Standardized Test Scores and Accountability Policy
A Quantile Regression Approach

By

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TERMINAL PROJECT

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Abstract

Standardized test scores are the primary mechanism that state and federal education policymakers use to hold schools accountable. Student achievement data is used to hold schools accountable for certain thresholds of test scores for all students, and in some cases, subgroups of students. The typical methods, specifically ordinary least squares, employed by policymakers and researchers that study student achievement are generally concerned with averages. The use of average effect models generally results in one-size-fits-all policy interventions meant to raise average tests scores across a large population of students. This approach often does not take into consideration the differential effects of explanatory variables across the entire distribution of standardized test scores. Quantile regression supplements ordinary least squares by generating information across the entire distribution of student achievement, from the lowest to highest performers. As this study shows, federal and subsequent state education policies are concerned with the lowest performers, and not just the average student or school. This study uses data from K-12 public schools in Oregon that test students in grades 3-8 and 11 in mathematics and reading. The results show that quantile regression is a useful tool for analyzing school standardized tests scores in an accountability framework by providing information that ordinary least squares generally misses.

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I. INTRODUCTION

Standardized test scores are the primary mechanism that state and federal education policymakers use to hold schools accountable. Student achievement data is used to hold schools accountable for certain thresholds of test scores for all students, and in some cases, subgroups of students. The typical methods, specifically ordinary least squares (OLS), employed by policymakers and researchers that study student achievement are generally concerned with averages. Federal and subsequent state education policies are concerned with the lowest performers, and not just the average student or school. Quantile regression (QR) allows researchers to analyze the entire distribution of student achievement, from the lowest to the highest performers.

Analyzing the conditional test score distribution (CTSD) can generate more detailed information on what affects the achievement of the lowest and highest student performers. For example, research shows that being poor has a negative effect on the average student's standardized test score. However, little is known about whether being poor has an equal effect on the lowest and highest performing students. This distinction is crucial in the current education policy environment that is focused on elevating the test scores of the lowest performing students to certain thresholds within the entire CTSD. Policymakers and researchers are concerned with how test scores are effected, conditional on other student variables. OLS generates information on how independent variables affect the average student's test scores. QR supplements OLS by allowing policymakers and researchers to explore the effects of independent variables across the entire CTSD.

Federal education policy requires that states identify certain schools that are struggling more than others and target interventions in those schools to improve student achievement. Specifically, the Elementary and Secondary Education Act (ESEA) flexibility waiver, which will be discussed below, requires that states identify the bottom 5 percent, bottom 5-15 percent, and the top 5 percent of schools in terms of student achievement in mathematics and reading. These schools are called Priority, Focus, and Model schools. The state of Oregon uses their state report card rating system to identify Priority, Focus, and Model schools.

Two research questions will be answered in this study. First, how well does the OLS model represent the entire CTSD of 3rd, 4th, 5th, 6th, 7th, 8th, and 11th grade mathematics and reading school achievement? Second, does QR provide useful information for the ODE school rating system and subsequently for identifying Priority, Focus, and Model schools? This study uses data from K-12 public schools in Oregon during the 2010-2011 academic year to answer these questions.

This study will first give an overview of accountability policy in education and specifically in Oregon. Second, the research questions for this study will be discussed. Third, a literature review covers studies that used QR in education and then briefly discusses research in relation to each of the explanatory variables used in this study. Fourth the data and methods used in this study and their limitations will be discussed. Fifth, the results of the OLS and QR models will be presented. Lastly, the implications of the results will be summarized.

II. ACCOUNTABILITY IN EDUCATION

Up until the mid 1950s, local school boards controlled educational policy at the school level. Over time, this control has transitioned out of local and into the hands of state and federal policymakers. National security and equality concerns generated the support necessary for increased state and federal control over education from the 1950s until the early 1980s. In 1957, Russia launched the first man-made satellite, *Sputnik*, into orbit. The education system took a share of the blame and the federal government responded with the National Defense of Education Act of 1957, which emphasized the need for high levels of math, science, and foreign language training for students (Cuban, 2006). Equality concerns produced the most expansive piece of federal legislation to date, the Elementary and Secondary Education Act (ESEA) of 1965. ESEA stayed away from standards, curriculum, and assessment, and focused on poverty by targeting funds to low-income students, particularly in the highly segregated south (Conley, 2001).

Economic concerns have dominated educational policy since 1983. The 1983 report, *A Nation at Risk*, strongly criticized the educational system and asserted that the United States would lose its economic supremacy if mediocre school performance continued. This report spurred action at every level of government and lead to strong academic standards, student assessment, and aligned curriculum as answers to the system crisis (Gardner, 1983). Federal control over education has grown incrementally since 1983. President George H.W. Bush presided over the 1989 Education Summit, which for the first time convened all the state governors to discuss national education goals. The wave of reform continued with Goals 2000, which encouraged states to develop academic standards. The standards movement culminated with No Child Left Behind Act (NCLB) in 2001.

NCLB, technically a reauthorization of ESEA, required all states to develop standards in mathematics and reading and to test students in grades 3-8, and 11 each year. The goal of NCLB was to use these standardized test scores to measure student adequate yearly progress (AYP) and hold schools accountable to NCLB's mandate of 100 percent proficiency for all students by 2014. Schools are still required to report AYP for all students and disaggregated by student subgroups along racial/ethnic and socioeconomic status lines as a result of NCLB. The effects of NCLB in terms of academic achievement, teaching, and its overall success will be debated for many years to come. ESEA flexibility waivers and the Race to the Top, both authorized by the Obama administration, have further complicated the effects of NCLB.

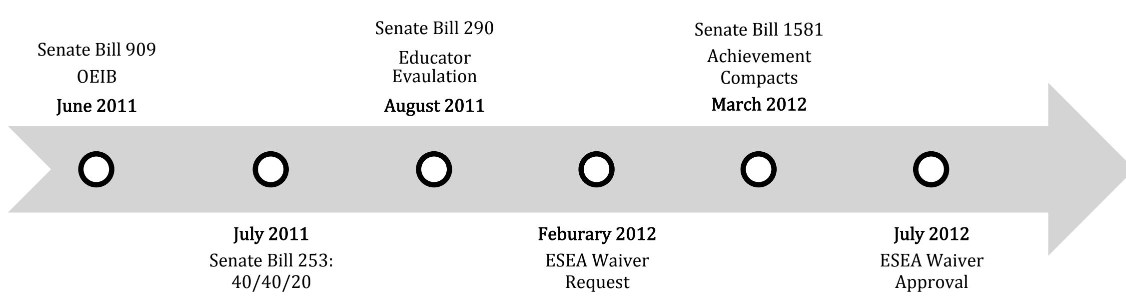
However, one consistency of NCLB, the ESEA flexibility waiver, and the Race to the Top, is the reliance on school and district standardized test scores as a measure of student success. Other measures include individual student achievement growth and graduation rates of high school students. These measures, for all students and disaggregated by subgroups, were hallmarks of the state of Oregon's ESEA flexibility waiver.

III. NEXT GENERATION OF ACCOUNTABILITY

The latest results of the National Assessment of Educational Progress (NAEP) painted a bleak picture of the state of education in Oregon. *Education Week's* annual state-by-state report, called "Quality Counts", used 2011 NAEP scores to compare states on a number of education metrics. Oregon ranked 43 out of 50 states on a composite score that included K-12 achievement, school finance, transitions and alignment, student chance of success, the teaching profession, and standards, assessments, and accountability (Education Week, 2013). Similarly, in 2010 the *Education Trust* found that Oregon was among the worst states in the county at closing the achievement gap between low/high-income and white/minority students (Education Trust, 2010).

Oregon received federal approval for its ESEA flexibility waiver in July of 2012. This followed the passages of Senate Bill 909, 253, 290, and 1581. These bills drastically reshaped the educational landscape in Oregon by altering the mission, authority, and organization of the Oregon Department of Education (ODE), and by overhauling the state's accountability system. Senate Bill 909 placed control of the entire education system from prekindergarten through college in the hands of Governor John Kitzhaber. The Governor is responsible for appointing a Chief Education Officer and a 12-member board, the Oregon Educational Investment Board (OEIB), to oversee the entire education system. Senate Bill 253 set the numerical goal that 40% of Oregonians will have a bachelor degree, 40% will have an associate or technical degree, and 20% will have a high school degree by 2025. The federal ESEA waiver requirement of creating teacher and administrator evaluation systems helped spawn Senate Bill 290, which committed Oregon to creating a framework for educator evaluation for teachers and administrators. Pursuant with the 40/40/20 goal, Senate Bill 1581 requires OEIB to enter into achievement compacts with every K-12 school district, education service district, community college, and each public university. The approval of the ESEA waiver and the passages of Senate Bill 909, 253, 290, and 1581 created the *Next Generation of Accountability* in Oregon. Figure 1 displays the relative dates of each bill and the ESEA waiver request and approval.

Figure 1: Oregon Education Policy - June 2011 to July 2012



Consistent with the accountability and standards movement, Oregon's *Next Generation of Accountability* relies heavily on standardized test scores to measure school success and achievement. Oregon's school report card rates schools and districts based on a composite score that measures student achievement (and participation), attendance, individual achievement growth, and graduation rates among all students and disaggregated by subgroups. Additionally, Senate Bill 1581 requires school districts to set annual achievement and growth rates through an achievement compact with the OEIB.

Oregon's report card has implications for one ESEA flexibility wavier requirement in particular. ODE is required to identify the lowest and highest performing Title 1 eligible schools using the achievement score produced by the Oregon report card rating system. Title 1 schools are eligible for the National School Lunch Program (NSLP). The lowest performing schools are broken into two types, Priority and Focus schools. These schools receive additional Title 1 funds and broad support from the state to help improve student success as measured by student achievement and graduation rates. The top performing, Model schools, are meant to become mentors to other schools and provide the basis for identifying the best practices and polices that lead to student success that can be spread to other schools.

- **Priority Schools**: approximately 5% of Title I schools in the state. Those with the lowest overall achievement, growth, and graduation rates.

- **Focus Schools**: approximately 10% of Title I schools in the state. Those with low overall achievement, growth, and/or graduation rates that also an achievement gap for historically underserved subgroups.

- **Model Schools**: approximately 5% of Title I schools in the state. Those with the highest achievement, growth, and graduation rates.

The Oregon report card rating system designates certain schools as low and high performing based on their position in the statewide school test score distribution. A successful rating system should correctly identify schools and apply interventions based on factors that predict achievement in schools with similar characteristics. Educational research historically has relied on methods, like OLS, that apply only to the average student or school. For instance, we know that student poverty negatively affects the average student's achievement. Little is known about the effects of explanatory variables on the entire CTSD of students from the lowest to highest achievers.

IV. RESEARCH QUESTION

This study asks if QR can supplement OLS when analyzing the predictors of school achievement in an accountability context. Research using OLS shows the effects that explanatory variables have on the average of the dependent variable.

OLS estimates result in policy interventions aimed at raising average test scores of students or schools. This study will add to these findings by using QR to explore differences across the entire CTSD. In other words, does the percentage of poor students within a school have a larger effect on low performing schools, as defined as the schools that scored in the bottom 10 percent of all schools? Or, does the effect stay relatively constant across the entire distribution of schools?

Two main research questions will be asked to answer the hypothesis above:

1. How well does the OLS model represent the entire CTSD of 3rd, 4th, 5th, 6th, 7th, 8th, and 11th grade mathematics and reading school achievement?

2. Does QR provide useful information for the ODE school rating system and subsequently for identifying Priority, Focus, and Model schools?

