12-2018

The Effect of Per-Pupil Expenditures on SOL Pass Rates

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Fall 2018

The University of Tennessee

Chancellor's Honors Program

Honors Philosophy: Senior Thesis

Contents

Abstract

This research explores the impact of public spending on academic success to examine the prevalence of educational inequity in the United States. This project expands knowledge about the factors that contribute to, as well as dilute, a quality education. Using data from the Virginia Department of Education from 2010 to 2017, including 3,760 observations at the school district level, I analyze the relationship between public spending and pass rates on standardized tests. Controls include school year, health status, test subject, high school graduation rates, college enrollment rates, unemployment rates, poverty rates, single-parent household rates, and violent crime rates. I find a significant and negative relationship between per-pupil expenditures and pass rates. When average salary of teachers is used as the independent variable, I find a significant and positive relationship between average salaries and pass rates at the county level.

In order to operationalize my research question, I investigated the effect of total per-pupil expenditures as well as the effect of average teacher salaries on pass rates of the Standards of Learning (SOL) tests in the state of Virginia at the county level. These tests are used throughout Virginia public schools to set learning and achievement expectations for core subjects in grades K-12. For this project, I used county-level per-pupil expenditure data for all 94 counties in Virginia between 2010 and 2017. That data set was merged with data sets that included county-level SOL pass rates as well as general demographics for each county across the same ten-year time period. I controlled for variables at the county level that I expected to have an effect on pass rates based on the relevant literature: high school graduation rates, poor health rates, college education rates, unemployment rates, percentage of children in poverty, percentage of single-parent

households, as well as violent crime rates. Contrary to my hypothesis, I found that an increase in spending had a small but significant and negative effect on SOL pass rates in Virginia from 2010 to 2017. Consistent with my hypothesis, I found that an increase in average teacher salaries had a positive significant effect on SOL pass rates.

Introduction

Why is it that the quality of education differs so much based on the public school a student attends? In this section I will discuss basic information about my project, identify my position relative to previous research, and provide a road map for the paper. In order to better understand the factors that contribute to academic success, I gathered data from various sources for this project. This project uses county-level data on the academic performance of K-12 students in public schools in all 94 counties in my home state of Virginia. The data spans from the year 2010 to 2017. This was the most recent data available and it was chosen in an effort to deliver the most accurate report of the current quality of education. The data set includes seven years of data in order to produce significant findings.

I decided to use data from the state of Virginia for this project, as opposed to a nationally representative sample, because per-pupil expenditures at the local and state level are often much higher than those at the federal level. Using county-level data allows for the examination of the effect of local per-pupil expenditures that would be very difficult otherwise. Additionally, I opted to use county-level data instead of individual-level data because individual-level data for all K-12 students would've produced a massive number of observations. Further, policy recommendations translate more easily from county-level data than individual-level data.

My hypothesis was that increased funding for public schools would lead to an increase in standardized test pass rates. This argument is a common one because it seems logical that increased funding would allow for improved resources in schools, higher salaries for teachers, and more extracurricular activities. All of these factors would likely contribute to an increase in quality of education, which can be represented by an increase in pass rates on standardized tests.

Although many studies have focused on educational inequity and per-pupil expenditures, I was not able to find any relevant county-level studies from the state of Virginia. The Virginia Department of Education offers state-level summaries of SOL pass rates and this project was intended to be a more comprehensive study of county-level SOL pass rates. In this paper, I will discuss the relevant literature, background and policy history before exploring and analyzing the data and results of the project. Lastly, I will offer policy recommendations and suggestions for future research.

Literature Review

The findings from the literature will be discussed in three parts: relating to public education generally, funding, and education in the state of Virginia. To offer an idea of the magnitude of spending for education, total expenditures for public education in the United States exceed $668 billion annually (NCES Fast Facts). Educational spending seems to be a controversial topic in the U.S. and many scholars have inquired what affect this funding has on students' quality of education. Many studies have asserted that there should be a positive relationship between public expenditures and quality of education (Raymond).

First, I will discuss commonly used measures of educational quality. Raymond's 1968 paper titled "Determinants of the quality of primary and secondary public education in West Virginia" describes the methods used in the study. This study used ACT scores as well as freshman grade point averages as quality measures. The sample was a group of 5,000 students entering West Virginia University. While both quality measures were well thought-out and also weighted to represent a more comprehensive population, ACT scores seem to be a problematic measure of the quality of education in public schools. Students with intentions of pursuing higher education have an incentive to take standardized tests such as the ACT or SAT, but those without those intentions do not, and therefore would not be included in the sample. The quality measures in Raymond's study would be a more accurate measure of the educational quality of students planning to pursue higher education.

