A Study of How Individual School Characteristics Affect School Performance

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Abstract

According to the Georgia Department of Education, over 20 billion dollars are spent on public education in Georgia every year. Knowing this, it is critical to understand what factors have the largest impact on student performance in order to budget money efficiently. Standardized test scores are used as a measure of student performance and compared to personnel and demographic information to determine the most impactful components. Both simple and multiple regression analyses are utilized to ascertain the relationship between standardized test scores and these variables. The analyses show many metrics that intuitively should be impactful have little to no correlation, and the percentage of students who qualify for the “Directly Certified” program, a poverty alleviation program, is the most significant.

I. Introduction

The school-choice platform of the new Education Secretary Betsy DeVos has public schools asking: what can we do to improve? As college education is becoming more critical to finding a job, an important metric for public schools to consider is standardized test score performance. If public high schools want to be seen as a path to university, it is essential to understand which factors have a positive influence on standardized test scores, as this will help allow students to attend better universities. Furthermore, and perhaps more importantly, studies have shown that standardized test score performance correlates with labor force quality.

This paper focuses on school level data for public high schools in the state of Georgia for the 2015-2016 academic year. The data set attempts to consider all public high schools in Georgia, however the Georgia Department of Education does not report SAT information for a school if fewer than ten students took the exam. Additionally, some schools failed to report their information for the previous school year, but these are exceptions and should not impact the results.

Although this study uses the average SAT score of the school as the metric for student performance, it is important to consider that other metrics can be used to measure this. We choose SAT scores for two main reasons: college prospects and the relationship between SAT scores and labor productivity. University is a place of significant growth, and if students continue their education in the best learning environment possible it will help them contribute more to society after graduation. Supporting this idea are studies indicating that high SAT scores lead to increased labor productivity in the long run. Other measurements of student performance can be used - such as state-level standardized test scores, AP test scores - but for the purpose of this study SAT scores are an accurate way to measure aptitude.

Similar studies have shown that factors such as expenditure per student and student-teacher ratio do not influence a school's overall test performance. These results are completely counterintuitive and indicate that the issue at hand requires more than additional funding schools. Consequently, we propose that poverty indicators will have a negatively impact SAT scores while participation rates will have a positive correlation. Should this hold true, it will suggest that government funding should be invested into poverty alleviation instead of school expenditure, and that the atmosphere and culture of a school is more consequential than funding.

II. Literature Review

The application of the production function framework to education can trace its roots to Coleman (1966). The study was mandated by the Civil Rights Act of 1964 to investigate disparities of educational opportunity within the educational system of the United States. In total, the study surveyed some 600,000 students, 60,000 teachers, and 3,000 schools. The initial purpose of the report was to shed light on the extent of discrepancies between primarily caucasian schools and primarily minority schools since the *Brown vs. Board of Education* ruling in 1954. However, the results proved controversial, as Coleman found that variation in schooling facilities accounted for relatively little of the variation on student performance (1966). Rather, each student's family background was more reflective of their educational outcome. In describing school facilities, Coleman used variables such as the age of the school, the presence of facilities such as auditoriums and laboratories, financial characteristics of school staff, and poverty alleviation programs such as free lunches. In describing family background, Coleman accounted for the presence of each parent, the presence of home items conducive to learning, the expectations of parents for their child, and the parents' education. Criticism of the statistical analysis of the report includes implicit bias towards the family background explanation, often leading to debates over the validity of Coleman's results. Nevertheless, the Coleman Report laid the groundwork for future studies on the factors which affect educational outcomes.

Building on the Coleman Report, Hanushek (1986) attempts to build a production function applied to the educational environment. Hanushek considers inputs for his function as those controllable by policy makers – characteristics of schools, teachers, curricula, etc – and those uncontrollable by policy makers – families, friends and innate endowments of the student. Additionally, Hanushek adjusts for the delayed response aspects of education; that is, educational output is measured at discrete increments, while true educational outcomes are cumulative processes accruing over a child's formative years. Hanushek (1986) uses average SAT scores by school as a metric for educational outcomes. Hanushek makes several efforts to increase the predictive nature of the input through adjusting the data. For example, when discussing the issues arising with measuring teacher performance, Hanushek suggests measuring teachers implicitly, rather than explicitly, by adjusting their student base such that each teacher serves identical students. In doing so, Hanushek provides a means to accurately describe teacher to teacher teaching efficiencies. His work shows that by adjusting school characteristics using his methods, schools' differences do explain the variability of student performance.

