Factors Determining 2001 Standardized Elementary Level Reading Scores in Michigan

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Elementary level reading comprehension is an essential skill which students need in order to excel in secondary school as well as undergraduate level language courses. Using a dataset from 4th grade standardized reading scores from Michigan in 2001, and controlling for district and local level effects, we find that standardized reading score pass rates per school are dependent on standardized math score rates as well as the rate of students who are receiving free lunch passes. Reading and math scores are highly correlated and can be used to roughly estimate the other.

Introduction

Quality of primary school education is one of the most important factors in determining life outcomes for children in the United States. In primary school, students learn foundational skills that set them up for the rest of their lives in areas including health, income, and other factors affecting quality of life. Active citizenship and socialization are also important factors which begin in primary education. Most countries have declared primary education as a basic right for all citizens. The main role of primary education is to teach children critical thinking and instill fundamental values which keep our society functioning. In addition to this, primary education provides a team environment with both peers and leaders and is a necessary step in the development of basic social skills.

Standardized tests are a method through which all students across a state as well as nationally answer the same questions and are scored in the exact same way. These tests come in a variety of subjects are the formatting of questions is typically multiple choice, true/false questions, and essays/open responses. Some standardized tests, such as the ACT and SAT, are done at a national level; others are statewide and test school districts on state level curriculum standards. Standardized testing at the primary school level provides a benchmark for understanding the way a student as well as a school district is performing compared to other students and other school districts, whether that be at a local, regional, or national level. Reading comprehension as well as math scores help administrators as well as teachers to shape district level policy in addition to interaction within the classroom; understanding the factors that determine these test scores is necessary in order to assign funding as well as remediate school districts and students. The MEAP, or Michigan Educational Assessment Program, was a standardized test taken at all public schools from elementary through middle/junior high from 1969 to 2014. It was replaced by the Michigan Student of Educational Progress, or M-STEP, in 2015. Testing was mandatory for all public-school students, with an almost near perfect test rate. The dataset I use is from the MEAP test results for Michigan primary schools for the year of 2001.

In this paper, I argue that reading comprehension pass rates across Michigan primary schools in 2001 are best predicted for by the rate of students who use free lunch programs for their given school. I argue that math and reading comprehension scores codetermine the other, with students typically scoring high in one category as well as the other. Free lunch rates for a given school help to control for the poverty level of a given school district, as students who are enrolled in free lunch programs tend to be in working class households. I argue, and the data shows that higher free lunch rates tend to mean lower reading comprehension scores.

Literature Review

By studying the standardized test scores in Michigan before and after spending was equalized across all districts in Proposal A in 1994, Papka (2004) argues that there is a statistically significant effect of increased spending on standardized pass rates, with a pronounced effect in districts that historically underperformed. Papka begins her argument by summarizing the context that this data was collected in; previous to this research, any spending-related datasets did not have a sufficiently impactful change in spending to record a non-trivial, statistically significant effect. The research was designed to avoid the limitations of these previous studies by using panel data techniques. Additionally, Proposal A conveniently reduces the risk of endogeneity simply through its design. Annual Michigan School Reports (MSRs) include breakdowns of spending per student, pupil-to-student ratios, pass rates of various standardized exams, and other relevant statistics including student demographics. Papka asserts on p. 822 that school lunch eligibility is a valid proxy variable for economic well-being. Having defined these variables, Papka begins to explain the results on page 833.

Maylone 2003 conducted a study whose objective was to determine the questions of how Michigan public school districts socio-economic factors correlate with district standardized test scores and how to combine correlation coefficients to form a regression that would accurately predict MEAP scores. The factors they used to determine socioeconomic status are similar to the terms used in my analysis; ‘Percent of District Students Receiving Free/Reduced Lunch Prices’ is the term we share in common, and in addition, they account for ‘Percent of District Lone Parent Households’ and ‘Annual Mean District Household Income’. They find that the biggest implication of the study is that decreasing child poverty rates would end up resulting in higher academic achievement, and more so than higher stakes testing and accountability plans, both of which were potential policy solutions at the time the thesis was published. The author’s data, as well as the literature review, suggests that there is much evidence that individual student characteristics such as low median family income, per-capita income, and median area housing prices correlate highly with poor district and district test scores. The study was unique in that it was the first of its kind to not focus on non-socioeconomic factors; previous studies for Michigan MEAP performance focused on pupil/staff ratio, class size, district per-pupil spending, principal leadership style, and teacher styles. It was the first of its kind to fully survey Michigan’s 500 non-charter school districts.