Quality of education can be defined as as "the adequacy of preparation for higher education" (Raymond). Raymond acknowledges that the study may not be externally valid because of the limiting factor of using ACT scores in the data, but goes on to say that "this aspect of education [adequacy of preparation for higher education] may prove representative of education in general".

Other studies have used gains in test scores as their dependent variable (Eide). This is an effective quality measure because the sample will be representative of all of the students in the grade because it reflects scores from a standardized test. Eide's study used a nationally representative longitudinal dataset of a cohort of public high school students. The dataset includes their math test scores as sophomores and then again as seniors. This use of a time-series data set is useful in controlling for individual heterogeneity.

Many scholars reference the quality of instruction as being relevant to the quality of education. This seems logical since students perform differently under the instruction of different teachers and teaching methods in general. Some studies use teachers' salaries as the quality measure for instruction (Raymond). Because one would expect a positive relationship between teachers' salary and the quality of instruction, it follows that school systems paying the highest salaries should procure the best teachers and thereby offer the best instruction, as long as teachers are relatively mobile (Raymond). This supports the use of average teacher salaries as an independent variable in my study of quality of education in Virginia.

The independent variable in Raymond's 1968 study was teachers' salaries and per-pupil expenditures were included as one of four direct determinates. Per-pupil expenditures are described as proxies for the adequacy of auxiliary facilities and thus should be positively related to quality (Raymond). The study showed that per-pupil expenditures had no significant effect on quality of education, but this could have been for a number of reasons. Because the study focused on the effect of teachers' salaries, observations of per-pupil expenditures did not include teachers' salaries in order to avoid multicollinearity. The National Center for Education Statistics writes that per-pupil expenditures normally include salaries, employee benefits, purchased services, tuition, and supplies (NCES Fast Facts). Raymond accounted for this by concluding that, had the salaries not been deleted, "it is quite probable that current expenditures would have proven significant" (Raymond). My decision to use per-pupil expenditures as an independent variable in this project was based on the fact that per-pupil expenditures generally include teachers' salaries as well as other seemingly important statistics about

public schools. Teachers' salaries were investigated independently to determine whether or not they would have the same effect.

Many other studies were set up similarly to that of Raymond. Some studies investigated the ways in which school resources affect achievement at different points of the conditional test score distribution (Eide). Eide's research was based on the idea that public funding affects populations of students differently. The 1998 study used quantiles to find that increasing per-pupil expenditures has a significant positive affect on test score gains at the bottom of the conditional distribution, but no significant impact on average test score gains. Eide focused on mathematics test scores, which are included in the data set for this project as well. Other individual controls in Eide's study include gender, race/ethnicity, presence of mother and father in the household, educational attainment of father and mother, family income, family size, community residence and region. While some of those variables are not compatible with county-level data, others were more easily included in this project such as percentage of single-parent households, high school graduation rates and college enrollment rates.

Background

Funding

In this section, I will discuss the background of public education in the state of Virginia, including funding, distribution of funding, and Standards of Learning**.** First, let us discuss school funding. The majority of funding for public schools comes from localities, and school divisions also rely heavily on state funding. This funding is used for many purposes but the vast majority is spent on instruction—salaries and benefits for

school staff comprise approximately 75 percent of total spending (Efficiency and Effectiveness of K-12 Spending). This number may fluctuate slightly across school divisions because while state and federal laws and regulations pose some restrictions on school divisions, the school divisions possess a significant amount of flexibility in deciding how to allocate the funds.

To offer an idea of the extent of this funding, Virginia school divisions spent a total of $15.6 billion on K-12 education in 2014 for 1.27 million students (Efficiency and Effectiveness of K-12 Spending). This means average per-pupil expenditures in 2014 were about $12,200. Virginia is close to the national average in per-pupil expenditures but relies more heavily on funding from localities than most states do. Interestingly, it is also the case that Virginia's students score above the national and southeast average in reading and mathematics on the National Assessment for Education Progress (Efficiency and Effectiveness of K-12 Spending).