An important point to discuss when using standardized tests as a metric for school performance is the selection bias inherent in these tests. Due to the selective nature of students who can perform well on these tests being those who take them, the data is nonrandom. Dynarski and Gleason (1993) observe and try to correct for this phenomenon in their study. Using the participation rates of the SAT, the researchers adjusted the SAT scores and then compared the state average rankings to another ranking created by the NAEP's average scores. The NAEP was given to a random sample of students suggesting it was a better determinant of the school system's performance. Dynarski and Gleason (1993) concluded that even with a simple linear model the participation rate was significantly correlated with the SAT scores and that correlation could be strengthened with a more complex model. They also showed that the adjusted score rankings were correlated with the other test, implying that adjusted scores are a better metric. The paper provided some keen insights, however the way they calculated participation rates was by dividing by the total number of 18 year olds in the year of their SAT data. This seems like an imprecise calculation since there are a significant number of 18 year olds who are no longer students and so including these people as eligible participants seems naive.

Finally the economic impact of what higher test scores mean needs to be examined. In Hanushek and Kimko (2000), the researchers consider what is an appropriate measure of a country's labor force. The authors determined that a standardized test was an effective measure of labor force quality along with normal quality of school metrics. From these measures they showed that the labor force quality has a strong positive relationship with economic growth. So through the comparative nature of standardized test the labor quality of a region can be measured and see how the quality influences the economic impact of these workers. Hanushek and Kimko (2000) did these studies on a country level which provide rather robust samples which may not translate directly to more refined data sets. Using this knowledge, if traditional schooling measurements can be directly linked to the test scores, then analysing characteristics of the schools could provide insights into the quality of work force produced by each school.

The study looks to build off of these reports to see if these conclusions can be applying to public high schools in the state of Georgia. One unique aspect of this study is that, instead of using individual student or state-wide data, the information gathered for the study comes from a school level. This means our study will give insight to how individual schools can change to better their student performance. This is only one step below county level data, which is where most of the budget allocation power lies, and it will be easy to aggregate our findings to the county level to affect policy making.

III. Data

A. Variable Descriptions

The dependent variable in this study is simply average SAT scores at the school level. The explanatory variables considered are summarized below. Some important definitions to keep in mind are Full-Time Equivalency (FTE) and Directly Certified. Full-time equivalency accounts for one student who is taking a complete course load; if there a student is taking a half course load, they would be considered as one half FTE. This is an appropriate way to measure school enrollment because it represents the school's demand for resources. As outlined by the Georgia Department of Education, a Directly Certified student is classified as falling into one of three categories:

1. Lives in a family unit receiving Supplemental Nutrition Assistance Program (SNAP) food stamp benefits,
2. Lives in a family unit receiving Temporary Assistance for Needy Families (TANF) benefits, or
3. Identified as homeless, unaccompanied youth, foster, or migrant.

This means that schools with a higher percentage of Directly Certified students are in areas where there is a larger need for government assistance programs.

fteexp

Full-Time Equivalency Expenditure; the amount of funding allocated to instructional purposes for the school divided by school FTE count. In short, this is the instructional expenditure per students. More money allocated to instruction should allow for a better education for the students.

nhq

Not Highly Qualified Percentage; the number of teachers employed at the school that are not “highly qualified” (less than a bachelor’s degree in education) divided by the total number of teachers. As the percentage of teachers who are not highly qualified increases, so do the odds that student will be taught by one of these teachers. A student might not receive a quality education in that course, and it could be a discouraging experience for them.

stratio

Student-Teacher Ratio: the school FTE count divided by the number of teachers employed at the school. If students are in a smaller classroom and are given more attention in class, this will result in a stronger desire to learn, which might lead to more preparation for the SAT.

satpart

SAT Participation; the number of students who took the SAT divided by the number of graduates. If a school creates a culture of succeeding and going to university, students might be more inclined to prepare for the SAT and take it. An important situation to consider is when schools force their students to take the exam. This would result in high participation rates, but students might not be serious about taking the exam and not perform as well. Consequently, we expect SAT participation to exhibit an “upside-down U curve” distribution against SAT scores.

white

White Percentage; the percentage of students at the school who are caucasian. This variable gives insight into the diversity of the school.

dircer

Directly Certified Percentage; the percentage of students at the school that are classified as “Directly Certified” (see definition above). This statistic serves as a poverty indicator.

