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Yearly Changes in Education Expenditure and Changes in Student Performance

Dale A. Manzo
Harvard University, manzodale@gmail.com

Yearly Changes in Education Expenditure and Changes in Student Performance

Abstract
Using data from the state of Florida in the 2000s, we dispute the findings of the Coleman report. We find that there is a positive relationship between changes in expenditure per pupil and changes in academic performance. This study takes advantage of changes in expenditure resulting from the Great Recession to formulate a quasi-experimental analysis of the relationship between expenditure per pupil and academic performance. Our conclusion is consistent with the theory of decreasing marginal returns to expenditure on education.

Keywords
Economics of Education, Education Finance, Labor Economics

Cover Page Footnote
I would like to thank my research advisor, Gregory Bruich, for his support throughout this process. Additionally, I would like to express gratitude for the expansive resources of Harvard University which were utilized in the completion of this research.

I. Introduction and Literature Review

There is widespread belief that the public education system in the United States is failing to achieve adequate results; what is not so universally believed is what the cause of this failure is and what can be done to improve student achievement. Beginning with the "Coleman Report" in 1966, there have been extensive academic studies completed on both the state of the public education system in America and how expenditure impacts academic achievement. This paper looks to add to the later question on public education- that of how expenditure impacts student performance.

In the study of education, one of the best metrics we have for gauging how well a school is serving its students is how those students perform on standardized tests. It is not different in this study, but we feel that given the economic implementations that standardized tests have been shown to have, we believe this metric is still important. We base this conclusion on a recent study by Raj Chetty of Harvard University which found that "students assigned to high-VA teachers are more likely to attend college, earn higher salaries, and are less likely to have children as teenagers (Chetty, Friedman, and Rockoff 2014). What they mean by high-VA is increased performance on standardized tests.

This paper explores the topic of how changes in expenditure impact changes in student performance. We take advantage of our unique data set that has a significant number of both increases and decreases in expenditure to see how such changes, and their respective magnitudes, impact changes in academic performance.

The field of the economics of education is currently of great interest both politically and in academia and has been for some time. Resulting from this widespread interest is a plethora of research available to consider when thinking about how public education is funded. As previously mentioned, one of the first large-scale academic inquiries into the topic was commissioned by Congress and was published in 1966 as the [report on] Equality of Educational Opportunity- now commonly known as the Coleman Report. This report was requested by Congress as part of the Civil Rights Act of 1964 and was commissioned specifically to look at differences in the educational opportunities for minority families across the U.S. The report found that factors outside the immediate control of the school—such as a student's family background and the composition of the socioeconomic status of fellow classmates—were more significant factors of student academic success than the level of spending per pupil in the school. In fact, the report found that spending per pupil was not a significant factor (Coleman 1966).

One academic who has continued to make significant contributions to the question on how school finances influence student academic achievement is Eric

Hanushek of Stanford University. Dr. Hanushek has published dozens of papers beginning in 1972 where he rejected the idea of using analysis of variance (ANOVA) as the sole means of studying the relationship between educational achievement and school expenditure (Eric A. Hanushek 1972). In 1981, Dr. Hanushek observed that "there is a growing consensus that public elementary and secondary schooling in the United States is in trouble" but found that simply throwing more money at the schools in trouble would not be an efficient solution to the mounting problem (Hanushek 1981). Hanushek has also discussed the possibility of fitting production functions to education. He observed, in his first paper on the subject, that one difference between fitting such functions to education compared to other products, is that due to the public interest in education, such imperfect functions are used to make real policy changes in courts and the legislature (Hanushek 1986). In 1996, Hanushek published a scathing response to a paper put out by Rob Greenwald et al. of the University of Chicago. In the paper, Greenwood found that school resources are systemically related to student performance and are so to a large magnitude (Greenwald, Hedges, and Laine 1996). In Hanushek's response, he critiques their research method and describes how he believes that they designed the study to reject their null hypothesis as they simply ask the question of if expenditure ever has any impact on student achievement. Hanushek claims that the answer to such a question is obvious in that some schools use resources more efficiently thus making resources matter sometimes. Hanushek claimed that this does not prove that across the board, higher expenditures result in better academic performance (Hanushek 1996). In an overview piece, Hanushek finds that "resources per se are not the issue. And there is little reason to believe that future resource flows will have the desirable impact on student outcomes unless other, more fundamental factors change" (Hanushek 2001).

Other, more recent, academic work that should also be considered includes a 2015 study which looked at changes in student performance resulting from exogenous changes in expenditure due to court mandates. This study also considered the long-run impact of such changes as they relate to post-school economic outcomes. The study found that "For children from low-income families, increasing per pupil spending yields large improvements in educational attainment, wages, family income, and reductions in the annual incidence of adult poverty" (Jackson, Johnson, and Persico 2015). For those interested in an overarching review of the history of the literature in the field, it is well worth the time to read through such a synopsis published in 2016 by the American Educational Research Association (Hedges et al. 2016).

For understanding how Florida distributes state funding to local school districts, we recommend looking over literature published by the Florida Department of Education (Education 2020). Additionally, reading an article by the Florida School Board Association that explains the funding process based on the 1973 law that establishes the process can be helpful to understand the mechanics behind our dataset (Association 2017) (K-20 EDUCATION CODE 2010).

It is beyond the scope of this paper to hypothesize as to why increases in expenditure are statistically significant—even when in amounts as small as say $100—but we believe that the increase in expenditures may have a psychological impact rather than a real impact. Regardless of the mechanics at play in the background, our data finds strong statistical significance and effect sizes that are large enough that they should be considered in policy making.

We find that there is a significant relationship between expenditure and student performance. We find this significance in looking at changes in expenditure and the resulting changes in student academic performance on standardized tests. This is contrary to the findings of the Coleman report (Coleman 1966) and the numerous studies by Hanushek (Eric A. Hanushek 1972; Hanushek 1981, 1986, 2003, 1996, 2001). Our findings for changes in expenditures represent a new theory in the field. This theory is that there are decreasing marginal returns to increases in expenditure. We find that this functional form indicates that positive increases in expenditure are necessary to prevent the dramatic decreases in student achievement when there are large decreases in expenditure. The fact that we see decreasing marginal returns indicates that it is less important how much expenditures are increased so long as there is an increase in the first place. It could be that such increases are necessary due to psychological impacts that decreases in expenditure have. The reason we find that this may be a necessary explanation is that there is a discrete difference in academic performance between small decreases in expenditure and small increases in expenditure. This discrete difference is not easily explained by the impact that a small decrease or increase has on the academic tools available in a classroom.

II. Research Design

In looking at the impact that changes in expenditure have on changes in academic performance, we take advantage of the fact that our data spans over a time period, the Great Recession, where we saw a large number of school districts decrease their expenditures rather than increase expenditures as they had been doing prior to this event. According to public statements by these districts, they decreased their expenditures “as required by the financial downturn” (Gayler 2008). We are able to use this feature of our data to complete a quasi-experimental analysis of the impact that changes in expenditure have on changes in academic performance. We use regression discontinuity and analysis of variance (ANOVA) to examine this relationship. ANOVA is essentially the same as differences in difference except for the fact that this test looks at differences in the means of the two groups rather than the discrete difference at the discontinuity as is done in regression discontinuity.

We believe that more rudimentary analyses that simply look at the variance between standardized test scores and levels of expenditure have significant omitted variable bias. This is virtually impossible to eliminate in such studies as the sheer number of potential confounds is innumerable. These confounds result in significant error in such models as shown in the equations below. In this equation, the Y is our academic outcome variables, and we only have one factor, S, that influences this outcome through β_1. What we will show is that $\beta_1$in such models is found to be very small- almost to the point that they are no longer considered statistically significant and all to the point that they are not significant for policy making. We demonstrate through our quasi-experimental analysis that $\beta_1$is negatively biased from its true value due to omitted variable bias.

$$Y_{it} = \beta_0 + \beta_1 S_{it} + u_{it}$$

In our equation we could theoretically include variables such as neighborhood characteristics (NC), average family income (FI), student housing type and quality (H), parental involvement (PI), and even peer quality (PQ). While these factors do not have any data and would be very difficult and controversial to attempt to quantify, understanding that they are likely in the model in the real world is important in understanding how looking at changes helps us eliminate such biases. Such a more realistic model would look more like the equation below.

$$Y_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 NC_{it} + \beta_3 FI_{it} + \beta_4 H_{it} + \beta_5 PI_{it} + \beta_6 PQ_{it} + u_{it}$$

Taking this more realistic model and applying it to our changes story demonstrates the power of looking at changes rather than levels. This is because we can anticipate the change in each of these characteristics to average approximately zero between one year and the next. For example, we would not expect drastic change in the neighborhood characteristics in just one year and even less likely would be a change in typical parent involvement or peer quality. Because we can assume these changes are zero, we can safely move from the first equation to the second without losing the strength of the estimation of our academic variable.

