A NATIONAL STUDY COMPARING CHARTER AND TRADITIONAL PUBLIC SCHOOLS USING PROPENSITY SCORE ANALYSIS

by

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ABSTRACT

The concept of school choice within the United States is not new. Private schools have been educating students since the founding of the United States. However, in 1988, Ray Budde proposed an alternative approach to school choice that has come to be known as charter schools (Kolderie, 2005). Unlike their private school counterparts, charter schools receive public funding, but they are relieved of many of the bureaucratic and regulatory constraints public schools adhere to, but are still held accountable for student performance. Despite claims by charter school advocates that charter schools are performing as well if not better than the public school counterparts (see e.g. Allen, Consolettie, & Kerwin, 2009), studies provide mixed results with regard to charter school performance (see e.g. Braun, Jenkins, & Grigg, 2006; Center for Research on Education Outcomes, 2009; Hubbard & Kulkarni, 2009). Ultimately, there is agreement that more research is necessary to address the question of whether charter schools provide substantially better academic experiences for students.

This study includes development of new methods designed for observational data analysis to investigate the question of whether students who attend charter schools outperform their public school counterparts on two key academic domains: reading and mathematics. The new methods represent extensions of modern methods for propensity score analysis (see below) and aim to reduce if not eliminate selection bias in the context of clustered data. Charter schools are, by definition, schools of choice, and this means that observational data methods are preferred for comparing such schools with others. In observational data contexts, simple comparisons of two groups such as traditional public and charter schools cannot help but ignore the inherent and systematic differences between the two groups. However, given well designed observational studies, and appropriate analysis methods, the effects of the selection bias can be reduced, if not eliminated. The end result is that the usual simple comparisons of two independent groups are replaced by comparisons that make adjustments for covariate differences.

This is done utilizing a class of statistical procedures introduced by Rosenbaum and Rubin (1983) called propensity score analysis. Propensity score analysis has seen considerable increased use in the social sciences within the last few years (Arpino & Mealli, 2008). However, its use in situations where multilevel, or clustered data are of interest, have been limited (Thoemmes & Kim, 2011). Using data from the 2007 National Assessment of Educational Progress (NAEP) for

mathematics and reading at grades four and eight, estimates of the differences between charter and public schools will be calculated at two levels, namely state and national. Given the variability of charter schools laws across states, it is important to consider the impact of clustering. Analyses will be conducted using the newly developed `multilevelPSA` package (Bryer, 2011) in R (R Development Core Team, 2008). Specifically, propensity scores will be estimated within each state and these will be used for matching or stratification of students within each state. Comparisons of specific students, or groups of students, will in all cases be done within states. Effects will then aggregated to provide state and national effect estimates.

As with all propensity score analyses, it is preferable to utilize multiple methods for estimating propensity scores (see e.g. Stuart, 2010). Doing so can help to provide confidence that results reflect what the data have to say, and is not merely an artifact of model specification or method choice. This study will utilize three overall approaches to propensity score analysis, namely stratification, matching, and multilevel stratification. Lastly, the use of graphics will be employed to evaluate balance and outcome differences using methods (functions) found in Helmreich and Pruzek (2009).

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CHAPTER 1: INTRODUCTION

Since the opening of the first charter school in Minnesota in 1991, the United States[1] has increasingly embraced charter schools as an important option for educational reform. In the last 10 years alone, the number of charter schools has grown from 507 in the 1998-1999 school year to 4,561 in the 2007-2008 school year (see figure 1; Center for Education Reform, 2010). Currently, 40 states and the District of Columbia have charter school laws (see appendix A for enrollment by state & appendix B for a thematic map of the U.S. depicting the number of operating charter schools as of 2008). And, given Arne Duncan's appointment as Secretary of Education by President Barack Obama, who has been a charter school supporter, charter school growth and support is unlikely to slow in the near future.

In principal, charter schools have opted out of bureaucratic rules and union contracts in order to gain academic autonomy in exchange for accountability and better academic environments for students (Wells, 2002). The idea is that, under this framework, teachers, administrators, students, and the community that comprise the charter school would be free to innovate. It is also the assumption that charter schools would serve as experimental schools where the innovations would inform reform of public education at large. However, some supporters argue for the eventual replacement of traditional public schools with charter schools, as further exemplified by the attempted school voucher legislation during the second Bush Administration.

Clearly charter schools have become a popular vehicle for educational reform among parents as well. The Center for Education Reform (2008) reports that 59% of charter schools have waiting lists averaging 198 students. Charter schools provide an apparent choice to parents and are copacetic to the United State's individualistic (see e.g., Hofstede & Hofstede, 2004; Maccall, 1847; Swart, 1962) culture. Moreover, like so many other fields, school reform has further emphasized marketization and privatization (Wells, 2002). The influence of capitalism on education is not new. A major contributor to the expanded role of education during the industrial revolution is capitalism itself. That is, education expanded its initial purpose of providing a minimally informed electorate to providing an educated work force, not to mention keeping children off the streets as child labor laws came into existence. However, the shift of capitalistic principles from being the inspiration of educational reform to being the educational reform has profound implications.

[1] Though this study focuses on charter schools in the U.S., Canada (Foundations for the Future Charter Academy, 2007), Chile (Larrañaga, 2004), England (?, ?), Germany (Herbst, 2006), and New Zealand (Lander, 2001) also have charter schools.

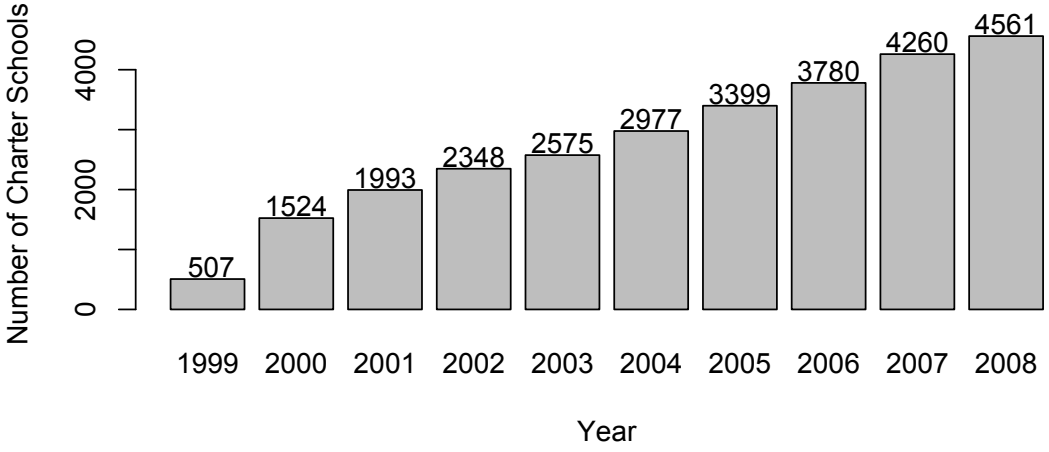

Figure 1: Charter School Growth 1999-2008

Proponents of charter schools argue that public schools have been bogged down by bureaucracy and union contracts. Freeing schools of these requirements then allows teachers and schools to innovate, which in theory leads to increased student performance. The principled argument is the "market metaphor" (Wells, 2002). That is, if schools were forced to compete for "customers" (i.e. students), then the differentiating factor between schools would be the quality of education.

Opponents on the other hand have questioned the accountability, equity, effectiveness, and sustainability of charter schools. Several studies have shown that charter schools are not only failing to increase student performance, in many instances they are performing well under their traditional public school counterparts (see e.g., Center for Research on Education Outcomes, 2009; ?, ?; Nelson, Rosenberg, & Meter, 2004). Others still argue whether charter schools may be a solution in search of a problem. Carnoy, Jacobsen, Mishel, and Rothstein (2005) in summarizing the controversy that ensued after the Nelson et al. (2004) study argue that:

> If, however, charter schools are not improving the achievement of disadvantages children, it may be that the cause of low student performance is not bureaucratic rules but something else. When a treatment is based on a diagnosis, and the treatment doesn't work, it is prudent to examine not only whether the treatment should be improved, but also whether the diagnosis might be flawed. (Carnoy et al., 2005)

Issues with Charter School Research

The issues surrounding charter schools are immense. However, given the implications for the current and future generations of students, the issue must be explored using the best data and methods available. As ? (?) point out, there are three major obstacles to addressing the question of "whether students in charter schools are learning more or less than they would have learned in conventional schools" (p. 1), namely:

1. The issues of counterfactuals. That is, there are several barriers to determine the causal relationship between school choice and learning.

2. The variation in types of charter schools.

3. The nature of student achievement. Research has shown there are many other factors that contribute to student success including, but not limited to, social economic status, parents education, motivation, etc. The ability to decipher how school choice contributes to student learning in the context of all the other factors proves difficult.

Though these issues are significant, they can to a large extent be reasonably addressed. We will not claim to fully account for these issues, however given the need for evidence to inform policy makers regarding charter school effectiveness, we will attempt to address these issues using the best data and methods available while clearly stating the limitations.

Issue one will be dealt with in more detail in chapter three. However, in short, the propensity score analysis (PSA) proposed for this study is arguably, assuming proper implementation, one of the best approaches to estimating causal inferences short of well designed randomized experiments. Of course in the context of an observational study the fundamental problem of causal inference Holland (1986) remains, but limitations of this will be addressed.

The issue of charter school variation is often cited in critiques of national or large scale charter school studies. Given that the charter school debate is a national debate that has implications at the Federal level, large scales studies are not only necessary, they are critical. If charter schools are to be offered wholly as an alternative to traditional public schools, then charter schools as a whole must be evaluated against public schools as a whole. More specifically, we wish not to evaluate whether a particular charter school, or type of charter school, is better, but whether the entire charter school concept is a better approach for educational reform.

Lastly, the environmental, social, community, and cultural factors that contribute to a student's academic achievement are often significantly underestimated. Often educational reform, as exemplified most recently by the No Child Left Behind Act, places the responsibility solely on the school without consideration of the context in which the school operates. We are encouraged by President Obama's remarks to his first Joint Session of Congress (?, ?):

> These education policies will open the doors of opportunity for our children. But it is up to us to ensure they walk through them. In the end, there is no program or policy that can substitute for a mother or father who will attend those parent/teacher conferences, or help with homework after dinner, or turn off the TV, put away the video games, and read to their child. I speak to you not just as a President, but as a father when I say that *responsibility for our children's education must begin at home* [emphasis added].

Though we must be acutely aware and acknowledge the fact that schools are merely one factor of many that contribute to a students academic achievement, it does not preclude us from evaluating schools for their part. Similar to issue one, we argue that PSA provides an approach to best approximate the effects of school choice.

Guiding Research Question

Given that charter schools are being offered as a solution for the needed educational reform nationally, it is imperative that they be evaluated from a national perspective. This study proposes to compare the academic performance in two domains of charter schools and public schools using the National Assessment of Educational Progress and propensity score analysis. More specifically, this study proposes to address the question: Are there differences between charter and public schools? And if so, what is the nature and extent of those differences?

CHAPTER 2: REVIEW OF THE LITERATURE

History of Charter Schools

Though Ray Budde is often credited with the current charter school movement (?, ?), the term *school choice* can be traced back to Adam Smith's *Wealth of Nations*, Thomas Paine's *Rights of Man*, and John Stuart Mill's *On Liberty* (Herbst, 2006). Prior to the Revolutionary War, given the religious diversity of colonial America, issues of education were left to local communities. However, after the war Revolutionary leaders argued that local schools were no longer sufficient for educating students for the emerging state and federal governments. It was Thomas Jefferson who, in 1779, introduced the first bill in Virginia that would establish a public school system. It was this, along with numerous other American intellects during the 1780s and 1790s, that established public schools throughout the young nation thereby relegating school choice to a choice between the public school and, predominately religious, private schools.

In the wake of the landmark report *A Nation at Risk* (The National Commission on Excellence in Education, 1983), Budde (1988) authored a pivotal document that started the charter school movement in the United States. In this document, Budde argues that system-wide changes to the way schools are structured are required including: more rigorous curriculum and graduation standards; extended school days and year; more homework; teacher accountability for student results; termination of "incompetent" teachers; and higher pay for teachers. To achieve these goals, he proposed a fundamental change to the "internal organization of the school district... making substantial changes in the roles of teachers, principals, the superintedent, the school board, parents, and others in the community" (p. 16). More specifically, a framework for charter schools was proposed that includes five stages over a three year period (see Figure 2). The five stages include: (1) generating ideas; (2) planning the charter; (3) preparing for teaching; (4) teaching under the educational charter; and (5) program monitoring and evaluation. For the first iteration of the cycle, stages one, two, and three occur prior to the opening of the school with stage one ideally beginning a full school year before. There are several features of this framework that deviate from traditional public school models, but most notably is the repetition of what may appear to be preparational stages. That is, the charter school must re-plan their school structure periodically (every three to five years according to Budde's framework) in a manner consistent to the initial charter school creation, thereby forcing a re-evaluation of the school bureaucracy.