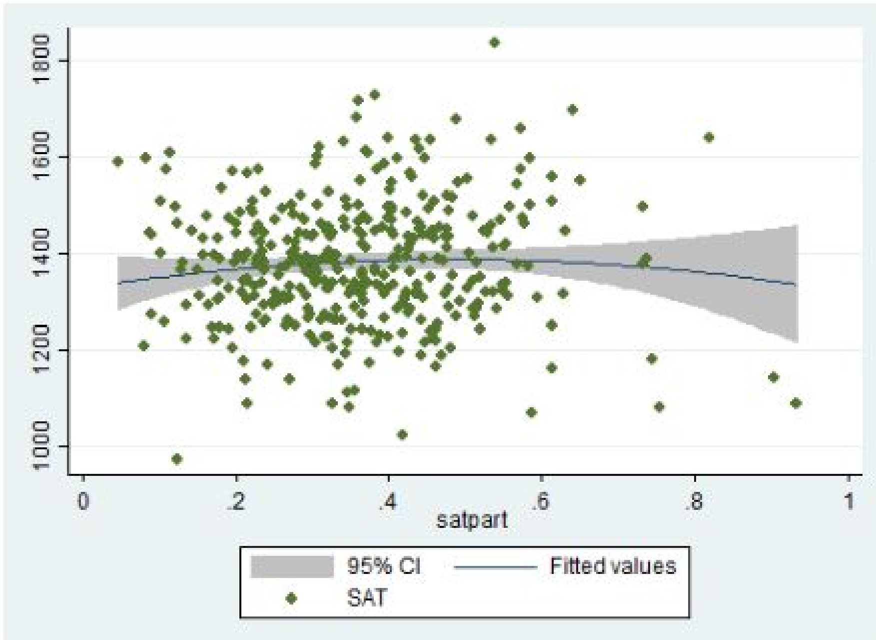
The Georgia Department of Education supplies all the data in this study. Schools send their information to the county offices, and this data is then sent to the State Department of Education. All data is from the 2015-2016 school year.

B. Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
fteexp	377	5119.27	935.66	3388.52	13833.17
nhq	377	0.01	0.03	0	.54
stratio	377	18.43	6.73	5	128.25
SATpart	377	0.36	0.14	0.05	0.93
white	377	0.43	0.28	0	0.98
dircer	377	0.27	0.16	0	.77
sat	377	1378.67	128.04	972	1837

After obtaining the data for SAT participation rate, it is evident that the relationship between SAT scores and SAT participation is generally linearly uncorrelated. However, when a quadratic line of best fit is placed on the scatter plot a vague outline of an “upside-down U curve” with minimal bow can be seen (plot placed below). This gives credence to a non-linear relationship between SAT scores and the SAT participation at an individual school. Consequently, the validity of using this variable to measure what it is intended to is uncertain, and it is best to run regression analyses with and without the variable to compare to the results.

Scatter SAT v Satpart



C. Gauss-Markov Assumptions

1. Linear in Parameters. The model is a multiple regression that is linear in parameters.
2. Random Sampling. The set of schools attempted to be considered is all Georgia Public High Schools, which would be the population. Unfortunately, the Georgia Department of Education does not provide statistics that apply to less than 10 students. Thus, the sample is biased to not include small schools. This is acceptable, as we want our findings to apply to large, traditional public schools.
3. No Perfect Collinearity. Perfect collinearity does not exist in the model; there may be degrees of high collinearity between explanatory variables such as not highly qualified teacher percentage and student-teacher ratio, but they are not perfectly collinear.

	sat	dircer	fteexp	nhq	stratio	satpart	white
sat	1.0000						
dircer	-0.6712	1.0000					
fteexp	-0.0463	0.0558	1.0000				
nhq	-0.1414	0.0135	-0.0685	1.0000			
stratio	0.0284	-0.1499	-0.3158	0.6990	1.0000		
satpart	0.0462	-0.1744	-0.0258	-0.1772	-0.0261	1.0000	
white	0.5549	-0.5323	0.0323	-0.0304	-0.0934	-0.2272	1.0000

4. Zero Conditional Mean. With more explanatory variables, there is a higher chance of zero conditional mean. Although many factors are considered, it is difficult to say that there are enough variables (or data available) to assume zero conditional mean.
5. Homoskedasticity. It is assumed that the error has the same variance, regardless of the explanatory variables.