Three conditions can be met to show that the OLS models in this study do not explain the entire CTSD. First, if an OLS coefficient is insignificant but some or all of the QR coefficients are significant. Second, if an OLS coefficient is significant but not all QR coefficients are significant. Third, if an OLS coefficient is significant but there are significant differences in magnitude between the QR coefficients as evidenced by significant t-tests of equality between the QR coefficients.

a) If an OLS coefficient is insignificant but some or all of the QR coefficients are significant

b) If an OLS coefficient is significant but not all QR coefficients are significant.

c) If an OLS coefficient is significant but there are significant differences in magnitude between the QR coefficients as evidenced by significant t-tests of equality between QR coefficients.

The last condition above also tells us about the effects of the ODE rating system in relation to Oregon's accountability policy. Comparisons in the 5th (Priority Schools), 15th (Focus Schools), and 95th (Model Schools) quantiles (or percentiles) will help show the efficiency of using micro or macro-based interventions based on a set of explanatory variables that predict achievement. T-tests were run for each explanatory variable in each QR model to test whether the 5th and 15th, 5th and 95th, and the 15th and 95th quantiles were equal.

Answering these questions will help inform Oregon education policymakers about the potential tradeoffs between different types of empirical models used to analyze student achievement. Also, separating the analysis into different grade and subject regressions will provide information not available to Oregon policymakers. Currently, the Oregon school rating system combines mathematics and readings scores across all grades over a two year period when assigning schools a achievement rating and also combines the scores of all students within schools. Thus, not much is known about how different factors affect different subjects or different grades. For instance, it would be beneficial to know that decreasing the student teacher ratio raises test scores in 3rd grade mathematics and reading but not in 5th grade. Aggregating results at the school level prevents policymakers from seeing this distinction.

V. LITERATURE

The literature review for this study is divided into two parts. First, research that used QR to analyze student achievement will be discussed. Historically, QR has been a little used method in educational research but recent scholars have discovered its potential. Most of these researchers have recognized that QR models supplement average effect models, specifically OLS. Second, literature in relation to the explanatory variables used in this study will be discussed. These variables include the school: percentage of students who qualify for FRL, the percentage African American, American Indian, Asian, and Hispanic students, percentage of teachers with a master degree, average years experience of teachers, average attendance rate, student to teacher ratio, enrollment, and total operating expenditures per student. This part of the literature review will show the potential directional effects we can expect from the OLS and QR models.

Quantile Regression in Education Research

The research relating to student achievement is expansive, but until recently few researchers in this field have used QR (Eide & Showater, 1998; Tian, 2006; Haile & Nguyen, 2008; Penner & Parrot, 2008; Tian, Wu, Li, Zhou, 2008; Reeves & Lowe, 2009; and Antecol, Eren, & Ozbeklik, 2013). Eide and Showater (1998) were the first to analyze student achievement using QR. The authors examined the effects of the student to teacher ratio, percentage of teachers with advanced degrees, per student funding, and school year length on the change in test scores from 10th to 12th grade. The results showed important differential effects within the CTSD in relation to enrollment and the student to teacher ratio.

Other researchers have also shown that certain student achievement predictors have differential effects at different points in the CTSD. Tian (2006) looked at the differential effects of family background on mathematics achievement in 10th, 11th, and 12th grade and found that students in the 5th, 10th, 25th, and 50th percentile across all grades were more affected by family background characteristics. The authors argue that educational policy should stray away from one-size-fits-all policy solutions based on the differential effects found in their QR model. Haile & Nguyen (2008) showed that the racial achievement gap was worse in the high end of the CTSD and suggest policies aimed at closing the achievement gap should be targeted at high performing at risk students. Penner and Parrot (2008) examined gender effects and found significant differences between boys and girls at different points within the CTSD. Reeves and Lowe (2009) used national 8th grade mathematics test scores to test whether a set of school and parent variables had differential effects within the CTSD. Tian, Wu, Li, Zhou (2009) found a positive correlation between mathematics and science achievement by using a double kernel approach to analyze longitudinal data in a QR model. In a randomized experiment, Antecol, Eren, & Ozbeklik (2013) used a fixed effect QR model to show that Teach for America (TFA) teachers exhibit consistent positive results along all quantiles of the CTSD, suggesting that TFA teachers are equally effective for low and high performing students.

All of the above studies looked at American students only, but numerous international scholars have used QR to explore differences in the CTSD (Levin, 2001; Fertig, 2003; and Guimarãesa & Sampaio, 2011). These studies explored the differential effects of class size reductions, gender, parental characteristics, and college entrance exam scores within the CTSD. Other authors have compared how family background characteristics affect the CTSD in the United States and 19 other European countries (see Woessmann, 2009).

This study adds to the literature by analyzing the policy implications of selecting certain percentile thresholds when examining statewide school achievement by applying a QR model directly to a state accountability system. The 5^{th}, 15^{th}, and 95^{th} quantiles are chosen for this study based on the theory that they correspond to the percentiles used to identify Priority, Focus, and Model schools. This allows for a more complete theory on how changes along the CTSD can create implications and opportunities for state accountability systems.

Explanatory Variables

School Socioeconomic Status

The most widely used variable designed to capture school socioeconomic status, and the one this study uses, is the percentage of students who are eligible for the NSLP. To be eligible, a child's family household income must be below 130 percent of the poverty line.

The negative relationship between student socioeconomic status and achievement is well documented and accepted in the literature. Sirin's (2005) meta-analysis of 74 studies analyzed the relationship between socioeconomic status and achievement and found that the majority of studies found a significant negative correlation. Tian (2006) is one of the only studies that used QR to look specifically at the differential effects of family background on mathematics achievement in 10^{th}, 11^{th}, and 12^{th} grade. Tian found that students across each grade in the bottom half of the CTSD were more affected by family background characteristics.

School Race Composition

The achievement gap between Caucasian and African American, Hispanic, and American Indian students has been well documented. Most research examines the racial achievement gap within rather than between schools. However, researchers have shown that urban schools that have higher percentages of minority students tend to on average perform worse than schools with lower percentages of minorities (Lieras, 2008). Haile & Nguyen (2008) used QR to show that the racial achievement gap was worse in the high end of the CTSD and suggest policies aimed at closing the achievement gap should be targeted towards students in the higher end of the CTSD.

School Location

The research analyzing school location and student achievement is inconclusive. This is partly due to a lack of quality research and partly from the differences in the definitions of school location, data sources, and methodology. For instance, definitions of "rural schools" in the literature range from 1.1 to 11.6 million nationwide (Arnold, Newman, Gaddy, and Dean, 2005). Randomized experiments in school location research are nearly impossible to implement making causal inferences difficult and results less consistent among researchers (Khattttri, Riley, & Kane (1997).

The most consistent finding among researchers is that suburban schools, which generally have low percentages of poor students, score higher than rural and urban schools. However, numerous studies have found no difference in academic achievement between schools located in rural, urban, or suburban areas when school socioeconomic status is controlled for (Fan & Chen, 1999). When significant differences are found, there is little agreement over who performs better between rural, urban, or suburban students. Reeves (2009) showed that urban schools in the 50th and 75th percentile in academic achievement performed worse than suburban schools and also found that rural students outperformed their suburban counterparts in the 5th and 25th percentile. Lee and McIntire (1999) found that rural students outperformed their urban and suburban counterparts. This study adds to the literature by using a more accurate definition of school location. Schools located in towns are included in each regression, something that very few, if any, researchers have explored.

Advanced Teacher Credentials

Research showing the importance of quality teachers has produced teacher evaluation systems across the United States. Historically, teacher evaluation has been politically unfeasible, partly because of the lack of quality research showing the link between teachers and student achievement. Teacher evaluation research generally employs value-added methods. Researchers track students from one year to the next in order to predict test scores. Teachers are then tied to students so researchers can assess the "value" they added (or didn't) in terms of improved test scores. The debate on this issue is very controversial, with one side claiming that teacher evaluation systems are being instituted too soon or aren't sophisticated enough to base teacher decisions on, while the other side points numerous studies that find quality teachers are immensely important. Despite this debate, teacher evaluation systems are being instituted in many states in the coming years, including Oregon.

The evidence relating to teacher credentials, specifically whether teachers have advanced degrees, and student achievement is also inconclusive. Wayne and Young's (2003) meta analysis showed that most studies produced insignificant results but the studies that controlled for the type of degree found that mathematics teachers with master degrees in mathematics raised student achievement relative to other teachers. Eide and Showater (1998) found no correlation between teachers with a master degree and student achievement using both an OLS and QR model.

Teacher Years of Experience

Many researchers have found that teachers increase their effectiveness more in the first years of teaching, but the rate of improvement flattens out as years of experience increases (Hanushek, Kain, O'Brien, & Rivkin, 2005). This conclusion is widely accepted in the literature with some caveats. First, it is unclear whether teachers with more experience are more effective because less effective teachers left the profession leaving a population of more effective teachers. A large population of quality teachers may bias results upward. Not controlling for teacher quality makes distinctions between teachers with similar quality less efficient, especially among those less experienced. Clotfelter, Ladd, and Vigdor (2007) addressed this issue and showed that teachers with more experience increase student achievement more than those with little experience.

Attendance

Often overlooked, student attendance has been shown to have a significant positive affect on student achievement. Intuitively, students who attend more school do better than those that do not (Lamdin, 1996; Roby, 2004). Lamdin (1996) found that student attendance is a strong predictor of student achievement and should be considered an essential part of the education production function. The state of Oregon includes attendance as part of one of the three components used to rate schools.

Student to Teacher Ratio

The relationship between the student to teacher ratio and achievement has been well researched, but no strong consensus has emerged. Many prominent researchers have tackled the issue and came to different conclusions. Hanushek (1986) and Hoxby (2000) asserted that the literature surrounding class size is inconsistent and conclude that class size doesn't have a significant effect on student achievement. Krueger (2003) asserted that Hanushek in particular used a flaw system in his meta-analysis and showed that smaller class sizes do indeed have a positive effect on student achievement.

Levin (2001) provides the only analysis specifically looking at the effects of class size within the CTSD. Using a two-stage least absolute deviation estimator (2LAD), an analog of two-stage least squares (2SLS), Levin found no evidence of positive effects from class size reductions on mathematics and reading achievement. The author's results were consistent in 4^{th}, 6^{th}, and 8^{th} grade in both an OLS and QR model.

Enrollment

There is little academic agreement in relation to effects school size has on student achievement. For instance, Kahoe, Schwartz, and Stone (1990) found that students in large elementary schools scored worse than those in smaller schools and advocate for a policy that would decrease school sizes. On the other hand, Eide and Showater (1998) showed that the relationship between school enrollment and student achievement was positive and significant in both an OLS and QR model. The largest effect was in the 5th quantile, suggesting that the students in the lower end of the CTSD benefited more from larger enrollments than those at higher points.

Dollars per Student

The relationship between school funding and student achievement is one of the most complicated and controversial issues in education. Hanushek (1996) attributes inconsistent findings in the school funding literature to methodological differences across studies. Many studies in Hanushek's meta-analysis found positive and significant results, but few addressed the methodological issues in defining dollars per student and drawing conclusions across states. Also, per-student variables calculated at the school or district level used to make conclusions at the class level fall victim to an ecological fallacy, which simply means making flawed conclusions at the individual level when using school or district level data. In such cases, only definitive conclusions can be drawn at the lowest level of aggregation. Eide and Showater (1998) found no significant relationship between school funding and achievement.

VI. DATA

Data from the 2010-2011 Oregon Assessment of Knowledge and Skills (OAKS) generated the dependent variables used in this study. Separate regressions were run for 3rd, 4th, 5th, 6th, 7th, 8th, and 11th grade in both mathematics and reading, resulting in 14 OLS and QR models. The school achievement score is defined as the percentage of total students within each grade and subject who met or exceeded the state achievement standard. Students who meet or exceed the state achievement standard are said to have a "mastery of the grade level knowledge and skills required for proficiency" (ODE, 2013). Each school district is required to administer and report school OAKS scores to ODE.