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta S_{it} + \beta_2 \Delta NC_{it} + \beta_3 \Delta FI_{it} + \beta_4 \Delta H_{it} + \beta_5 \Delta PI_{it} + \beta_6 \Delta PQ_{it} + \Delta u_{it}$$

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta S_{it} + \Delta u_{it}$$

Therefore, despite still not being able to quantify these potential confounds, we can be confident in quantifying their average change from one year to the next at zero. Because we can make this assumption, we can assume that our new model does not have an omitted variable bias which we cannot assume in less sophisticated analyses. In the appendix, we additionally show how using two-way fixed effects can help eliminate this bias as well.

III. Data

Academic Data

We chose to use the state of Florida as our case study for the purposes of this study for a few reasons. The first reason is that since the early 2000s, Florida has publicly released academic performance metrics as well as expenditure metrics for all public districts in the state. Additionally, in Florida there is one school district that serves each county exclusively meaning that we can track county-level demographic data that coincides with the district in question. While this feature is not critical for this study, it was critical in a parallel study I completed at Yale examining how the relationships found in this study are influenced by the racial characteristics of the community (Manzo 2021). The final feature that made Florida the ideal state for the study to collect data from is that there were four academic variables offered in the data; the first being the percentage of students proficient in mathematics (called “postmath” in our dataset), the second being the percentage of students making gains in mathematics (called “postmathgain” in our dataset), the third being the percentage of students proficient in reading (called “postread” in our dataset), and the final being the percentage of students making gains in reading (called “postgainread” in our dataset). It was important for us to have the factors accounting for the percentage of students making gains in math and reading so as not to unjustly dock schools that do not have many students proficient in the given subject but do have a large percentage of students making gains from their respective starting point.

To collect our academic data, we took advantage of Florida’s FCAT (Florida Comprehensive Assessment Test) public reporting that began in the early 2000s.[1] We aggregated the four academic variables from the initial school year 2003-2004 to the final school year that reported data in this way which was academic year 2010-2011. This meant that we have a total of eight years of academic data and seven change periods (i.e., the ability to look at changes from one school year to the next). As previously mentioned, using this specific time period was important as it has significant numbers of both positive, typically

[1] This data is publicly available via the Florida Department of Education. It can be downloaded from https://www.fldoe.org/accountability/accountability-reporting/school-grades/archives.stml#1996-1997

before the Great Recession, and negative, typically after the Great Recession, changes in expenditure per pupil.

To summarize our academic variables, we generated a new variable, abcsum(pre and post) that weighted equally the four academic variables to generate a new summation variable. This variable provides a bird's eye view at the academic performance of students attending the district in question. To access how this performance changes with changes in expenditure, we generated a new variable, difabcsum, that tracks these changes. These variables were generated according to the following formulas:

$$abcsumpre = \frac{(premath + premathgain + preread + pregainread)}{4}$$

$$abcsumpost = \frac{(postmath + postmathgain + postread + postgainread)}{4}$$

$$difabcsum = abcsumpost - abcsumpre$$

Expenditure Data

After collecting our academic data, our next step was to collect data on school expenditure per student for each of the school districts in each year of interest. We chose to use expenditure data rather than budget data because while on the surface they might sounds similar, they are actually vastly different. Using expenditure data eliminated yearly variance that could have been present in budgets if say the district allocated funds for a new building to be built; while this additional variance would appear in the budget, it is not present in the expenditure per student figure. While some may question if this decision skews our findings by eliminating the impact that large capital projects such as renovations and new buildings have on students, we find that this was the best option as with only seven change periods a spike in spending resulting from such projects could skew our findings to an unacceptable degree.

Because we are interested in the impact that changes in expenditure have on student performance, we are interested only in changes that are real and not simply the effect of inflation. Because data from the Florida Department of Education is always reported in the actual amount spent and is not adjusted for inflation to a base year, we had to manually find the real changes in expenditure. To do so, we created a new variable known as "difinflexp" which stands for "the difference from the inflation expected value. This variable was calculated according to the following formula:[2]

$$difinflexp = postexp - (preexp * (1 + \pi))$$

[2] Postexp is the actual reported expenditure per student in the following year. Prexp is the actual reported expenditure in the previous year. Π is the inflation rate between the periods.

Using this new variable allows us to see if the district in question is actually changing their expenditure per student or is simply keeping up with inflation. It is important to note that a district that increases its spending but not to a degree equal to or greater than inflation would be considered to have decreased their expenditure per student between the periods despite them reporting higher expenditures.

It is important to note that for changes in expenditure, we did remove outliers from our dataset. Doing so removed only three instances from our dataset but removed outliers that were over 10 standard deviations from the mean (our cutoff was three). In examining such extreme outliers, we determined that they were the results of extreme corrections that a select few districts had to make in response to the Great Recession. It is also important to note that we did run these same analyses with the outliers present and the results of the study were still found even with the outliers present.

IV. Results

Since the Coleman Report was published in 1966, there has continued to be ongoing academic and public debate around the subject of whether or not school expenditure per student is an important determinant of student academic achievement. Coleman (1966) found that variation in per pupil expenditure was not significantly related to variation in student performance on standardized tests. In discussing the current state of research in the field at the time, Eric Hanushek found that not only do most studies find that level of expenditure per pupil is not statistically significant, but even the ones that do find statistical significance often find that the coefficient is negative (Hanushek 2003). The results of this study run contrary to these findings as we do find statistical significance between changes in academic performance and changes in expenditure per pupil. We tested changes in all four academic variables—which like the Coleman report, are the result of standardized testing—as well as our aggregate educational achievement summary variable against changes in expenditure. Of all our variables, statistical significance in this relationship is found for all but one academic variable- the change in the percentage of students making gains in reading.

It is the hypothesis of this paper that changes from year to year in expenditure per student are a significant factor of changes in student academic performance. We find that this relationship is non-linear and that positive changes in expenditure result in approximately equal changes in academic performance. For negative changes in expenditure, we find that big decreases result in significantly worse academic outcomes than small decreases.

By looking at changes in spending from one year to the next we assume that we account for many potentially confounding variables. While we do not explicitly account for them in the new model, the fact that we are only looking at changes between two years at any given time results in a significantly more limited time period where other variables external to the school itself may be changing. Not only does looking at changes in spending account for numerous confounding variables, we also believe that changes in spending themselves have a significant impact on student performance. We will demonstrate that it is less of a story about how much spending is increased—so far as the impact on academic performance is concerned—but rather that an increase is present at all. Our data will show that even very small increases in expenditure per pupil are associated with significant increases in student performance from one year to the next.

Mathematics and Changes in Expenditure per Pupil

In this model, we are looking at changes rather than levels; this means that we are looking at both the change in expenditure from one year to the next as well as the change in academic performance from one year to the next. As our academic variables are all measured in percentage of students proficient or making gains, a positive value of one for our change variable in academics represents an absolute increase of 1 percentage point in the percentage of students proficient or making gains.

For the percentage of students proficient in mathematics, the effect size of a district choosing to increase their expenditure per pupil rather than decrease or keep the expenditure the same is large. The effect of choosing an increase is 1.345(.942, 1.748). While choosing not to increase expenditures is still typically associated with an increase in the percentage of students proficient in mathematics, the increase is significantly lower at .68(.365, .994). This means that a district that does increase its budget can expect a total increase of between 1.307 and 2.742 percentage points while a district that does not increase its budget could only expect to see an increase of less than 1 percentage point. The statistical results of this test are shown in Table 1.