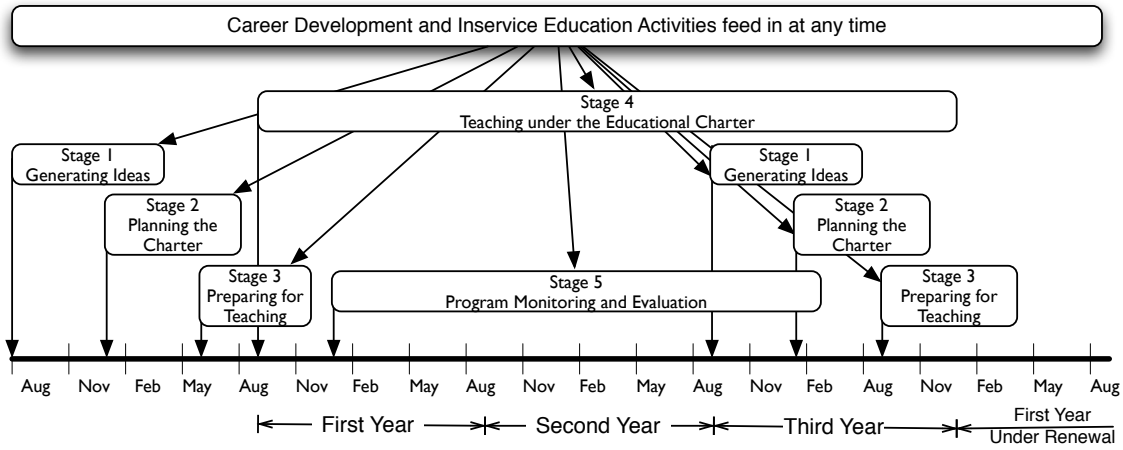

Figure 2: Stages of a Charter School Life Cycle (adapted from Budde, 1988)

Following the suggestions of Budde, Minnesota passed the first charter school law in 1991 with California being the second following in 1992. As of spring 2009, 40 states and the District of Columbia have charter school laws which comprise 1,407,421 students in 4,578 schools (Center for Education Reform, 2010). According to National Alliance of Public Charter Schools (2009), there are currently over 200 studies that examine charter school achievement.

Empirical Evidence for Charter School Effectiveness

Given that program evaluation and accountability are fundamental components of the philosophical foundations of charter schools, there are remarkably few *high quality* empirical studies that address, at a national level, the academic effectiveness of charter schools (c.f. National Alliance of Public Charter Schools, 2009; ?, ?). That is not to say that there are not any studies that examine charter school achievement. The National Alliance of Public Charter Schools (2009) provide a review of 140 studies selected on several criteria. Their review reveals significant gaps in the research with regard to states evaluated, research quality that addresses achievement, as well as timeliness of results. This is further exemplified by a meta-analysis conducted by ? (?) that includes just 13 studies that represent nine states. In this section we will provide an overview of the current literature available vis-à-vis the published meta-analysis and literature reviews. We then focus on two recent studies that together provide the context for the study proposed here. More specifically, a hierarchical linear modeling analysis of the 2005 NAEP study (?, ?) and a matching study comparing charter and public schools in 16 states (Center for Research on

Education Outcomes, 2009).

Overview of Current Studies

Research has shown that parents of students in charter schools are generally more satisfied with the charter school than the public school and will also tend to be more involved in their child's education (?, ?, ?). However, their satisfaction may simply be a rationalization (?, ?). Moreover, Fuller et al. (1996, as cited in ?, ?) suggest that parents that choose charter schools "believe that the charter must therefore be superior to a conventional public school" (p. 177). This is collaborated by a study conducted by ? (?) that examines school choice in Chicago Public Schools whereby more than half of students elect to attend another Chicago Public School (e.g. career academy, high-achieving school) rather than their locally assigned school. Though students who opt out of their local school are more likely to graduate, ? (?) argue that "those who opt out are superiour along unobservable dimensions such as their motivation level and parental involvement" (p. 755).

The National Alliance of Public Charter Schools (2009) provides perhaps the most comprehensive review of available research on charter school performance. The current report, *Charter School Achievement: What We Know* is now in its fifth edition having been updated periodically to account for recent studies. In addition to covering published research reports, the review includes unpublished reports including conference presentations, dissertations, policy group and think tank reports, and state evaluations. Of the 210 studies identified, 140 are included in their review given that the study compares charter schools with traditional public schools, the study uses "serious research methods" (p. 2), and "examines a significant segment of the charter sector." The studies are then further categorized into one of three categories: (1) panel studies that are longitudinal and examine student growth over time; (2) cohort change studies that are longitudinal but use some other method than tracking individual students; and (3) snapshot studies that examine school performance at a single point in time (also known as observational studies).

Table 1 summarizes the findings of the 140 studies included first, by breaking out the year(s) the study's data is based upon, and second by the results reported. It should be noted that many of the pre-2001 studies were concentrated in a few states (Arizona, California, Florida, North Carolina, and Texas). This is expected given that these states are among the earliest to adopt charter school laws (see appendix A) as well as the substantial increase in the number of charter

Table 1: Summary of Studies on Charter School Achievement

	Pre 2001				Post 2001			
	Larger Gains	Similar Gains	Mixed Gains	Smaller Gains	Larger Gains	Similar Gains	Mixed Gains	Smaller Gains
Math	4	4	4	20	17	17	1	14
	(13%)	(13%)	(13%)	(63%)	(35%)	(35%)	(2%)	(29%)
Reading	7	10	3	14	18	12	1	14
	(21%)	(29%)	(9%)	(41%)	(40%)	(27%)	(2%)	(31%)

Source: National Alliance of Public Charter Schools, 2009

schools since 2000 (see figure 1). The National Alliance of Public Charter Schools conclude that:

> [I]t becomes dramatically clear that studies examining public charter schools in more recent academic years show that charter schools produce more instances of larger achievement gains in both math and reading when compared to traditional public schools. (p. 3)

However, this interpretation downplays the fact that approximately 30% of charter schools performed worse than their traditional public school counterpart. These results are consistent with a recent by the Center for Research on Education Outcomes (2009) that reported that 37% of charter schools performed worse than their public school counterpart (this study is discussed in more detail below).

? (?) employ more stringent selection criteria for including studies in their meta-analysis. More specifically, only studies that used experimental student-level growth-based methods were included, resulting in a total of 14 studies published between 2001 and 2007 utilizing data ranging from 1998 through 2005. Similarly to National Alliance of Public Charter Schools (2009), studies included a limited number of locations including Arizona, California (three of which from San Diego specifically), Chicago, Delaware, Florida, Idaho, North Carolina, and Texas with one additional anonymous location. Overall, their analysis of the available studies provide very mixed results. However, some patterns to charter and public school differences emerge, specifically that charter schools generally outperform traditional public schools in elementary school reading and middle school math, though effect sizes for the latter are small. However, for high school reading and math charter schools are generally underperforming traditional public schools, but it should be noted that studies examining these grade levels is relatively small (see also, National Alliance of Public Charter Schools, 2009).

Two NAEP Studies Using HLM

An increasingly used statistical method that allows for the analysis of studies where observations are not independent is hierarchical linear modeling (HLM), or multi-level analysis. In the context of the charter school question, comparing students in charter schools to public school counterparts with, say ordinary least squares or ANOVA, is inappropriate since these statistical models do not account for the school effects. HLM provides a model for which school effects can be partitioned from student effects thereby providing adjustments for the lack of independence of observations (see e.g., ?, ?, ?).

Braun, Jenkins, and Grigg have published two research reports utilizing NAEP and HLM that look at how public school students compare to private school students (?) and charter schools students (?). Note that the former study used the 2005 administering of NAEP whereas the latter used the 2003 administering of NAEP. A key advantage of using NAEP is that many student (see appendix C) and school level variables are available. Moreover, as of 2003 charter schools have been oversampled to ensure sufficient sample sizes for appropriate comparisons to be made.

Comparing Private and Public Schools.

For the private school study (?, ?), results found that students in private schools scored significantly higher than public school students in both mathematics and reading at grades 4 and 8. Differences ranged from 8 points for grade 4 mathematics to 18 points for grade 8 reading. Adjusting for student characteristics with HLM resulted in reductions in all four comparisons of approximately 11 to 14 points. After adjustment, private school students still scored significantly higher than public school students in grade 8 reading, but public schools scored significantly better in grade 4 mathematics. There was no significant difference for grade 4 reading and grade 8 mathematics.

Comparing Charter and Private Schools.

For the charter school study (?, ?) analysis was conducted in three phases for both reading and mathematics. In phase one, all charter schools were compared to all public schools. Results found that, when student characteristics were adjusted for, charter schools performed on average 4.2 points lower than publics schools in reading (corresponding effect size is 0.11 standard deviations) and 4.7 points lower in mathematics (corresponding effect size is 0.17 standard

deviations).

Phase two separated charter schools into two groups: charter schools that are associated with a public school district (PSD) and those that are not. Separate analysis were performed for each charter school type with public schools. For reading, there was no significant difference between charter schools affiliated with a PSD and public schools. However, for schools not affiliated with a PSD, charter school students scored significantly lower than public school students with an adjusted difference of 0.17 standard deviations. Similarly for mathematics, there was no difference between charter schools affiliated with a PSD and public schools but charter schools not affiliated with PSD scored significantly lower with an adjusted difference of 0.23 standard deviations.

Lastly, phase three compared only charter and publics schools located in a central city and serving a high-minority population. For reading, there was no significant difference between charter and public schools for any model. For mathematics however, charter schools not affiliated with a PSD scored significantly lower than public school students with an adjusted difference of 0.17 standard differences. There was no difference for schools affiliated with a PSD.

The CREDO Study

The Center for Research on Education Outcomes (2009) conducted a study of more than 1.7 million records from 2400 charter within 16 states. The methodology involves creating a Virtual Control Record (VCR) for each charter school student (see also, ?, ?; Northwest Evaluation Association, 2009) which is used to find matching student from an eligible traditional public school. Students within a traditional public school become available in a pool of potential matches when at least one student is identified as transferring to a charter school. Once the "feeder schools" are identified, all students from feeder schools are pooled and serve as the source to select matches to the charter school students. Students are then matched on the following factors: grade-level, gender[2], race/ethnicity, free or reduced price lunch status, English language learner status, special education status, and prior test score on state achievement tests. This procedure, which is similar to propensity matching, resulted in 83.7% and 84.4% of charter school students being matched to a public school student for reading and math, respectively.

Once matches were determined, ordinary least squares regression was utilized to analyze both math and reading scores, separately, across the charter school students and matched public school

[2]Gender was not available in Florida

students. Moreover, controls for student characteristics used above, excluding gender, along with state indicators and scores affected by Hurricane Katrina, were added to the basic model. Overall results show that charter school students performed, on average, 0.01 and 0.03 standard deviations below public school students for reading and math, respectively. Both results are significant at $p \leq 0.01$.

Though the magnitude of the overall effects may not necessarily suggest charter schools are performing substantially lower than their public school counterparts, further analysis by Center for Research on Education Outcomes (2009) reveal more nuanced understanding of the differences. More specifically, the effectiveness of charter schools varied considerably by state. Five states (Arkansas, Colorado, Illinois, Louisiana, & Missouri) were found to have higher learning gains for charter schools. Six states (Arizona, Florida, Minnesota, New Mexico, Ohio, & Texas) were found to have lower learning gains for charter schools. The remaining four states (California, District of Columbia, Georgia, & North Carolina) had either mixed results or no difference in academic gains.

Lastly, the Center for Research on Education Outcomes (2009) found variation of charter school effectiveness across school characteristics. That is, schools that focused on elementary or middle grades separately, tended to perform as well or better than their public school counterparts. However, for charter schools that focused on high grades or multi-level grades performed anywhere from .02 to .08 standard deviations below public schools. Moreover, school level comparisons find that only 17% of charter schools perform better than public schools while 46% perform no differently and 37% perform significantly worse.

CHAPTER 3: METHOD

This chapter will outline the methods that will be utilized to describe and analyze the data in order to address the research questions central to this study. Given the strong political interests in the question of charter school effectiveness and the implications for educational policy both at the state and national level, obtaining good empirical evidence, preferably with strong causal inferences, is most desirable. The *gold standard* of inferential research is the randomized experiment. A research design that addresses the charter school question proposed here would require that students be randomly assigned, possibly with blocking on key covariates, to either a charter or public school. The theoretical justification for such a scheme is that any systematic differences between the two groups would be balanced through the randomization processes. However, in practice, especially in education, such randomization is neither feasible nor ethical. The result of the lack of randomization is a phenomenon called selection bias. That is, any comparisons of the two groups will be biased given the fact that the units of study, students in this study, self-selected to be in their respected group. Propensity score analysis (?, ?) is a statistical approach whereby the differences between the two groups are balanced by the careful analysis of covariate information. This procedure lends itself well to secondary analysis of observational data.

Overview of NAEP

The source of the data that will be utilized in this study is provided by the National Center for Educational Statistics (NCES) which is within the U.S. Department of Education's Institute of Education Sciences (IES). The National Assessment of Educational Progress (NAEP) was started in 1971 and has provided national measures of student achievement in many subjects including mathematics, reading, science, writing, history, civics, and the arts. In 2003 NAEP began assessing charter schools as well as private and public schools. This study will utilize the 2007 administering of the NAEP assessments in mathematics and reading within grades four and eight. The 2007 assessment included over 6,000 public schools and over 200 charter schools comprising of over 145,000 and 3,000 students, respectively. Given this relatively large, nationally representative sample, analysis of NAEP assessments utilizing propensity score analysis may prove to provide valuable insights into the academic differences between charter and public schools.