ODE collects additional data from each school and provides this information publically on its website. These variables include the school: percentage of students who qualify for FRL, percentage African American, American Indian, Asian, and Hispanic students, percentage of teachers with a master degree, average years experience of teachers, average attendance, student to teacher ratio, enrollment, and total operating expenditures per student. The only variable not collected directly by ODE is the location of schools. The National Center on Education Statistics (NCES) classifies all public schools into 12 area definitions across four broad locations: city, suburb, town, or rural. Table 2 provides definitions for all the variables used in this study.

TABLE 2: Variable Definitions

Variable	Definition
OAKs scores*	Percentage of students within a school who meet or exceed the state standard
FRL	Percentage of students eligible for free or reduced lunch
Asian	Percentage of Asian students
African American	Percentage of African American students
Hispanic	Percentage of Hispanic students
American Indian	Percentage of American Indian students
Rural	Territory outside of an urbanized area and urban cluster
Town	Territory inside urban cluster but outside urbanized area
City	Principle city inside an urbanized area
Suburb	Outside a principal city but inside an urbanized area
Master	Percentage of teachers with a master degree or higher
Experience	Average years of experience across all teachers
Attendance	Average attendance rate
Ratio	Total students divided by total teachers
Enrollment	Headcount of all students on October 1st, 2010
$ per Student	Total operating cost divided by enrollment

* dependent variable

Charter and alternative schools were excluded from this study because of their unique status as quasi-public schools. These schools can choose their own curriculum, policies, and practices and often offer specialized programs that parents self select their children into. Also, schools that weren't rated on the Oregon Report Card were excluded. Very small, newly opened, or recently reconfigured schools generally fall into the "no rating" category.

VII. METHODS

Quantile Regression

The traditional methods, specifically OLS, employed by education researchers and policymakers to analyze student achievement use the average of the dependent variable to generate coefficients for explanatory variables. For example, an OLS coefficient of 1.5 tells us that a one-unit increase in an explanatory variable raises the average test score of the population by 1.5 percent. Many states, including Oregon, are required to identify the bottom 5 percent, bottom 5-15 percent, and the top 5 percent of schools each year based on a state developed rating system that places schools within a state-wide test score distribution. Policymakers should have accurate information about the effects of different predictor variables on the overall population and also at different points within the CTSD.

Koenker and Basset (1978) produced the first model that used sample quantiles to minimize the sum of absolute deviations at different cut points in the CTSD of the dependent variable. This was motivated by the theory that QR was only valid when the conditional quantile function (CQF) was linear. As it turns out, quantile models can be correctly specified even if the CQF is not linear (Angrist & Pischke, 2008).

OLS uses the average in the sample population to fit a linear line that minimizes the sum of squared residuals between Y and X values. The resulting conditional expectation function (CEF) estimates the expected value (or average) of the dependent variable given a set of x explanatory variables. Following Angrist and Pischke (2008), Figure 1 displays the CEF, where m is the sample average.

FIGURE 1: $\mathrm{E}\,[Y_i|X_i] = \arg\min \mathrm{E}[(Y_i - \mathrm{m}(X_i))^2]$

QR minimizes the sum of absolute residuals at certain cut points in the CTSD, which produces the conditional quantile function (CQF). Figure 2 displays the CQF, where τ represents the quantile of interest and P_τ is the asymmetric loss function that minimizes the absolute residuals at a given quantile.

FIGURE 2: $Q_\tau\,[Y_i|X_i] = \arg\min \mathrm{E}[(P_\tau(\mathrm{Y} - \mathrm{q}(X_i))^2]$

The conditional median is the point in the CTSD where half the values are below and half are above. Generating the CQF for quantiles other than the median requires the solving of a linear programming problem using an asymmetric loss function, shown in Figure 3 (this is done by many statistical programs, including Stata).

FIGURE 3: $P_\tau\,(u) = (\tau - 1(\mathrm{u} < 0))$

The loss function weighs values positively and negatively to generate a minimand (minimization point) for the conditional quantile of interest. Figure 4 shows the minimization formula for generating quantile coefficients by substituting the linear function $X_i\mathrm{b}$ in for $\mathrm{q}(X_i)$. This is the analog of Figure 2. The coefficient, β_b, is generated by fitting a linear line to Y_i using the loss function.

FIGURE 4: $Q_\tau\,[Y_i|X_i] = \arg\min \mathrm{E}[(P_\tau(\mathrm{Y} - X_i\mathrm{b}))^2]$

Put more simply, QR examines how quantiles within the CTSD change conditional on a set of explanatory variables. For example, if it's found that schools with more experienced teachers increase the average test scores of the lowest performing schools, it means that those low performing schools with more experienced teachers have higher scores than those low performing schools with less experienced teachers, holding all else equal. This result would not mean that those low performing schools with more experienced teachers are now not low performing, as defined by the schools that scored in the bottom 10 percent of all schools.

Interpreting Coefficients

The interpretation of OLS and QR coefficients is very similar. The OLS model explains the average effects of school level explanatory variables on school achievement. However, OLS models can miss the differential effects across the CTSD. QR is used to examine whether the effects of school level variables are equal from low to high achieving schools.

The interpretation of QR coefficients is similar but not the same as the interpretation of OLS coefficients. For example, in an OLS model a positive coefficient of 1.5 on teacher experience would imply that schools test scores on average increase by 1.5 points for every year increase in school teacher experience. QR coefficients explain the effects within the CTSD but not the effects on schools themselves. This distinction is important when analyzing QR models. For instance, if it's found that the percentage of FRL students is negative and significant at the 15^{th} percentile, it doesn't necessarily mean that if a school lowers its percentage of FRL students that it will score better than the 15^{th} percentile. Instead, it simply means that at the 15^{th} percentile, schools with low percentages of FRL students scored better than those with higher percentages, holding all else equal.

Regression Procedure

Four separate regressions for each grade, one OLS and one simultaneous QR model for each subject (i.e. 3^{rd} grade mathematics, 3^{rd} grade reading, 4^{th} grade mathematics, etc.) were run with the same set of explanatory variables. These regressions will help answer the first research question. The second research question will be answered using the test option in Stata. Simultaneous quantile regression runs one regression using the selected quantiles and has the added feature of allowing the user to test the equality of quantile coefficients. For this study, three tests will be run for each explanatory variable (5^{th}=15^{th}; 5^{th}=95^{th}; 15^{th}=95^{th}). This will show any significant differential effects between Priority, Focus, and Model schools.

Each model accounts for heteroskedascity to more accurately compare the significance of coefficients. Heteroskedascity may be present in the data for a number of reasons. For example, the variance in test scores is unlikely to be equal across the distribution of school poverty. Most likely, the variance in school average test scores increases as the school percentage of students eligible for FRL increases. However, it's likely that those schools with low percentages of FRL students will have a narrower variance near the top of the CTSD. The OLS models used robust standard errors and QR models used bootstrap standard errors with 100 bootstrap repetitions to account for heteroskedascity.

VIII. LIMITATIONS

A limitation of this study is the endogeneity problem that plagues most educational research. OLS models assume that class size is endogenous of school achievement. In other words, the average class size among schools varies randomly and is not correlated with other exogenous variables. If this assumption doesn't hold it could bias OLS coefficients. This should be considered when interpreting the results of this study. Students are often self selected into schools with inputs (i.e. enrollment, location, average class size, etc.) that align with their parent's preferences. Parents who value their child's academic success may decide to enroll their children in schools with lower student to teacher ratios in addition to providing other supports that improve student achievement. Self-selection is generally exercised through school choice. The three main forms of school choice in Oregon are interdistrict, intradistrict, and parents choosing their residence based on school attendance zones.

The nature of one-year data is a second limitation of this study. The results of this study provide a snap shot of schools within Oregon in the 2010-2011 academic year. The effects of the explanatory variables should not be interpreted in causality terms. In other words, the negative correlation between the student to teacher ratio and 11th grade reading scores should not be interpreted as large class sizes cause lower school test scores. However, we can say that larger student to teacher ratios predict lower school test scores in 11th grade reading.

IV. RESULTS

The results are broken out by explanatory variable for simplification. First, within each explanatory variable section, there will be a general discussion in relation to the OLS coefficients. Second, both research questions will be answered generally across grades and subjects. The research question section above describes the three conditions that can be met to show that OLS models do not explain the entire CTSD. The third condition also answers the second research question, which asks if there are significant differences between Priority, Focus, and Model schools in terms of individual explanatory variables.

Regression results specific to each explanatory variable will also be shown within each section. These tables directly compare one explanatory variable across each model (i.e. 3rd grade mathematics, 3rd grade reading, 4th grade mathematics, etc.). Full results for each model, complete with standard errors, can be found in the appendix.

School Socioeconomic Status

Not surprisingly, the percentage of students eligible for FRL was a strong predictor of school achievement. Table 2 shows the coefficients for FRL across all 14 models. The OLS coefficients for FRL were significant for all but two grades (3rd and 7th grade reading). The direction of the coefficients for every significant finding was negative, implying that school test scores decreased as FRL percentage increased. This is consistent with past research showing that student poverty has a negative effect on student achievement. The OLS coefficients for mathematics achievement ranged from -.11 to -.28, whereas the coefficients for reading achievement ranged from -.07 to -.14. In other words, it appears that FRL was a stronger predictor and had a larger effect on mathematics school achievement.

TABLE 2: School Percentage of FRL Eligible Students

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-0.245***	-0.336***	-0.295***	-0.309***	-0.119**
Grade 4	-0.194***	-0.285***	-0.284***	-0.198***	-0.118*
Grade 5	-0.277***	-0.251***	-0.299***	-0.318***	-0.251***
Grade 6	-0.277***	-0.209**	-0.359***	-0.435***	-0.061
Grade 7	-0.182***	-0.148*	-0.283***	-0.252***	-0.023
Grade 8	-0.110*	-0.110	-0.038	-0.222***	0.058
Grade 11	-0.136**	-0.247*	-0.183*	-0.179**	-0.002
Reading					
Grade 3	-0.040	-0.132*	-0.120***	-0.034	-0.001
Grade 4	-0.071***	-0.163***	-0.102***	-0.053***	0.001
Grade 5	-0.143***	-0.205***	-0.158***	-0.154***	-0.053*
Grade 6	-0.129***	-0.205***	-0.189***	-0.186***	-0.020
Grade 7	-0.070	-0.178**	-0.175***	-0.106*	-0.010
Grade 8	-0.114**	-0.175**	-0.181**	-0.184***	-0.048
Grade 11	-0.085**	-0.067	-0.029	-0.076*	-0.073***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The QR results for FRL showed that the OLS models missed some features of the CTSD across all grades and subjects. In 3rd grade reading the OLS coefficient was insignificant but the 5th and 15th coefficients were significant. The same was true in 7th grade reading where the 5th, 15th, and 50th quantiles were significant. This suggests that the OLS model missed the negative effect that FRL had in the bottom of the CTSD in 3rd and 7th grade reading. In 6th, 7th, and 11th grade mathematics and 4th and 8th grade reading the OLS coefficients and every quantile except the 95th were significant. This suggests that the effects of FRL were greater in the bottom of the CTSD.

There were significant differences between the 5th and 95th and the 15th and 95th quantiles in 3rd, 4th, 5th, 6th, and 7th grade mathematics and 3rd, 4th, 6th, and 7th grade reading. In other words, there appears to be drastic differences in the effect that FRL had on school achievement between Priority/Focus and Model schools. Collectively, these results suggest that FRL was a stronger predictor of mathematics achievement, but there is little distinction between the 5th, 15th, and 50th quantiles. For reading, the results were also consistently significant and decreased monotonically from the 5th, 15th, and 50th quantiles. This suggests that the percentage of FRL students has different effects for the lowest and highest performing schools.