Cimmiyotti 2013 examines the data from 95 California public school students on 2 individual math and reading comprehension tests as well as the 2011-2012 STAR test for that given academic year. The reading comprehension test examined students’ performance in fluency, comprehension, and vocabulary abilities, and compared it to the standard for the rest of the grade in the state. The author finds that there was a correlation between academic performance in reading and mathematics at the primary school level. This correlation was found when individual grade levels’ results were isolated from each other as well when grades 2 through 5 were tested at the same time. Furthermore, the correlation between reading math scores increased the higher the grade level, suggesting that there was an effect on the scores which students made in earlier grade levels and their performance down the line. The author posits that if the correlation increase holds after further testing, it may suggest that early reading intervention benefits ‘all other academic disciplines’.

This analysis’ contribution to the literature is that it uses data unique to Michigan from 2001, which has not been done outside of the context of affairs internal to the Michigan Department of Education. This data provides an outlook of the ways that certain variables can interact to determine school test scores across the entire state, with a large enough sample size to determine robustly what the factors, given the variables provided, have the most explanatory power.

Data

For the dataset I used, MEAP01, there were several variables in the dataset. All of these variables had been determined initially by their author to be somewhat responsible for driving math score pass rates and reading score pass rates, though not all of them did so in a way which made sense for this given analysis. The variables chosen are from an analysis done previously by the Michigan Department of Education, collected in 2001. The variables included in the initial analysis, which was given by the Introductory Econometrics textbook, were as follows: dcode (district code), bcode (building code), math4 (percentage of students satisfactory, 4th grade math), read4 (percentage of students satisfactory, 4th grade reading), lunch (percentage of students eligible for free or reduced lunch), enroll (school enrollment), expend (total spending in dollars), exppp (expenditures per pupil: expend/enroll), and the natural logarithms of enrollment, expenditure, and expenditure per students were accounted for initially. The control variable I chose for the simple regression was the variable lunch, which tracked the percentage of students eligible for free or reduced lunch. When controlling for read4 (percentage of students satisfactory, 4th grade reading), only math4 (percentage of students satisfactory, 4th grade math) and lunch rates had a significantly large correlation. Math4 was not used as a variable because testing for it was similar enough when the same control variables were used as read4 that there was not a novel signal to be found. District and building code variables were not used because there was not information in the dataset as to the geography of the codes; district code could have been used had there been an understanding of where the districts were located within Michigan, and building code at a subregional level, but dummy variables were not able to be used because of the lack of information about these variables. Expenditures per pupil were not used because of its low explanatory ability on the percentage of students testing satisfactory in 4th grade reading, and the natural logarithms of enrollment, expenditure, and expenditure per student were also not used because of their low explanatory ability on the percentage of students testing satisfactory in 4th grade reading. As a backup, the coefficient of determination was also calculated for the expenditures per pupil, and the natural logarithms of enrollment, expenditure, and expenditure per student. The explanatory power of these values was also rather low, meaning that they do not seem to be a way of explaining the pass rates of standardized test scores in general in these schools.

The data is pulled from the Introductory Econometrics: A Modern Approach (7th edition) by Jeffrey Woolridge. The author pulled the data is from a study by the Michigan Department of Education. The department of education surveyed n = 1,823 Michigan primary schools' standardized test scores from the year 2001. Specifically, 4th grade reading scores were used in order to isolate out the highest grades test score (in order to determine final outcomes in terms of standardized test scores for a given elementary school. I made no adjustments to the data for the purposes of this analysis, as the writers of the textbook had already cleaned and organized the data so that statistical analysis could be done without any need for alteration. Math scores had an average of a 71.91% pass rate per school, with a standard deviation of 19.95 percent, a minimum of 0, and a maximum of 100, meaning that some scores had a pass rate of 0, and some schools had a 100% pass rate. Reading pass rates averaged 60.06% pass rate per school, with a standard deviation of 19.15 percent, a minimum of 0, and a maximum of 100, where some schools had a pass rate of 0, and some schools had a 100% pass rate School lunch rates averaged 39.25%, with a standard deviation of 26.42%, a minimum of 0% students eligible for free/reduced lunch and a maximum of 100% students eligible for free or reduced lunch. Enrollment averaged 401.94 students per school, with a standard deviation of 169.83 students, a minimum of 62 students, and a maximum of 1496 students in one school. Expenditure (in dollars) had a mean of $2,369,844, with a standard deviation of $864,936, a minimum of $275,985 and a maximum of $7,665,998 spent in for one school. Expenditures per student averaged $5194 per student, with a standard deviation of $1091.89 per student, a minimum of $1206.88, and a maximum of $11957.64 per student. The natural logarithm of enrollment averaged 5.91 students per school, with a standard deviation of .42 students, a minimum of 4.127 students, and a maximum of 7.31 students in one school. The natural logarithm of expenditure (in dollars) (in dollars) had a mean of $14.44, with a standard deviation of $.41, a minimum of $12.53 and a maximum of $15.85 spent. The natural logarithm of expenditure of student, lexppp, had a mean of $8.53 per student, with a standard deviation of $.215 per student, a minimum of $7.10 per student, and a maximum of $9.39 per student spent.