More than simply providing large samples, another key advantage of NAEP is the fact that it is not designed to assess individual students or schools, but instead is designed to inform

subject-matter achievement, instructional experiences, and school environments (Braun, Jenkins, & Grigg, 2006). To achieve this goal, NAEP utilizes a complex item-sampling design such that individual students are presented a subset of the total items, thereby reducing the burden on participants. Though not appropriate for assessing individual student achievement, in aggregate the NAEP measures provide a robust and accurate estimate of student achievement.

In addition to subject area measures, NAEP includes student, teacher, and school questionnaires that provide contextual information about the students' environment. Given that PSA relies on adjusting for selection bias by adjusting for known covariates, it are the answers to these questionnaires that will serve as the basis for determining a students propensity score, or likelihood of being in the treatment (i.e. charter school in the context of this study). In addition to typical demographic items such as gender and race, students are asked about computers, books, magazines, and encyclopedias in the home; parents education level; and the level of interaction with academics within the home (see appendix C for complete list of items).

The responsibility for developing the assessment objectives and test specifications lies with the National Assessment Governing Board which was created by Congress in 1988. Traditionally they are the states that have provided the legal guidance for school governance including accountability measures. Given the varied standards across states, it is this governing board that is to determine nationally what are appropriate achievement goals for each age and grade. The following two sections will provide the framework for mathematics and reading assessments.

Mathematics

Since 1990, the Council of Chief State School Officers (CCSSO) has been contracted to design a framework for the mathematics assessment (National Assessment Governing Board, 2006a). The framework was most recently updated in 2000 to take into account state standards, the National Council of Teachers of Mathematics (NCTM) standards, the Trends International Mathematics and Science Study (TIMSS), the Achieve Project, and a 2001 report issued by the National research Council of the National Academy of Sciences. The result of their work was six recommendations for the mathematics assessment regarding content areas, mathematical complexity of items, distribution of items, item formats, manipulatives, and calculators. For the purposes of the study proposed, a composite score will be utilized that is comprised of five content areas, number properties and operations; measurement; geometry; data analysis and probability;

Table 2: Distribution of Math Items by Grade and Content Area

Content Area	Grade 4	Grade 8
Number Properties and Operations	40%	20%
Measurement	20%	15%
Geometry	15%	20%
Data Analysis and Probability	10%	15%
Algebra	15%	30%

and algebra. Table 2 provides details regarding the distribution of items comprising the composite score for the grade four and eight assessments.

Reading

The NAEP Reading Framework (2006) provides guidelines and a theoretical basis for reading assessment. This framework is designed with the input of individuals and organizations involved in reading education including researchers, policymakers, teachers, and business representatives. However, a particular emphasis is placed on the work of the National Institute for Child Health and Human Development (NICHID). More specifically, the NICHID summarizes how the research describes a reader as:

> In the cognitive research, reading is purposeful and active. According to this view, a reader reads a text to understand what is read, to construct memory representations of what is understood, and to put this understanding to use. (p. 4, NICHD, 2000, as cited in National Assessment Governing Board, 2006b)

Moreover, reading is considered to be a complex process rather than a simple set of skills. As such, the NAEP reading assessment is designed such that comprehension is defined as:

> "[I]ntentional thinking during which meaning is constructed through interactions between text and reader" (Harris & Hodges, 1995). Thus, readers derive meaning from text when they engage in intentional, problem solving thinking processes. (p. 14, NICHD, 2000, as cited in National Assessment Governing Board, 2006b)

Given this framework, NAEP provides an excellent tool for evaluating overall reading achievement, but not to diagnosis specific individuals.

The NAEP reading assessment is designed to account for three reading contexts: reading for literacy experience, reading for information, and reading to perform a task. Within these contexts, four aspects of reading are considered: forming a general understanding, developing interpretation, making reader/text connections, and examining content and structure. The reading assessment is

administered by supplying students with booklets that contain reading materials and comprehension questions. The questions consist of both multiple-choice and constructed-response question formats with at least half of the questions being of the constructed-response type.

Analysis

Phase I

Propensity score analysis (PSA; ?, ?) is a statistical method or approach that attempts to adjust for selection bias in observational studies and has become increasingly popular in medical research (?, ?) and in the social sciences (Thoemmes & Kim, 2011).

Most of the studies conducted using PSA involve analysis in two phases where phase one involves the the calculation of propensity scores or matching for both treatment and control units of analysis; and phase two involves the comparison of those two groups. However, in situations where data is multilevel, or clustered, special consideration is necessary both at phase I and II. For the NAEP data, the state variable will be used as the level 2 identifier. The algorithm in the `multilevelPSA` package ? (?) will facilitate the multilevel PSA analysis. Specifically, for phase I, three approaches will be used for stratifying students for comparison, namely conditional inference trees ? (?), logistic regression, and matching. For each approach, the stratification procedure will be performed separately for each state so that direct comparisons between students in phase II do not occur between states. That is, students within a stratification or two students being matched must reside in the same state.

Phase II

The second phase of the propensity score analysis involves comparing dependent variables of students with similar propensity scores using standard t-tests and reporting corresponding confidence intervals and effect sizes. However, for multilevel data analysis occurs in two states. First, comparisons are made for each state. The results from each state can then be aggregated to provide an overall difference and effect size.

Graphical Representation

Given the large amount of data that needs to be summarized, the use of graphics will be emphasized. The `multilevelPSA` package provides a number of graphing functions that extend the

framework introduced by Helmreich and Pruzek for multilevel PSA. Figure 3 represents a multilevel PSA assessment plot. In this graphic, the x-axis corresponds public school grade 8 NAEP scores and the y-axis corresponds to charter school grade 8 NAEP scores. Each colored circle is a state with its size corresponding the number of students within each state. The distribution of differences between charter and public schools across states are represented as tick marks along the diagonal line in the bottom left of the graphic. Differences are aggregated (and weighted by size) across states. For grade 8 math, the overall adjusted mean for charter school students is 281 and the overall adjusted mean for public school student is 278. The dashed blue line parallel to the unit line corresponds to the overall adjusted mean difference and likewise, the dashed green lines correspond to the confidence interval.

Figure 4 provides a more nuanced depiction of the differences both between and across states. Similar to the mutlielvel PSA assessment plot, each blue dot corresponds to a state and is sized relative to the number of students within each state. The light gray dots correspond to each of the strata within each state. The graphic also provides confidence intervals for each state as well as the overall adjusted mean difference and confidence interval.

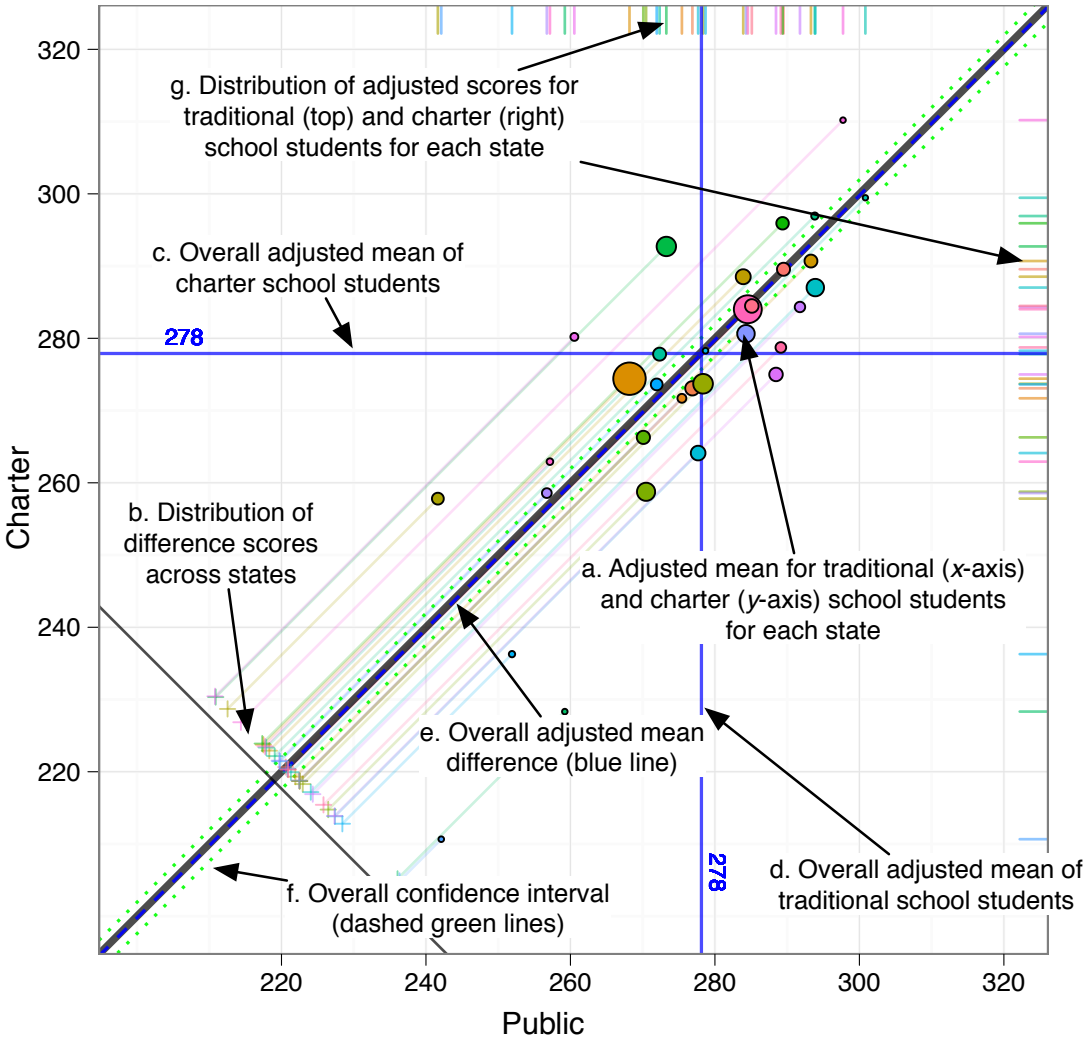

Figure 3: Multilevel PSA Assessment Plot: Grade 4 Math

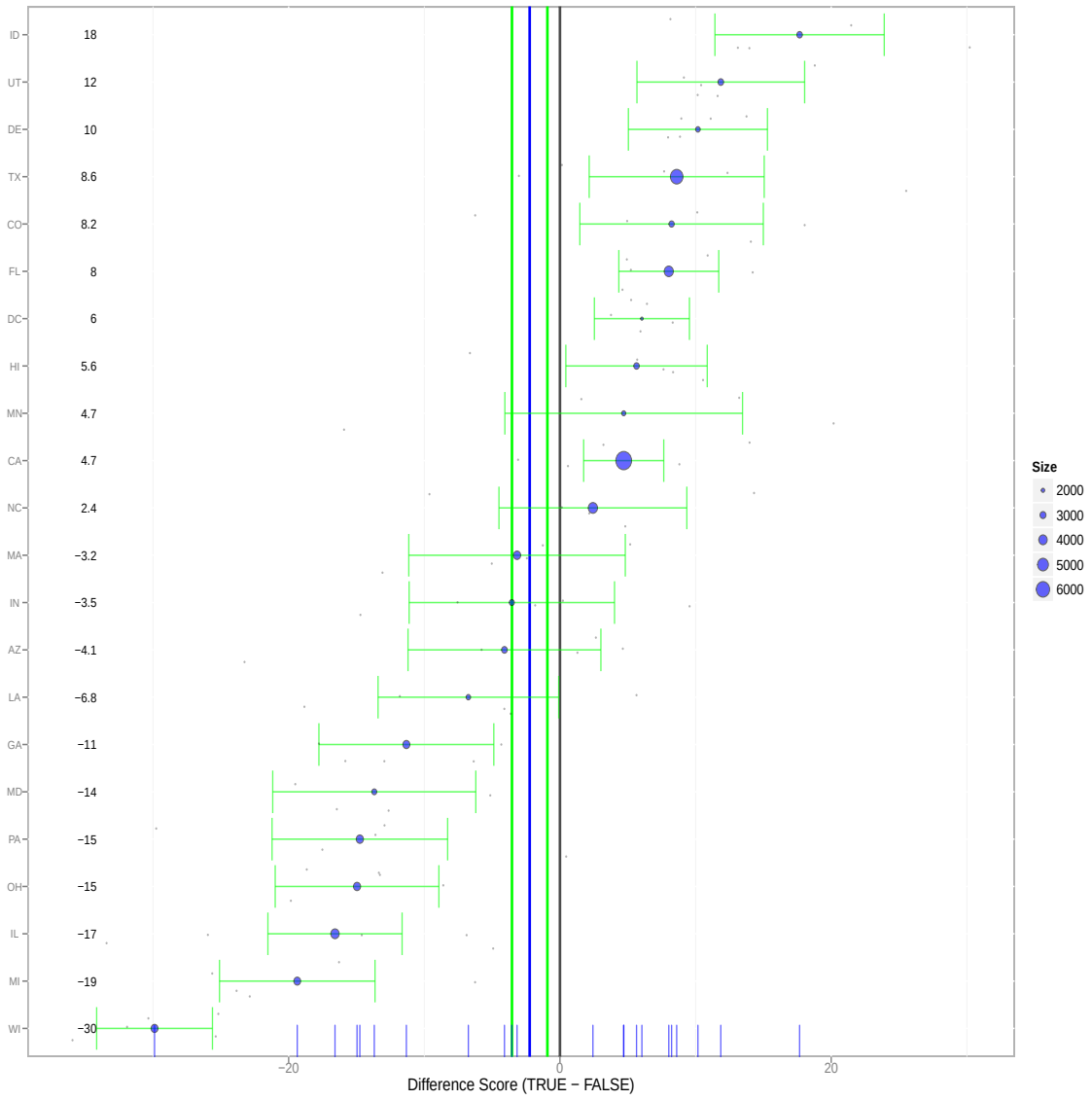

Figure 4: Multilevel PSA Difference Plot: Grade 8 Math

CHAPTER 4: RESULTS

In this chapter I will outline in detail the results of all the propensity score models described in chapter three. Since NAEP is organized such that each grade and subject combination is a separate dataset, this chapter will focus on the analysis of grade four math. The results for grade four reading, grade eight math, and grade eight reading are included in the appendices. The chapter begins with a discussion of data preparation, followed by details of the nine propensity score methods used, and concludes with a summary, including tables and figures, of the overall results across all grades and subjects.