Distribution of Funding

Next, I will discuss the distribution of school funding in Virginia and the background behind it. A measure of fiscal capacity called the Local Composite Index (LCI) was developed as a wealth measure for school districts (Salmon). Basic State Aid is determined for each school division based on the LCI and a number of other factors. The economic productivity of certain areas of the state can skew the Basic State Aid numbers significantly. In Virginia, the majority of economic productivity occurs in Northern Virginia, Richmond, and Hampton Roads. These areas have a profound affect on the rest of the state—Salmon offers the following example: "if real estate values in any of these three areas suffer in a recession- particularly if they experience a more rapid

and deeper drop than the commonwealth as a whole- the large-high growth school divisions will see their LCIs decline significantly, while the vast majority of other school divisions will see their LCIs increase precipitously". Despite the individual calculation of funding for school divisions, this funding is interrelated with the economy of parts of the state and of the state as a whole.

Standards of Learning

Next, I will discuss the Standards of Learning tests in Virginia—what they entail, and the requirements for passing. There are five SOL assessments in Virginia: English reading, English writing, mathematics, history and social science, and science. The purpose of these assessments, according to the Virginia Department of Education, is to "establish minimum expectations for what students should know and be able to do at the end of each grade or course in English, mathematics, science, history/ social science and other subjects" (Virginia Department of Education). This definition is important because it clarifies that the purpose of these test is to establish a bare-minimum benchmark for the state. All assessments, with the exception of the English writing SOL, are composed of 35 to 50 items intended to "measure content knowledge, scientific and mathematical processes, reasoning and critical thinking skills" (Virginia Department of Education). The English writing assessment is divided into multiple-choice questions and an essay.

Student achievement on all assessments is measured as basic, proficient or advanced, where basic conveys progress toward proficiency (Virginia Department of Education). Performance on SOLs is graded on a scale of zero to 600, with 400 serving as the minimum level of accepted proficiency and 500 and up indicating advanced proficiency (Virginia Department of Education). Pass rates, as they are used in this

project, reflect the percentage of students who achieved at least the minimum level of accepted proficiency.

SOL testing in Virginia has evolved over the last few years. First, nearly all of SOL tests are now taken online; exceptions are made for students with a documented and disability-related need to use pencil and paper for the assessments (Virginia Department of Education). These online tests have allowed for the Virginia Department of Education to use adaptive testing such as the sixth-grade mathematics SOL test. This adaptive format is innovative because it "provides each student with an assessment customized to his or her ability level" (Virginia Department of Education). More tests of this nature will likely be introduced in the near future. Lastly, elementary and middle school students who narrowly fail SOL assessments or fail because of extenuating circumstances now have the opportunity to retest before the end of the year. As these SOL assessment policies chance, the results must be interpreted accordingly.

Policy History

In this section, I will discuss the history of education policy in Virginia. The Commonwealth of Virginia has had a long and complicated history of lack of funding for public schools. More specifically, like many states, there are severe funding disparities across school divisions in Virginia; the least affluent school divisions have been suffering most. Virginia has one of the least equalized school finance systems, in terms of the distribution of funding for elementary and secondary public education (Salmon).

A somewhat recent case in Virginia exemplifies the extent of the inequality. In 1991, a group of 41 low fiscal capacity school divisions sued the state in Scott v.

Commonwealth of Virginia (Salmon). These school divisions, constituting the Coalition for Equity in Educational Funding, alleged "the state system of school finance was unconstitutional because it failed to provide a uniform system of public education which provides children throughout the Commonwealth with substantially equal educational opportunity" (Salmon). The Virginia Supreme Court asserted that education is a fundamental right under the State constitution, but the constitution does not necessitate equal per-pupil expenditures or equal programs across all school districts (Education Law Center). The Supreme Court also declared that funding is decided upon by the General Assembly.

Since the recession, funding for Virginia schools has decreased significantly. While virtually all state agencies have cut spending, funding for public education has fallen particularly low. Specifically, as of 2014, Virginia school divisions spend nine percent less on average per-pupil expenditures than they did in 2005 (Efficiency and Effectiveness of K-12 Spending). This report emphasized the significance of these reductions in spending in certain divisions: "spending declined by more than 10 percent for 59 divisions, including four divisions that now spend at least 20 percent less". In other words, per-pupil expenditures decreased significantly across the state while many divisions are educating more students. This is likely due to budget cuts that reduced the number of instructors and staff. Beyond numbers of teachers, teachers' salary growth was also limited and more teachers are now required to pay a higher percentage of health insurance and retirement benefit costs (Efficiency and Effectiveness of K-12 Spending). These state budget reductions have negatively affected the quality of public schools

throughout Virginia but especially those in lower fiscal capacity school divisions (Salmon).

