome is because of the change on research methodology from 2013-2015. Because of this, there isn't enough evidence to prove the reverse causality but enough evidence to disprove the research hypothesis of positive correlation in terms of South Dakota specifically.

In conclusion of this section, even when analyzing the states separately—the outcome is the same. For this time period, these specific states, and these given total expenditure per pupil and graduation test passing rates—total expenditure per pupil has *no effect* on student achievement. While this conclusion is not different than the conclusion determined in section 1.5, it confirms the findings found for the aggregate dataset. This careful examination of the data at state level also confirms that this phenomenon is not state specific and that each state has roughly the same outcome as the general aggregate dataset.

1.7 Conclusion

The goal of this paper is to explore the key drivers of educational success and what implications it has on policy development. More specifically, the paper focuses on student achievement and how school expenditure drives student success. The data the paper uses are specific to the educational level found in three distinct states—Connecticut, Ohio, and South Dakota. The explanatory variable is the public district expenditure per pupil data. The dependent variable is the percent of students that pass the math or reading graduation tests for all public districts in these three states. This paper also includes multiple years from 2007-2017 to create a panel data set and provide more robust results.

The model this paper uses is panel data analysis with fixed effects— time, district and state fixed effects. This way obtains the true effect of expenditure on student achievement as the paper holds the average of each district and year constant. The analysis also holds state specific effects constant to confirm that the model only encompasses the effect that expenditure has on achievement. Because of this, the paper multiplies the state specific dummy variables by the year to ensure these effects get picked up and are not masked by the district fixed effects. The paper uses a variety of different models including multiple fixed effects, dual fixed effects, singular fixed effects, log transformed explanatory total expenditure per pupil, first differences, and first differences with fixed effects. This confirms consistent results and that the analysis is robust.

The key result of this paper contradict the initial hypothesis that schools that spend more on education produce more successful students. Instead, the results show that school expenditure does not have any significant effect on academic outcomes of students no matter what combination of variables used or the model in question. This result was tested by the combination of models and variables and went through different rounds of analysis before the conclusion that total expenditure per pupil has no effect on student achievement. This could be due to a litany of reasons such as the complexity of education as well as qualitative factors such as teaching quality, school environment, parental influence & pressure, classroom technology & size and overall internal student motivation. This result is further analyzed even when looking at state specific regressions. Despite inconsistent results at a state level regression wise, when exploring the data it is clear there is no correlation between expenditure per pupil and performance on the graduation tests.

That being said, there are many limitations to the research above including the explanatory variable of school expenditure and dependent variable of graduation test results. Further research needs to look into a variety of directions including looking for different explanatory factors. This can include overall wealth of the school district, school revenue, school taxation, teaching quality, technological capabilities etc. This way research can best understand the true factors that push student success and explore them more concretely. Further research needs to broaden the definition of student success as well. This can include graduation rates, college matriculation, average starting salary etc. The definition of success is nuanced and must be explored further to truly understand if students are “better off.” This definition will always be subjective and up for debate but hopefully as more research is conducted—academics can come to a consensus. Finally, to build off this paper’s methodology, further research should dive into a broader time-span greater than 2007-2017 and states other than Connecticut, Ohio, and South Dakota to truly gauge what effect school spending has on student achievement.

Research Figures:

Figure 1:

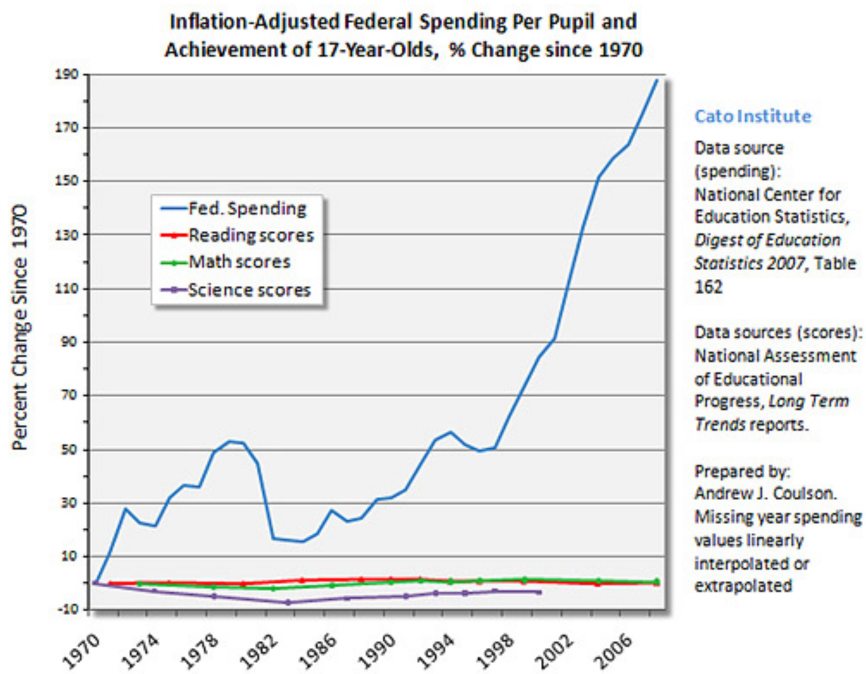

Figure 1: Educational Spending and Student Achievement 1970-2006

Figure 2:

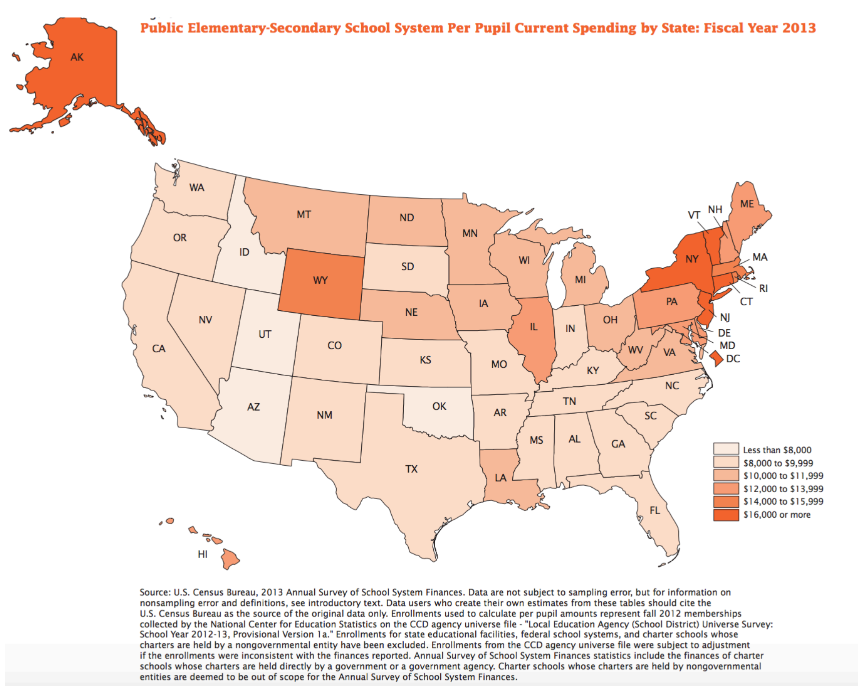

Figure 2: FY 2013 School System Spending per pupil by State

Figure 3:

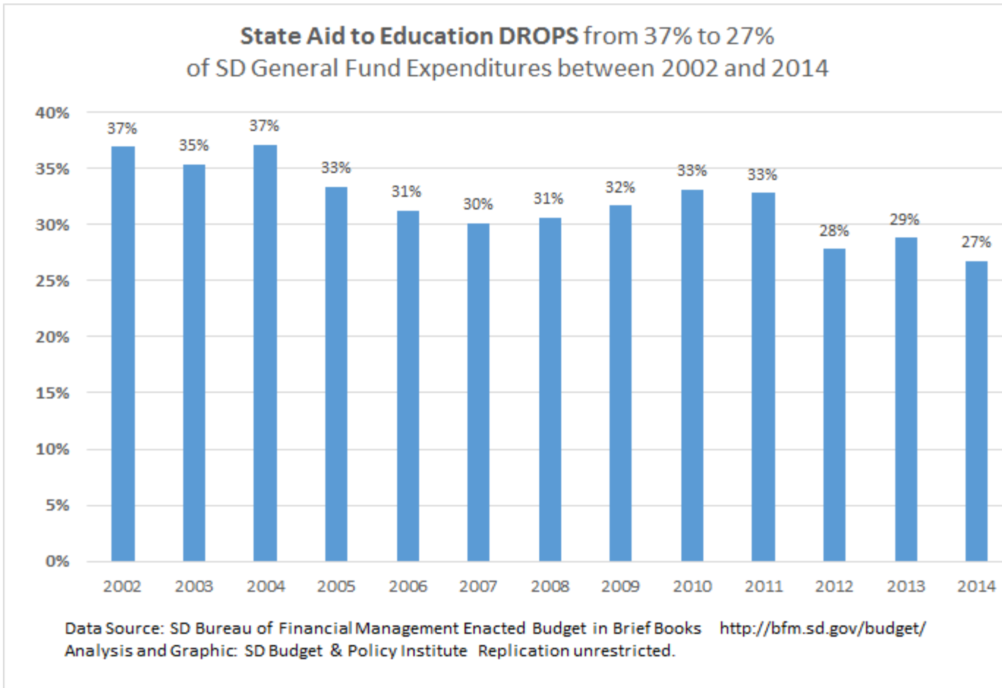

Figure 3: South Dakota state aid to K12 education 2002-2014

Figure 4:

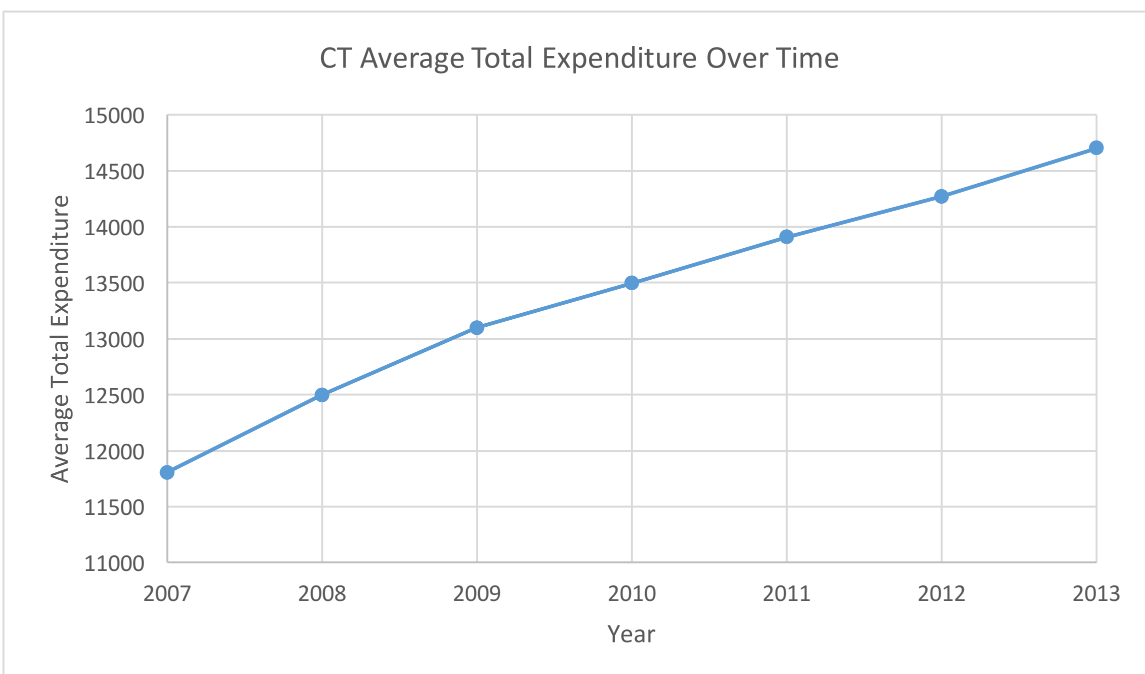

Figure 4: Average Expenditure per pupil in Connecticut 2007-2013

Figure 5:

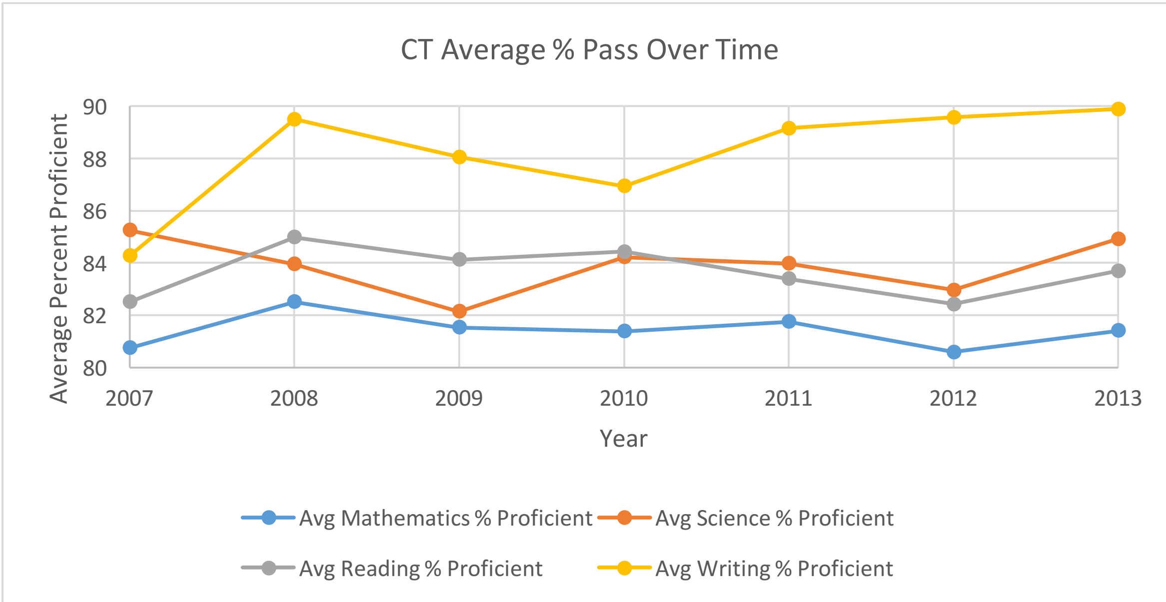

Figure 5: Average passing percentage Connecticut graduation tests 2007-2013

Figure 6:

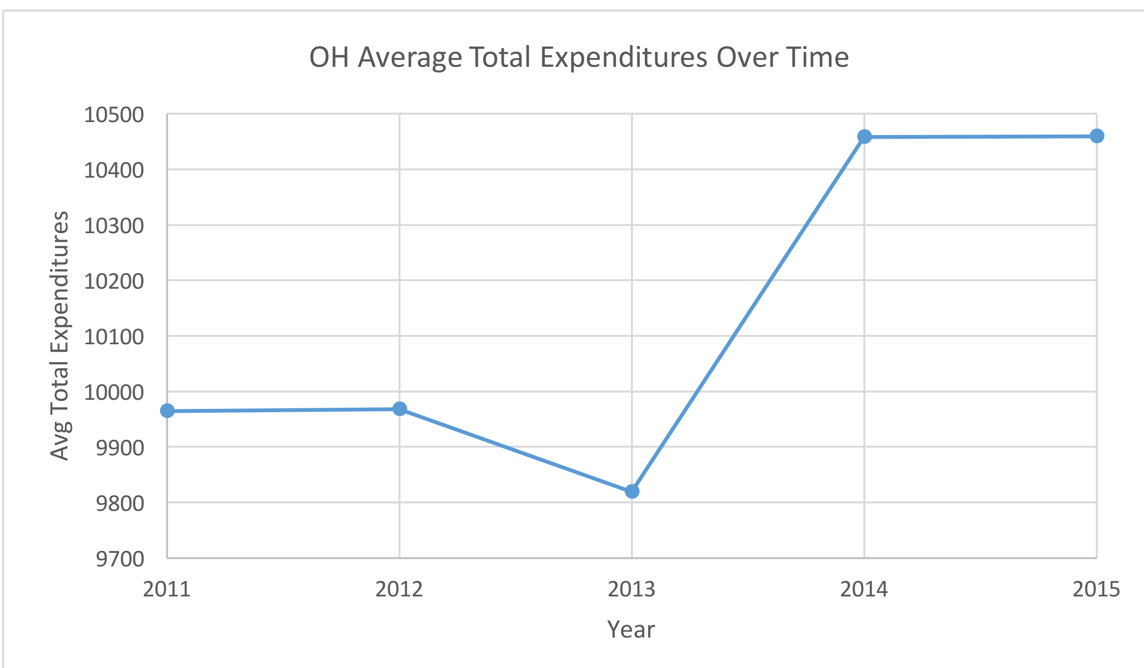

Figure 6: Average Expenditure per pupil in Ohio 2011-2015

Figure 7:

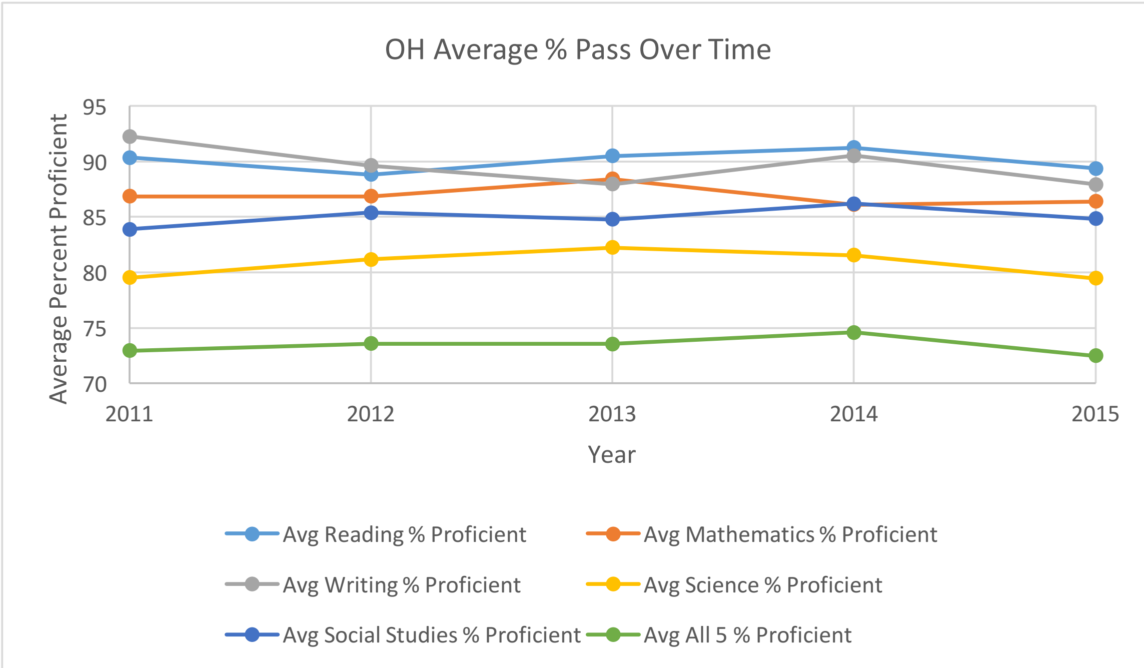

Figure 7: Average passing percentage Ohio graduation tests 2011-2015

Figure 8:

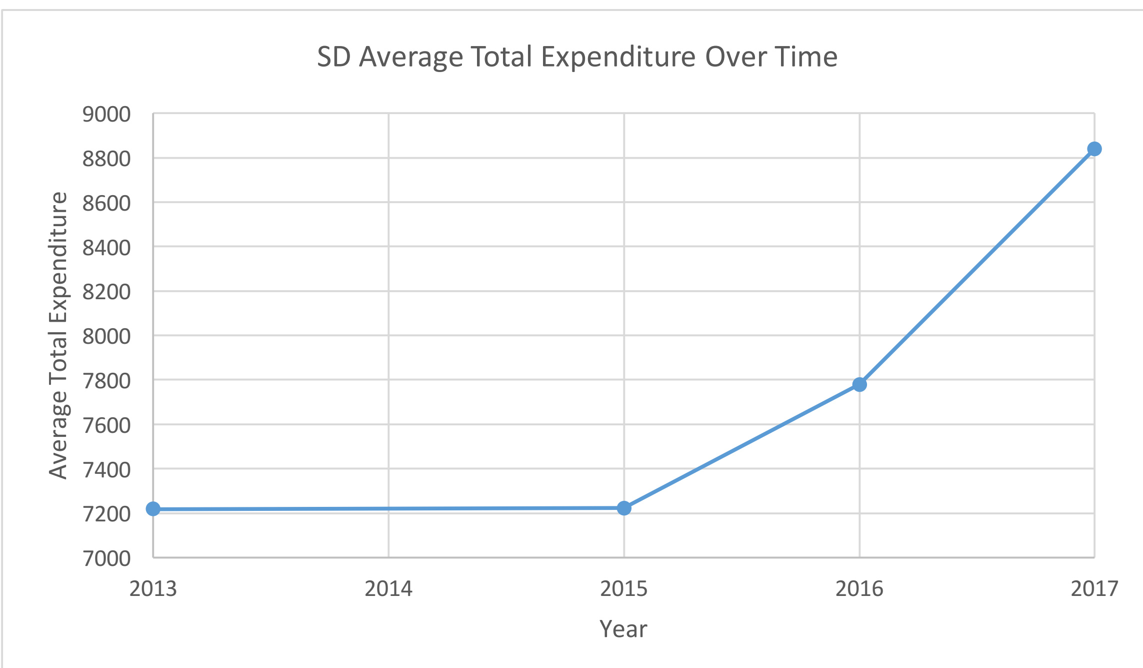

Figure 8: Average Expenditure per pupil in South Dakota 2013, 2015-2017

Figure 9:

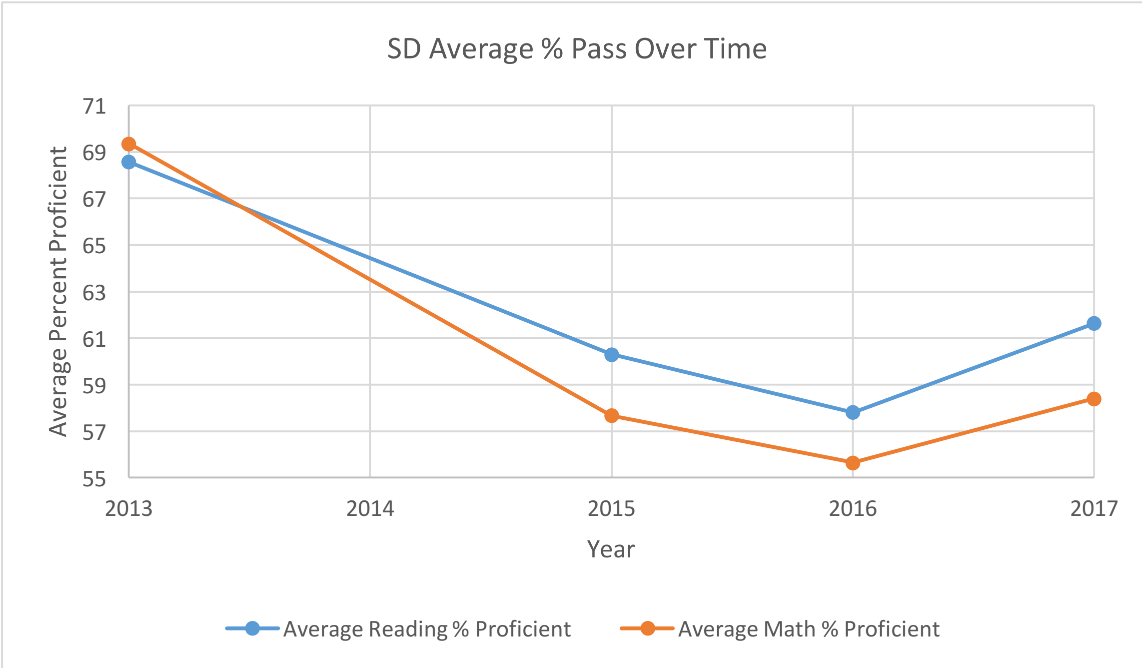

Figure 9: Average passing percentage South Dakota graduation tests 2013, 2015-2017