All analysis was conducted using R (?, ?)[3]. R provides a number of advantages over other applications including a framework for extending its core functionality through R packages. I have written and published two R packages primarily for conducting the analysis in this dissertation. The `naep` package provides functions to read and work with the National Assessment of Educational Progress (NAEP) data sets. Secondly, the `multilevelPSA` package provides functions to conduct multilevel propensity score analysis as described above. Both of these packages are available from the Comprehensive R Archive Network (CRAN).

Formatting note. Since the development of the R packages are in and of themselves a major component of this dissertation, I will make reference to some of the functions available. All references to R packages and functions will appear in a `fixed width font`.

Data Preparation

Missing Data Imputation

Stratification by logistic regression (using two approaches to covariate selection) and matching require a complete dataset to estimate the models. As such, missing data was imputed using multivariate imputation by chained equations van Buuren and Groothuis-Oudshoorn (n.d.) vis-à-vis the MICE package ? (?) in R.

Propensity Score Analysis with Stratification

[3]All R scripts are available from Github at `https://github.com/jbryer/Dissertation`. Due to the licensing agreement with NCES, data is not included. However, researchers with access to the 2009 restricted use data should be able to replicate the analysis outlined in this chapter.

Table 3: Descriptive Statistics of Dependent Variables (Unadjusted)

	Charter		Public		Mean	Confidence	
Subject	Mean	SD	Mean	SD	Difference	Interval	
Grade 4 Math	231.2	28.3	237.3	28.5	-6.0	-7.0	-5.0
Grade 4 Reading	212.9	33.0	217.1	34.5	-4.2	-5.3	-3.1
Grade 8 Math	271.8	35.5	279.4	35.8	-7.5	-8.7	-6.4
Grade 8 Reading	256.2	32.9	259.8	32.6	-3.6	-4.7	-2.6