Data and Methods

In this section, I will discuss the type and source of data, basic statistics in the data, the method of analysis, and expected relationships based on the literature. First, I collected and merged data from multiple datasets in order to run this regression. I gathered county-level data on all counties in Virginia from the County Health Rankings and Roadmaps website—this data is collected and reported each year and includes a number of health-related topics. This data set includes county-level data on fair/ poor health, high school graduation, college enrollment, unemployment, children in poverty, single parent households, and violent crime. Per-pupil expenditures data was available on the Virginia Department of Education website. This data included local, state, federal, and total expenditures by school division (or county) and is released as part of the Superintendent's Annual Report for Virginia. There was also useful data on the Virginia Department of Education's school quality profiles website. This data is released annually—county-level data including the subject of the SOL as well as the pass rate were used in this project. The five SOL tests included in the data set are English: Reading, English: Writing, History and Social Science, Mathematics and Science. All of the data from 2010 to 2017 was collected and merged into a single dataset to include cross-sectional and time series data.

Table 1 shows the abbreviations each variables as well as units of analysis of the data.

Table 1:

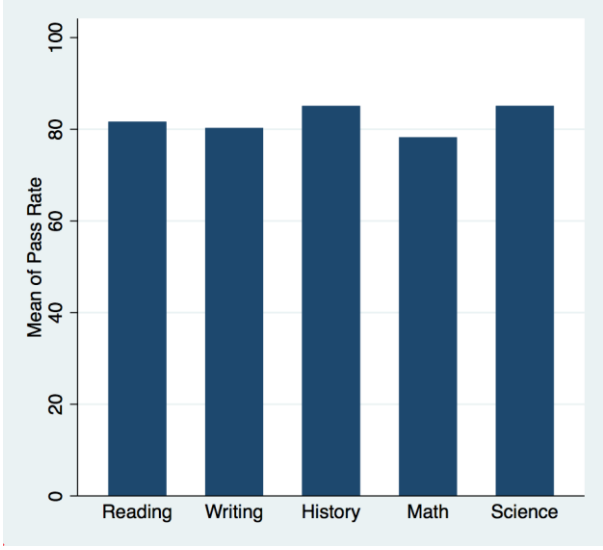
Variable Name	Description
subject	Subject of SOL test
passrate	% of students that passed test by county by year
avsalary	Average salary of all teaching positions by county by year
spendperpup	Per-pupil expenditure by county by year ($)
schoolyear	Fiscal year: 4=2010, 5=2011…11=2017
healthstatus	% of adults that reported fair or poor health in county
hsgrad	Graduation rate in county
college	% of adults age 25-44 with some post-secondary education in county
unemployed	% of population ages 16+ unemployed and looking for work in county
childreninpoverty	% of children (under age 18) living in poverty in county
singleparenthouseholds	% of children that live in single-parent households in county
violentcrimerate	Violent crimes per 100,000 population in county

Per-pupil Expenditures Summary Statistics:

Variable	Obs	Mean	Std. Dev.	Min	Max
Spendperpup	5170	10647.71	1966.266	8103	20543

As shown above, there is a massive range of per-pupil expenditures included in the data set. Between 2010 and 2017 across all counties in Virginia, the lowest per-pupil expenditure was a mere $8,103 while the highest per-pupil expenditure amounted to $20,543. This indicates tremendous discrepancies between underfunded and well-funded school districts in Virginia and generates questions regarding the potential difference $12,000 per student could make.

Average Pass Rate by Subject:



The bar graph above depicts the variation in pass rates by subject from 2010 to 2017. It is clear that there is not much variation between subjects, which suggests that it may not be necessary to run regressions using individual SOL tests but rather the average pass rates on all SOL tests.

Next, I will discuss the method of analysis used in this project. I used multivariate regression to determine the relationship between per-pupil expenditures and pass rates on standardized testing. In this regression, the independent variable is per-pupil expenditures and the dependent variable is pass rates. I controlled for the following variables: school year, health status, high school graduation rate, college enrollment rate, unemployment rate, percentage of children in poverty, percentage of single-parent households, and percentage of violent crime. These variables were included in the regression in an attempt to isolate the effect of funding on academic success. The variables were chosen based on their inclusion in studies in the relevant literature as well as independent thinking. The

second regression included all of the same control variables, but used average salary of instructional staff instead of per-pupil expenditures as the independent variable.