IV. Results

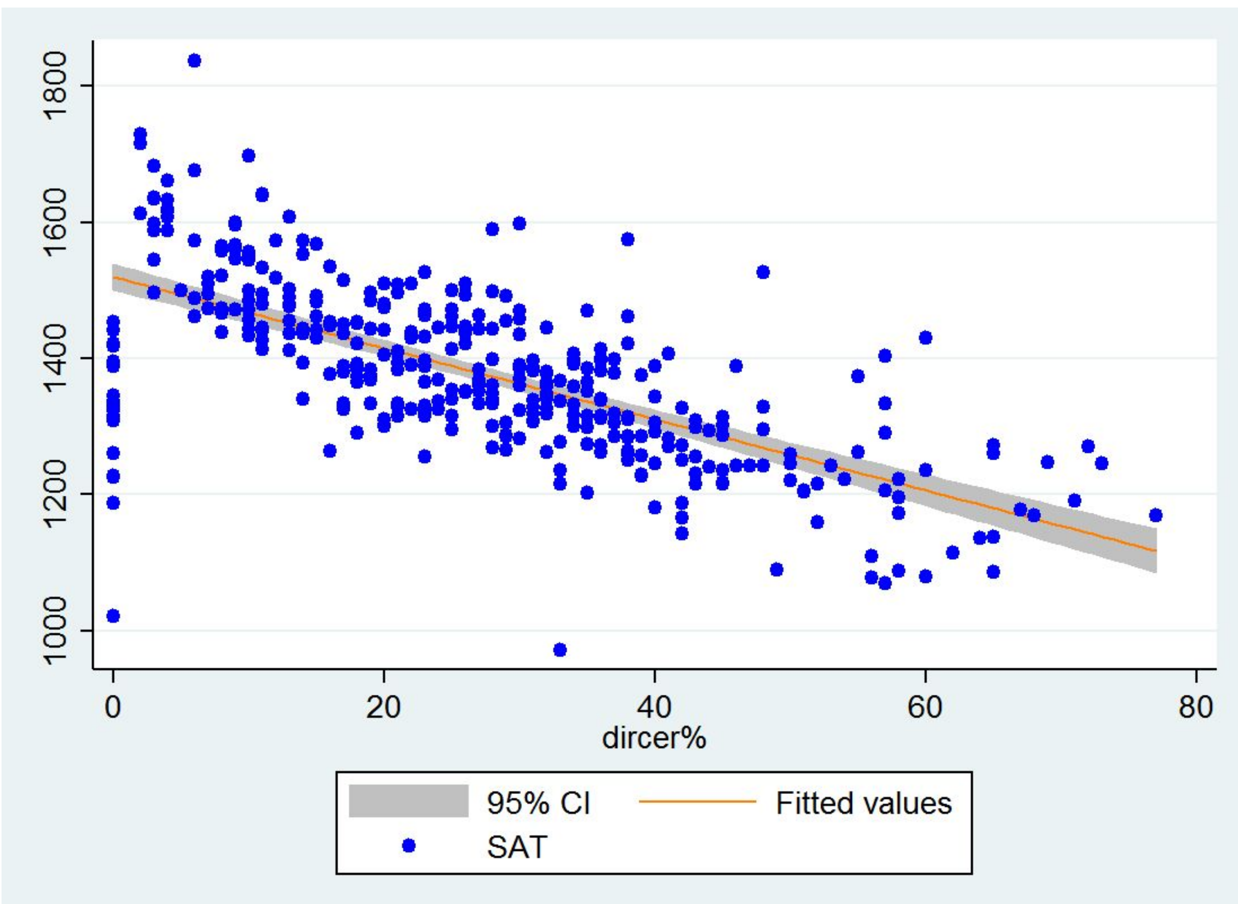
A. Simple Linear Regression

$$SAT = \beta_0 + \beta_1 dircer$$
$$SAT = 1519.6 - 521.89 dircer$$

The percentage of students qualifying for Directly Certified Programs was chosen for the simple linear regression because it is the only poverty indicator released by the Georgia Department of Education. Our hypothesis states that poverty indicators would be the most significant factors in determining student test score performance; indeed, percentage of students qualifying for directly certifies programs had the highest R-squared value of any individual dependent variable. The next highest R-squared value for a single dependent variable was percentage of caucasian students, but this statistic is highly correlated with percentage of students qualifying for directly certified program, meaning the effect of percentage of caucasian students on SAT scores is biased by percentage of students qualifying for directly certified program. The coefficient of -521.89 indicates that for each percentage point increase in directly certified students at a school, average SAT score for the school decreases by just over 5 points. This means a full one hundred percent difference could result in a 522 point swing - this is 1.74 standard deviations on the SAT national exam, as the national exam is fit to an average of a 1500 points and a standard deviation of 300 points. The intercept in this model is interest at 1519.65; because the intercept is greater than 1500, it indicates that without the influence of poverty indicators, Georgia high schools perform slightly over the national average of the SAT score. Both the intercept and slope coefficient have extremely high t-values and p-values of 0.000, which means that they are statistically significant with high levels of confidence.

Something to note on the scatter of percentage of students qualifying for directly certified programs is that there are seventeen schools reporting that zero percent of their students take part in the program. The highest SAT score in these schools is only 1454, while the model predicts an average score of over fifty points higher. Perhaps these schools simply did not provide their statistics and the report defaulted to a value of zero, or their students are ineligible for other reasons. Running the simple regression without these zero percent cases leads to a coefficient of 631.05 and an R-squared value of 0.6000, meaning that the percentage of students qualifying for the directly certified program could be even more correlated with SAT score distribution. Unfortunately, we could not verify that these cases of zero percent were in fact inaccurate, so for the rest of the paper we assume they are valid. We do keep in mind that percentage of students qualifying for directly certified programs could be more significant and impactful than our models predict.