School Race Composition

There were few commonalities in how the school percentage of Asian, African American, American Indian, and Hispanic students predicted school achievement. The OLS results for mathematics show there were three instances of positive and four instances of negative coefficients across all grades and races. The percentage of Asian students had a positive effect in 5th and 11th grade. The percentage of Hispanic students had a negative effect in 7th grade and a positive effect in 11th grade. The percentage of African American students had a negative effect in 3rd grade, while the percentage American Indian students had a negative effect in 5th and 11th grade. Table 3 shows that the percentage of American Indian students within a school had a clear pattern of negative effects in reading. The OLS coefficients were negative and significant across all grades. The other significant coefficients were the percentage of African American students (negative in 6th and 11th grade), Hispanic students (negative in 3rd grade), and Asian students (positive in 11th grade).

TABLE 3: School Percentage of American Indian Students

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-0.076	-0.178	0.196	0.009	-0.003
Grade 4	-0.302	-0.483	-0.266	-0.429*	-0.244
Grade 5	-0.207*	-0.578	-0.025	-0.145	-0.252
Grade 6	-0.121	0.141	-0.044	0.030	-0.086
Grade 7	-0.114	0.168	0.139	0.034	-0.515**
Grade 8	-0.222	-0.374	-0.009	-0.135	-0.694*
Grade 11	-0.377***	-0.257	-0.273	-0.493**	-0.575**
Reading					
Grade 3	-0.159**	-0.030	-0.224*	-0.169	-0.020
Grade 4	-0.123***	-0.001	-0.218**	-0.124**	-0.015
Grade 5	-0.217***	-0.208	-0.213	-0.098	-0.111
Grade 6	-0.165*	-0.456	-0.014	-0.150	0.282
Grade 7	-0.206*	-0.415	-0.300	-0.083	0.013
Grade 8	-0.309***	0.113	-0.166	-0.326***	-0.317
Grade 11	-0.219***	-0.325*	-0.289**	-0.274***	-0.192**

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Again, the QR results showed that the OLS coefficients did not fully explain the differential effects of the school racial composition. Across all four races there were 9 instances of insignificant OLS coefficients but significant QR coefficients. Likewise, of the 19 significant OLS coefficients, 17 had differential effects within the QR results. There is no clear pattern within these differential effects. Of the 17, there were some with all insignificant quantiles and some with one or more significant quantiles. The point is that the majority of the time the OLS coefficients did not fully explain the entire CTSD.

There were significant differences in coefficient equality with at least one significant finding in every race category. A detailed discussion of all the findings is not necessary, but it is clear that in some grades school racial composition has effects that are not equal among Priority, Focus, and Model schools. However, no clear pattern emerged with all three possible coefficient combinations being unequal in some cases.

School Location

The variables rural, town, and city are dummy variables for the location of schools (see Table 2). These variables are interpreted in relation to schools located in the suburbs, the omitted dummy variable. For mathematics school achievement, the OLS coefficients clearly showed that on average, schools located in the suburbs outperformed schools located in rural and town areas. Table 3 shows that the coefficients on rural were large, negative, and significant for every grade except 8th grade mathematics and 5th grade reading. The coefficients on town were smaller than rural, but negative and significant in every grade except 6th grade mathematics. Again, the OLS results for reading achievement were negative but less significant and of smaller magnitude. Schools located in cities performed no worse than schools located in the suburbs in both mathematics and reading.

TABLE 3: Schools Located in Rural Areas

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-6.557***	-3.810	-10.28***	-6.418**	-2.518
Grade 4	-4.856**	-8.350	-3.779	-4.368*	-0.399
Grade 5	-3.895**	-4.030	-0.531	-4.069*	-3.482
Grade 6	-6.945***	-1.135	-4.078	-4.154	-14.87***
Grade 7	-6.986***	-10.61*	-9.043**	-5.411**	-13.72**
Grade 8	-4.023	-11.59**	-5.225	2.229	-6.842
Grade 11	-5.817**	-8.454	-4.076	-6.196*	-2.216
Reading					
Grade 3	-3.682***	-11.79***	-5.867***	-2.881*	0.198
Grade 4	-1.507*	0.193	-2.692	-1.78*	-0.042
Grade 5	-1.757	-1.083	-1.399	-0.803	-0.648
Grade 6	-6.365***	-8.205**	-8.928***	-4.689***	-7.449***
Grade 7	-3.644**	-8.650***	-5.556*	-2.970	-2.218
Grade 8	-4.770**	-1.859	-4.107	-4.234*	-5.348
Grade 11	-2.811*	-0.917	-2.690	-2.206	-0.794

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The OLS coefficients did not describe the entire CTSD in terms of school location. For instance, the OLS results showed that schools located in cities performed no worse than suburb schools, but the QR results showed that schools located in cities performed better in 3rd and 8th grade mathematics in the 5th quantile and in 7th grade reading in the 15th quantile. This suggests that low-performing schools located in cities performed better than their suburban counterparts in only a few grades. Like the school race findings, there was no clear pattern but nearly all of the significant OLS coefficients failed to explain the entire CTSD with many quantiles being insignificant.

Also like the school race findings, all school location variables showed inequalities between the quantile coefficient combinations. The most significant of these finds was among rural schools in 3rd grade reading. No combination of the 5th, 15th, and 95th coefficients was equal, suggesting that rural schools along the CTSD experience distinctly different effects based on school location.

Advanced Teacher Credentials

The teacher characteristic variables in this study measured the percentage of teachers with a master degree and average years of experience among all teachers within a school. Table 4 shows there were few significant OLS coefficients for the percentage of teachers with a master degree across all grades in both mathematics and reading. The only significant coefficient was in 4th grade reading (0.05). The direction of this coefficient suggests that the percentage of teachers with a master degree predicted an increase in school achievement.

TABLE 4: Percentage of Teachers with a Master Degree

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-0.064	0.015	-0.063	-0.026	-0.109
Grade 4	0.031	0.216***	0.22**	-0.031	-0.022
Grade 5	0.036	0.044	0.085*	0.017	-0.005
Grade 6	0.003	0.077	0.086	-0.028	-0.086
Grade 7	-0.034	0.183*	0.187*	-0.027	-0.077
Grade 8	-0.116	-0.154	-0.009	-0.028	-0.093
Grade 11	0.019	0.033	-0.059	0.025	0.078
Reading					
Grade 3	0.035	0.022	0.045	0.009	0.004
Grade 4	0.053***	0.109*	0.031	0.039**	0.008
Grade 5	-0.013	-0.041	-0.041	-0.006	-0.009
Grade 6	0.007	0.058	-0.001	0.034	-0.003
Grade 7	0.053	0.132	0.093	0.012	0.007
Grade 8	-0.086	-0.051	-0.017	-0.047	-0.004
Grade 11	-0.013	-0.028	-0.05	-0.018	0.02

*** p<0.01, ** p<0.05, * p<0.1

The OLS coefficients on the percentage of teachers with a master degree, again, missed some key aspects of the CTSD that were captured by the QR models. The OLS models showed that on average, the percentage of teachers with master degrees was not a significant predictor of school achievement in mathematics. However, positive and significant quantile coefficients are found in 4th (5th and 15th quantiles), 5th (15th quantile), and 7th (5th and 15th quantiles) grade mathematics. This implies that the percentage of the teachers with a master degree had the largest effect in the bottom of the mathematics CTSD in these grades. The insignificant 15th and 95th quantile coefficients in 4th grade reading also showed that the OLS model did not explain the entire CTSD.

There also appeared to be differences between the 5th and 95th and the 15th and 95th quantiles in 4th and 7th grade reading and 4th grade mathematics. The percentage of teachers with a master degree may have differential effects for the bottom and top of the CTSD.

Teacher Years of Experience

Table 5 shows that the average years of experience among teachers within a school produced positive OLS coefficients that were significant in 3rd, 4th, and 5th grade mathematics and reading and 7th grade reading. This suggests that school achievement increased, as elementary teachers within a school collectively were more experienced. Again, the mathematics coefficients were larger than in reading.

TABLE 5: School Average Teacher Years of Experience

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	0.399*	0.546	0.797**	0.365	0.327
Grade 4	0.470*	0.580	0.649	0.376	0.0588
Grade 5	0.580**	1.166***	0.796**	0.347	-0.249
Grade 6	0.476	0.366	0.176	0.586*	0.177
Grade 7	0.427	0.664	0.710	0.490	0.383
Grade 8	0.433	0.471	0.725	0.312	0.133
Grade 11	0.039	0.354	0.062	0.283	0.566
Reading					
Grade 3	0.289**	0.232	0.395**	0.153	0.038
Grade 4	0.350***	0.760***	0.541***	0.291***	0.015
Grade 5	0.273**	0.686**	0.199	0.181	0.101
Grade 6	0.139	0.314	0.193	-0.018	0.246
Grade 7	0.544**	0.221	0.224	0.376	0.307
Grade 8	0.341	0.478	0.504	0.305	-0.188
Grade 11	0.001	0.043	-0.061	-0.041	0.235

*** p<0.01, ** p<0.05, * p<0.1

The 6th grade mathematics OLS coefficient was insignificant but missed the significant coefficient in the 50th quantile. Also, the OLS coefficients did not show the lack of significance in the high end of the CTSD as evidenced by no significant 95th quantile coefficients. Consistent with the OLS findings, the only inequalities among the different combinations of quantile coefficients were in the elementary school grades. These inequalities were between the low and high end of the CTSD showing that teacher experience had differential effects for Focus/Priority and Model schools.

Attendance

The average attendance rate was a very strong predictor of school achievement in every grade except for 11th grade mathematics. Table 6 shows that all coefficients were positive, suggesting that as school average attendance increased, so to did school achievement. The coefficients were larger in mathematics, which is consistent with the results from other explanatory variables. The OLS coefficients in mathematics ranged from 3 to 3.5, while in reading the coefficients ranged from 0.6 to 2.7. These results are not surprising given the theory that seems to be forming around the idea that mathematics achievement is affected more by the explanatory variables in this study.

TABLE 6: School Average Attendance Rate

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	3.098***	3.400	3.019**	3.564***	2.098
Grade 4	3.371***	0.395	1.605	4.157***	3.257**
Grade 5	3.570***	3.264**	2.871***	3.311***	4.295***
Grade 6	2.979***	2.499	2.218**	2.626**	4.571***
Grade 7	3.017***	2.570**	3.362***	3.317***	2.612*
Grade 8	3.071***	0.0230	2.722**	3.689***	4.139***
Grade 11	0.646	1.242	1.066	0.784	0.851
Reading					
Grade 3	1.995***	2.700***	2.231***	1.707***	0.277
Grade 4	1.484***	1.040	1.367*	1.621***	0.285
Grade 5	2.088***	2.604**	2.808***	2.290***	0.845
Grade 6	1.590***	1.049	0.356	1.487***	2.359**
Grade 7	2.104***	1.266	1.527**	2.087***	1.852***
Grade 8	2.682***	3.049**	3.494***	2.612***	2.830***
Grade 11	0.563**	0.517	0.948**	0.459	0.891***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The average attendance rate was the first variable not to satisfy the first condition of having an insignificant OLS finding but significant quantile coefficients. However, among the 13 regressions with significant OLS coefficients, 9 had insignificant quantile coefficients, again showing the usefulness of QR in explaining more of the CTSD than OLS. There was no pattern among the insignificant quantile coefficients.