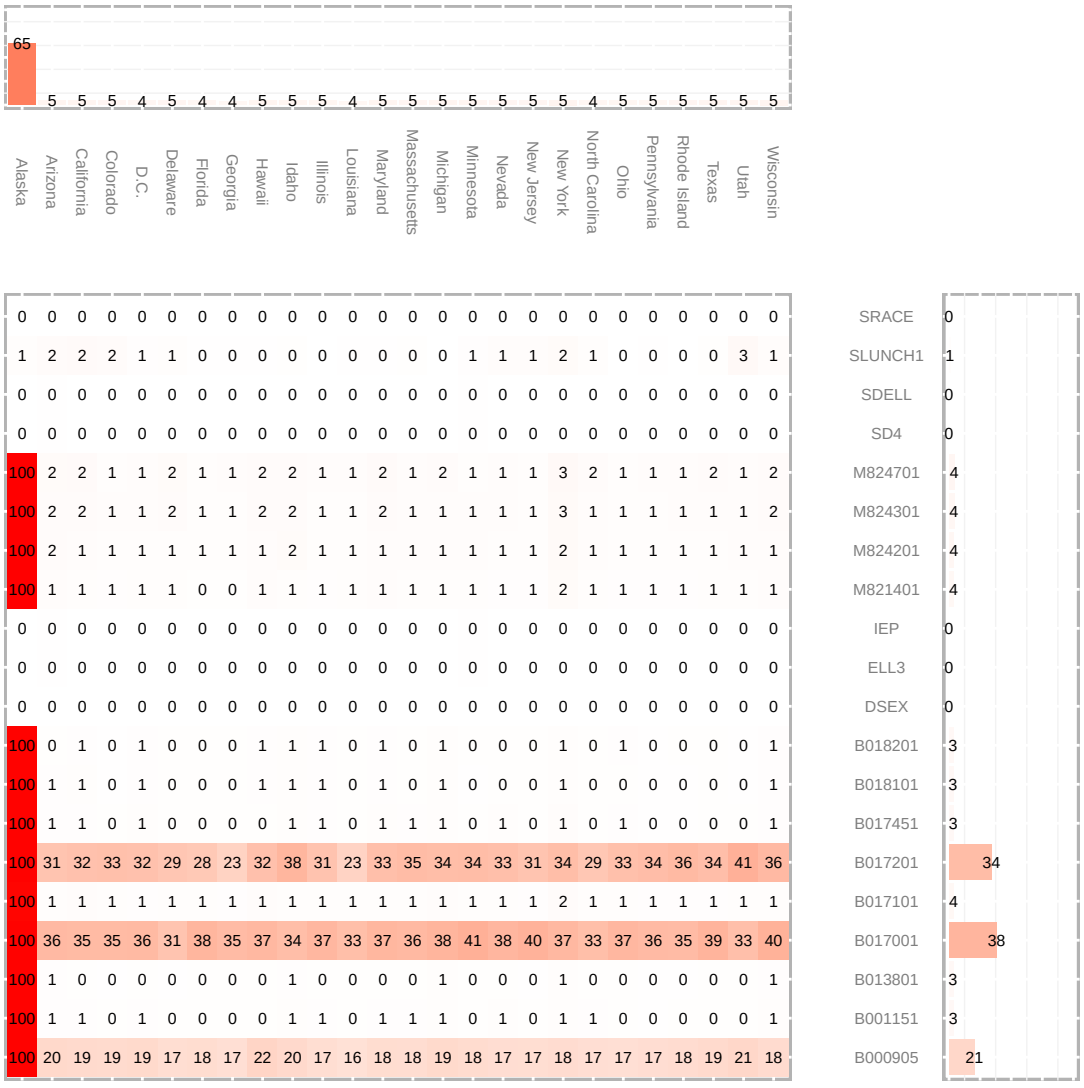

Figure 5: Missing Data Plot: Grade 4 Math

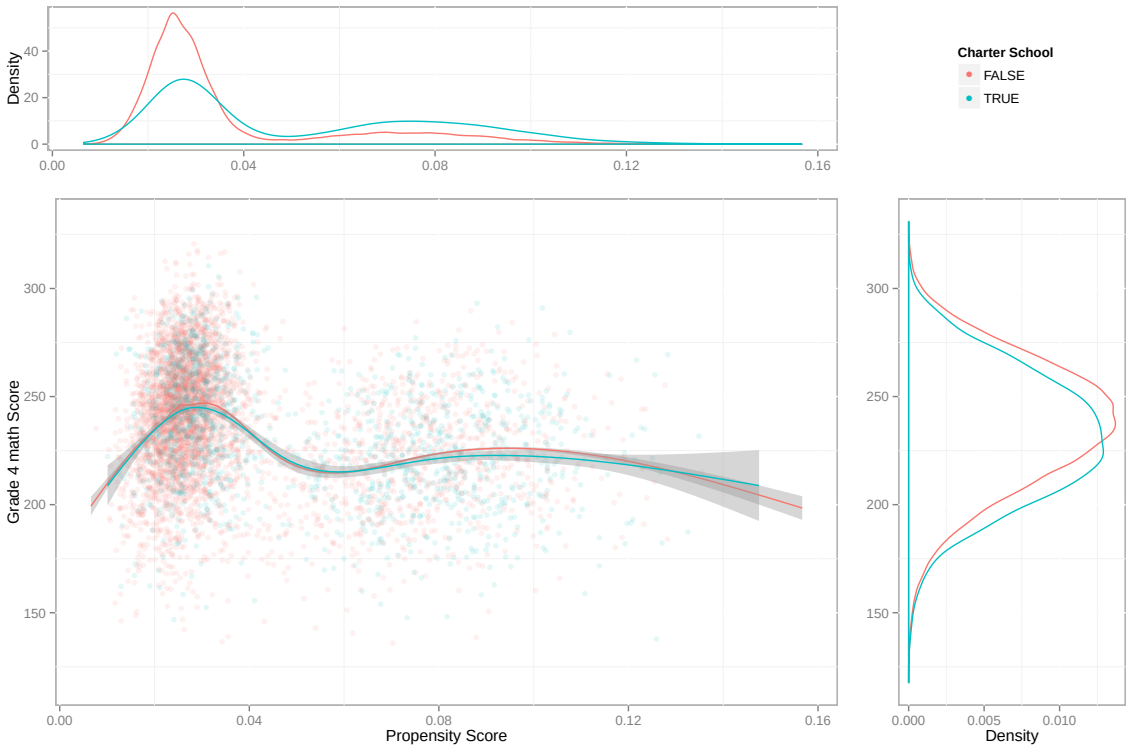

Figure 6: Loess Regression Assessment Plot: Grade 4 Math

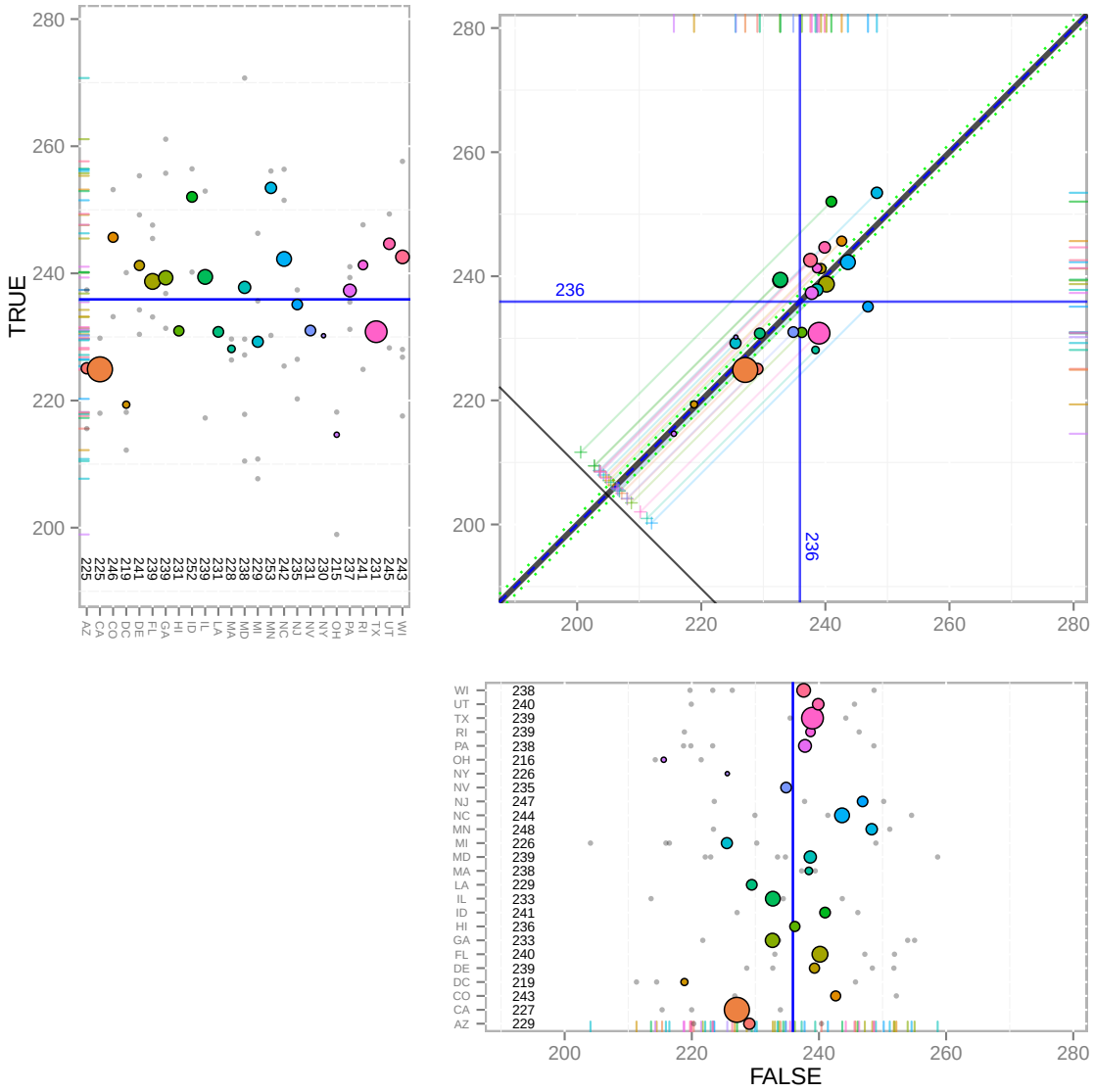

Figure 7: Multilevel PSA Assessment Plot: Grade 4 Math

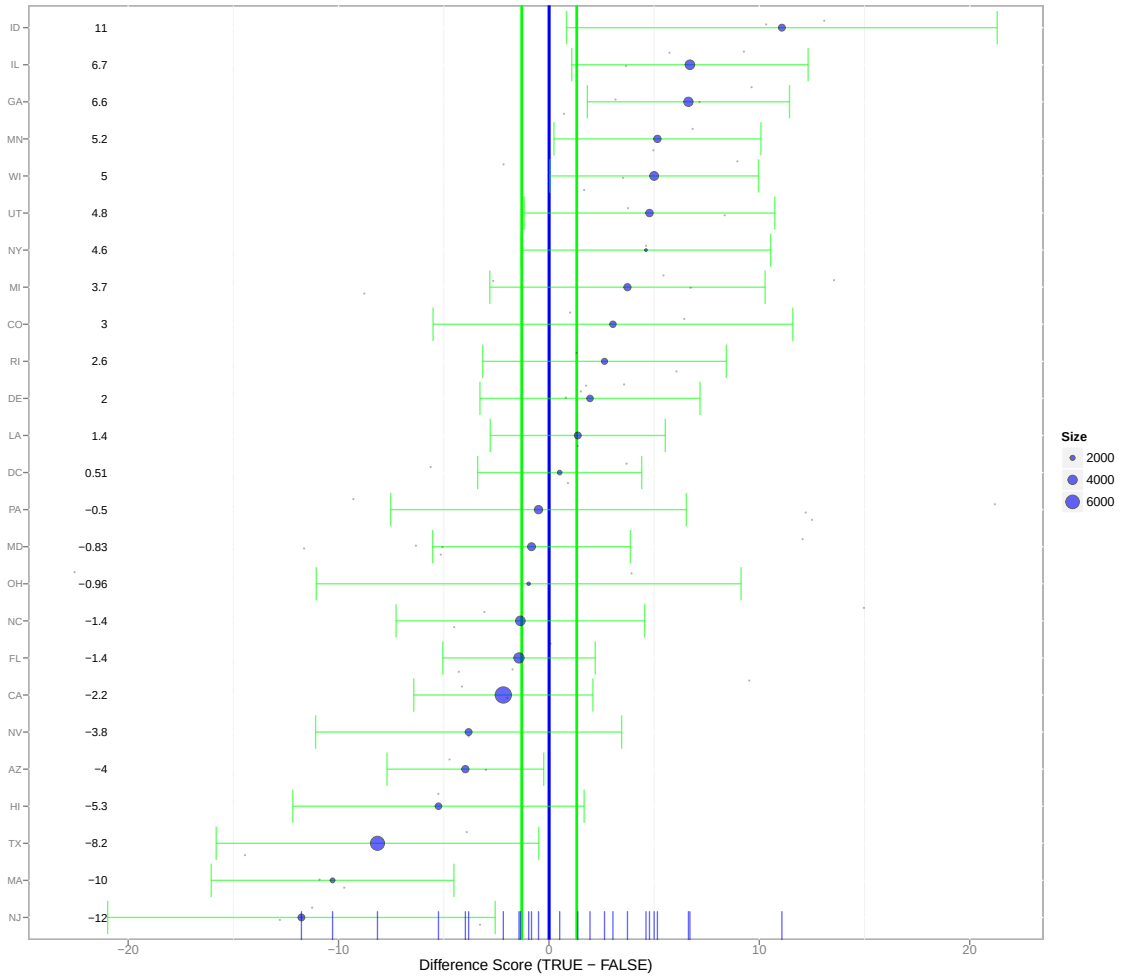

Figure 8: Multilevel PSA Difference Plot: Grade 4 Math

Propensity Score Matching

Multilevel Propensity Score Analysis

Phase I

Phase II

Graphical Representations of Multilevel PSA

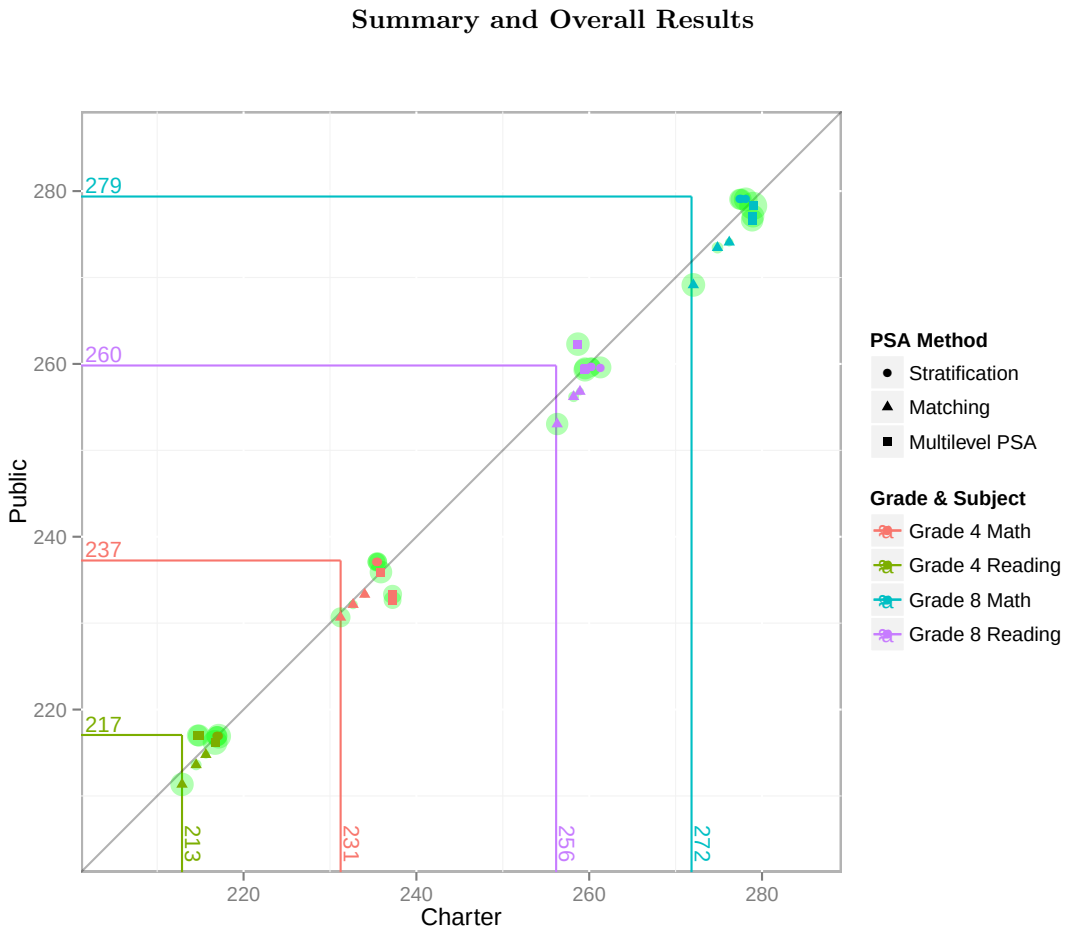

Figure 9: PSA Circle Plot of Adjusted Means

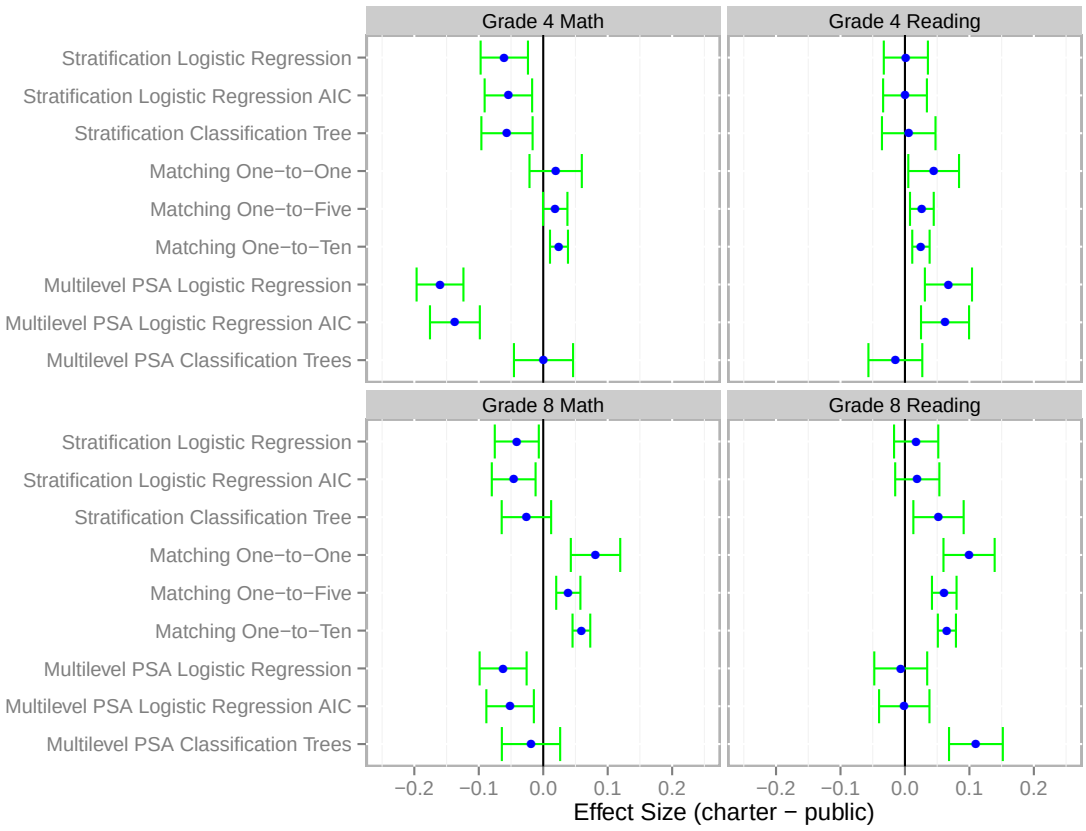

Figure 10: Overall Differences in Effect Size

Method	Charter	Public	ATE	95% CI	
			Grade 4 Math		
Stratification Logistic Regression	235.37	237.09	-1.72	-2.77	-0.68
Stratification Logistic Regression AIC	235.55	237.09	-1.54	-2.59	-0.49
Stratification Classification Tree	235.48	237.09	-1.60	-2.74	-0.47
Matching One-to-One	231.22	230.67	0.55	-0.61	1.71
Matching One-to-Five	232.67	232.14	0.53	-0.01	1.07
Matching One-to-Ten	234.02	233.32	0.70	0.30	1.09
Multilevel PSA Logistic Regression	237.24	232.67	-4.57	-3.53	-5.60
Multilevel PSA Logistic Regression AIC	237.24	233.33	-3.91	-2.80	-5.01
Multilevel PSA Classification Trees	235.90	235.91	0.01	1.32	-1.30
			Grade 4 Reading		
Stratification Logistic Regression	216.96	216.92	0.05	-1.13	1.23
Stratification Logistic Regression AIC	216.92	216.92	0.00	-1.17	1.17
Stratification Classification Tree	217.12	216.92	0.20	-1.23	1.63
Matching One-to-One	212.88	211.34	1.53	0.18	2.89
Matching One-to-Five	214.51	213.60	0.90	0.27	1.54
Matching One-to-Ten	215.63	214.78	0.85	0.39	1.32
Multilevel PSA Logistic Regression	214.69	217.01	2.32	3.58	1.07
Multilevel PSA Logistic Regression AIC	214.85	216.99	2.14	3.42	0.86
Multilevel PSA Classification Trees	216.71	216.19	-0.51	0.93	-1.95
			Grade 8 Math		
Stratification Logistic Regression	277.58	279.05	-1.47	-2.69	-0.25
Stratification Logistic Regression AIC	277.41	279.06	-1.64	-2.86	-0.43
Stratification Classification Tree	278.11	279.04	-0.94	-2.31	0.44
Matching One-to-One	272.05	269.14	2.91	1.53	4.28
Matching One-to-Five	274.85	273.45	1.39	0.72	2.07
Matching One-to-Ten	276.21	274.08	2.12	1.63	2.61
Multilevel PSA Logistic Regression	278.86	276.63	-2.23	-0.92	-3.54
Multilevel PSA Logistic Regression AIC	278.95	277.11	-1.84	-0.52	-3.16
Multilevel PSA Classification Trees	278.98	278.30	-0.68	0.94	-2.30
			Grade 8 Reading		
Stratification Logistic Regression	260.20	259.63	0.57	-0.55	1.69
Stratification Logistic Regression AIC	260.25	259.63	0.62	-0.49	1.74
Stratification Classification Tree	261.30	259.60	1.70	0.43	2.97
Matching One-to-One	256.29	253.04	3.25	1.95	4.54
Matching One-to-Five	258.19	256.20	1.99	1.37	2.61
Matching One-to-Ten	258.93	256.81	2.12	1.67	2.58
Multilevel PSA Logistic Regression	259.51	259.30	-0.21	1.13	-1.55
Multilevel PSA Logistic Regression AIC	259.52	259.49	-0.03	1.24	-1.31
Multilevel PSA Classification Trees	258.70	262.29	3.60	4.96	2.23

Table 4: Summary of Overall Propensity Score Results

CHAPTER 5: DISCUSSION

Given the significant difference in sample n's for charter and public schools (i.e. there are as much as three to four orders of magnitude more public schools students available in the NAEP data sets), it is expected that there would be public school students who would not have a counterpart from the charter school group. However, the relatively high percentage of public schools students who do not have a charter school counterpart (as much as 35%) suggest that there may be imbalance between the two groups as a whole. That is, although reasonable balance was achieved with regard to the individual strata where comparisons are made, the overall sample imbalance, as evidenced by the unmatched public school students, suggests that public schools serve a more heterogeneous population.