Scatter of SAT v Dircer



B. *Unrestricted Multiple Linear Regression*

$$SAT = \beta_0 + \beta_1 fteexp + \beta_2 nhq + \beta_3 stratio + \beta_4 satpart + \beta_5 white + \beta_6 dircer$$

$$SAT = 1389.7 - 0.0001 fteexp - 906.6 nhq + 2.7 stratio - 6.9 satpart + 135.2 white - 380.5 dircer$$

Our inclusive model tests the impact of full time equivalency expenditures, not highly qualified percentage, SAT participation, proportion of student body that identifies as white and percentage of students who qualify for poverty reduction programs on a high school's average SAT score. Full-time equivalency expenditure, insignificant at ten percent, shows a nearly zero slope. This shows the relative ineffectiveness of adding additional funding to instructional expenditure to improve educational outcomes. As the percentage of not highly qualified staff increases by one percent, average SAT scores fall by 9.07 points. This is both statistically significant at one percent confidence and economically significant; hiring not highly qualified teachers can have an intensely detrimental impact on student performance. The model indicates that as the student-teacher ratio increases by one, meaning that the student population doubles without hiring more educators, average SAT scores rises by 2.7 points. This is both statistically significant at five percent confidence and economically significant. Still, there is some suspicion about this coefficient, as it is unintuitive for larger class size to improve student performance, and we look to explain this phenomenon in other regression models. As the percentage of student participating in SAT testing increases by one percent, average SAT scores fall by 6.9 points. This is statistically insignificant, but interestingly shows a negative relationship with average SAT scores. As the percent of the student population that identifies as white increases by one percent, the average SAT score increases by 1.4 points. This is statistically significant at one percent confidence, and economically significant as it shows the extent of racial discrepancies in education outcomes despite decades of equalization efforts. Lastly, as the percentage of directly certified students increases by one percent, average SAT scores will decrease by 3.8 points. This is statistically significant at one percent, and economically significant in that poverty is shown to have a large impact on educational outcomes. Taken as a whole, this model has an R-squared of 0.5289, showing that the variation in the independent variables account for fifty three percent of the variation in SAT scores.