Multivariate regression analysis was the appropriate method for this data because it can predict the unknown effect of changing one variable on another, while controlling for other relevant factors. When using regression analysis, it is assumed that there is a linear relationship between the variables and that the relationship is additive. This method was appropriate for the research question because I am investigating a relationship between two variables. There are many other variables that affect this relationship and I made an attempt to control for those that were both referenced in the literature and accessible. Because the data set includes time-series and cross-sectional data, a multivariate regression offered a way to measure the effects.

Table 2 shows expected relationships between each variable and the effect on pass rates on standardized tests.

Table 2:

Variable	Expected Relationship
spendperpup	+
avsalary	+
schoolyear	+
healthstatus	-
hsgrad	+
college	+
unemployed	-
childreninpoverty	-
singleparenthouseholds	-
violentcrimerate	-

These expected relationships are based in literature or common sense. For example, let us examine *hsgrad*. As indicated in Table 1, the variable *college* represents the percentage of adults with some form of college education in the county. One would expect that as

that rate increases, and a county has more college-educated adults, it would also produce more students who pass their SOL assessments. Additionally, many previous studies included high school graduation rates at the county level or education level of parents for individual-level data. In addition to *college,* one would expect for *spendperpup, avsalary, schoolyear,* and *hsgrad* to be positively related to pass rates. On the other hand, one would expect *healthstatus, unemployed, childreninpoverty, singleparenthouseholds,* and *violentcrimerates* to be negatively related to pass rates in a county. Some of these variables, such as *childreninpoverty* and *unemployed,* may be highly related to each other so it will be necessary to run a VIF test to determine whether or not there is multicollinearity.

Data Analysis & Visualization

In this section, I will present and explain the main findings, analyze these findings, and identify potential problems with this analysis. The main findings for regression 1 are depicted in the following tables. Table 3 shows overall model fit and Table 4 depicts the parameter estimates.

Regression 1:

$$Passrate = \alpha_0 + \beta_1 Spendperpup + \beta_2 Schoolyear + \beta_3 Healthstatus + \beta_4 HSgrad + \beta_5 College + \beta_6 Unemployed + \beta_7 Childreninpoverty + \beta_8 Singleparenthouseholds + \beta_9 Violentcrimerate + e_i$$

Table 3:

Number of obs	3,185
F (9, 3175)	172.22
Prob > F	0.000
R-squared	0.3053
Root MSE	6.8085

Table 3 explains the overall model fit. There were 3,185 observations used in this regression analysis. The p-value of 0.0000 is associated with the F-statistic and it explains the reliability of per-pupil expenditures to predict pass rates. The p-value is lower than 0.05, which expresses statistical significance in the regression. The R-Squared value is an overall measure of the strength of association of all of the variables—this R-Squared value of 0.3053 indicates that approximately 31% of the variation in pass rates can be explained by per-pupil expenditures when all other variables in the regression are held constant.

Table 4:

passrate	Coef.	Robust SE	t	P>|t|	[95%	Conf. Interval]
spendperpup	-0.000125	0.0000645	-1.94	0.053	-0.0002515	1.36E-06
schoolyear	0.433678	0.0800298	5.42	0.000	0.2767629	0.5905936
healthstatus	0.206907	0.0338022	6.12	0.000	0.1406312	0.2731839
hsgrad	-0.192529	0.021086	-9.13	0.000	-0.2338732	-0.1511862
college	0.000047	0.0000126	3.77	0.000	0.0000229	0.0000723
unemployed	-0.087210	0.1131884	-0.77	0.441	-0.3091407	0.134719
childreninpoverty	-0.360562	0.0317701	-11.35	0.000	-0.4228547	-0.2982705
singleparenthouseholds	-0.264863	0.0198432	-13.35	0.000	-0.3037703	-0.2259567
violentcrimerate	-0.003397	0.0024815	-1.37	0.171	-0.0082626	0.0014684
_cons	105.940	2.007902	52.76	0.000	102.004	109.8778

The parameter estimates shown in table 4 offer significant insight into the ways in which the above variables affect pass rates on standardized tests. Contrary to some of the literature, as well expected relationships shown in Table 2, the sign of *spendperpup* is negative and there is no evidence from the model to support the hypothesis. Specifically, a $1 increase in per-pupil expenditures is associated with a 0.013% decrease in pass rates.

Because the p-value is 0.053, this is arguably not statistically significant. The number zero is included in the range of the 95% confidence interval, which suggests that this variable is not significant.