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Appendix A

Charter Schools & Student Enrollment by State

Table 5: Charter Schools & Student Enrollment by State

State	Law Enacted	Totals for Charter Schools[b]			NAEP Students	
		Operating	Closed	Students	Charters	Publics
Alabama[a]		0	0	0	0	2759
Alaska	1995	26	5	5,198	69	2517
Arizona	1994	510	96	119,903	99	2674
Arkansas	1995	25	6	6,750	30	2407
California	1992	802	103	316,468	417	7803
Colorado	1993	151	10	54,497	108	2598
Connecticut	1996	21	5	3,932	0	2531
Delaware	1995	21	2	8,740	180	2641
Washington DC	1996	93	16	25,385	652	1336
Florida	1996	382	82	108,382	175	3876
Georgia	1993	83	5	40,807	64	3465
Hawaii	1994	32	0	7,317	132	2605
Idaho	1998	32	1	10,492	59	2784
Illinois	1996	74	8	27,683	33	4015
Indiana	2001	50	2	12,631	11	2720
Iowa	2002	10	0	1,462	0	2839
Kansas	1994	40	10	3,361	17	2726
Kentucky[a]		0	0	0	0	2696
Louisiana	1995	66	10	23,634	97	2264
Maine[a]		0	0	0	0	2658
Maryland	2003	34	2	7,301	6	2825
Massachusetts	1993	64	6	23,905	56	3667
Michigan	1993	250	27	94,092	134	2480
Minnesota	1991	159	29	28,371	16	2875
Mississippi	1997	1	0	367	0	2613
Missouri	1998	39	5	13,125	38	2771
Montana[a]		0	0	0	0	2581
Nebraska[a]		0	0	0	0	2688
Nevada	1997	26	7	7,295	0	2662
New Hampshire	1995	11	2	1,212	0	2803
New Jersey	1996	64	19	17,986	0	2813
New Mexico	1993	70	3	11,426	54	2722
New York	1998	118	10	32,602	16	3745
North Carolina	1996	103	32	30,445	72	4090
North Dakota[a]		0	0	0	0	2307
Ohio	1997	293	48	94,171	45	3746
Oklahoma	1999	14	1	4,770	0	2612
Oregon	1999	93	8	13,612	41	2626
Pennsylvania	1997	133	12	61,823	64	2709
Rhode Island	1995	11	0	2,894	30	2621
South Carolina	1996	36	10	8,705	16	2697
South Dakota[a]		0	0	0	0	2889

Charter Schools & Student Enrollment by State (cont.)

State	Law Enacted	Totals for Charter Schools[b]			NAEP Students	
		Operating	Closed	Students	Charters	Publics
Tennessee	2002	14	1	2,585	54	2815
Texas	1995	331	33	108,541	199	7070
Utah	1998	68	1	23,233	38	2722
Vermont[a]		0	0	0	0	2003
Virginia	1998	4	3	275	0	2848
Washington[a]		0	0	0	0	2968
West Virginia[a]		0	0	0	0	2831
Wisconsin	1993	221	37	41,799	114	2592
Wyoming	1995	3	0	244	0	1897
Total		4,578	657	1,407,421	3,164	156,963

[a]State currently does not have a charter school law.
[b]Source: Center for Education Reform (2010)

Appendix B

Thematic Map of Number of Charter Schools by State in 2008

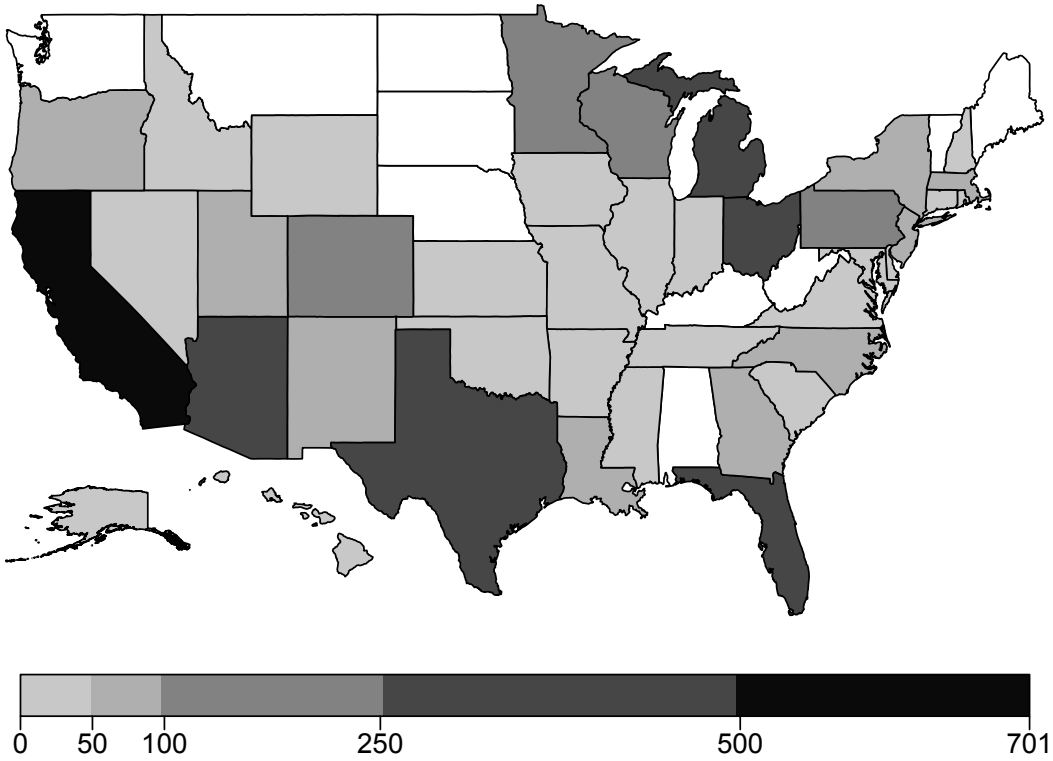

Figure 11: Thematic Map of Number of Charter Schools by State in 2008

Appendix D

Descriptive Statistics

Table 6: Grade 4 Math Descriptive Statistics

	Traditional		Charter	
Race/ethnicity from school records (raw data)				
White	90268	57%	1202	33%
Black	27565	17%	1546	43%
Hispanic	27927	18%	642	18%
Asian Amer/Pacif Is	7657	5%	172	5%
Amer Ind/Alaska Nat	3753	2%	35	1%
Other	2168	1%	28	1%
Unknown	0	0%	0	0%
Natl School Lunch Prog eligibility (3 categories)				
Eligible	79160	50%	2074	57%
Not eligible	79273	50%	1381	38%
Info not available	905	1%	170	5%
Unknown	0	0%	0	0%
Student has Individualized Education Plan				
Yes, IEP	17871	11%	332	9%
Yes, 504 plan	1414	1%	23	1%
Yes, 504 in process	0	0%	0	0%
Not IEP	140022	88%	3270	90%
Omitted	0	0%	0	0%
Unknown	31	0%	0	0%
Student classified Eng Lang Learner (3 categories)				
Yes	13002	8%	275	8%
No	143127	90%	3273	90%
Formerly ELL	3174	2%	77	2%
Omitted	0	0%	0	0%
Unknown	35	0%	0	0%
Gender				
Male	81536	51%	1796	50%
Female	77802	49%	1829	50%
Unknown	0	0%	0	0%
Student classified as having a disability (504)				
Student with disabi	19285	12%	355	10%
Not student with di	140022	88%	3270	90%
Omitted	31	0%	0	0%
Unknown	0	0%	0	0%
Student classified SD or ELL				
Student with disabi	17847	11%	328	9%
English language le	11564	7%	248	7%
Both SD and ELL	1438	1%	27	1%
Neither SD nor ELL	128441	81%	3022	83%
Unknown	48	0%	0	0%
Newspaper in home				

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	Charter		Traditional	
Yes	44894	28%	966	27%
No	55957	35%	1334	37%
I Don't Know	55462	35%	1210	33%
Omitted	3004	2%	115	3%
Multiple	21	0%	0	0%
Unknown	0	0%	0	0%
Magazines in home				
Yes	89988	56%	1998	55%
No	38593	24%	877	24%
I Don't Know	27543	17%	627	17%
Omitted	3190	2%	123	3%
Multiple	24	0%	0	0%
Unknown	0	0%	0	0%
Books in home				
0-10 books	19625	12%	423	12%
11-25 books	33693	21%	825	23%
26-100 books	52311	33%	1079	30%
More than 100 books	50511	32%	1181	33%
Omitted	3159	2%	117	3%
Multiple	39	0%	0	0%
Unknown	0	0%	0	0%
Computer in home				
Yes	136033	85%	3078	85%
No	19502	12%	413	11%
Omitted	3787	2%	134	4%
Multiple	16	0%	0	0%
Unknown	0	0%	0	0%
Encyclopedia in home				
Yes	80440	50%	1874	52%
No	25501	16%	514	14%
I Don't Know	50222	32%	1120	31%
Omitted	3146	2%	114	3%
Multiple	29	0%	3	0%
Unknown	0	0%	0	0%
Pages read in school and for homework				
5 or fewer	33661	21%	819	23%
6-10	27785	17%	618	17%
11-15	20828	13%	442	12%
16-20	22687	14%	488	13%
More than 20	51046	32%	1134	31%
Omitted	3259	2%	124	3%
Multiple	72	0%	0	0%
Unknown	0	0%	0	0%
Talk about studies at home				
Never or hardly eve	29003	18%	578	16%
Every few weeks	21264	13%	468	13%
About once a week	18741	12%	400	11%
2-3 times a week	31451	20%	680	19%

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	Charter		Traditional	
Every day	55569	35%	1377	38%
Omitted	3247	2%	121	3%
Multiple	63	0%	1	0%
Unknown	0	0%	0	0%
Days absent from school last month				
None	79833	50%	1622	45%
1-2 days	46548	29%	1111	31%
3-4 days	18267	11%	434	12%
5-10 days	7351	5%	207	6%
More than 10 days	4078	3%	130	4%
Omitted	3207	2%	120	3%
Multiple	54	0%	1	0%
Unknown	0	0%	0	0%
Language other than English spoken in home				
Never	85236	53%	1679	46%
Once in a while	33507	21%	833	23%
Half the time	11284	7%	297	8%
All or most of time	26049	16%	695	19%
Omitted	3214	2%	121	3%
Multiple	48	0%	0	0%
Unknown	0	0%	0	0%
Do math at after-school or tutoring program				
Yes	53627	34%	1532	42%
No	101907	64%	1955	54%
Omitted	3780	2%	137	4%
Multiple	24	0%	1	0%
Unknown	0	0%	0	0%
Math work is too hard				
Never or hardly eve	46369	29%	1028	28%
Sometimes	87164	55%	1964	54%
Often	14112	9%	305	8%
Always or almost	7374	5%	177	5%
Omitted	4254	3%	151	4%
Multiple	65	0%	0	0%
Unknown	0	0%	0	0%
Math work is too easy				
Never or hardly eve	21759	14%	518	14%
Sometimes	77107	48%	1656	46%
Often	31769	20%	634	17%
Always or almost	24192	15%	648	18%
Omitted	4467	3%	167	5%
Multiple	44	0%	2	0%
Unknown	0	0%	0	0%
Like math				
Never or hardly eve	18905	12%	406	11%
Sometimes	38466	24%	794	22%
Often	33116	21%	680	19%
Always or almost	64083	40%	1567	43%

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	Charter		Traditional	
Omitted	4724	3%	177	5%
Multiple	44	0%	1	0%
Unknown	0	0%	0	0%