Table 1

Regression results

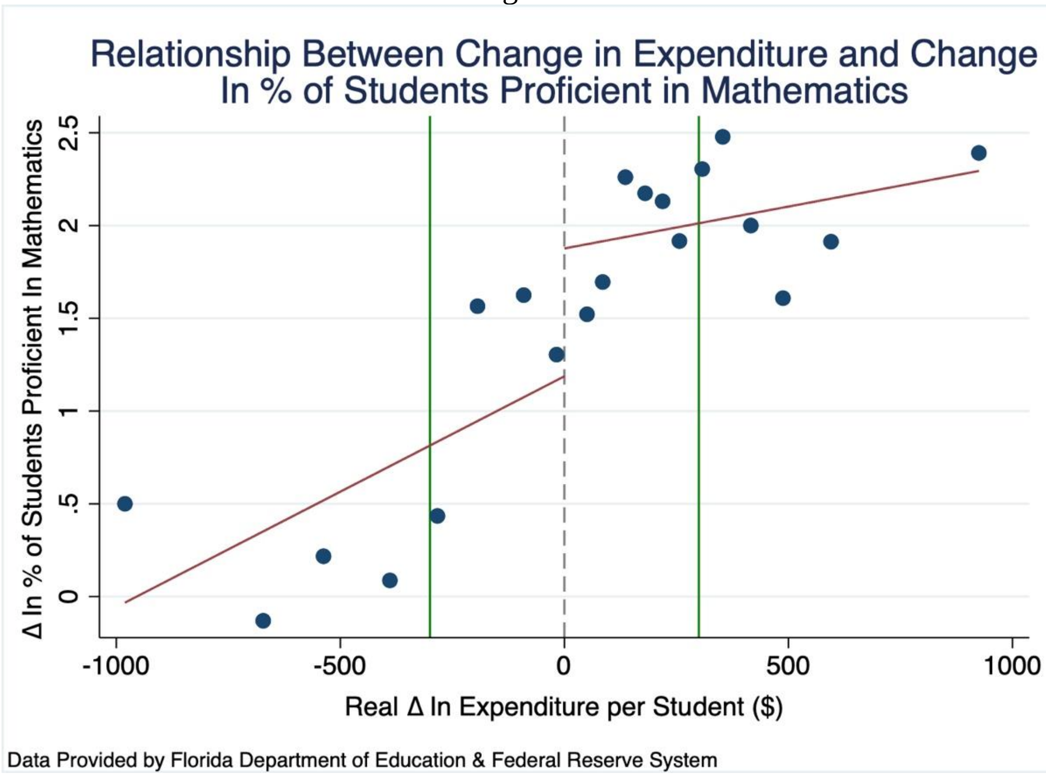
difmath	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	1.345	.205	6.56	0	.942	1.748	***
Constant	.68	.16	4.25	0	.365	.994	***

Mean dependent var	1.499	SD dependent var	2.249
R-squared	0.085	Number of obs	463
F-test	43.014	Prob > F	0.000
Akaike crit. (AIC)	2026.332	Bayesian crit. (BIC)	2034.608

**** p<.01, ** p<.05, * p<.1*

What is important to understand here is that increases in expenditure per student need not be large to see such an impact. This is demonstrated in the regression discontinuity in figure 1 below. In this figure, a regression discontinuity is performed at zero change in expenditure per student. What we see is a significant jump from when there is no change or a negative change to when there is even a very small increase in expenditure. The vertical green lines represent a decrease and increase of $300 respectively. We can see that according to our simple linear regressions, a decrease in spending of a mere $300 is associated with less than a 1 percentage point increase in the percentage of students proficient while an increase of only $300 is associated with an increase of over 2 percentage points in the percentage of students proficient in mathematics. We can also see the non-linearity of the relationship in how steep the relationship is when there is a decrease in expenditure compared to the relatively flat relationship we see when the change is positive. This is a trend we will continue to see across our academic variables and our academic summary statistic.

Figure 1



Looking now at the change in the percentage of students making gains in mathematics, the effect of an increase in expenditure is even stronger. Our test finds that districts that choose not to increase their expenditures can expect to see a decrease in the percentage of students making gains. We find that these districts can expect to see a decrease of between 0.788 and 1.709 percentage points of their students making gains in mathematics. For districts that choose to increase their expenditure by even a small amount, the story is much brighter as they can expect to see in a worst-case scenario a decrease in the percentage of students making gains of 0.71 percentage points but in a best-case scenario, they may actually see an increase of up to 1.391 percentage points. While neither of these scenarios are what we would ideally like to see—which is increases in performance across the board as was the case with proficiency—the range of scenarios for districts that increase their expenditure is far better than for districts that choose not to. The statistical test is shown in Table 2.

Table 2

Regression results

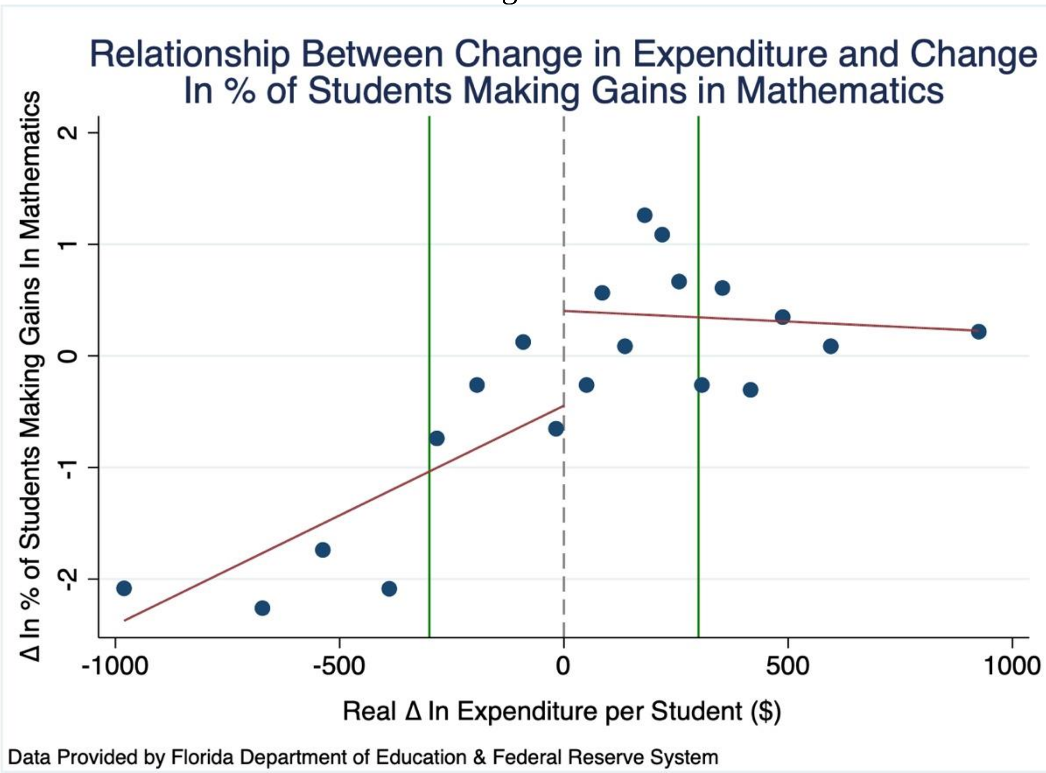
difgainmath	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	1.589	.3	5.29	0	.999	2.179	***
Constant	-1.249	.234	-5.33	0	-1.709	-.788	***

Mean dependent var	-0.281	SD dependent var	3.243
R-squared	0.057	Number of obs	463
F-test	28.012	Prob > F	0.000
Akaike crit. (AIC)	2379.121	Bayesian crit. (BIC)	2387.397

**** p<.01, ** p<.05, * p<.1*

We can also observe this relationship through regression discontinuity as shown in Figure 2. As we did with proficiency levels, we have regression discontinuity at zero change in expenditure and include two observation lines at -300 and 300. As our ANOVA test would predict, we see a jump in performance at the change from a small decrease in expenditure to a small increase in expenditure. At our observation lines, we see that a decrease of just $300 is associated with a decrease in performance of about 1 percentage point while an increase of the same $300 is associated with an increase in performance of around 0.4 percentage points. While still possible for there to be decreases in the percentage of students making gains in reading when there is an increase in expenditure, it is far less likely than when there is a decrease in expenditure- where it is virtually certain. We again see non-linear decreasing marginal gains from additional expenditure per pupil. This relationship further demonstrates the decreasing marginal returns to additional expenditure per pupil.