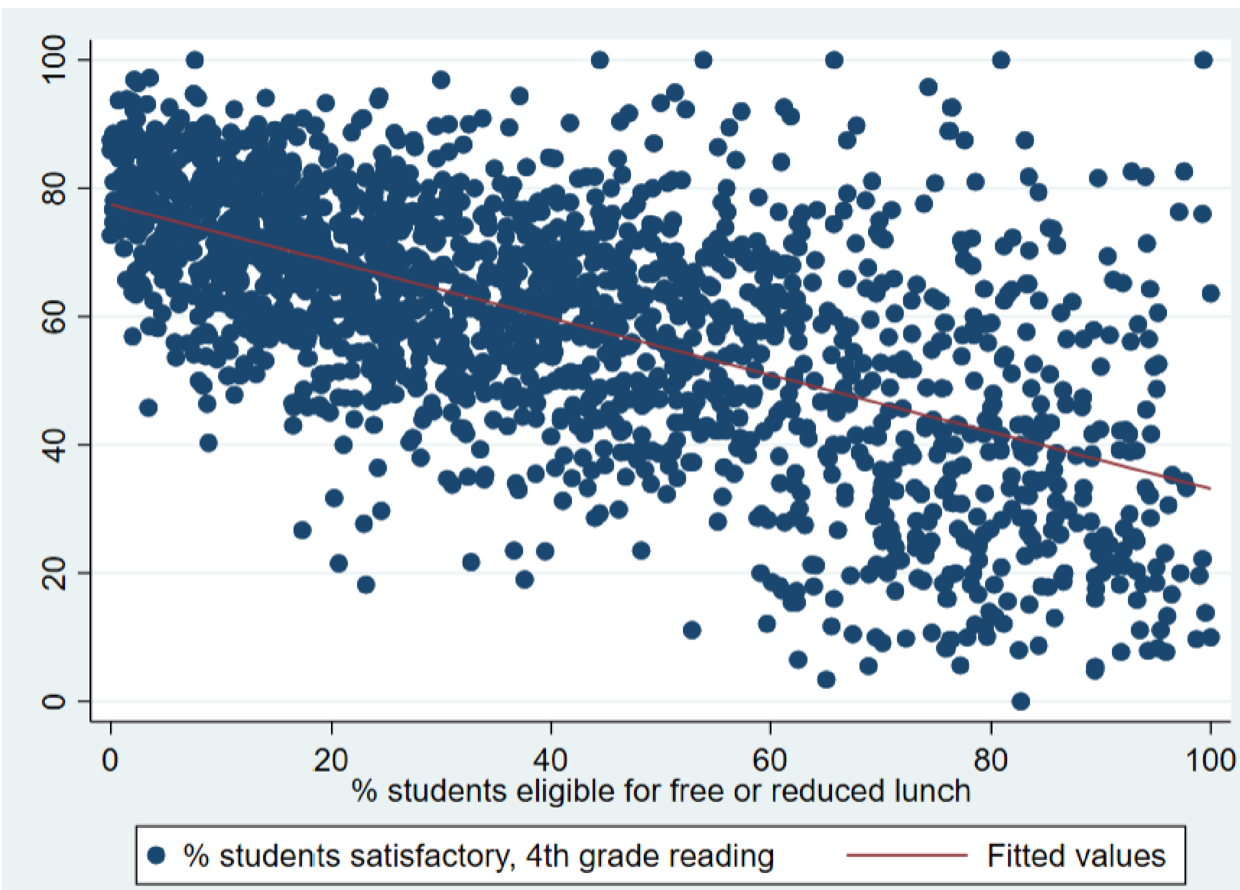

Figure 1: Scatter plot of main explanatory variable, lunch (percentage of students eligible for free or reduced lunch) and read4 (percentage of students satisfactory in standardized testing, 4th grade

reading). A general negative correlation is present in the data, as indicated by the downward slope of the regression line.