Next, there are a few more interesting findings from Table 4. A few of the variables contradicted the values suggested in Table 3's expected relationships. For example, *hsgrad* had a negative coefficient, which was particularly surprising because one would expect a more educated county to produce more students who pass SOL tests. It was also interesting to find that *unemployed* and *violentcrimes* were not statistically significant variables in explaining pass rates—this is indicated by the fact that both p-values are higher than 0.05. Finally, the t-value of -13.35 for *singleparenthouseholds* and the t-value of -11.35 for *childreninpoverty* indicate that both are significant in the regression at the 99.99% confidence level. These are both significant in the expected direction of the regression, as referenced in Table 2.

The main findings in this regression reveal that my hypothesis that increased per-pupil expenditures would lead to an increase in pass rates on standardized tests could not be supported by the county-level data from 2010 to 2017. There are a few potential issues with this analysis. The first is that increased per-pupil expenditures within a school division could be due to economically advantaged communities with great focus on education, but it could also be part of an attempt to raise standards in underperforming school divisions. This could lead to complications in interpreting the data. Further, it is possible that other variables that were not included in the regression are significant in explaining the variation in pass rates of standardized tests. For example, other studies included multiple measures of educational quality such as GPA and ACT scores, whereas

SOL pass rates were the only measure of educational quality in this regression. Lastly, certain variables that likely have an effect on pass rates are either unobserved or unobservable, such as the near-impossibility of quantifying intrinsic motivation. Because *spendperpup* was negatively related to pass rates, it would be interesting to use *avsalary* as the independent variable to determine pass rates.

Regression 2:

$$Passrate = \alpha_0 + \beta_1 Avsalary + \beta_2 Schoolyear + \beta_3 Healthstatus + \beta_4 HSgrad + \beta_5 College + \beta_6 Unemployed + \beta_7 Childreninpoverty + \beta_8 Singleparenthouseholds + \beta_9 Violentcrimerate + e_i$$

The second regression uses all of the same control variables as the first regression; the only difference is the use of *avsalary* as the independent variable used to determine pass rates.

Table 5

Number of obs	3,185
F (9, 3175)	179.93
Prob > F	0.0000
R-squared	0.3053
Root MSE	6.8087

Interestingly, the R-squared value of 0.3053 remained exactly the same from the previous regression. This indicates that, holding control variables constant, both *spendperpup* and *avsalary* explain about 31% of the variation in pass rates. The p-value is lower than 0.05, which expresses a statistically significant regression.

Table 6

passrate	Coef.	Std. Err.	t	P>|t|	[95%	Conf. Interval]
avsalary	0.0000475	0.000023	2.06	0.039	2.37E-06	0.0000926
schoolyear	0.4050442	0.0804422	5.04	0.000	0.2473201	0.5627682
healthstatus	0.2176262	0.0336202	6.47	0.000	0.1517067	0.2835457
hsgrad	-0.1925192	0.0209914	-9.17	0.000	-0.2336774	-0.1513611
college	0.0000435	0.0000126	3.46	0.001	0.0000189	0.0000682
unemployed	-0.0072157	0.1137071	-0.06	0.949	-0.2301624	0.2157311
childreninpoverty	-0.3482136	0.0334113	-10.42	0.000	-0.4137235	-0.2827036
singleparenthouseholds	-0.2724219	0.0198838	-13.7	0.000	-0.3114082	-0.2334356
violentcrimerate	-0.0046351	0.002512	-1.85	0.065	-0.0095604	0.0002902
_cons	102.0607	2.220942	45.95	0.000	97.70606	106.4153

The parameter estimates from Regression 2 indicate very different results than the first regression. The most interesting finding is that an increase in the average teacher's salary is associated with an increase in pass rates at the county level. The p-value of 0.039 indicates that this is significant. The variables *college* and *schoolyear* also show a positive relationship with pass rates. Consistent with Regression 1, both *childreninpoverty* and *singleparenthouseholds* are significant in the expected direction of the regression.

Breusch-Pagan test for heteroskedasticity

Ho: Constant variance
Variables: fitted values of passrate

chi2(1)	140.39
Prob > chi2	0.0000

The Breusch-Pagan test can identify heteroskedasticity in a regression. Originally, the second regression did not include Hal White's robust standard errors. The p-value of 0.000 in the BP test indicates that we can reject the null of homoscedasticity. This means

that the standard errors in the regression were skewed, but the coefficients were unaffected. To account for this heteroskedasticity problem in the second regression, the regression was repeated using robust standard errors.