The only inequality among the quantile coefficients in reading was between the 5th and 95th quantile in 8th grade. In mathematics, the 15th and 95th quantiles were not equal in the 3rd, 5th, and 6th grade, and the 5th and 95th were not equal in the 3rd grade. Again, the only inequalities were between the bottom and top of the CTSD, suggesting that school average attendance affects Priority/Focus schools differently than Model schools.

Student to Teacher Ratio

School characteristics had little predictive power in the OLS models. Table 7 shows that the student to teacher ratio was significant only in 3rd grade mathematics and 11th grade reading. The negative coefficient in the 3rd grade implies that high student to teacher ratios within schools had a negative effect on school achievement. The positive coefficient in 11th grade reading implies the opposite.

TABLE 7: School Student to Teacher Ratio

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-0.572*	0.090	-0.502	-0.279	-0.565
Grade 4	0.069	0.870	0.075	-0.180	-0.222
Grade 5	-0.437	-0.435	0.184	-0.563**	-0.591
Grade 6	-0.078	0.464	-0.131	-0.073	-0.428
Grade 7	-0.048	-0.167	-0.010	-0.269	0.317
Grade 8	-0.132	-0.259	-0.407	0.252	-0.542
Grade 11	0.120	0.226	-0.094	0.316	-0.299
Reading					
Grade 3	-0.179	-0.541	-0.138	-0.121	-0.053
Grade 4	-0.014	0.149	0.013	-0.007	-0.024
Grade 5	-0.204	-0.686*	-0.096	-0.185	-0.059
Grade 6	0.099	0.269	0.001	0.168	-0.244
Grade 7	-1.034	0.855	2.291	-0.921	-2.011
Grade 8	0.058	-0.004	0.111	0.291	0.382
Grade 11	-0.042	0.653*	0.395	-0.128	-0.411**

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The OLS coefficients missed features of the CTSD in 5th grade mathematics and reading. The only inequality among the quantile coefficients was also found in 11th grade reading where the 5th and 15th quantile were not equal to the 95th quantile, again implying differences between the low and high achieving schools.

The student to teacher ratio has little predictive power, but again the QR model supplemented OLS by providing additional information about the CTSD.

Enrollment

Both the school enrollment and average dollar per student variables were logged to normalize their distributions. Table 8 shows that school enrollment was positive and significant in 11th grade mathematics and reading. This suggests that larger high schools on average performed better than smaller high schools. The variability and large increase in high school enrollment from middle to elementary school might help explain this finding. The difference between a small and large elementary/middle school and a small and large high school are quite different. Large high schools are able to provide, given adequate funding, a greater variety of advanced classes and extra curricular activities that may translate into increased student motivation, creativity, and subsequently higher school achievement.

TABLE 8: School Enrollment

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	1.186	5.395	3.339	-0.410	-3.779
Grade 4	0.685	4.461	5.336	2.497	-4.109
Grade 5	2.198	14.61***	10.26**	3.590**	-4.842
Grade 6	-0.611	4.759	7.395**	0.330	-6.091**
Grade 7	-1.112	4.357	-0.557	-2.318	-0.643
Grade 8	2.394	5.898	6.152**	1.014	-2.178
Grade 11	2.697*	7.216**	7.067***	0.930	1.704
Reading					
Grade 3	1.053	3.801	2.994	-0.391	-0.146
Grade 4	-0.414	1.647	0.944	-0.812	-0.279
Grade 5	-0.102	7.600***	4.012*	-0.650	-1.864
Grade 6	-1.564	0.808	-1.379	-1.580*	-2.674*
Grade 7	-1.034	0.855	2.291	-0.921	-2.011
Grade 8	0.859	7.800**	2.045	0.930	-6.286**
Grade 11	3.157***	5.946***	5.990***	2.409**	0.202

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The QR results explained more about the CTSD in 5th, 6th, 8th, and 11th grade mathematics and reading. The insignificant OLS coefficients failed to show the positive effects in the lower end of the distribution. In other words, it appears that larger schools had positive effects for low performing schools and negative effects for high performing schools. This is consistent with the findings in both 11th grade mathematics and reading where the positive quantile coefficients are in the bottom of the CTSD and disappear in the 95th quantile.

This theory is backed up by t-tests for the equality between the 5th, 15th, and 95th quantile. The 5th and 15th quantile coefficients were not significantly different in any grade, but both were significantly different from the 95th quantile in all grades. This suggests that school size has very different effects for Priority/Focus and Model schools.

School Funding

Table 9 shows that the OLS coefficients for school operating cost per student were insignificant across all grades in both subjects with the exception of 11th grade reading. There is a very plausible reason for this. In 1990, the state of Oregon passed measure 5 which limited the amount of property taxes school districts could collect. Prior to 1990, the spilt between property taxes, state funds, and federal funds was roughly 60/30/10, today that ratio is closer to 35/50/15. State legislators realized immediately in the early 1990s that the general fund would be responsible for providing the majority of school funds and created a formula that was meant to equalize funding between districts and schools. An example of this formula can be seen in the 2010-2011 funding differences between Hillsboro and North Clackamas school districts near Portland, Oregon. Hillsboro spent $741 more per student than North Clackamas and had about $4 million more in budgeted revenue. This was despite the fact that North Clackamas budgeting roughly $23 million more than Hillsboro in local revenue. The state stepped in to help equalize the funding by allocating roughly $17 million more state funds to the Hillsboro School District. This equalization produces much less variability in school funding.

TABLE 9: School Operating Cost per Student

	OLS	q05	q15	q50	q95
Mathematics					
Grade 3	-2.694	0.642	-3.430	-8.920	-1.629
Grade 4	8.494	11.16	13.52	9.947	3.911
Grade 5	1.359	-0.180	-0.480	3.796	11.14
Grade 6	3.465	-1.284	12.25*	5.038	-8.828
Grade 7	-5.747	-8.184	-5.133	-9.113*	11.22
Grade 8	-12.79	-27.93*	-26.76**	-12.79	1.057
Grade 11	10.23	9.906	3.716	9.281	9.448
Reading					
Grade 3	-0.574	-3.020	-2.624	-0.601	0.033
Grade 4	2.900	-1.333	3.210	1.409	-0.125
Grade 5	1.633	-11.10	4.515	2.398	0.379
Grade 6	1.449	-8.928	-9.595*	5.235	1.063
Grade 7	-1.636	-3.137	3.002	-5.532	0.530
Grade 8	-0.646	-7.866	-0.991	4.229	4.025
Grade 11	12.48***	21.56**	25.76***	9.748**	-2.536

*** p<0.01, ** p<0.05, * p<0.1

Consistent with all of the above results, the OLS models did not fully explain the entire CTSD in some grades. Significant quantile coefficients were found in 6th, 7th, and 8th grade mathematics and 6th grade reading. These results were sporadic and exhibited no patterns. The quantile coefficients in 11th grade reading were positive and significant in the 5th, 15th, and 50th quantiles suggesting that increased school funding had a positive effect on the bottom of the CTSD. Likewise, school funding appeared to have a different effect for Priority/Focus and Model schools.

X. IMPLICATIONS

There are many potential policy implications that result from this study. It is helpful to categorize these results into three sections. The first two sections will summarize the answers to the two research questions and discuss the policy implications of the findings. The last section will discuss the important overall trends found in this study.

Research Question 1: How well does the OLS model represent the entire CTSD of 3rd, 4th, 5th, 6th, 7th, 8th, and 11th grade mathematics and reading school achievement?

The simple answer to this question is somewhat well. First, within the results of every explanatory variable, at least one grade contained an insignificant OLS coefficient but had significant quantile coefficients. This met the first condition. Second, again within every explanatory variable (with the exception of average attendance which had nearly all significant OLS coefficients) there was at least one instance where an OLS coefficient was significant but at least one of the quantile coefficients was insignificant. Finally, there was at least one inequality between the 5th, 15th, and 95th quantile coefficients across all explanatory variables.

Taken together, these results clearly show that education administrators can benefit from the use of QR when weighing trade-offs between different types of policy interventions or research designs. Traditional regression methods are useful in that they describe the average of the CTSD, but are not useful in describing the effects within the entire CTSD. For example, an OLS estimate in this study showed that the percentage of FRL within schools had a negative effect on school test scores in 5th grade reading. However, what the OLS model missed and what the QR showed was that the negative effect decreased monotonically from the 5th to the 95th quantile. Interventions aimed at increasing the reading test scores of schools should take this into consideration when designing policies. There are numerous other examples of the explanatory advantages of QR that are discussed in the results above.

Significant efficiency could be lost from one-size-fits-all policy interventions that ignore differential effects across the CTSD. Using the above example, efficiency will be lost if an intervention aimed at increasing the reading achievement of poor schools focuses on all poor schools equally. As the results show, the emphasis should be put on those schools in the bottom of the CTSD, where the negative effects are the greatest. This is consistent with the aim of contemporary educational policy, which is increasingly aimed at boosting the achievement of the lowest performers. This study used schools as the unit of analysis, but QR could be used in designing policies aimed at closing the achievement gap within schools by identifying what negatively effects the achievement of the lowest performing students.

Research Question 2: Does QR provide useful information for the ODE school rating system and subsequently for identifying Priority, Focus, and Model schools?

Again, the simple answer to this question is somewhat well. The majority of QR coefficient inequalities were between the 5th/15th and the 95th quantiles. This suggests that explanatory variables in this study affect Priority/Focus schools in significantly different ways than Model schools. Policymakers should carefully evaluate differences between Priority, Focus, and Model schools across the different predictors of student achievement when considering implementing best practices from Model schools in Priority and Focus schools. QR can also be useful in deciding which policy interventions to undertake in Priority and Focus schools by helping policymakers choose the most applicable interventions based on those variables that have strong negative effects in the lower end of the CTSD.

Schools located in rural areas provide the best example in thinking about how a targeted policy intervention could work in Priority and Focus schools. From the results it appears that being located in rural areas affects schools in the 5th and 15th quantiles similarly in mathematics but not in reading. In reading the rural effect is greater for Priority schools. Specific policies aimed at boosting achievement in rural Priority and Focus schools should consider placing more emphasis on reading in Priority schools but treat mathematics the same in both types of schools. Again, these results should not be considered a policy solution but instead as a starting point for understanding the differences between otherwise similar schools.

General Findings

Interventions and programs aimed at increasing school achievement should consider placing more emphasis on mathematics achievement. There is a clear pattern of stronger effects in mathematics across all grades and explanatory variables. This is consistent with the actual average test scores across all schools and grades in 2010-2011. In mathematics, the aggregate average of 62 suggests that on average, across all schools, only 62 percent of students are proficient in mathematics. This is compared to 82 percent in reading. More research is needed to fully understand how public policy can improve mathematics achievement.

An obvious implication from the OLS and QR models is the need to explore the relationship between reading achievement and schools with high percentages of American Indian students. The OLS coefficients showed that school achievement declined as the percentage of American Indian students increased across all grades. Reasons for this negative relationship are speculative at best and more research is needed to explore the causes. It appears from the results that all schools with high percentages of American Indian students can be treated equally, that is, there were no significant differences between schools in the 5th, 15th, and 95th quantiles.

Schools located in rural and town areas performed worse than their suburban counterparts. The results showed that being located in rural areas predicted lower achievement across all grades and subjects with the exception of 5th grade reading. The results are not as strong for schools located in towns, but the results are negative and significant across all grades in mathematics except for 6th grade. Potential reasons for this include a concentration of high poverty students in these schools and a lack of experienced or qualified teachers. Summary statistics showed that suburban schools had small percentages of students who were eligible for FRL and high percentages of teachers with master degrees.