Data Tables:

Table 1:

Year	Connecticut	Ohio	South Dakota
2007	$11805.37	-	-
2008	$12495.90	-	-
2009	$13096.15	-	-
2010	$13495.42	-	-
2011	$13907.37	$9964.98	-
2012	$14270.16	$9968.19	-
2013	$14702.42	$9819.29	$7217.84
2014	-	$10458.28	-
2015	-	$10459.42	$7222.71
2016	-	-	$7778.74
2017	-	-	$8839.95

Table 1: Average district expenditure per pupil for each state over time

Table 2:

Year	Connecticut	Ohio	South Dakota
2007	80.74	-	-
2008	82.51	-	-
2009	81.52	-	-
2010	81.38	-	-
2011	81.74	86.87	-
2012	80.58	86.87	-
2013	81.40	88.42	69.35
2014	-	86.11	-
2015	-	86.41	57.68
2016	-	-	55.65
2017	-	-	58.41

Table 2: Average percent of students that pass math graduation test for each state over time

Table 3:

Year	Connecticut	Ohio	South Dakota
2007	82.50	-	-
2008	84.98	-	-
2009	84.13	-	-
2010	84.43	-	-
2011	83.38	90.35	-
2012	82.41	88.84	-
2013	83.69	90.50	68.57
2014	-	91.25	-
2015	-	89.36	60.30
2016	-	-	57.82
2017	-	-	61.63

Table 3: Average percent of students that pass reading graduation test for each state over time

Table 4:

Statistic	FE District/Time/State (Model 1)	FE District/Time (Model 2)
Math Pass Coef (SE)	0.135 (1.65)	1.461 (2.07)
Reading Pass Coef (SE)	-0.327 (1.5)	0.077 (1.51)
Math CI	[-3.11, 3.38]	[-2.58, 5.51]
Reading CI	[-3.27, 2.61]	[-2.89, 3.04]
# Obs	4074	4074
R^2	0.94	0.91

Table 4: Regression output of Models 1 & 2 that regress log expenditure on graduation test passing rates

Table 5:

Statistic	FE District/Time/State (Model 3)	FE District/Time (Model 4)
Math Pass Coef (SE)	0.00003 (0.0)	0.0003 (0.0)
Reading Pass Coef (SE)	-0.00003 (0.0)	0.00003 (0.0)
Math CI	[0.00, 0.00]	[0.00, 0.01]
Reading CI	[0.00, 0.00]	[0.00, 0.00]
# Obs	4074	4074
R^2	0.94	0.88

Table 5: Regression output of Models 3 & 4 that regress expenditure on graduation test passing rates

Table 6:

Statistic	No FE (Model 5)	FE State Only (Model 6)
Δ Math Pass Coef (SE)	0.00004 (0.0)	-0.0006 (0.0)
Δ Reading Pass Coef (SE)	0.0006 (0.0)	0.0005 (0.0)
Δ Math CI	[0.00, 0.01]	[0.00, 0.00]
Δ Reading CI	[0.00, 0.00]	[0.00, 0.01]
# Obs	3259	3259
R^2	0.1	0.02

Table 6: Regression output of Models 5 & 6 that regress change in expenditure on change in graduation test passing rates

Table 7:

Statistic	CT FE Dist/Time	OH FE Dist/Time	SD FE Dist/Time
Math Pass Coef (SE)	-5.182 (4.51)	-1.163 (1.5)	11.701 (9.33)
Reading Pass Coef (SE)	0.872 (4.67)	-0.206 (1.23)	-1.497 (8.93)
Math CI	[-14.04, 3.68]	[-4.1, 1.77]	[-6.65, 30.05]
Reading CI	[-8.29, 10.04]	[-2.62, 2.21]	[-19.05, 16.06]
# Obs	726	2852	496
R^2	0.85	0.83	0.78

Table 7: Regression output that regress change in log expenditure on graduation test passing rates for each state

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