C. Restricted Multiple Linear Regression 1

$$SAT = \beta_0 + \beta_1 nhq + \beta_2 satpart + \beta_3 white + \beta_4 dircer$$
$$SAT = 1447.3 - 513.9nhq - 7.0satpart + 121.3white - 410.6dircer$$

The first restricted model removes instructional expenditure per student and student-teacher ratio. These explanatory variables are removed because they are factors involving direct spending of school funding. The goal of this second model is to compare the impact of monetary initiatives in the school to cultural factors. After removing instructional expenditure per student and student-teacher ratio, the coefficients of participation percentage,percentage of caucasian students and percentage of students qualifying for directly certified programs do not change much at all. The last variable remaining, percentage of not highly qualified teachers, is nearly cut in half. The reason for this can be explained by the high correlation (nearly seventy percent) between percentage of not highly qualified teachers and student-teacher ratio. Because the relationship between SAT scores and percentage of not highly qualified teachers is negative and the relationship between student-teacher ratio and percentage of not highly qualified teachers is positive, omitting the student-teacher ratio variable from the regression analysis is causing a negative bias on the not-highly qualified teacher variable. This negative bias is what is causing the coefficient for not highly qualified teachers to contract so significantly. Aside from the bias that removing student-teacher ratio causes, the model is relatively unchanged, and confirms the suspicion that altering school expenditure strategies will not affect student performance by a significant amount.

D. Restricted Multiple Linear Regression 2

$$SAT = \beta_0 + \beta_1 nhq + \beta_2 white + \beta_3 dircer$$
$$SAT = 1443.4 - 508.2nhq + 122.9white - 408.2dircer$$

The further restricted model shows the influence of not highly qualified staff, percentage of white students and percentage of directly certified students on SAT scores, removing SAT participation from the previous model. This model is the first model where all of the explanatory variables are significant at one percent. The absence of SAT participation minimally impacts the other variables, which is expected given that SAT participation showed a small significance in the previous model. Thus, the purpose of this model is to show the remaining variables provide a similar result with lower per variable variance and higher per variable significance. To further show the minimal impact of dropping the SAT participation variable, the R-squared value falls to 0.5209 from 0.5210. We consider this the best model in terms of estimating student performance while mitigating the variance on the coefficients.

E. Restricted Multiple Linear Regression 3

$$SAT = \beta_0 + \beta_1 stratio + \beta_2 white + \beta_3 dircer$$
$$SAT = 1447.2 - 0.5 stratio + 121.9 white - 413.4 dircer$$

The final model serves to show a juxtaposition to the original multiple regression model. In the first model we can see a positive sign on the coefficient of the student-teacher ratio, yet that seems counterintuitive. The natural idea is that as you reduce class size each teacher can better direct their attention to the students and provide for each student's learning needs, which is represented in the fourth model by the negative sign on the coefficient. It seems puzzling that the sign of the coefficient would flip with the inclusion of the more variables. At this point a closer examination of the relationship between percentage not highly qualified teachers and the student-teacher ratio is important to understand. A quick glance at section 3.C.3 provides that the correlation coefficient between these variables is exceedingly high at 0.699. This strong linear relationship provides the needed insight; as the student-teacher ratio increases the demand for teachers rises exponentially and so schools begin to hire less and less qualified teachers in an effort to reduce class size. Once this overextension reaches the point of hiring a significant number not highly qualified teachers, then a schools SAT scores will suffer a severe impact. The impact of not highly qualified teachers is so detrimental that those schools who elect to have larger class sizes actually benefit from this decision, providing a solid reasoning for the positive sign of the coefficient of student-teacher ratio.

F. Robustness Test

To verify that instructional expenditure per student (fteexp), student-teacher ratio (stratio), and participation percentage (satpart) are jointly insignificant to SAT scores, a multiple hypothesis test can be conducted on the three variables.
The unrestricted model for this test is as follows:

$$SAT = \beta_0 + \beta_1 fteexp + \beta_2 nhq + \beta_3 stratio + \beta_4 satpart + \beta_5 white + \beta_6 dircer$$

And the null hypothesis for the F-Test is:

$$H_0 : \beta_0 = 0, \beta_3 = 0, \beta_4 = 0$$

The secondary hypothesis, H_1,is that H_0 is not true.
In the unrestricted model regression of SAT scores on instructional expenditure per student, percentage of not highly qualified teachers, student-teacher ratio, SAT participation rate, percentage of caucasian students, and percentage of Directly Certified students, R-squared value was 0.5298 and the degrees of freedom was 370. After withdrawing instructional expenditure per student and student-teacher ratio to create the restricted model, R-squared value was 0.5120 and the difference of the restricted and unrestricted degrees of freedom was 3. Considering both of these regressions, the F statistic comes out to:

$$F = \frac{\frac{.5298^2 - .5209^2}{3}}{\frac{1 - .5298^2}{370}} = 1.603$$

The critical value at ten percent for 3 numerator degrees of freedom and infinite denominator degrees of freedom is 2.08. Consequently, the test concludes that instructional expenditure per student, participation percentage and student-teacher ratio are not jointly significant ten percent.