Table 7: Grade 4 Math Unadjusted NAEP Score

	Charter Schools						Public Schools					
	n	mean	sd	median	min	max	n	mean	sd	median	min	max
Overall	3625	231.93	28.19	232.18	136.95	310.45	159338	238.34	27.71	239.71	117.69	334.07
Alaska	102	247.41	24.64	248.79	183.80	296.82	2496	238.50	28.87	240.91	133.70	314.90
Arkansas	226	229.38	29.27	230.22	145.74	294.08	2836	228.66	29.47	229.71	142.09	324.86
Canal zone	170	223.41	26.86	221.21	152.40	290.14	7241	227.05	30.42	227.52	127.08	330.95
Connecticut	132	250.45	28.67	256.63	148.19	308.90	2550	242.34	28.39	244.89	130.83	317.99
D.C.	512	217.48	26.97	215.26	146.95	306.62	1282	219.99	32.15	219.20	133.26	317.28
Florida	195	240.20	26.34	238.76	168.45	294.30	2586	239.42	24.64	239.68	159.44	316.57
Idaho	166	241.09	24.28	244.36	175.09	293.17	4531	239.76	24.97	240.17	147.51	324.61
Illinois	164	241.86	25.56	244.89	183.18	310.45	3865	232.69	28.18	232.54	140.58	316.17
Iowa	57	230.95	26.26	234.88	146.85	273.46	2695	236.28	31.24	239.72	127.32	314.05
Kansas	60	255.08	20.79	255.56	183.42	300.83	3024	240.97	24.84	242.25	139.84	314.77
Kentucky	78	229.74	27.71	231.49	147.64	295.55	4059	232.94	29.83	233.75	117.69	318.75
Michigan	65	230.80	16.68	230.98	197.30	279.19	2830	229.16	24.90	229.32	144.26	308.71
Mississippi	141	219.12	26.52	217.25	164.93	293.18	3249	239.22	27.40	238.06	148.45	318.09
Missouri	52	229.29	22.62	226.30	179.65	284.75	3615	248.36	25.63	249.08	145.76	317.96
Montana	215	218.06	29.43	216.04	136.95	288.98	3204	229.38	31.66	231.15	128.36	318.70
Nebraska	109	247.68	26.51	248.08	188.30	302.32	3204	248.59	27.03	251.09	150.58	323.00
New York	72	231.01	31.20	229.16	162.07	303.29	2977	234.90	25.81	236.10	137.78	303.75
North Dakota	74	224.15	23.57	223.48	179.04	284.71	2780	247.30	26.13	249.06	155.28	325.63
Oklahoma	60	229.73	21.88	230.70	189.84	269.90	3997	239.50	26.83	240.45	145.65	315.10
Oregon	96	249.72	19.40	250.68	206.39	290.68	4320	243.07	26.92	243.12	130.47	323.33
Rhode Island	124	218.15	22.02	217.22	159.99	269.17	3324	237.62	29.58	239.43	126.61	319.60
Utah	79	230.94	23.07	227.57	185.38	297.38	2404	239.08	28.41	241.89	136.10	307.88
Washington	91	231.23	20.75	229.44	166.83	278.23	6193	238.97	24.48	239.19	139.25	317.06
West Virginia	197	247.20	25.79	250.06	164.01	305.53	3145	239.22	28.47	241.50	130.38	319.46
DoDEA/DDESS	136	229.43	26.14	226.78	178.41	289.56	3694	237.95	29.14	239.24	134.42	320.51

Table 8: Grade 4 Reading Descriptive Statistics

	Traditional		Charter	
Race/ethnicity from school records (raw data)				
White	96992	58%	1343	34%
Black	29127	17%	1636	42%
Hispanic	28133	17%	705	18%
Asian Amer/Pacif Is	8114	5%	162	4%
Amer Ind/Alaska Nat	3898	2%	49	1%
Other	2333	1%	41	1%
Unknown	0	0%	0	0%
Natl School Lunch Prog eligibility (3 categories)				
Eligible	82354	49%	2223	56%
Not eligible	85304	51%	1528	39%
Info not available	939	1%	185	5%
Unknown	0	0%	0	0%
Student has Individualized Education Plan				
Yes, IEP	16579	10%	307	8%
Yes, 504 plan	1385	1%	29	1%
Yes, 504 in process	0	0%	0	0%
Not IEP	150596	89%	3600	91%
Omitted	0	0%	0	0%
Unknown	37	0%	0	0%
Student classified Eng Lang Learner (3 categories)				
Yes	12095	7%	285	7%
No	153110	91%	3569	91%
Formerly ELL	3357	2%	82	2%
Omitted	0	0%	0	0%
Unknown	35	0%	0	0%
Gender				
Male	85214	51%	1960	50%
Female	83383	49%	1976	50%
Unknown	0	0%	0	0%
Student classified as having a disability (504)				
Student with disabi	17964	11%	336	9%
Not student with di	150596	89%	3600	91%
Omitted	37	0%	0	0%
Unknown	0	0%	0	0%
Student classified SD or ELL				
Student with disabi	16722	10%	314	8%
English language le	10853	6%	263	7%
Both SD and ELL	1242	1%	22	1%
Neither SD nor ELL	139727	83%	3337	85%
Unknown	53	0%	0	0%
Newspaper in home				
Yes	47839	28%	1141	29%
No	59247	35%	1327	34%
I Don't Know	58294	35%	1343	34%
Omitted	3205	2%	125	3%
Multiple	12	0%	0	0%

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	Charter		Traditional	
Unknown	0	0%	0	0%
Magazines in home				
Yes	95695	57%	2225	57%
No	40167	24%	911	23%
I Don't Know	29309	17%	667	17%
Omitted	3404	2%	133	3%
Multiple	22	0%	0	0%
Unknown	0	0%	0	0%
Books in home				
0-10 books	19634	12%	434	11%
11-25 books	35306	21%	901	23%
26-100 books	56725	34%	1217	31%
More than 100 books	53526	32%	1258	32%
Omitted	3359	2%	126	3%
Multiple	47	0%	0	0%
Unknown	0	0%	0	0%
Computer in home				
Yes	144162	86%	3362	85%
No	20419	12%	428	11%
Omitted	3999	2%	146	4%
Multiple	17	0%	0	0%
Unknown	0	0%	0	0%
Encyclopedia in home				
Yes	85818	51%	2035	52%
No	25320	15%	544	14%
I Don't Know	54087	32%	1229	31%
Omitted	3350	2%	128	3%
Multiple	22	0%	0	0%
Unknown	0	0%	0	0%
Pages read in school and for homework				
5 or fewer	34944	21%	912	23%
6-10	30880	18%	746	19%
11-15	23139	14%	449	11%
16-20	23805	14%	529	13%
More than 20	52313	31%	1167	30%
Omitted	3450	2%	129	3%
Multiple	66	0%	4	0%
Unknown	0	0%	0	0%
Talk about studies at home				
Never or hardly eve	29602	18%	648	16%
Every few weeks	22498	13%	475	12%
About once a week	19884	12%	429	11%
2-3 times a week	33893	20%	687	17%
Every day	59212	35%	1566	40%
Omitted	3465	2%	129	3%
Multiple	43	0%	2	0%
Unknown	0	0%	0	0%
Days absent from school last month				

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	Charter		Traditional	
None	84418	50%	1838	47%
1-2 days	49650	29%	1177	30%
3-4 days	19327	11%	474	12%
5-10 days	7608	5%	208	5%
More than 10 days	4136	2%	109	3%
Omitted	3396	2%	128	3%
Multiple	62	0%	2	0%
Unknown	0	0%	0	0%
Language other than English spoken in home				
Never	90390	54%	1798	46%
Once in a while	36078	21%	901	23%
Half the time	12161	7%	362	9%
All or most of time	26507	16%	743	19%
Omitted	3412	2%	129	3%
Multiple	49	0%	3	0%
Unknown	0	0%	0	0%
Learn a lot when reading books				
Never or hardly eve	8448	5%	185	5%
Sometimes	59897	36%	1331	34%
Often	50052	30%	1076	27%
Always or almost	46493	28%	1201	31%
Omitted	3687	2%	142	4%
Multiple	20	0%	1	0%
Unknown	0	0%	0	0%
Reading is a favorite subject				
Never or hardly eve	25581	15%	611	16%
Sometimes	60476	36%	1409	36%
Often	36703	22%	783	20%
Always or almost	41959	25%	987	25%
Omitted	3855	2%	146	4%
Multiple	23	0%	0	0%
Unknown	0	0%	0	0%
Do reading at after-school or tutoring program				
Yes	60364	36%	1718	44%
No	102803	61%	2029	52%
Omitted	5387	3%	189	5%
Multiple	43	0%	0	0%
Unknown	0	0%	0	0%
Go to book clubs, competitions, fairs for reading				
Yes	49006	29%	1255	32%
No	113968	68%	2491	63%
Omitted	5592	3%	189	5%
Multiple	31	0%	1	0%
Unknown	0	0%	0	0%
Read for fun on own				
Never or hardly eve	25028	15%	584	15%
Once or twice/month	24696	15%	569	14%
1-2 times a week	41186	24%	923	23%

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	Charter		Traditional	
Almost every day	72670	43%	1677	43%
Omitted	4984	3%	182	5%
Multiple	33	0%	1	0%
Unknown	0	0%	0	0%
Talk with friends about what you read				
Never or hardly eve	46333	27%	997	25%
Once or twice/month	34554	20%	739	19%
1-2 times a week	43383	26%	943	24%
Almost every day	40113	24%	1106	28%
Omitted	4180	2%	150	4%
Multiple	34	0%	1	0%
Unknown	0	0%	0	0%
Read a book you chose yourself				
Never or hardly eve	22712	13%	593	15%
Sometimes	40804	24%	1009	26%
Often	42467	25%	932	24%
Always or almost	56171	33%	1196	30%
Omitted	6413	4%	205	5%
Multiple	30	0%	1	0%
Unknown	0	0%	0	0%

Table 9: Grade 4 Reading Unadjusted NAEP Score

	Charter Schools						Public Schools					
	n	mean	sd	median	min	max	n	mean	sd	median	min	max
Overall	3936	213.26	32.94	215.22	92.27	302.97	168597	218.76	33.66	221.79	14.71	330.96
Alaska	117	226.06	33.86	233.08	101.93	278.72	2666	214.43	36.60	219.70	78.50	302.46
Arkansas	242	213.15	34.22	216.30	105.63	294.52	2943	208.58	38.27	212.92	14.71	319.32
Canal zone	183	196.96	35.30	194.82	92.27	286.62	7822	204.44	35.95	206.11	51.07	318.34
Connecticut	143	229.69	33.61	235.33	124.55	291.85	2777	225.49	34.52	230.29	85.98	316.87
D.C.	541	198.75	31.53	199.60	102.07	280.99	1307	204.14	37.69	203.42	71.14	330.96
Florida	216	222.89	27.69	223.23	152.52	293.06	2649	225.96	27.61	227.81	113.17	309.18
Idaho	185	227.25	24.58	228.11	141.86	288.14	4771	224.10	29.65	226.17	97.23	312.59
Illinois	179	220.16	32.54	220.82	94.63	287.95	4056	215.07	33.27	216.54	89.20	321.26
Iowa	78	215.14	36.63	222.41	96.15	289.85	2914	210.77	38.37	214.86	50.22	309.30
Kansas	72	242.29	27.73	247.02	157.89	290.30	3169	220.49	31.59	224.11	73.45	294.68
Kentucky	81	204.56	33.03	206.21	134.27	276.43	4314	213.09	36.59	216.16	82.70	322.40
Michigan	73	200.08	24.97	197.83	158.07	269.88	3079	207.87	31.56	209.30	75.54	298.16
Mississippi	152	207.05	28.29	208.95	142.04	274.30	3297	220.71	32.60	220.73	109.43	322.77
Missouri	54	225.77	22.09	225.23	169.00	265.05	3894	229.30	30.48	231.56	95.48	309.48
Montana	217	201.20	31.78	202.59	123.87	289.31	3487	212.74	34.23	215.29	75.67	302.63
Nebraska	109	221.06	36.91	223.34	101.89	285.11	3506	222.79	34.75	227.05	58.17	316.17
New York	75	215.17	29.94	216.60	134.65	278.63	3155	210.12	35.62	213.99	18.03	295.53
North Dakota	80	213.75	21.85	212.65	153.51	263.03	2805	230.06	28.90	231.41	118.16	321.05
Oklahoma	69	220.92	30.41	218.55	157.69	300.34	4162	221.95	32.22	224.25	99.34	306.82
Oregon	104	226.53	26.97	227.31	148.58	287.27	4720	219.46	34.73	223.00	40.55	309.55
Rhode Island	138	196.41	31.14	196.45	112.19	273.31	3464	218.63	32.97	220.65	101.22	305.91
South Dakota	56	225.22	31.87	229.31	148.54	285.83	3027	217.79	35.12	221.68	44.79	306.49
Tennessee	59	218.66	33.26	221.67	130.12	302.97	3846	216.38	36.39	218.94	45.75	316.07
Utah	85	217.99	31.30	218.14	135.33	283.96	2566	222.83	34.75	226.45	49.36	310.49
Washington	100	217.52	24.77	220.63	151.32	277.02	5854	216.69	30.85	216.91	91.15	318.03
West Virginia	203	228.59	27.26	231.71	137.46	287.80	3290	218.54	32.67	222.79	46.89	303.80
DoDEA/DDESS	153	200.04	32.60	198.92	123.03	273.93	3935	214.63	35.37	218.79	92.04	301.72