Figure 2



Reading and Changes in Expenditure per Pupil

To begin our analysis with regard to reading, we complete an ANOVA test for our dummy variable for increase against our variable for the change in the percentage of students proficient in reading. Our test finds that districts that choose to increase their spending have an increase in the percentage of students proficient in reading of between 0.292 and 0.952 percentage points higher than districts that do not increase expenditures. This analysis can be seen in Table 3.

Table 3

Regression results

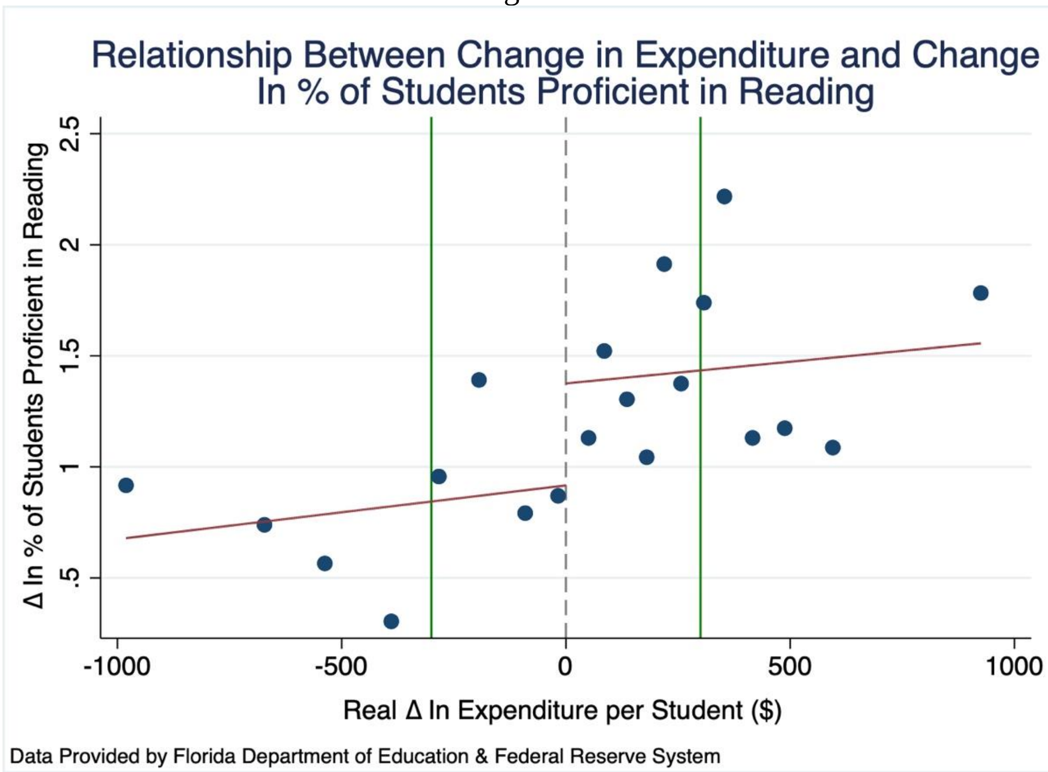
difread	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	.622	.168	3.70	0	.292	.952	***
Constant	.818	.131	6.23	0	.56	1.076	***

Mean dependent var	1.197	SD dependent var	1.789
R-squared	0.029	Number of obs	463
F-test	13.689	Prob > F	0.000
Akaike crit. (AIC)	1842.150	Bayesian crit. (BIC)	1850.425

**** p<.01, ** p<.05, * p<.1*

While in both scenarios districts see an increase in the percentage of students proficient in reading, these gains are significantly greater when districts choose to increase their expenditures by even small amounts. This difference can be seen in our regression discontinuity in Figure 3. According to our model, a decrease in spending of just $300 is associated with an increase in reading proficiency of less than 1 percentage point while an increase in spending by that same $300 results in an increase of about 1.5 percentage points. We can also see that there is more variation for positive changes in expenditure than there is for negative changes; this additional variation that we see is in the positive direction of changes in academic performance. This variation is not significantly negative and does not lead us to believe that districts that choose to increase their expenditures would underperform districts that did not increase their expenditures.

Figure 3



The relationship between our academic variables and our variable measuring the real change in expenditure per pupil has been relatively consistent so far- districts that increase expenditure per pupil perform better to a statistically significant degree than districts that keep expenditure constant or decrease expenditure. Unfortunately, our final academic variable does not perform like the rest; the change in the percentage of students making gains in reading is not correlated in a statistically significant manner by real changes in expenditure per pupil. The lack of statistical significance is demonstrated in Table 4 where despite having a positive coefficient of .361, the standard error for an increase is .294 which results in a confidence interval that is both positive and negative. With such a confidence interval, we cannot be confident if there is an effect and if there is an effect, we cannot be sure if it is positive or negative. What we are confident in—to the 95% confidence level—is that the true population mean for districts with an increase in expenditure is somewhere between a decrease of 0.794 and an increase of 1.261 percentage points. For districts with a decrease in expenditures, the absolute change is somewhere between a decrease of 0.578 and an increase of 0.323 percentage points.

Table 4

Regression results

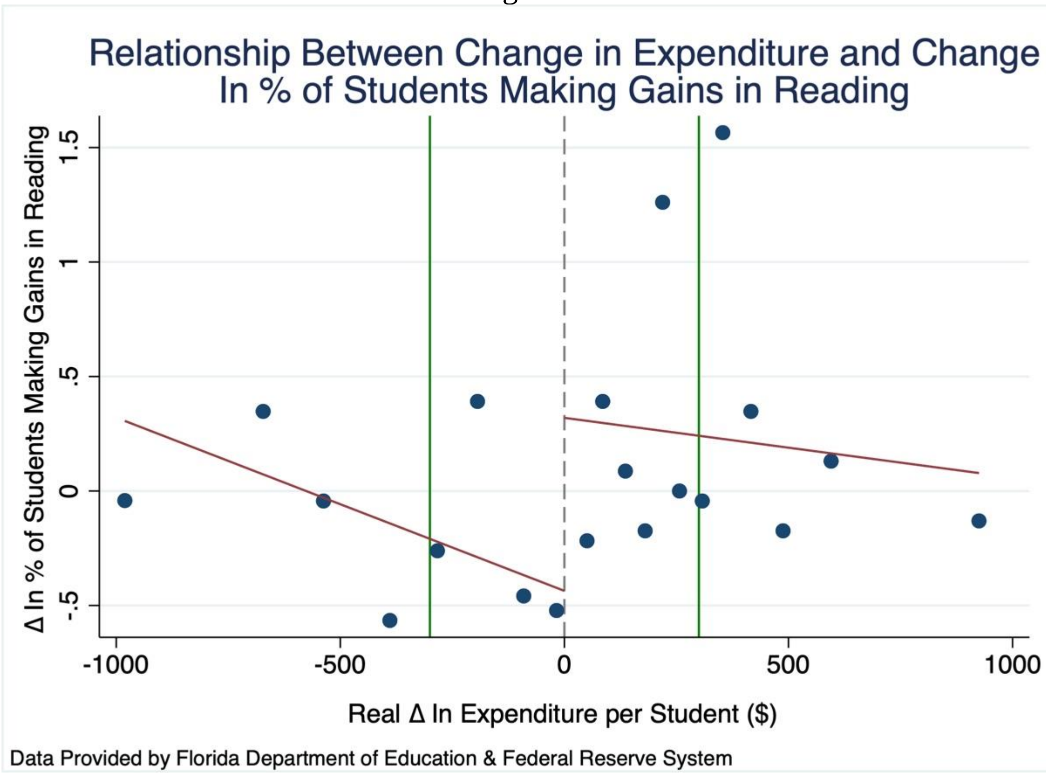
difgainread	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	.361	.294	1.23	.22	-.216	.938	
Constant	-.127	.229	-0.55	.58	-.578	.323	