V. Conclusion

Ultimately, our regression model study confirmed the idea that school funding initiatives, such as instructional expenditure per student and teachers per student, are insignificant to student performance when measured through SAT score. Instead, the two most important factors were found to be percentage of students qualified for directly certified programs and percentage of not highly qualified teachers. Although the coefficient of not highly qualified teachers is larger than that of percentage of students qualified for directly certified programs, it should be noted that the directly certified variable fits with the data much more closely. As noted above, a simple regression of percentage of students qualified for directly certified programs on SAT yielded an R-squared value of 0.4506, while a simple regression of percentage of not highly qualified teachers on SAT yielded an R-squared value of merely 0.0629. This discrepancy shows that percentage of students qualified for directly certified programs explains more of the SAT scores than percentage of not highly qualified teachers. In short, we have determined that decreasing the percentage of not highly qualified teachers and the percentage of students qualified for directly certified programs will improve student performance, and consequently improve worker productivity in the long run. These are the factors local policy makers should emphasize when deciding the annual budget.

Additional ways to improve the model would be to add more variables, such as: if a school is a charter school, if a school is in a rural, suburban or urban area, teacher salaries, and average household income across the school district. These statistics were not provided by the Georgia Department of Education and are difficult to obtain - estimates might be necessary for some of them. Still, access to these explanatory variables could improve the model and provide clarity to factors of student performance. Furthermore, comparing private schools and public schools would provide insight into which education system produces the best results for student performance. Another addition which is outside the scope of the current study is the SAT score adjustment proposed by Dynarski and Gleason (1993), which would have lacked a similar impact since the participation rates in this study had little significance. If this adjustment could be made it could provide even stronger results due to the controlling of dropout rates.

Further research into this topic would be extremely valuable to both schools and governments as it could provide an in-depth look at the productivity of schools. Expanding the data pools to the entire United States and then comparing across states would be a major next step in this project. Using this research as a stepping stone, an exciting study would be to follow up the results of the SAT predictions with concrete data on the productivity of the students produced and see the any possible connects. This would require a longitudinal study, but would confirm that student productivity through SAT scores is valid. This study created an excellent dive into the inner workings of the Georgia school system, producing intriguing results and providing a concrete base to continue research on the topic of optimizing schooling productivity.

VI. References

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VII. Appendix

A. STATA Outputs

a. Simple Linear Regression

```
. regress sat dircer

      Source |       SS           df       MS      Number of obs   =       377
-------------+----------------------------------   F(1, 375)       =    307.53
       Model |  2777575.82         1  2777575.82   Prob > F        =    0.0000
    Residual |  3386956.07       375  9031.88286   R-squared       =    0.4506
-------------+----------------------------------   Adj R-squared   =    0.4491
       Total |  6164531.89       376  16395.0316   Root MSE        =    95.036

------------------------------------------------------------------------------
         sat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      dircer |  -521.8885   29.76007   -17.54   0.000     -580.406    -463.371
       _cons |   1519.645   9.411983   161.46   0.000     1501.138    1538.152
------------------------------------------------------------------------------
```