Variable	Obs	Mean	Std. dev.	Min	Max
dcode	1,823	53028.27	23907.06	1010	83070
bcode	1,823	3394.557	2442.929	1	8838
math4	1,823	71.909	19.95409	0	100
read4	1,823	60.06188	19.14729	0	100
lunch	1,823	39.2519	26.41672	0	100
enroll	1,823	401.9358	169.8257	62	1496
expend	1,823	2036984	864936.1	275985	7665998
exppp	1,823	5194.865	1091.89	1206.882	11957.64
lenroll	1,823	5.910937	.4204482	4.127134	7.31055
lexpend	1,823	14.44408	.4115472	12.5281	15.85231
lexppp	1,823	8.533143	.214971	7.095796	9.389126

Figure 2: Table of summary statistics for the data given under the MEAP01 data set, provided by Introductory Econometrics: A Modern Approach (7th edition) by Jeffrey Woolridge. The author pulled the data from a study by the Michigan Department of Education.

The parameters that were determined to be robust and useful for this study were free lunch rates for the simple regression. The multiple regression used included the free lunch rates as well as expenditures per school, and number of students enrolled in the school. The linearity of these variables (via their relationship to the reading score pass rate) was checked by cross referencing the residual and the fitted plot and was found to be linear. The data was randomly sampled from the population provided, given that every elementary school in Michigan was surveyed and the results were given in this table. Non-collinearity was tested for between free/reduced lunch rates, expenditures per school, and number of students enrolled at the school via an F-test that is covered in the Extensions section below.

Results

Simple Regression

The simple regression for the data set uses the free/reduced lunch percentage for a given school to explain the reading score pass percentage per school. The coefficient for free/reduced lunch rates was -.44, with a constant of 77.45. For the n = 1823 4^{th} grade elementary school classes that were surveyed, the regression is as follows:

$$read4 = 77.45 - .44lunch + u$$

The STATA output was as follows:

read4	Coefficient	Std. err.
lunch	-.4431021	.0134418
_cons	77.45448	.6359212

Multiple Regression

The simple regression for the data set uses the free/reduced lunch percentage for a given school to explain the reading score pass percentage per school. The coefficient for free/reduced lunch rates was -.45, the coefficient for expenditures was 2.14e-6, and the coefficient for enrollment was -.02, with a constant of 82.57. For the n = 1823 4^{th} grade elementary school classes that were surveyed, the regression is as follows:

$$read4 = 82.57 - .45lunch + 2.14e6expend - .02enroll + u$$

The STATA output table is as follows:

read4	Coefficient	Std. err.
lunch	-.4530601	.0136416
expend	2.14e-06	7.35e-07
enroll	-.0225981	.0037122
_cons	82.57491	1.05096

The combined results for both simple and multiple regressions were as follows:

Dependent Variable Read4 OLS Results		
Independent Variables	Model 1	Model 2
Lunch	-.443** (.013448)	-.453** (7.35e-7)
Enroll		-.023** (.004)
Expend		2.14e-6** (7.35e-7)
Number of Observations	1823	1823
R-Square	.3737	.3912

The combination of both the control variable for enrollment within a school as well as the expenditure for a given school increased the explanatory power of the regression from the single to the multiple regression by 1.8%, while 37.37% of the change in reading score pass rates in a school could be explained by the percentage of students enrolled in free/reduced lunch programs. Although much of the explanatory power of the regression was able to be explained by lunch rate alone, the enrollment and expenditure variables provided some description of how the percentage passing reading scores functioned (and much more so than the variables already discussed and not used).

Extensions

The significance of the simple regression was found via the t-statistic & p-values, and the confidence intervals present in the STATA output, which is as follows:

Simple Regression

For the lunch variable in the simple regression, the t statistic was -32.96, and the p-value estimated was .000. We were able to reject the null hypothesis that free/reduced lunch rates do not have an effect on the reading score percentage passed, and instead found that there was a significant effect. The confidence interval for the coefficient of the lunch rates was [-.469, -.417].

read4	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
lunch	-.4431021	.0134418	-32.96	0.000	-.469465	-.4167392
_cons	77.45448	.6359212	121.80	0.000	76.20726	78.70169

Figure 3: STATA output for the simple regression that include t statistic, p-value, and confidence intervals for the given coefficient.