Mean dependent var	0.093	SD dependent var	3.086
R-squared	0.003	Number of obs	463
F-test	1.511	Prob > F	0.220
Akaike crit. (AIC)	2358.823	Bayesian crit. (BIC)	2367.098

**** p<.01, ** p<.05, * p<.1*

Looking at this same relationship from our regression discontinuity graph makes it seem like the relationship holds here. This is contrary to what our ANOVA tests tells us, so the question is why this is the case. While our regression discontinuity graph makes it appear that the relationship holds in this case as well, there is too much variation in our data for us to be confident at even the 90% confidence level. According to our data, we could only be confident at the 75% confidence level and that does not meet the expectations of this study. So, while the graph in Figure 4 appears to have this relationship present, the variation in the data requires us to fail to reject our null hypothesis that the relationship is not present. Because statistical significance is not found, it would additionally be improper to make conclusions regarding the predictions by the linear regressions at our observation points of -300 and 300. We do not have a clear theory as to why students making gains in reading would be the only academic factor that is not predicted by changes in spending. It might be that our data just has an unusual amount of variation for this variable and that the relationship in the population is in fact there. Or it could be that making gains in reading is influenced differently from other academic variables and that the relationship is not present in the population. Our data does not make this clear and we do not hypothesize one way or the other.

Figure 4



Changes in Academic Summary Statistic and Changes in Expenditure

Having examined the relationship between changes in expenditure and changes in all of our academic variables, we now examine the relationship between our change in expenditure variable and changes in our academic summary variable. Changes in this variable represent the average change across all of our academic variables when there is a change in expenditure per pupil from one year to the next. A change of one in this variable represents an average change of 1 percentage point in each of our academic variables. As we have previously shown, each variable changes differently and all have slightly different relationships with changes in expenditure, but the purpose of this summary statistic is to provide a baseline explanation as to the impact that a change in expenditure has on the overall academic performance of students.

We begin our analysis with an ANOVA test between our academic summary statistic and our dummy variable for real increases in expenditure. Our analysis finds that the summary relationship is significant and that districts that choose to increase their expenditures beyond the inflation-expected amount see statistically significant increases in student academic performance. What our test finds is that for districts that choose not to increase their expenditures per pupil, the expected average change in academic performance is between a decrease of 0.256 and an increase of 0.317 percentage points. For schools that choose to increase expenditures, the prediction is significantly more optimistic with a predicted average increase of between 0.357 and 1.663 percentage points. With statistically significant results, we can be confident to the 95% level that districts that choose to increase expenditure per pupil—in any amount—will see improved academic performance compared to districts that choose not to increase expenditures. Additionally, it is important to observe that the coefficient for an increase in expenditure is quite large at 0.979 percentage points. What this means is that districts that choose to increase their expenditures can expect an average increase of nearly 1 percentage point across each of their academic variables on standardized tests. This conclusion has an important policy implementation in that it finds that increases in expenditure result in increases in overall student academic performance. The statistical analysis is shown in Table 5.

Table 5

Regression results

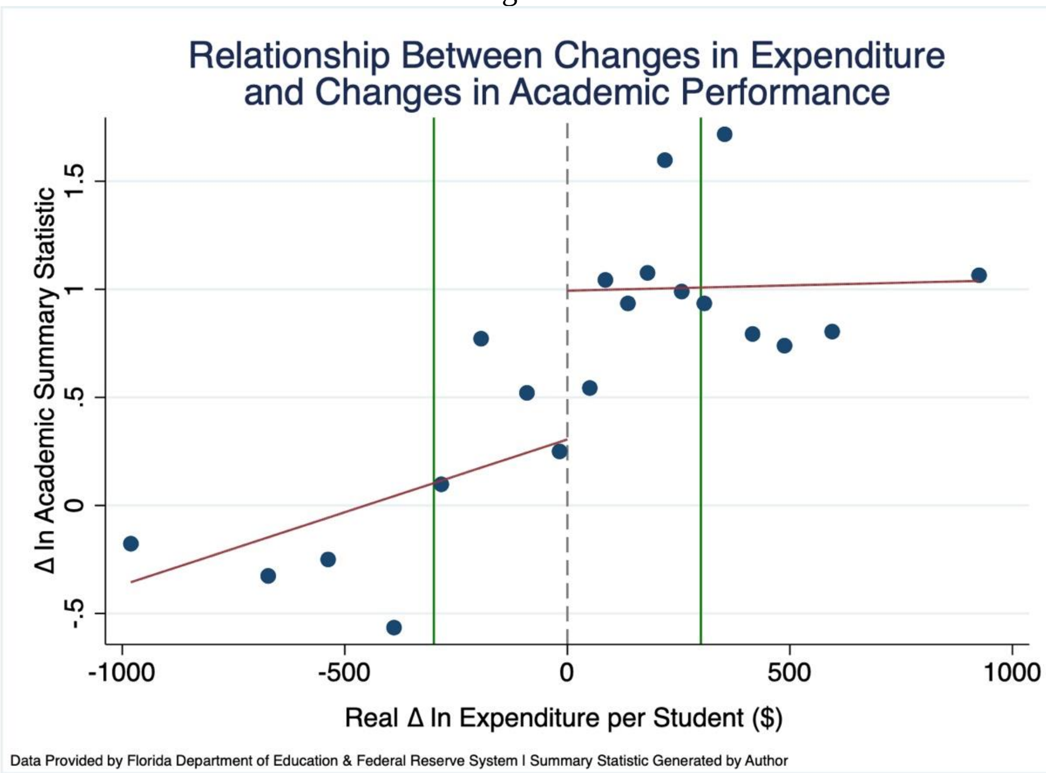
difabcsum	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	.979	.187	5.25	0	.613	1.346	***
Constant	.03	.146	0.21	.835	-.256	.317	

Mean dependent var	0.627	SD dependent var	2.015
R-squared	0.056	Number of obs	463
F-test	27.525	Prob > F	0.000
Akaike crit. (AIC)	1939.084	Bayesian crit. (BIC)	1947.359

*** *p<.01*, ** *p<.05*, * *p<.1*

We can also observe this relationship in our regression discontinuity analysis shown in Figure 5. We can observe that, according to our linear regressions fitted to the data, a small decrease in spending of $300 is associated with just barely a positive average change in the summary statistic variable of 0.1 percentage points which is virtually no change whatsoever from the previous year. For an increase in expenditure of the same $300 though, we find that this is associated with an average change in the summary statistic of about 1 percentage point. This means that an increase in expenditure between years is associated with an average increase of 1 percentage point for all academic variables which represents a major increase in student academic performance. Additionally, we can observe that our regression line is virtually flat for positive increases in expenditure which verifies the claim that it is not important how much expenditures increase, but rather the important contributor is that there is some increase. Furthermore, this confirms the theory of decreasing marginal returns to increases in expenditure. This has important policy implementations as we find that so long as an increase is present, it is not important for that increase to be large. Having a large increase seems to produce similar impacts on performance as small increases- albeit at a higher cost.

Figure 5



It is also important to note that this relationship holds across terciles of expenditure per pupil. To demonstrate this, we can look at the regression discontinuity graph in Figure 6 which separates our data into terciles and then runs the regression discontinuity analysis for each individually. As shown in Table 6, statistical significance is found for districts in the lowest expenditure per pupil and highest expenditure per pupil terciles. Statistical significance is not found in the middle expenditure tercile but there is still a positive coefficient for this group; it may be that there is too much variation in this tercile's data, or it could be that middle-expenditure districts behave differently from high and low expenditure districts which both have positive statistically significant coefficients. Unsurprisingly, the largest coefficient is found for districts that spend the lowest per pupil indicating that for schools with currently low expenditure per student, increases in expenditure have a very strong impact on increasing student academic performance. For all terciles, we see positive jumps at our regression discontinuity of zero change in expenditure so while statistical significance is only found for two out of our terciles, it is clear that the relationship between real changes in expenditure and changes in academic performance is strong for the majority of school districts in our data. Table 8 displays the regression discontinuity tests for our academic variables.