School attendance rates appear to be a strong positive predictor of school achievement. Consistently across all grades and subjects school achievement increased as average attendance rates increased. The results are larger for mathematics and less significant in the 11th grade. Research and subsequent policy could identify those schools with low attendance rates and see if any lessons can be taken from schools with high attendance rates. An efficient transportation policy in a rural school district with high attendance rates could be applied to a rural school district with an inefficient transportation policy and subsequently low attendance rates. The QR model doesn't add much to the story. Average attendance rates seem to affect the different segments of the CTSD in similar ways.

XI. CONCLUSION

The objective of this study was to provide an example of using QR in an educational policy and accountability framework. The results of this study support the use of QR as a supplement to traditional average effect models. The OLS models showed many significant results across all grades and subjects but failed to explain the entire CTSD in many instances. The QR results suggest there may be differential effects for all the explanatory variables in this study at different points within the CTSD for both mathematics and reading achievement.

When specifically looking at Priority, Focus, and Model schools its clear that there are differences between the lowest and highest achieving schools in many cases. Policies that take the best practices from Model schools and implement them in Priority and Focus schools must be careful not to ignore the differential effects in the lower end of the CTSD. QR can also be useful in formulating interventions by identifying the predictor variables that have the largest negative effects in Priority and Focus schools.

Outside of the advantages of QR, four general findings emerged. First, all explanatory variables had a greater effect on mathematics versus reading achievement. Second, strong negative effects in reading achievement were found in schools with high percentages of American Indian students. Third, schools located in rural areas and towns exhibited lower school achievement relative to suburban schools. Lastly, high attendance rates had a strong positive effect on school achievement. Future research into Oregon school achievement should explore these issues in more detail.

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APPENDIX

TABLE 1: Mathematics Simultaneous QR: Grade 3 (n=629)

VARIABLES	Grade 3	q05	q15	q50	q95
FRL%	-0.245***	-0.336***	-0.295***	-0.309***	-0.119**
	(0.0428)	(0.105)	(0.0587)	(0.0514)	(0.0555)
African American	-0.374**	-0.415	-0.755**	-0.383	-0.416
	(0.168)	(0.412)	(0.348)	(0.271)	(0.260)
Asian	0.166	0.700	0.145	0.0173	0.0411
	(0.147)	(0.461)	(0.297)	(0.172)	(0.272)
Hispanic	-0.0649	0.0876	-0.298	-0.100	-0.172
	(0.107)	(0.324)	(0.246)	(0.140)	(0.224)
American Indian	-0.0757	-0.178	0.196	0.00880	-0.00344
	(0.113)	(0.319)	(0.266)	(0.151)	(0.221)
Rural	-6.557***	-3.810	-10.28***	-6.418**	-2.518
	(1.972)	(5.119)	(3.666)	(2.536)	(2.413)
Town	-3.936**	-2.335	-6.111	-1.844	-3.235
	(1.852)	(4.269)	(3.810)	(2.169)	(2.295)
City	1.741	7.314**	0.597	2.493	2.924
	(1.552)	(3.595)	(1.968)	(1.901)	(2.403)
Master	-0.0640	0.0149	-0.0636	-0.0261	-0.109
	(0.0450)	(0.101)	(0.0658)	(0.0560)	(0.0750)
Experience	0.399*	0.546	0.797**	0.365	0.327
	(0.242)	(0.485)	(0.390)	(0.313)	(0.)
Attendance	3.098***	3.400	3.019**	3.564***	2.098
	(1.014)	(2.070)	(1.343)	(1.230)	(1.457)
Ratio	-0.572*	0.0895	-0.502	-0.279	-0.565
	(0.301)	(0.701)	(0.340)	(0.445)	(0.389)
Enrollment	1.186	5.395	3.339	-0.410	-3.779
	(1.917)	(4.202)	(2.726)	(2.260)	(2.432)
$ per Student	-2.694	0.642	-3.430	-8.920	-1.629
	(5.922)	(10.31)	(8.747)	(7.438)	(8.277)
Constant	-182.4	-309.7	-200.9	-166.1	-51.48
	(116.4)	(246.5)	(170.4)	(145.2)	(179.0)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 2: Mathematics Simultaneous QR: Grade 4 (n=628)

VARIABLES	Grade 4	q05	q15	q50	q95
FRL%	-0.194***	-0.285***	-0.284***	-0.198***	-0.118*
	(0.0408)	(0.0728)	(0.0686)	(0.0468)	(0.0688)
African American	-0.0598	0.0704	-0.422	-0.0755	0.172
	(0.247)	(0.493)	(0.455)	(0.294)	(0.293)
Asian	0.321	0.559	0.457	0.453	0.223
	(0.217)	(0.510)	(0.482)	(0.281)	(0.219)
Hispanic	0.197	0.333	0.188	0.286	0.220
	(0.173)	(0.419)	(0.374)	(0.211)	(0.160)
American Indian	-0.302	-0.483	-0.266	-0.429*	-0.244
	(0.188)	(0.447)	(0.408)	(0.227)	(0.189)
Rural	-4.856**	-8.350	-3.779	-4.368*	-0.399
	(1.999)	(5.325)	(4.381)	(2.608)	(2.638)
Town	-4.629**	-9.008***	-2.144	-4.267*	-4.312*
	(1.891)	(3.420)	(4.582)	(2.224)	(2.435)
City	0.357	0.373	2.966	0.139	-0.0692
	(1.514)	(3.333)	(3.106)	(1.681)	(1.907)
Master	0.0306	0.216***	0.220**	-0.0307	-0.0218
	(0.0464)	(0.0758)	(0.0877)	(0.0500)	(0.0691)
Experience	0.470*	0.580	0.649	0.376	0.0588
	(0.244)	(0.521)	(0.545)	(0.274)	(0.343)
Attendance	3.371***	0.395	1.605	4.157***	3.257**
	(0.974)	(1.360)	(1.982)	(1.089)	(1.324)
Ratio	0.0692	0.870	0.0748	-0.180	-0.222
	(0.282)	(0.566)	(0.659)	(0.251)	(0.459)
Enrollment	0.685	4.461	5.336	2.497	-4.109
	(1.726)	(3.468)	(3.387)	(1.827)	(2.775)
$ per Student	8.494	11.16	13.52	9.947	3.911
	(6.259)	(9.751)	(8.830)	(7.492)	(6.797)
Constant	-326.4***	-134.3	-259.1	-411.7***	-218.2
	(116.2)	(166.2)	(234.9)	(127.3)	(155.8)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 3: Mathematics Simultaneous QR: Grade 5 (n=620)

VARIABLES	Grade 5	q05	q15	q50	q95
FRL%	-0.277***	-0.251***	-0.299***	-0.318***	-0.251***
	(0.0419)	(0.0833)	(0.0641)	(0.0443)	(0.0803)
African American	-0.155	0.223	-0.196	-0.238	-0.146
	(0.148)	(0.412)	(0.233)	(0.244)	(0.292)
Asian	0.304**	0.801*	0.262	0.223	0.205
	(0.146)	(0.474)	(0.213)	(0.209)	(0.274)
Hispanic	0.0551	0.342	-0.189	0.000562	0.277
	(0.104)	(0.377)	(0.157)	(0.144)	(0.222)
American Indian	-0.207*	-0.578	-0.0251	-0.145	-0.252
	(0.106)	(0.409)	(0.162)	(0.154)	(0.209)
Rural	-3.895**	-4.030	-0.531	-4.069*	-3.482
	(1.976)	(3.919)	(3.292)	(2.189)	(2.760)
Town	-4.570**	-5.853	-4.997	-4.413**	-1.396
	(1.807)	(3 7)	(3.091)	(1.973)	(4.210)
City	1.561	2.504	0.619	0.516	2.146
	(1.510)	(3.722)	(2.497)	(1.792)	(2.745)
Master	0.0359	0.0436	0.0849*	0.0169	-0.00529
	(0.0450)	(0.0749)	(0.0490)	(0.0444)	(0.0796)
Experience	0.580**	1.166***	0.796**	0.347	-0.249
	(0.251)	(0.407)	(0.328)	(0.235)	(0.362)
Attendance	3.570***	3.264**	2.871***	3.311***	4.295***
	(0.861)	(1.369)	(1.040)	(0.990)	(1.414)
Ratio	-0.437	-0.435	0.184	-0.563**	-0.591
	(0.288)	(0.611)	(0.484)	(0.231)	(0.361)
Enrollment	2.198	14.61***	10.26**	3.590**	-4.842
	(1.969)	(3.617)	(4.014)	(1.807)	(3.309)
$ per Student	1.359	-0.180	-0.480	3.796	11.14
	(6.120)	(10.46)	(7.721)	(6.722)	(11.90)
Constant	-284.5***	-342.5*	-281.5**	-281.7**	-368.0*
	(105.3)	(182.0)	(129.1)	(131.6)	(196.2)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 4: Mathematics Simultaneous QR: Grade 6 (n=389)

VARIABLES	Grade 6	q05	q15	q50	q95
FRL%	-0.277***	-0.209**	-0.359***	-0.435***	-0.0612
	(0.0582)	(0.0841)	(0.0798)	(0.0754)	(0.0805)
African American	-0.119	-0.471	-0.424	-0.187	-0.108
	(0.189)	(0.409)	(0.381)	(0.270)	(0.321)
Asian	0.203	0.0898	-0.00917	0.0299	0.0293
	(0.204)	(0.423)	(0.357)	(0.254)	(0.368)
Hispanic	-0.0212	-0.159	-0.0247	-0.0631	-0.238
	(0.139)	(0.370)	(0.232)	(0.201)	(0.269)
American Indian	-0.121	0.141	-0.0440	0.0298	-0.0864
	(0.144)	(0.320)	(0.243)	(0.182)	(0.261)
Rural	-6.945***	-1.135	-4.078	-4.154	-14.87***
	(2.367)	(4.897)	(3.264)	(3.818)	(4.306)
Town	-3.427	-2.092	-2.876	-1.138	-9.775**
	(2.466)	(4.857)	(2.805)	(3.370)	(4.546)
City	-2.479	1.815	-1.682	-1.884	-5.290
	(2.121)	(4.835)	(1.933)	(2.590)	(4.131)
Master	0.00286	0.0772	0.0860	-0.0282	-0.0859
	(0.0578)	(0.144)	(0.0834)	(0.0620)	(0.0876)
Experience	0.476	0.366	0.176	0.586*	0.177
	(0.342)	(0.501)	(0.467)	(0.347)	(0.369)
Attendance	2.979***	2.499	2.218**	2.626**	4.571***
	(0.892)	(1.534)	(1.095)	(1.167)	(1.239)
Ratio	-0.0779	0.464	-0.131	-0.0726	-0.428
	(0.372)	(0.716)	(0.486)	(0.467)	(0.499)
Enrollment	-0.611	4.759	7.395**	0.330	-6.091**
	(2.066)	(3.731)	(2.872)	(2.917)	(2.967)
$ per Student	3.465	-1.284	12.25*	5.038	-8.828
	(5.537)	(15.71)	(7.199)	(6.163)	(11.20)
Constant	-232.8**	-221.4	-299.3**	-215.6	-204.0
	(103.7)	(223.7)	(132.2)	(150.3)	(140.0)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 5: Mathematics Simultaneous QR: Grade 7 (n=296)