Multiple Regression

For the lunch variable in the multiple regression, the t statistic was -33.21, and the p-value estimated was .000. We were able to reject the null hypothesis that free/reduced lunch rates do not have an effect on the reading score percentage passed, and instead found that there was a significant effect. The confidence interval for the coefficient of the lunch rates was [-.480, -.426]. For the expenditure variable in the multiple regression, the t statistic was 2.91, and the p-value estimated was .004. We were able to reject the null hypothesis that expenditure rates do not have an effect on the reading score percentage passed, and instead found that there was a significant effect. The confidence interval for the coefficient of the lunch rates was [6.96e-7, 3.58e-6]. For the enrollment variable in the multiple regression, the t statistic was -6.09, and the p-value estimated was .000. We were able to reject the null hypothesis that enrollment rates do not have an effect on the reading score percentage passed, and instead found that there was a significant effect. The confidence interval for the coefficient of the lunch rates was [-.030, -.015].

We used the F-Test to check for multicollinearity in the model, with the STATA output as follows:

```
. test lunch expend enroll

 ( 1)  lunch = 0
 ( 2)  expend = 0
 ( 3)  enroll = 0

       F(  3,  1819) =  389.53
            Prob > F =    0.0000
```

With a value of 389.53 falling into the range of the statistic, we could conclude that free/reduced lunch rates, expenditure and enrollment rates are linearly independent from each other and not multicollinear.

Conclusion

Reading score percentage pass rates in Michigan public elementary schools in 2001 are controlled by multiple variables, including free/reduced lunch rates, number of students enrolled in the school, and the expenditures per school. Although most of the explanatory power of the regressions we used came from the free/reduced lunch rates variable, some of the trend could be understood as a function of enrollment and expenditure. As the number of students using free/reduced lunch programs in the school increased, there was a decrease in the percentage of students with passing standardized reading test scores. Public policy implications for this study include the understanding that school districts with a higher number of students using reduced/free lunch programs might need supplemental programming for students in reading and potentially intervention via the state board of education (at least for the state of Michigan).

References

Cimmiyotti, Caleb Bartholet, "Impact of Reading Ability on Academic Performance at the Primary Level" (2013). *Graduate Master's Theses, Capstones, and Culminating Projects*. 127. https://doi.org/10.33015/dominican.edu/2013.edu.18

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Appendix (STATA output)

```
. regress read4 lunch

      Source |       SS           df       MS      Number of obs   =     1,823
-------------+----------------------------------   F(1, 1821)      =   1086.66
       Model |  249639.691         1  249639.691   Prob > F        =    0.0000
    Residual |  418339.731     1,821   229.73077   R-squared       =    0.3737
-------------+----------------------------------   Adj R-squared   =    0.3734
       Total |  667979.422     1,822  366.618783   Root MSE        =    15.157

------------------------------------------------------------------------------
       read4 | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       lunch |  -.4431021   .0134418   -32.96   0.000     -.469465   -.4167392
       _cons |   77.45448   .6359212   121.80   0.000     76.20726    78.70169
------------------------------------------------------------------------------
```

Figure 1: Simple regression output for read4 (Reading score pass rate per school) as a function of lunch (free lunch rate for a given school).

```
. regress read4 lunch expend enroll

      Source |       SS           df       MS      Number of obs   =     1,823
-------------+----------------------------------   F(3, 1819)      =    389.53
       Model |  261280.414         3  87093.4712   Prob > F        =    0.0000
    Residual |  406699.009     1,819  223.583842   R-squared       =    0.3912
-------------+----------------------------------   Adj R-squared   =    0.3901
       Total |  667979.422     1,822  366.618783   Root MSE        =    14.953

------------------------------------------------------------------------------
       read4 | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       lunch |  -.4530601   .0136416   -33.21   0.000    -.4798149   -.4263054
      expend |   2.14e-06   7.35e-07     2.91   0.004     6.96e-07    3.58e-06
      enroll |  -.0225981   .0037122    -6.09   0.000    -.0298787   -.0153175
       _cons |   82.57491    1.05096    78.57   0.000     80.51369    84.63613
------------------------------------------------------------------------------
```