AIC/ BIC

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
	3,185	-11203.85	-10623.77	10	21267.54	21328.21

The Akaike Information Criterion (AIC) was used to compare Regression 1 and Regression 2. The AIC can be an objective way to compare the model fit. The R-squared value can also indicate this but the AIC is ultimately a better test to use because while the R-squared value changes depending on the addition of a variable, the AIC would not necessarily change. The AIC change with the predictors' composition and better indicates the quality of the model fit. The AIC and BIC values above reflect that of Regression 2, but Regressions 1 and 2 had almost exactly the same AIC and BIC values. This indicates that both explain about the same amount of variation in the data.

VIF

Variable	VIF	1/VIF
childreninpoverty	4.15	0.241249
unemployed	2.79	0.357963
singleparenthouseholds	2.75	0.364277
schoolyear	2.47	0.404799
healthstatus	2.11	0.474878
avsalary	1.97	0.507005
hsgrad	1.61	0.62302
violentcrimerate	1.23	0.810001
college	1.08	0.928493

Mean VIF	2.24	

Multicollinearity violates one of the classic assumptions. Perfect multicollinearity is a mathematical problem but imperfect multicollinearity can be trickier to solve. Good theoretical modeling can help to mitigate multicollinearity but it is important to test for it in a regression because it can cause instability of coefficients as well as an increase in variance. The VIF of these variables is calculated by dividing 1 by 1 minus the R-squared value. A VIF value above 5 indicates a problem with multicollinearity. Based on the VIF table above, it appears that multicollinearity is not a problem in this regression.