VARIABLES	Grade 7	q05	q15	q50	q95
FRL%	-0.182***	-0.148*	-0.283***	-0.252***	-0.0232
	(0.0544)	(0.0874)	(0.0823)	(0.0543)	(0.0710)
African American	-0.250	-0.720**	-0.548*	-0.470*	0.0800
	(0.175)	(0.303)	(0.298)	(0.270)	(0.316)
Asian	0.227	0.147	0.355	0.0132	0.522
	(0.205)	(0.359)	(0.307)	(0.324)	(0.412)
Hispanic	0.0626	-0.413*	-0.172	-0.0333	0.332
	(0.133)	(0.219)	(0.178)	(0.189)	(0.213)
American Indian	-0.114	0.168	0.139	0.0343	-0.515**
	(0.142)	(0.194)	(0.215)	(0.185)	(0.230)
Rural	-6.986***	-10.61*	-9.043**	-5.411**	-13.72**
	(2.563)	(5.786)	(3.979)	(2.689)	(6.374)
Town	-5.995**	-2.980	-0.995	-4.751	-15.14***
	(2.527)	(4.158)	(3.172)	(2.970)	(5.784)
City	2.201	0.655	0.914	4.498	-6.663
	(2.256)	(3.991)	(3.739)	(2.852)	(5.269)
Master	-0.0336	0.183*	0.187*	-0.0270	-0.0765
	(0.0668)	(0.108)	(0.111)	(0.0648)	(0.0791)
Experience	0.427	0.664	0.710	0.490	0.383
	(0.316)	(0.618)	(0.498)	(0.349)	(0.586)
Attendance	3.017***	2.570**	3.362***	3.317***	2.612*
	(0.669)	(1.144)	(1.012)	(0.740)	(1.392)
Ratio	-0.0475	-0.167	-0.00953	-0.269	0.317
	(0.347)	(0.773)	(0.493)	(0.357)	(0.640)
Enrollment	-1.112	4.357	-0.557	-2.318	-0.643
	(1.690)	(3.143)	(3.693)	(1.850)	(2.486)
$ per Student	-5.747	-8.184	-5.133	-9.113*	11.22
	(7.400)	(13.37)	(7.601)	(5.379)	(14.57)
Constant	-149.9*	-149.7	-219.6	-135.9	-253.5*
	(85.62)	(197.0)	(138.2)	(88.71)	(142.2)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 6: Mathematics Simultaneous QR: Grade 8 (n=298)

VARIABLES	Grade 8	q05	q15	q50	q95
FRL%	-0.110*	-0.110	-0.0375	-0.222***	0.0575
	(0.0582)	(0.0949)	(0.116)	(0.0719)	(0.118)
African American	-0.171	-0.120	-0.317	-0.226	0.174
	(0.158)	(0.412)	(0.365)	(0.244)	(0.540)
Asian	0.208	0.373	-0.0181	0.372	0.812*
	(0.221)	(0.493)	(0.429)	(0.313)	(0.441)
Hispanic	0.144	0.232	-0.153	0.121	0.459
	(0.139)	(0.376)	(0.296)	(0.181)	(0.369)
American Indian	-0.222	-0.374	-0.00944	-0.135	-0.694*
	(0.147)	(0.388)	(0.286)	(0.187)	(0.392)
Rural	-4.023	-11.59**	-5.225	2.229	-6.842
	(2.639)	(5.220)	(4.045)	(4.134)	(7.503)
Town	-5.937**	-13.31***	-7.455*	1.687	-4.647
	(2.584)	(4.839)	(3.919)	(4.073)	(6.249)
City	3.118	4.223	3.126	7.868***	2.155
	(2.228)	(5.105)	(3.724)	(2.938)	(5.903)
Master	-0.116	-0.154	-0.00974	-0.0280	-0.0928
	(0.0713)	(0.147)	(0.101)	(0.0893)	(0.124)
Experience	0.433	0.471	0.725	0.312	0.133
	(0.350)	(0.658)	(0.589)	(0.469)	(0.676)
Attendance	3.071***	0.0230	2.722**	3.689***	4.139***
	(0.721)	(1.686)	(1.373)	(1.129)	(1.589)
Ratio	-0.132	-0.259	-0.407	0.252	-0.542
	(0.380)	(0.963)	(0.683)	(0.433)	(0.564)
Enrollment	2.394	5.898	6.152**	1.014	-2.178
	(1.942)	(3.888)	(3.069)	(2.744)	(3.754)
$ per Student	-12.79	-27.93*	-26.76**	-12.79	1.057
	(8.466)	(15.41)	(13.34)	(11.81)	(15.80)
Constant	-104.0	291.9	12.94	-166.3	-277.3
	(95.53)	(260.6)	(195.9)	(162.1)	(230.8)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 7: Mathematics Simultaneous QR: Grade 11 (n=216)

VARIABLES	Grade 11	q05	q15	q50	q95
FRL%	-0.136**	-0.247*	-0.183*	-0.179**	-0.00165
	(0.0572)	(0.143)	(0.0978)	(0.0867)	(0.101)
African American	-0.183	0.319	0.115	0.238	-0.227
	(0.228)	(0.525)	(0.448)	(0.406)	(0.432)
Asian	0.691***	0.0646	0.157	0.577	0.850*
	(0.235)	(0.520)	(0.378)	(0.355)	(0.449)
Hispanic	0.327***	0.175	0.212	0.418**	0.475*
	(0.119)	(0.279)	(0.187)	(0.194)	(0.280)
American Indian	-0.377***	-0.257	-0.273	-0.493**	-0.575**
	(0.121)	(0.311)	(0.208)	(0.197)	(0.257)
Rural	-5.817**	-8.454	-4.076	-6.196*	-2.216
	(2.523)	(7.267)	(5.369)	(3.201)	(4.352)
Town	-5.297**	-5.942	-6.705**	-6.987***	-3.430
	(2.291)	(5.148)	(3.116)	(2.626)	(4.989)
City	-2.681	-1.678	-2.390	-1.593	-0.427
	(1.905)	(3.154)	(2.683)	(2.581)	(3.672)
Master	0.0191	0.0327	-0.0589	0.0248	0.0776
	(0.0696)	(0.142)	(0.110)	(0.0913)	(0.103)
Experience	0.0391	0.354	0.0615	0.283	0.566
	(0.305)	(0.605)	(0.501)	(0.402)	(0.562)
Attendance	0.646	1.242	1.066	0.784	0.851
	(0.491)	(0.964)	(0.708)	(0.674)	(1.087)
Ratio	0.120	0.226	-0.0942	0.316	-0.299
	(0.333)	(0.591)	(0.467)	(0.447)	(0.664)
Enrollment	2.697*	7.216**	7.067***	0.930	1.704
	(1.427)	(3.550)	(2.409)	(2.290)	(3.057)
$ per Student	10.23	9.906	3.716	9.281	9.448
	(6.419)	(13.88)	(9.216)	(6.807)	(13.38)
Constant	-89.45	-185.7	-92.99	-86.18	-88.47
	(73.45)	(170.0)	(124.5)	(92.15)	(165.7)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 8: Reading Simultaneous QR: Grade 3 (n=632)

VARIABLES	Grade 3	q05	q15	q50	q95
FRL%	-0.0398	-0.132*	-0.120***	-0.0339	-0.000441
	(0.0244)	(0.0674)	(0.0406)	(0.0267)	(0.0102)
African American	-0.0513	-0.356	-0.267	0.0222	-0.0250
	(0.114)	(0.289)	(0.216)	(0.180)	(0.0836)
Asian	0.00774	-0.0268	0.144	0.104	0.00648
	(0.0942)	(0.247)	(0.158)	(0.141)	(0.0585)
Hispanic	-0.111*	-0.311	-0.0438	-0.104	-0.0266
	(0.0635)	(0.226)	(0.134)	(0.118)	(0.0530)
American Indian	-0.159**	-0.0296	-0.224*	-0.169	-0.0200
	(0.0642)	(0.232)	(0.127)	(0.116)	(0.0509)
Rural	-3.682***	-11.79***	-5.867***	-2.881*	0.198
	(1.069)	(3.249)	(2.008)	(1.482)	(0.616)
Town	-2.490**	-3.666	-0.684	-3.334***	0.129
	(1.011)	(2.901)	(1.876)	(1.211)	(0.732)
City	0.537	-2.051	0.370	0.738	0.273
	(0.857)	(2.213)	(1.581)	(0.928)	(0.577)
Master	0.0354	0.0219	0.0454	0.00933	0.00378
	(0.0248)	(0.0529)	(0.0438)	(0.0206)	(0.0102)
Experience	0.289**	0.232	0.395**	0.153	0.0376
	(0.140)	(0.315)	(0.195)	(0.164)	(0.0628)
Attendance	1.995***	2.700***	2.231***	1.707***	0.277
	(0.472)	(0.882)	(0.845)	(0.537)	(0.269)
Ratio	-0.179	-0.541	-0.138	-0.121	-0.0527
	(0.156)	(0.442)	(0.246)	(0.158)	(0.0732)
Enrollment	1.053	3.801	2.994	-0.391	-0.146
	(1.015)	(2.789)	(2.016)	(1.023)	(0.380)
$ per Student	-0.574	-3.020	-2.624	-0.601	0.0333
	(3.481)	(7.053)	(5.380)	(3.736)	(1.721)
Constant	-96.31	-153.2	-117.0	-57.53	70.22**
	(60.79)	(118.6)	(103.2)	(62.10)	(33.75)

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

TABLE 9: Reading Simultaneous QR: Grade 4 (n=627)

VARIABLES	Grade 4	q05	q15	q50	q95
FRL%	-0.0713***	-0.163***	-0.102***	-0.0526***	0.00149
	(0.0162)	(0.0394)	(0.0282)	(0.0185)	(0.00939)
African American	-0.111	-0.285	-0.331*	-0.264**	0.00990
	(0.0980)	(0.280)	(0.193)	(0.116)	(0.0670)
Asian	-0.0488	-0.326	0.0584	0.00972	0.00333
	(0.0699)	(0.244)	(0.191)	(0.0826)	(0.0437)
Hispanic	-0.0612	-0.125	0.000996	-0.0699	-0.0320
	(0.0387)	(0.135)	(0.103)	(0.0453)	(0.0450)
American Indian	-0.123***	-0.000884	-0.218**	-0.124**	-0.0150
	(0.0362)	(0.144)	(0.110)	(0.0509)	(0.0519)
Rural	-1.507*	0.193	-2.692	-1.780*	-0.0422
	(0.911)	(2.708)	(2.080)	(1.064)	(0.594)
Town	-1.210	-2.812	-2.097	-1.573	0.0632
	(0.887)	(2.732)	(1.876)	(0.995)	(0.528)
City	0.405	3.588*	1.964	0.307	0.180
	(0.730)	(2.045)	(1.260)	(0.874)	(0.554)
Master	0.0531***	0.109*	0.0308	0.0393**	0.00826
	(0.0195)	(0.0583)	(0.0381)	(0.0199)	(0.0122)
Experience	0.350***	0.760***	0.541***	0.291***	0.0145
	(0.0991)	(0.257)	(0.190)	(0.106)	(0.0667)
Attendance	1.484***	1.040	1.367*	1.621***	0.285
	(0.376)	(0.931)	(0.760)	(0.401)	(0.298)
Ratio	-0.0139	0.149	0.0130	-0.00660	-0.0241
	(0.122)	(0.409)	(0.259)	(0.157)	(0.0702)
Enrollment	-0.414	1.647	0.944	-0.812	-0.279
	(0.753)	(2.813)	(1.598)	(0.738)	(0.411)
$ per Student	2.900	-1.333	3.210	1.409	-0.125
	(2.105)	(5.418)	(4.092)	(2.893)	(1.216)
Constant	-75.48*	-27.75	-80.01	-70.69	71.20**
	(43.16)	(122.9)	(86.63)	(52.10)	(31.01)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 10: Reading Simultaneous QR: Grade 5 (n=621)