Table 6

Regression results

difabcsum	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base 0	0	.	.	.	.	.	
1	1.072	.187	5.74	0	.705	1.44	***
: base 1	0	.	.	.	.	.	
2	.076	.222	0.34	.732	-.36	.512	
3	.82	.223	3.68	0	.382	1.258	***
Constant	-.324	.207	-1.57	.118	-.731	.083	

Mean dependent var	0.627	SD dependent var	2.015
R-squared	0.090	Number of obs	463
F-test	15.049	Prob > F	0.000
Akaike crit. (AIC)	1926.496	Bayesian crit. (BIC)	1943.047

**** p<.01, ** p<.05, * p<.1*

Figure 6

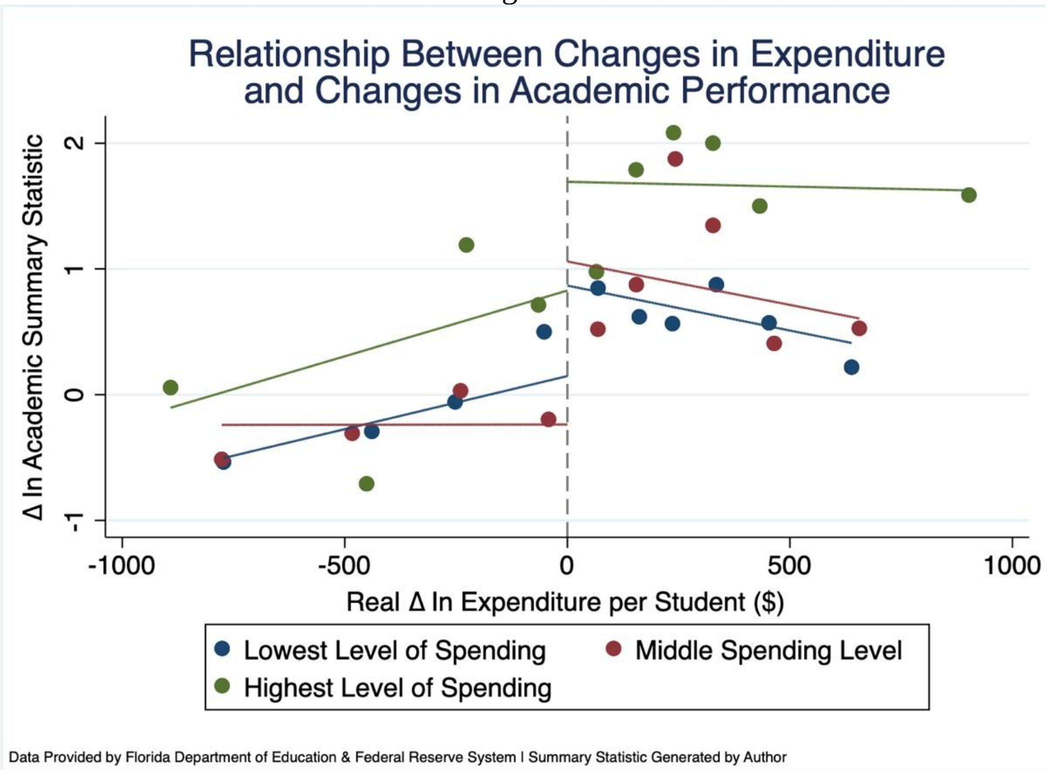


Table 7

Table 7. Regression Discontinuity at difinflexp=0					
	Δ in Mathematic Proficiency	**Δ in Mathematic Gains**	**Δ in Reading Proficiency**	**Δ in Reading Gains**	**Δ in Academic Summary Stat**
difinflexp>0	1.345***	1.589***	0.622***	0.361	0.979***
	[.942, 1.748]	[0.999, 2.179]	[0.292, 0.952]	[-0.216, 0.938]	[0.613, 1.346]
Intercept	0.68	-1.249	0.818	-0.127	0.03
	[0.365, 0.994]	[-1.709, -0.788]	[0.56, 1.076]	[-0.578, 0.323]	[-0.256, 0.317]
R-Squared	0.085	0.057	0.029	0.003	0.056
Number of observations	463	463	463	463	463

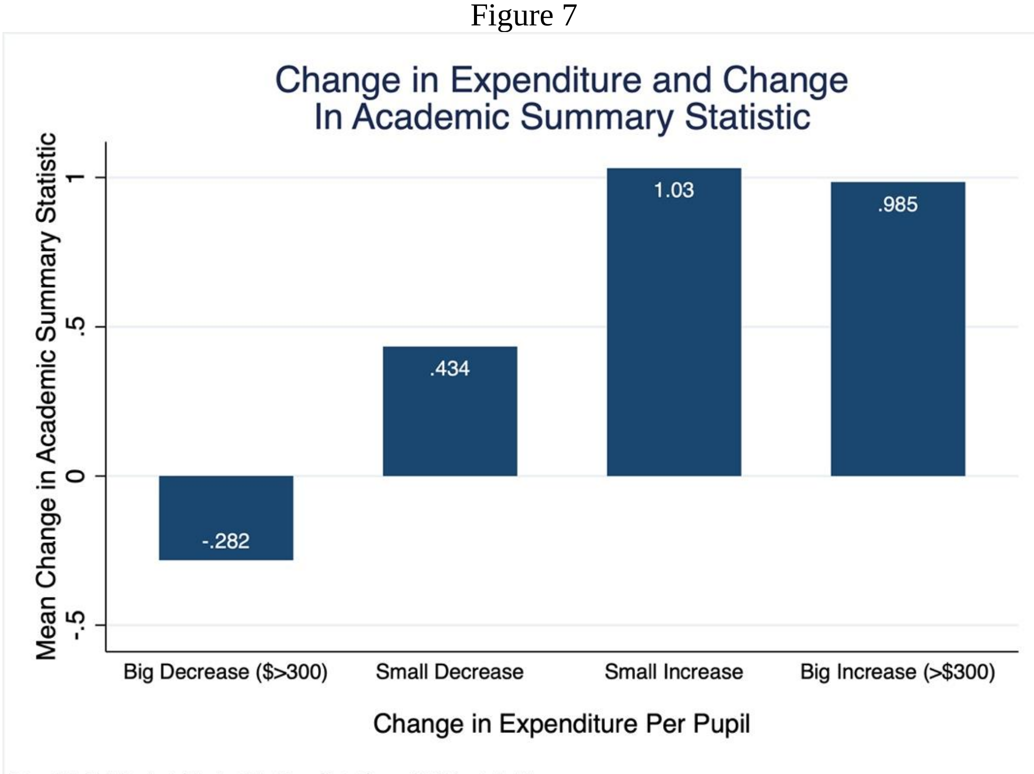
Note: *** P<0.01, ** P<0.05, * P<0.1

Non-Linearity of Relationship Between Changes in Expenditure and Changes in Academic Performance

What we find is that there is a non-linear relationship between changes in expenditure and changes in student academic achievement. We find that large decreases in expenditure per pupil result in detrimental decreases in student performance, but the impact of increases is relatively plat in terms of the degree when the change is positive.

As shown in Figure 7 below, both small and large increases in expenditure per pupil result in about a 1 percentage point increase in our academic summary statistic. This graph also demonstrates how different the impact is between small decreases and small increases on changes in the academic summary statistic. While small increases result in about 1 percentage point increase on average, small decreases result in less than half a percentage point increase. Additionally, we see the dramatic negative impact that large decreases in expenditure have on student achievement. Here, we see decreases in our academic summary statistic from one year to the next. This graph makes it abundantly clear that the relationship between changes in expenditure and changes in student performance on standardized tests is non-linear. This non-linearity indicates that the educational production function has decreasing marginal returns to increases in expenditure.