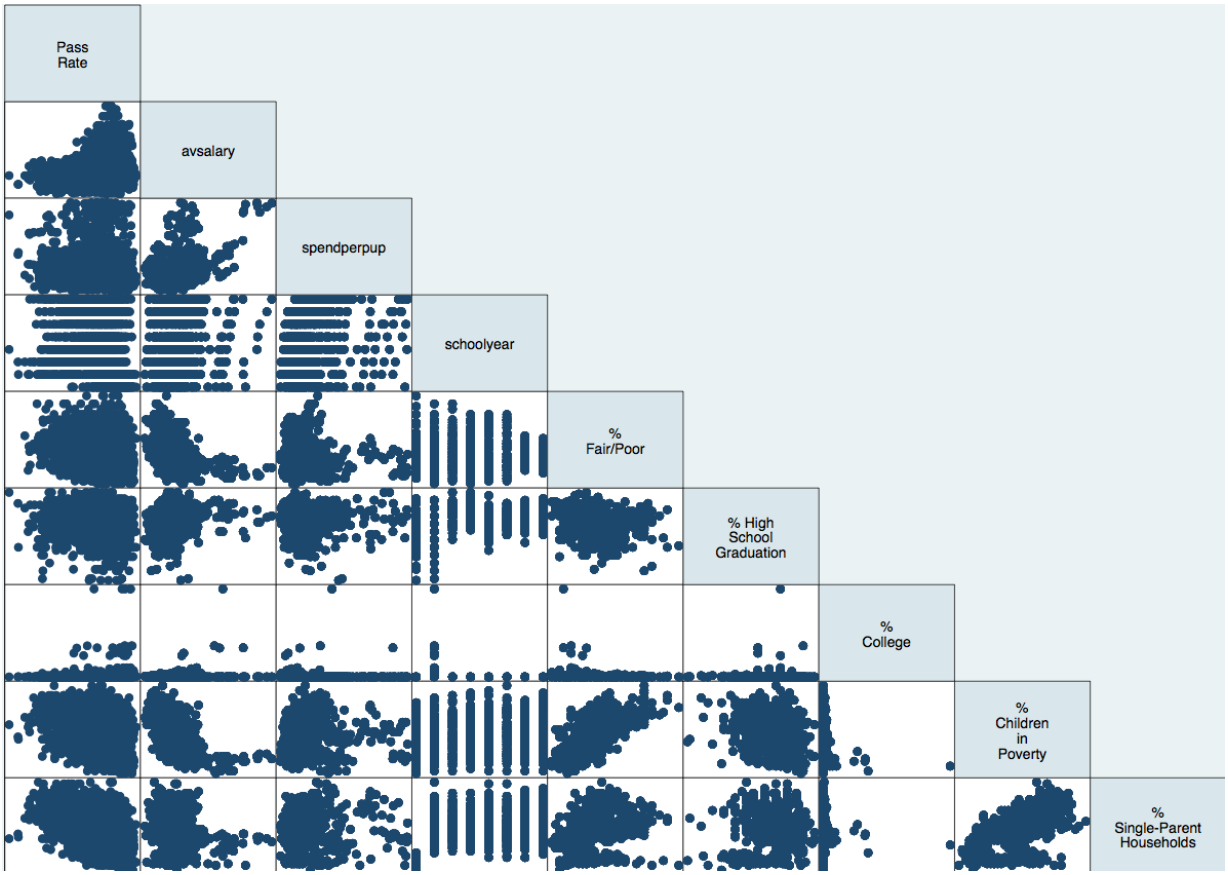
Regression Table 1

	Regression 1	**Regression 2**
	passrate	passrate
spendperpup	-0.000125	
	(-0.0000715)	
schoolyear	0.434***	0.405***
	(-0.0805)	(-0.0814)
healthstatus	0.207***	0.218***
	(-0.0314)	(-0.0312)
hsgrad	-0.193***	-0.193***
	(-0.0186)	(-0.0186)
college	0.0000476***	0.0000435***
	(-0.000011)	(-0.0000111)
unemployed	-0.0872	-0.00722
	(-0.103)	(-0.103)
childreninpoverty	-0.361***	-0.348***
	(-0.0298)	(-0.0314)
singleparenthouseholds	-0.265***	-0.272***
	(-0.018)	(-0.0179)
violentcrimerates	-0.0034	-0.00464
	(-0.00242)	(-0.00245)
avsalary	0.0000475	

	(-0.0000281)	
_cons	105.9***	102.1***
	(-1.814)	(-2.118)
N	3185	3185
Adj R-sq	0.303	0.303

This regression table allows us to compare the two regressions side by side. The dependent variable, pass rates, is listed at the top of the table. The standard errors are shown in parenthesis under the coefficients for each variable. The most significant difference highlighted by this table is that *spendperpup* is negatively related to pass rates while *avsalary* is positively related to pass rates. Additionally, the p values are represented by asterisks as following: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Matrix Graph



This matrix graph provides an excellent way to examine the relationships between variables. Through the use of this graph, we are able to examine the relationship between any two variables in the regression. *Unemployed* and *violentcrimerate* were not included in the matrix graph because of their high p-values relative to the p values of the other variables—this indicates that those two variables were not as significant in the regression. This matrix shows the somewhat strong positive correlation between *avsalary* and pass rates in contrast with a lesser correlation between *spendperpup* and pass rates. The strongest positive relationship in the matrix seems to be between *childreninpoverty* and *singleparenthouseholds*, which is logical. It can be interpreted to mean that as the

percentage of single parent households increases, the percentage of children in poverty will also increase. It is also important to note the relatively strong negative correlations between both *childreninpoverty* and *singleparenthouseholds* and pass rates.

Conclusions, Policy Recommendations and Future Research

My research question inquired into the relationship between funding for public schools and the quality of education in public schools. This research question is of great importance because of growing educational inequity in the U.S. The experiences and academic successes of public school students vary widely by school district and I was interested to learn whether or not lack of funding was a primary cause of that issue.

To investigate this general research question, I explored a more specific question: what effect do per-pupil expenditures have on SOL pass rates at the county level in the state of Virginia? Would average salary of teachers by county produce the same effect? These questions were much more feasible because of the data available through the Virginia Department of Education. Based on the OLS regressions described earlier, it is evident that between the years of 2010 and 2017, there is no evidence that an increase in per-pupil expenditures resulted in higher SOL pass rates. During the same time period, an increase in average teachers salaries was associated with an increase in SOL pass rates at the county level in Virginia, and was statistically significant. There are practical, theoretical and empirical implications of these findings. First, in the policy realm, it is unclear whether or not generally allocating more money to school divisions is the most effective solution to the problem of educational inequity. Theoretically, although

teacher's salaries are part of the measurement for per-pupil expenditure, allocating more money directly to salaries could be more effective.

Based on these findings, the following are policy recommendations to address educational inequality. Based on the significance of the percentage of single-parent households within the county on SOL pass rates, one solution could be to increase the number of mentors within schools. An increase in single-parent households within the county had strong negative effects on SOL pass rates, which may indicate that students that come from single-parent households would benefit from additional mentorship. This could come in the form of counselors, coaches, or other adult figures to set positive examples. Additionally, it is possible that changing the curriculum for those pursuing a teaching degree could increase the quality of instruction. In the future, it would be interesting to research common traits of those struggling in an academic setting versus those excelling in an academic setting at the individual level. This could offer insight into the most important individual traits that are related to academic success and could hopefully be expanded to a wider population of students.

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