VARIABLES	Grade 5	q05	q15	q50	q95
FRL%	-0.143***	-0.205***	-0.158***	-0.154***	-0.0530*
	(0.0249)	(0.0516)	(0.0488)	(0.0247)	(0.0303)
African American	-0.134	-0.330*	-0.365	-0.236	-0.0935
	(0.122)	(0.191)	(0.244)	(0.217)	(0.133)
Asian	0.104	0.242	0.187	-0.0279	0.0570
	(0.0956)	(0.233)	(0.174)	(0.174)	(0.131)
Hispanic	-0.0441	-0.0484	-0.0961	-0.187	-0.0411
	(0.0678)	(0.149)	(0.139)	(0.141)	(0.118)
American Indian	-0.217***	-0.208	-0.213	-0.0984	-0.111
	(0.0690)	(0.155)	(0.151)	(0.149)	(0.110)
Rural	-1.757	-1.083	-1.399	-0.803	-0.648
	(1.200)	(2.933)	(1.979)	(1.391)	(1.688)
Town	-2.419**	-4.337	-3.514*	-0.956	-1.717
	(1.132)	(2.828)	(2.004)	(1.177)	(1.753)
City	1.061	1.714	0.401	1.431	-0.457
	(0.924)	(2.610)	(1.300)	(1.009)	(1.408)
Master	-0.0130	-0.0405	-0.0412	-0.00607	-0.00892
	(0.0244)	(0.0643)	(0.0406)	(0.0345)	(0.0331)
Experience	0.273**	0.686**	0.199	0.181	0.101
	(0.130)	(0.337)	(0.291)	(0.156)	(0.171)
Attendance	2.088***	2.604**	2.808***	2.290***	0.845
	(0.515)	(1.081)	(0.929)	(0.630)	(0.620)
Ratio	-0.204	-0.686*	-0.0962	-0.185	-0.0590
	(0.164)	(0.406)	(0.238)	(0.236)	(0.230)
Enrollment	-0.102	7.600***	4.012*	-0.650	-1.864
	(1.039)	(2.612)	(2.321)	(1.228)	(1.245)
$ per Student	1.633	-11.10	4.515	2.398	0.379
	(3.103)	(8.000)	(5.032)	(4.171)	(3.319)
Constant	-114.9*	-98.24	-239.3**	-136.8*	26.90
	(61.51)	(142.7)	(106.4)	(73.89)	(67.00)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 11: Reading Simultaneous QR: Grade 6 (n=390)

VARIABLES	Grade 6	q05	q15	q50	q95
FRL%	-0.129***	-0.205***	-0.189***	-0.186***	-0.0195
	(0.0339)	(0.0666)	(0.0604)	(0.0293)	(0.0487)
African American	-0.274**	-0.142	-0.636**	-0.272*	-0.623**
	(0.135)	(0.435)	(0.255)	(0.160)	(0.250)
Asian	0.0246	0.526	-0.138	0.0127	-0.543**
	(0.138)	(0.446)	(0.251)	(0.118)	(0.255)
Hispanic	-0.0497	0.229	-0.211	-0.0185	-0.480***
	(0.0918)	(0.372)	(0.139)	(0.0950)	(0.177)
American Indian	-0.165*	-0.456	-0.0140	-0.150	0.282
	(0.0977)	(0.402)	(0.153)	(0.0926)	(0.172)
Rural	-6.365***	-8.205**	-8.928***	-4.689***	-7.449***
	(1.348)	(3.863)	(2.384)	(1.603)	(2.699)
Town	-3.783***	-0.917	-4.529*	-2.780*	-6.869**
	(1.399)	(3.375)	(2.638)	(1.565)	(2.985)
City	-0.192	3.479	2.214	-0.978	-1.263
	(1.111)	(2.654)	(1.951)	(1.414)	(2.050)
Master	0.00681	0.0583	-0.00105	0.0343	-0.00335
	(0.0363)	(0.110)	(0.0553)	(0.0330)	(0.0524)
Experience	0.139	0.314	0.193	-0.0182	0.246
	(0.183)	(0.439)	(0.304)	(0.159)	(0.160)
Attendance	1.590***	1.049	0.356	1.487***	2.359**
	(0.454)	(1.229)	(0.889)	(0.551)	(0.988)
Ratio	0.0991	0.269	0.000718	0.168	-0.244
	(0.201)	(0.594)	(0.349)	(0.171)	(0.344)
Enrollment	-1.564	0.808	-1.379	-1.580*	-2.674*
	(1.008)	(3.562)	(2.175)	(0.876)	(1.381)
$ per Student	1.449	-8.928	-9.595*	5.235	1.063
	(3.983)	(7.992)	(5.347)	(3.801)	(4.453)
Constant	-61.48	53.63	152.2	-85.22	-114.1
	(60.47)	(141.7)	(97.65)	(68.44)	(105.1)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 12: Reading Simultaneous QR: Grade 7 (n=298)

VARIABLES	Grade 7	q05	q15	q50	q95
FRL%	-0.0702	-0.178**	-0.175***	-0.106*	-0.0100
	(0.0444)	(0.0827)	(0.0497)	(0.0584)	(0.0413)
African American	-0.0552	0.00569	-0.155	-0.179	-0.0881
	(0.143)	(0.325)	(0.248)	(0.243)	(0.213)
Asian	0.0257	0.366	0.0785	0.00425	-0.194
	(0.163)	(0.340)	(0.258)	(0.251)	(0.263)
Hispanic	0.0426	0.247	0.0976	-0.0789	-0.163
	(0.106)	(0.270)	(0.204)	(0.177)	(0.163)
American Indian	-0.206*	-0.415	-0.300	-0.0829	0.0130
	(0.108)	(0.279)	(0.205)	(0.180)	(0.187)
Rural	-3.644**	-8.650***	-5.556*	-2.970	-2.218
	(1.700)	(2.727)	(2.961)	(2.706)	(3.423)
Town	-2.401	0.113	0.813	-2.219	-4.936*
	(1.497)	(2.365)	(1.860)	(2.401)	(2.745)
City	1.662	2.215	3.356*	1.104	-1.839
	(1.372)	(2.402)	(1.836)	(2.241)	(2.118)
Master	0.0530	0.132	0.0925	0.0119	0.00749
	(0.0485)	(0.108)	(0.0637)	(0.0605)	(0.0533)
Experience	0.544**	0.221	0.224	0.376	0.307
	(0.264)	(0.734)	(0.307)	(0.310)	(0.248)
Attendance	2.104***	1.266	1.527**	2.087***	1.852***
	(0.465)	(0.786)	(0.625)	(0.564)	(0.640)
Ratio	0.194	0.542	0.332	0.0567	-0.0110
	(0.255)	(0.377)	(0.318)	(0.322)	(0.254)
Enrollment	-1.034	0.855	2.291	-0.921	-2.011
	(1.256)	(2.613)	(2.030)	(1.762)	(2.190)
$ per Student	-1.636	-3.137	3.002	-5.532	0.530
	(4.758)	(8.670)	(5.833)	(6.490)	(5.757)
Constant	-99.06*	-29.14	-109.5	-53.20	-72.58
	(59.55)	(115.7)	(96.24)	(85.07)	(92.55)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 13: Reading Simultaneous QR: Grade 8 (n=299)

VARIABLES	Grade 8	q05	q15	q50	q95
FRL%	-0.114**	-0.175**	-0.181**	-0.184***	-0.0481
	(0.0483)	(0.0878)	(0.0746)	(0.0479)	(0.0793)
African American	-0.0429	-0.489	-0.163	-0.0993	-0.119
	(0.122)	(0.341)	(0.272)	(0.135)	(0.357)
Asian	0.0492	-0.490	-0.0885	0.148	0.107
	(0.172)	(0.341)	(0.303)	(0.180)	(0.480)
Hispanic	0.0951	-0.223	-0.0389	0.109	0.160
	(0.103)	(0.264)	(0.208)	(0.0947)	(0.362)
American Indian	-0.309***	0.113	-0.166	-0.326***	-0.317
	(0.103)	(0.283)	(0.205)	(0.0960)	(0.354)
Rural	-4.770**	-1.859	-4.107	-4.234*	-5.348
	(1.953)	(3.211)	(2.871)	(2.465)	(6.529)
Town	-2.853	1.363	1.542	-0.883	-3.100
	(1.871)	(4.285)	(2.279)	(2.303)	(6.488)
City	2.405	6.337	4.693	2.475	1.928
	(1.562)	(4.034)	(2.868)	(1.539)	(5.101)
Master	-0.0855	-0.0506	-0.0173	-0.0470	-0.00389
	(0.0577)	(0.140)	(0.0891)	(0.0488)	(0.0904)
Experience	0.341	0.478	0.504	0.305	-0.188
	(0.239)	(0.532)	(0.366)	(0.276)	(0.422)
Attendance	2.682***	3.049**	3.494***	2.612***	2.830***
	(0.558)	(1.219)	(0.831)	(0.592)	(0.955)
Ratio	0.0582	-0.00436	0.111	0.291	0.382
	(0.247)	(0.618)	(0.369)	(0.257)	(0.436)
Enrollment	0.859	7.800**	2.045	0.930	-6.286**
	(1.530)	(3.441)	(2.105)	(1.430)	(3.145)
$ per Student	-0.646	-7.866	-0.991	4.229	4.025
	(5.449)	(14.25)	(7.157)	(4.417)	(7.570)
Constant	-162.4**	-192.6	-258.3**	-204.4***	-172.3
	(71.29)	(203.6)	(114.3)	(64.08)	(129.8)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 14: Reading Simultaneous QR: Grade 11 (n=217)

VARIABLES	Grade 11	q05	q15	q50	q95
FRL%	-0.0850**	-0.0670	-0.0289	-0.0755*	-0.0729***
	(0.0335)	(0.0585)	(0.0636)	(0.0443)	(0.0249)
African American	-0.573**	-0.798*	-0.976**	-0.612*	0.0200
	(0.235)	(0.444)	(0.453)	(0.327)	(0.337)
Asian	0.352**	0.503	0.472	0.446**	0.0427
	(0.153)	(0.326)	(0.288)	(0.193)	(0.184)
Hispanic	0.0209	-0.0230	-0.0496	0.116	0.0764
	(0.0752)	(0.173)	(0.126)	(0.0969)	(0.0793)
American Indian	-0.219***	-0.325*	-0.289**	-0.274***	-0.192**
	(0.0605)	(0.187)	(0.126)	(0.0780)	(0.0871)
Rural	-2.811*	-0.917	-2.690	-2.206	-0.794
	(1.581)	(5.431)	(4.174)	(1.764)	(1.719)
Town	-1.182	2.953	-0.700	-1.499	-1.752
	(1.444)	(3.503)	(3.095)	(1.922)	(1.422)
City	-1.162	3.312	0.393	-0.746	0.146
	(1.176)	(2.542)	(2.204)	(1.362)	(1.638)
Master	-0.0130	-0.0283	-0.0504	-0.0178	0.0204
	(0.0374)	(0.0821)	(0.0702)	(0.0515)	(0.0307)
Experience	0.001	0.043	-0.061	-0.041	0.235
	(0.165)	(0.407)	(0.367)	(0.230)	(0.198)
Attendance	0.563**	0.517	0.948**	0.459	0.891***
	(0.280)	(0.530)	(0.436)	(0.397)	(0.253)
Ratio	-0.0418	0.653*	0.395	-0.128	-0.411**
	(0.177)	(0.378)	(0.332)	(0.167)	(0.183)
Enrollment	3.157***	5.946***	5.990***	2.409**	0.202
	(0.800)	(2.158)	(1.858)	(1.150)	(1.044)
$ per Student	12.48***	21.56**	25.76***	9.748**	-2.536
	(3.618)	(8.458)	(7.927)	(4.525)	(4.029)
Constant	-88.55**	-207.7**	-276.9***	-46.77	44.55
	(42.07)	(94.44)	(89.19)	(60.41)	(39.03)

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$