Figure 7



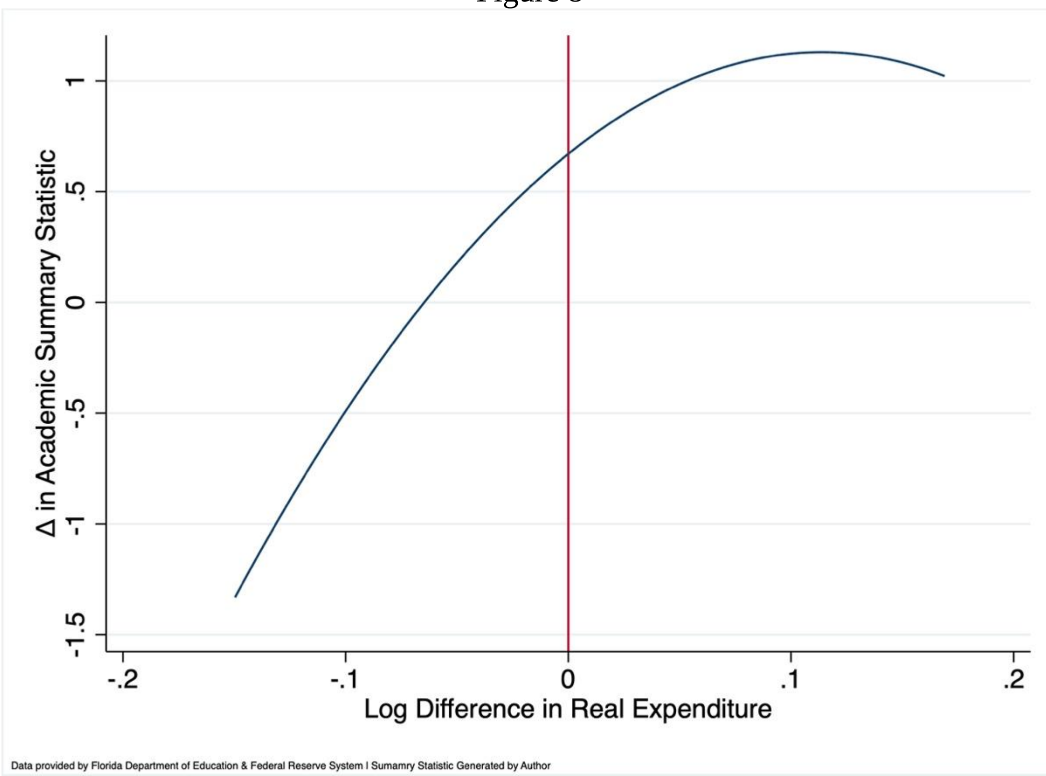
It is worth examining this non-linear relationship up-close to better understand it. First, we take a closer look at just small changes- both negative and positive. In doing so, we limit our data to only observations where the change has an absolute value of less than $300; this limits our data to 230 of our 463 observations. In this up-close observation, we see how dramatic the differences in educational performance are between districts that either increase their expenditure by a small amount or decrease their expenditure by a small amount. What we see, again in Figure 7, is that districts that increase their budgets by a small amount perform over twice as well in the change in their academic summary statistic relative to districts that decrease their expenditure by a similarly small amount.

When comparing our big changes relative to their respective small changes, we can again see non-linearity. While the absolute value of the mean for big and small decreases are relatively similar and their standard deviations are similar as well, how they compare to their respective small decreases is dramatically different. For increases in expenditure, there is very little difference between the mean change in the academic summary statistic between the small and big increase groups. The story is very different though for decreases. To start, small decreases in expenditure still result in increases in academic performance whereas big decreases in expenditure result in decreases in academic performance. In addition to them moving in opposite directions, the scale of the difference between them is large at about 0.716 compared to just 0.045 for the increase groups.

This non-linearity means that while it is not important how large an increase in expenditure is, it is important that the change in expenditure is positive. This means that if a district wants to allocate additional financial resources to improve academic performance, they likely don’t need to make such an increase very large to see worthwhile impact. In fact, our data shows that increases in expenditures per pupil by a large amount yield no greater gain than is seen when there are increases in expenditures by much smaller amounts. Additionally, if a change must be negative, it is important that the change is not large—over $300 in this data—to prevent detrimental decreases in academic performance.

To further demonstrate the decreasing marginal returns we see in the data, we look at how log changes in expenditure per pupil is related to changes in our academic summary statistic. What we see in Figure 8 is that when stepping right (i.e., increasing expenditure per pupil), the slope of the relationship levels off, but when stepping left (i.e., decreasing expenditure per pupil) the slope is gets exponentially steeper as we step further negative. If it is true that in the population there are decreasing marginal returns to changes in expenditure per pupil, then it becomes clear why in our earlier regressions we see less extreme coefficients for increases than we see for decreases. This is because for increases, they are reaching the low marginal return part of the relationship and for decreases they are in the high marginal return (albeit in the negative direction) part of the relationship. Because of this, increases in expenditure per pupil of 10% result in much smaller absolute differences than decreases in expenditure by the same 10%. The difference is that the 10% increase in expenditure will result in an increase in student performance while the 10% decrease in expenditure will result in a significant decrease in student performance.

Figure 8



The fact that amongst districts that increase expenditures, we see no statistically significant relationship between the degree of the increase and the degree of the increase in student performance leads us to wonder if the way that additional funds are spent is significantly different between districts that increase expenditure by small amounts and districts that make increases in larger amounts. It may be that districts that increase expenditures by small amounts are more careful with how they allocate the money than districts that are increasing by large amounts. This could be what leads to decreasing marginal returns. To judge this, we would need to know how the additional funds are allocated which is outside the scope of this study and our dataset. We do not have any reason to hypothesize the cause, but it could be that Hanushek is correct when he explains that it is not that money doesn't matter, it is just that how money is spent is more important than how much is spent (Hanushek 2015). Additional research on how additional funding is spent should look at potential differences between allocation equations when the increase in expenditure is large rather than small. This should also be considered for when districts choose to decrease their expenditures; it could be that small decreases are done in ways designed to not disrupt the learning environment while big decreases cannot help but disrupt the learning environment. This may explain why we see a negative coefficient in academic performance for big decreases but not small decreases. While testing such hypotheses is outside the scope of this study, a better understanding of such relationships is important to understand before making policy decisions on changes in expenditure. This theory could be contrary to the theory on decreasing marginal returns or the theories could both be correct if it matters how the additional funds are spent, but also decreasing marginal returns are present regardless of how the additional funds are spent.

V. Conclusion

With education being such an important factor in the well-being of society, understanding what factors influence the academic performance of students and which ones are most efficient in doing so is of vital importance. This paper contributes to the ongoing discussion on how expenditure impacts student performance. In this analysis, we took advantage of the Great Recession causing decreases in expenditure across many school districts to complete a quasi-experimental analysis of how changes in expenditure impact changes in student academic performance. We find that the educational production function has decreasing marginal returns to increases in expenditure. This feature of the function results in relatively flat changes in achievement when increases in expenditure are made but dramatically negative changes in achievement when large decreases in expenditure are made.

While it was not within the scope of this paper to hypothesize and test why it might be that the presence of an increase in expenditures has a discrete impact on changes in student performance, future studies should examine this relationship and seek to better understand why we see such a trend.

We used quasi-experimental econometric tools to examine this relationship and found there to be statistical significance between changes in expenditure and changes in academic performance. This finding runs contrary to traditional understandings of the role that expenditure per pupil plays in the American public school system. As such, additional studies should test the external validity of these findings and examine whether these findings are universal or if there is something special about the state of Florida during this period. Additionally, larger scale studies should incorporate bigdata on how funding allocations change with funding levels. Such additional data could help us understand the mechanics at play.