b. Multiple Linear Regression

```
. regress sat fteexp nhq stratio satpart white dircer

      Source |       SS           df       MS      Number of obs   =       377
-------------+----------------------------------   F(6, 370)       =     69.49
       Model |  3266072.33         6  544345.389   Prob > F        =    0.0000
    Residual |  2898459.55       370  7833.67447   R-squared       =    0.5298
-------------+----------------------------------   Adj R-squared   =    0.5222
       Total |  6164531.89       376  16395.0316   Root MSE        =    88.508

------------------------------------------------------------------------------
         sat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      fteexp |  -6.97e-06   .0052808    -0.00   0.999    -.0103911    .0103771
         nhq |  -906.6172   214.5476    -4.23   0.000    -1328.503   -484.7316
     stratio |   2.663296    1.08504     2.45   0.015     .5296765    4.796916
     satpart |  -6.885752   36.78327    -0.19   0.852    -79.21623    65.44473
       white |   135.2435   21.41952     6.31   0.000      93.1242    177.3627
      dircer |  -380.5274   37.00203   -10.28   0.000     -453.288   -307.7667
       _cons |   1389.687   48.31797    28.76   0.000     1294.674    1484.699
------------------------------------------------------------------------------
```

```
. regress sat nhq satpart white dircer

      Source |       SS           df       MS      Number of obs   =       377
-------------+----------------------------------   F(4, 372)       =    101.14
       Model |  3211465.13         4  802866.284   Prob > F        =    0.0000
    Residual |  2953066.75       372  7938.35149   R-squared       =    0.5210
-------------+----------------------------------   Adj R-squared   =    0.5158
       Total |  6164531.89       376  16395.0316   Root MSE        =    89.097

------------------------------------------------------------------------------
         sat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nhq |  -513.8643   147.7951    -3.48   0.001    -804.4828   -223.2458
     satpart |  -6.993552   37.02815    -0.19   0.850    -79.80427    65.81717
       white |   121.3315   20.89014     5.81   0.000     80.25391     162.409
      dircer |  -410.6072   35.40767   -11.60   0.000    -480.2315   -340.9829
       _cons |   1447.321   26.14617    55.35   0.000     1395.908    1498.734
------------------------------------------------------------------------------

. regress sat dircer white stratio

      Source |       SS           df       MS      Number of obs   =       377
-------------+----------------------------------   F(3, 373)       =    127.18
       Model |  3117197.03         3  1039065.68   Prob > F        =    0.0000
    Residual |  3047334.86       373  8169.79854   R-squared       =    0.5057
-------------+----------------------------------   Adj R-squared   =    0.5017
       Total |  6164531.89       376  16395.0316   Root MSE        =    90.387

------------------------------------------------------------------------------
         sat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      dircer |  -413.4482   34.41473   -12.01   0.000    -481.1194    -345.777
       white |   121.8831   19.89048     6.13   0.000      82.7716    160.9946
     stratio |  -.4966806   .7158131    -0.69   0.488    -1.904216    .9108544
       _cons |   1447.236   23.40008    61.85   0.000     1401.223    1493.248
------------------------------------------------------------------------------

. regress sat nhq white dircer

      Source |       SS           df       MS      Number of obs   =       377
-------------+----------------------------------   F(3, 373)       =    135.19
       Model |  3211181.96         3  1070393.99   Prob > F        =    0.0000
    Residual |  2953349.93       373  7917.82824   R-squared       =    0.5209
-------------+----------------------------------   Adj R-squared   =    0.5171
       Total |  6164531.89       376  16395.0316   Root MSE        =    88.982

------------------------------------------------------------------------------
         sat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nhq |  -508.1749   144.5055    -3.52   0.000    -792.3224   -224.0274
       white |   122.8908   19.16468     6.41   0.000     85.20643    160.5752
      dircer |  -408.1634   32.91623   -12.40   0.000    -472.8881   -343.4388
       _cons |   1443.394   15.83024    91.18   0.000     1412.266    1474.521
------------------------------------------------------------------------------
```

B. Estimation Results

Independent Variables	SLR	MLR4	MLR3	MLR2	MLR1
dircer	-521.8885*** (29.76007)	-408.1634*** (32.91623)	-413.4482*** (34.41473)	-410.6072*** (35.40767)	-380.5274*** (37.00203)
nhq		-508.1749*** (144.5055)		-513.8643*** (147.7951)	-906.6173*** (214.5476)
white		122.8908*** (19.16468)	121.8831*** (19.89048)	121.3315*** (20.89014)	135.2435*** (21.41952)
satpart				-6.993556 (37.02815)	-6.885756 (36.78327)
fteexp					-.000007 (.0052808)
stratio			-0.4966806 (.7158131)		2.663296** (1.08504)
_cons	1519.645*** (9.411983)	1443.394*** (15.83024)	1447.236*** (23.40008)	1447.321*** (26.14617)	1389.687*** (48.31797)
R^2	.4506	.5209	.5057	.5210	.5298

[1]Numbers in parentheses denote standard error estimates

[2]***, **, * denote significance at 1%, 5%, and 10%