Figure 2: Multiple Regression output for read4 (Reading Score pass rate per school) as a function of lunch (% students eligible for free or reduced lunch cost), expenditure ($ amount spent per school), and enrollment (number of students attending a given school).

```
. test lunch expend enroll

 ( 1)  lunch = 0
 ( 2)  expend = 0
 ( 3)  enroll = 0

       F(  3,  1819) =  389.53
            Prob > F =    0.0000
```

Figure 3: F-test for multicollinearity between lunch (% students eligible for free or reduced lunch cost), expenditure ($ amount spent per school), and enrollment (number of students attending a given school). Given the score, the possibility of multicollinearity is rejected and it is determined that lunch, expend and enroll are not multicollinear.

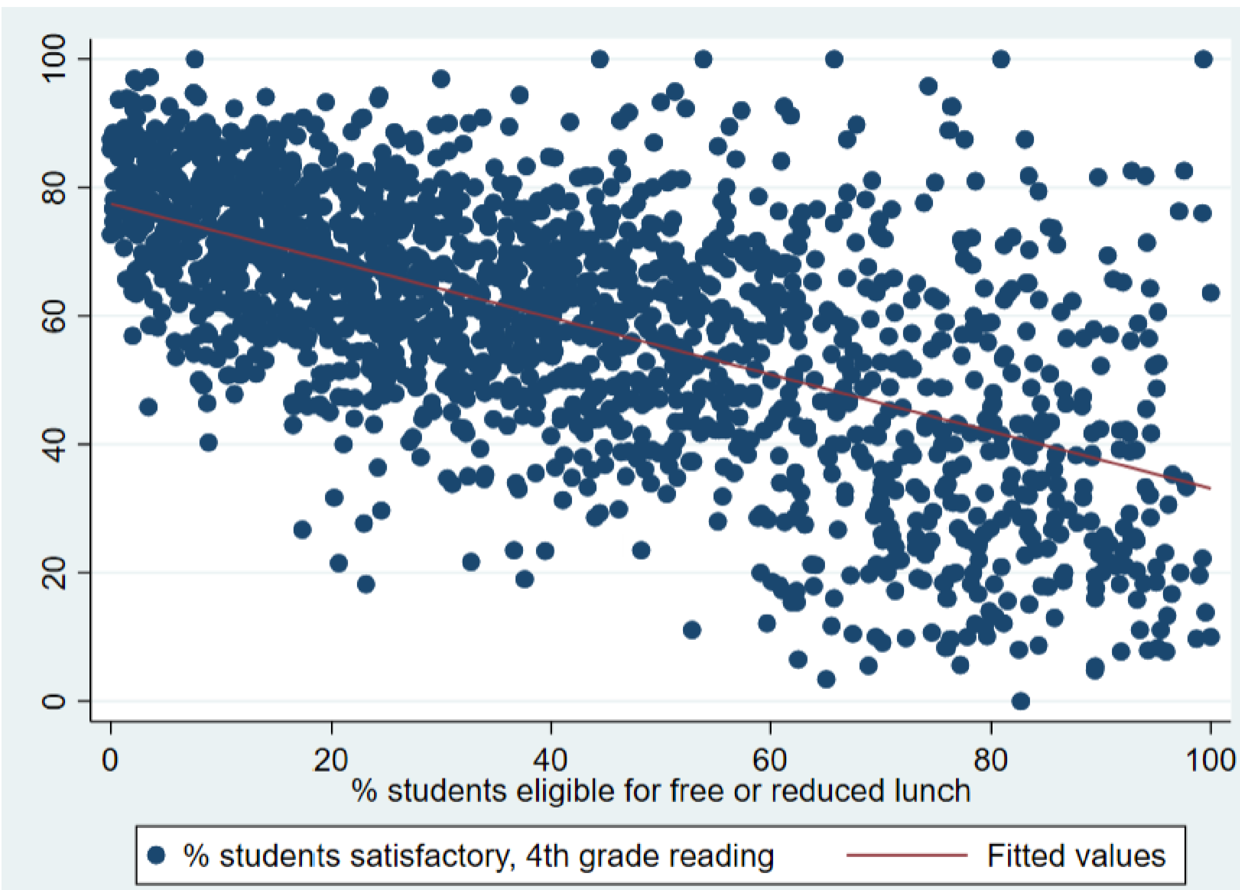

Figure 4: Scatter plot for read (reading score pass rate per school) and lunch (% students eligible for free or reduced lunch cost).