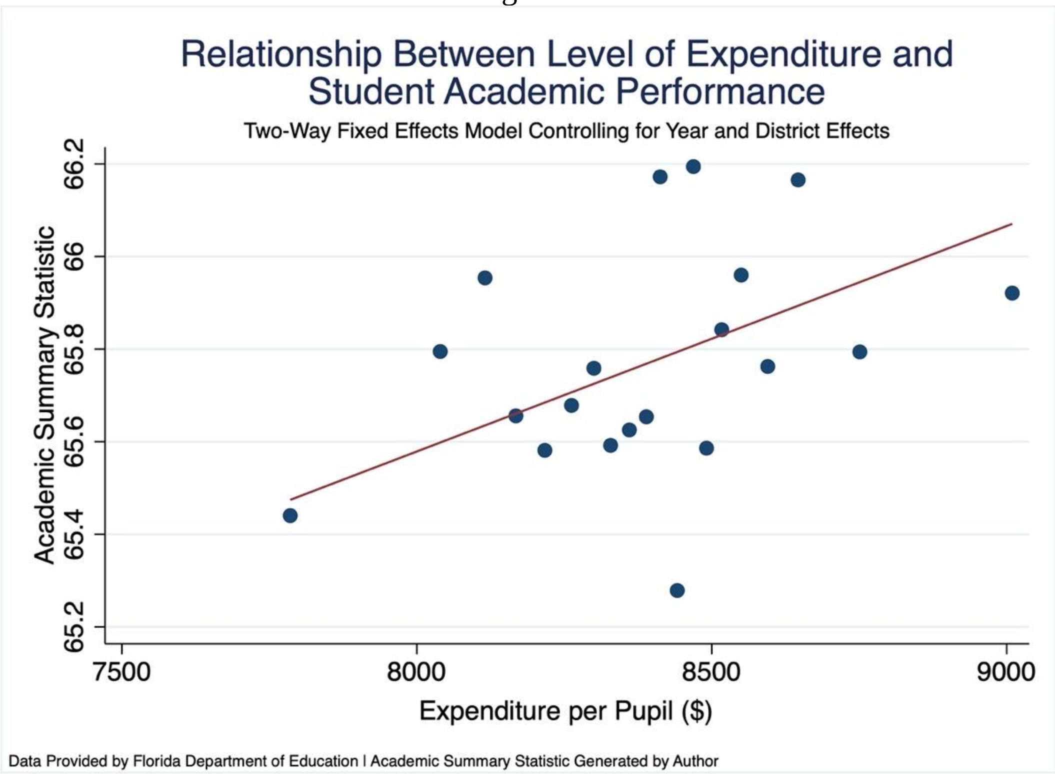
This study recognized the existence of omitted variable bias in our limited data and we accept the fact that this would have skewed our data had we used less sophisticated methods. By looking at changes from each year, we were able to make assumptions that allowed us to not be concerned with omitted variable bias in the story on changes in expenditure. We do recognize that there could still be omitted variable bias if such variables are also changing over the period, but we feel confident that this is very limited in our data. This again is why such quasi-experimental designs are superior to more rudimentary studies that only look at variance between districts that spend a lot per pupil and those that spend less.

It is vital to understand how both small and large increases in expenditure resulted in similar increases to academic performance relative to small decreases in expenditure. This further indicates that it may not be a real effect caused by the additional funding but rather the presence of an increase in expenditure may have a positive psychological effect on the learning community. While the findings of this paper are that the presence of a small increase in expenditure per pupil increases student performance from one year to the next, we do not hypothesize as to why this is the case. Our data makes it clear that it is likely not a real impact of the additional funding as we showed that the degree of a positive change in expenditure is not important for changes in academic performance. What we do not know though is the mechanics behind the relationship. Our data is simply not deep enough to determine if there is a psychological effect, an effect caused by different allocation methods, or some other mechanism. We leave open this question of why changes in expenditure are related in a non-linear way to changes in academic performance to future studies.

Appendix

In addition to looking at changes, we used a two-way fixed effects model that controlled for the fixed effects of both year and district to demonstrate that the relationship between expenditure per student and student performance on standardized tests holds even when controlling for the effects of district and year. What we can see in Figure 9 is that when these are controlled for, we see a positive correlation between expenditure per pupil and our academic summary statistic. It is important to note that this model controls for the fixed effect of both years and the district. This is essentially the same as when we looked at changes between periods in our changes analysis. Looking at our data in this fixed-effects model, we lose some of the important non-linearity information we learned in the main analysis. One benefit though of looking at the data in this way is that the quasi-experimental feature of our data is not necessary for these conclusions to hold.

Figure 9



Because this model does not show the non-linearity of the relationship between changes in expenditure and changes in academic performance, the model does not demonstrate the detrimental impact that decreases in expenditure can have on academic performance. This is why our changes model is preferred over this two-way fixed effects model. Additionally, because our changes model takes advantage of a naturally occurring recession and thus is quasi-experimental in nature, we can make the same assumptions regarding the elimination of significant omitted variable bias. Therefore, the primary statistical method of this study is favored over this additional method. We do include this method here in the appendix though as this method can be used outside the quasi-experimental context and can be beneficial for determining external validity in future studies.

References

Association, Florida School Boards. 2017. *UNDERSTANDING THE FEFP*. https://fsba.org/wp-content/uploads/2016/11/2016-17-FEFP-101.pdf.

Chetty, Raj, John N. Friedman, and Jonah E. Rockoff. 2014. "Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood." *American Economic Review* 104 (9): 2633-79. https://doi.org/10.1257/aer.104.9.2633. https://www.aeaweb.org/articles?id=10.1257/aer.104.9.2633.

Coleman, James S. 1966. *Equality of Educational Opportunity*. (U.S. Department of Health, Education, and Welfare).

Education, Florida Department of. 2020. Funding for Florida School Districts. edited by Office of Funding and Financial Reporting in the Bureau of School Business Services.

Eric A. Hanushek, John F. Kain. 1972. "On the Value of 'Equality of Educational Opportunity' as a Guide to Public Policy." In *On Equality of Educational Opportunity*, edited by In Frederick Mosteller and Daniel P. Moynihan (ed.), 116-145. New York: Random House.

Gayler, David E. 2008. 2008-2009 Annual Budget. edited by Educational Support Services. Port Charlotte, Florida: Charlotte County Public Schools.

Greenwald, Rob, Larry V. Hedges, and Richard D. Laine. 1996. "The Effect of School Resources on Student Achievement." *Review of Educational Research* 66 (3): 361-396. https://doi.org/10.2307/1170528. http://www.jstor.org.ezp-prod1.hul.harvard.edu/stable/1170528.

Hanushek, Eric A. 1981. "Throwing Money at Schools." *Journal of Policy Analysis and Management* 1 (1): 19-41.

---. 1986. "The Economics of Schooling: Production and Efficiency in Public Schools." *Journal of Economic Literature* 24 (3): 1141-1177.

---. 1996. "A More Complete Picture of School Resource Policies." *Review of Educational Research* 66 (3): 397-409.

---. 2001. "Spending on Schools." In *A Primer on American Education*, 69-88. Stanford, CA: Hoover Institution Press.

---. 2003. "The Failure of Input-based Schooling Policies*." *The Economic Journal* 113 (485): F64-F98. https://doi.org/https://doi.org/10.1111/1468-0297.00099. https://onlinelibrary.wiley.com/doi/abs/10.1111/1468-0297.00099.

---. 2015. Money Matters After All? Accessed August 5, 2021.

Hedges, Larry V., Terri D. Pigott, Joshua R. Polanin, Ann Marie Ryan, Charles Tocci, and Ryan T. Williams. 2016. "The Question of School Resources and Student Achievement: A History and Reconsideration." *Review of Research in Education* 40: 143-168. http://www.jstor.org.ezp-prod1.hul.harvard.edu/stable/44668621.

Jackson, C. Kirabo, Rucker C. Johnson, and Claudia Persico. 2015. *The Effects of School Spending on Educational and Economic Outcomes: Evidence from School Finance Reforms.* National Bureau of Economic Research, Inc. https://EconPapers.repec.org/RePEc:nbr:nberwo:20847.

K-20 EDUCATION CODE. 2010. In *XLVIII*, edited by State of Florida. Tallahassee, Florida.

Manzo, Dale A. 2021. Evidence of a Relationship Between Racial Composition of Community and School Funding and Academic Performance. Yale College.