Table 10: Grade 8 Math Descriptive Statistics

	Traditional		Charter	
Race/ethnicity from school records (raw data)				
White	89701	59%	1114	27%
Black	26613	18%	1711	41%
Hispanic	23669	16%	974	24%
Asian Amer/Pacif Is	7318	5%	230	6%
Amer Ind/Alaska Nat	3250	2%	55	1%
Other	1497	1%	46	1%
Unknown	0	0%	0	0%
Natl School Lunch Prog eligibility (3 categories)				
Eligible	67525	44%	2358	57%
Not eligible	83452	55%	1553	38%
Info not available	1071	1%	219	5%
Unknown	0	0%	0	0%
Student has Individualized Education Plan				
Yes, IEP	14792	10%	377	9%
Yes, 504 plan	1308	1%	38	1%
Yes, 504 in process	0	0%	0	0%
Not IEP	135935	89%	3715	90%
Unknown	13	0%	0	0%
Student classified Eng Lang Learner (3 categories)				
Yes	6615	4%	276	7%
No	142006	93%	3712	90%
Formerly ELL	3404	2%	140	3%
Unknown	23	0%	2	0%
Gender				
Male	76976	51%	1996	48%
Female	75072	49%	2134	52%
Unknown	0	0%	0	0%
Student classified as having a disability (504)				
Student with disabi	16100	11%	415	10%
Not student with di	135935	89%	3715	90%
Omitted	13	0%	0	0%
Unknown	0	0%	0	0%
Student classified SD or ELL				
Student with disabi	15250	10%	389	9%
English language le	5765	4%	250	6%
Both SD and ELL	850	1%	26	1%
Neither SD nor ELL	130158	86%	3464	84%
Unknown	25	0%	1	0%
Newspaper in home				
Yes	55041	36%	1501	36%
No	62855	41%	1740	42%
I Don't Know	31056	20%	862	21%
Omitted	3068	2%	27	1%
Multiple	28	0%	0	0%
Unknown	0	0%	0	0%
Magazines in home				

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	Charter		Traditional	
Yes	92419	61%	2444	59%
No	40632	27%	1198	29%
I Don't Know	15801	10%	456	11%
Omitted	3172	2%	32	1%
Multiple	24	0%	0	0%
Unknown	0	0%	0	0%
Books in home				
0-10 books	21803	14%	578	14%
11-25 books	32216	21%	966	23%
26-100 books	51674	34%	1404	34%
More than 100 books	42985	28%	1148	28%
Omitted	3318	2%	34	1%
Multiple	52	0%	0	0%
Unknown	0	0%	0	0%
Computer in home				
Yes	133737	88%	3658	89%
No	13012	9%	386	9%
Omitted	5276	3%	86	2%
Multiple	23	0%	0	0%
Unknown	0	0%	0	0%
Encyclopedia in home				
Yes	106692	70%	3015	73%
No	22181	15%	571	14%
I Don't Know	19857	13%	509	12%
Omitted	3290	2%	35	1%
Multiple	28	0%	0	0%
Unknown	0	0%	0	0%
Pages read in school and for homework				
5 or fewer	44700	29%	1192	29%
6-10	32989	22%	928	22%
11-15	21654	14%	582	14%
16-20	17204	11%	512	12%
More than 20	31906	21%	865	21%
Omitted	3486	2%	46	1%
Multiple	109	0%	5	0%
Unknown	0	0%	0	0%
Talk about studies at home				
Never or hardly eve	35140	23%	825	20%
Every few weeks	28163	19%	776	19%
About once a week	26142	17%	698	17%
2-3 times a week	31254	21%	924	22%
Every day	27771	18%	863	21%
Omitted	3512	2%	44	1%
Multiple	66	0%	0	0%
Unknown	0	0%	0	0%
Days absent from school last month				
None	65078	43%	1692	41%
1-2 days	52510	35%	1393	34%

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	Charter		Traditional	
3-4 days	20084	13%	651	16%
5-10 days	7792	5%	257	6%
More than 10 days	3158	2%	101	2%
Omitted	3369	2%	35	1%
Multiple	57	0%	1	0%
Unknown	0	0%	0	0%
Mother's education level				
Did not finish h.s.	15175	10%	444	11%
Graduated h.s.	30320	20%	789	19%
Some ed after h.s.	25294	17%	752	18%
Graduated college	55231	36%	1396	34%
I Don't Know	22091	15%	701	17%
Omitted	3648	2%	44	1%
Multiple	289	0%	4	0%
Unknown	0	0%	0	0%
Father's education level				
Did not finish h.s.	15904	10%	457	11%
Graduated h.s.	30398	20%	730	18%
Some ed after h.s.	19878	13%	504	12%
Graduated college	46634	31%	1115	27%
I Don't Know	35054	23%	1267	31%
Omitted	3955	3%	52	1%
Multiple	225	0%	5	0%
Unknown	0	0%	0	0%
Language other than English spoken in home				
Never	86942	57%	1938	47%
Once in a while	28690	19%	860	21%
Half the time	11236	7%	428	10%
All or most of time	20361	13%	821	20%
Omitted	4766	3%	80	2%
Multiple	53	0%	3	0%
Unknown	0	0%	0	0%
Do math at after-school or tutoring program				
Yes	25981	17%	1025	25%
No	109053	72%	2712	66%
Omitted	16955	11%	393	10%
Multiple	59	0%	0	0%
Unknown	0	0%	0	0%
Math work is too easy				
Never or hardly eve	25733	17%	667	16%
Sometimes	79651	52%	2205	53%
Often	29995	20%	800	19%
Always/almost alway	11127	7%	339	8%
Omitted	5343	4%	111	3%
Multiple	199	0%	8	0%
Unknown	0	0%	0	0%
Math work is challenging				
Never or hardly eve	17626	12%	418	10%

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	Charter		Traditional	
Sometimes	64961	43%	1726	42%
Often	44818	29%	1298	31%
Always/almost alway	16629	11%	512	12%
Omitted	7824	5%	174	4%
Multiple	190	0%	2	0%
Unknown	0	0%	0	0%
Math work is engaging and interesting				
Never or hardly eve	34020	22%	756	18%
Sometimes	53378	35%	1415	34%
Often	38173	25%	1054	26%
Always or almost	19386	13%	732	18%
Omitted	7027	5%	171	4%
Multiple	64	0%	2	0%
Unknown	0	0%	0	0%
Math is fun				
Strongly disagree	17997	12%	472	11%
Disagree	49601	33%	1262	31%
Agree	62324	41%	1685	41%
Strongly agree	17723	12%	629	15%
Omitted	4319	3%	80	2%
Multiple	84	0%	2	0%
Unknown	0	0%	0	0%
Like math				
Strongly disagree	17227	11%	428	10%
Disagree	34661	23%	922	22%
Agree	69362	46%	1827	44%
Strongly agree	26051	17%	875	21%
Omitted	4628	3%	74	2%
Multiple	119	0%	4	0%
Unknown	0	0%	0	0%
Math is a favorite subject				
Strongly disagree	31790	21%	863	21%
Disagree	43981	29%	1133	27%
Agree	40525	27%	1020	25%
Strongly agree	30609	20%	1004	24%
Omitted	5108	3%	109	3%
Multiple	35	0%	1	0%
Unknown	0	0%	0	0%

Table 11: Grade 8 Math Unadjusted NAEP Score

	Charter Schools						Public Schools					
	n	mean	sd	median	min	max	n	mean	sd	median	min	max
Overall	4130	272.20	35.28	271.11	169.36	393.58	152048	280.77	34.88	281.50	126.93	400.47
Arkansas	105	273.39	34.78	265.78	169.36	343.91	2810	276.52	37.05	277.89	127.19	388.86
Canal zone	525	270.52	32.62	271.64	179.08	355.79	6606	266.15	36.73	265.25	146.91	384.02
Connecticut	125	294.37	39.89	294.63	184.51	393.58	2604	287.16	35.40	289.18	150.14	388.99
D.C.	825	256.83	30.99	254.59	173.87	346.00	870	251.82	39.61	250.26	142.88	384.80
Florida	201	294.07	34.66	294.89	204.19	374.46	2541	283.58	30.34	283.45	163.22	380.68
Idaho	272	283.12	29.62	282.81	192.00	370.99	4055	275.81	33.28	276.45	155.34	374.40
Illinois	90	262.43	29.52	262.06	193.38	330.81	3420	272.88	33.19	271.68	150.65	379.68
Iowa	167	278.44	33.09	281.78	183.00	354.42	2652	273.38	35.74	276.02	141.25	387.09
Kansas	90	302.88	29.24	303.84	198.35	377.42	2881	286.73	33.00	288.11	155.23	390.15
Kentucky	110	262.54	28.28	263.47	186.53	346.25	3981	276.59	34.83	276.44	145.80	377.44
Louisiana	77	283.53	31.97	290.89	206.16	341.36	2571	286.85	30.56	287.45	180.13	375.12
Michigan	90	266.23	32.25	264.51	193.70	359.20	2498	272.22	31.66	270.90	144.33	379.44
Mississippi	73	265.06	26.02	264.32	210.36	330.42	3132	280.86	37.37	279.87	165.91	380.51
Missouri	61	291.78	28.81	294.00	227.58	353.68	3513	294.51	36.13	295.84	160.48	390.57
Montana	160	250.50	32.19	248.72	182.79	361.40	3221	268.85	39.61	269.65	152.12	381.41
Nebraska	80	296.78	37.39	299.59	186.61	371.70	2818	293.76	33.17	295.30	176.56	388.60
Oregon	93	285.52	33.31	287.31	201.69	346.33	4347	281.90	36.25	282.12	138.57	399.87
Rhode Island	94	264.65	29.71	260.31	205.85	355.42	3400	278.90	34.16	278.95	159.93	383.14
Tennessee	112	266.91	31.22	268.06	185.07	329.18	3439	282.63	36.14	284.27	141.96	391.93
Washington	134	291.15	37.59	291.27	199.06	372.41	5650	283.48	33.17	283.10	147.24	392.43
West Virginia	118	294.04	32.96	298.47	221.08	366.48	2765	282.25	33.24	284.52	153.63	374.36
DoDEA/DDESS	231	252.79	31.72	251.29	178.28	376.65	3243	282.00	34.97	284.13	143.51	372.36

Table 12: Grade 8 Reading Descriptive Statistics

	Traditional		Charter	
Race/ethnicity from school records (raw data)				
White	89855	59%	1147	28%
Black	26163	17%	1631	40%
Hispanic	23219	15%	974	24%
Asian Amer/Pacif Is	7232	5%	241	6%
Amer Ind/Alaska Nat	3341	2%	50	1%
Other	1494	1%	45	1%
Unknown	0	0%	0	0%
Natl School Lunch Prog eligibility (3 categories)				
Eligible	66739	44%	2282	56%
Not eligible	83449	55%	1593	39%
Info not available	1116	1%	213	5%
Unknown	0	0%	0	0%
Student has Individualized Education Plan				
Yes, IEP	13779	9%	334	8%
Yes, 504 plan	1433	1%	38	1%
Yes, 504 in process	0	0%	0	0%
Not IEP	136080	90%	3714	91%
Unknown	12	0%	2	0%
Student classified Eng Lang Learner (3 categories)				
Yes	5609	4%	278	7%
No	142262	94%	3674	90%
Formerly ELL	3422	2%	132	3%
Unknown	11	0%	4	0%
Gender				
Male	76149	50%	1887	46%
Female	75155	50%	2201	54%
Unknown	0	0%	0	0%
Student classified as having a disability (504)				
Student with disabi	15212	10%	372	9%
Not student with di	136080	90%	3714	91%
Omitted	12	0%	2	0%
Unknown	0	0%	0	0%
Student classified SD or ELL				
Student with disabi	14453	10%	343	8%
English language le	4850	3%	249	6%
Both SD and ELL	759	1%	29	1%
Neither SD nor ELL	131226	87%	3463	85%
Unknown	16	0%	4	0%
Newspaper in home				
Yes	54092	36%	1448	35%
No	63146	42%	1765	43%
I Don't Know	31080	21%	842	21%
Omitted	2962	2%	33	1%
Multiple	24	0%	0	0%
Unknown	0	0%	0	0%
Magazines in home				

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	Charter		Traditional	
Yes	92551	61%	2405	59%
No	39842	26%	1194	29%
I Don't Know	15813	10%	455	11%
Omitted	3079	2%	34	1%
Multiple	19	0%	0	0%
Unknown	0	0%	0	0%
Books in home				
0-10 books	20713	14%	567	14%
11-25 books	31676	21%	960	23%
26-100 books	52567	35%	1392	34%
More than 100 books	43159	29%	1134	28%
Omitted	3145	2%	35	1%
Multiple	44	0%	0	0%
Unknown	0	0%	0	0%
Computer in home				
Yes	133345	88%	3639	89%
No	12521	8%	351	9%
Omitted	5411	4%	97	2%
Multiple	27	0%	1	0%
Unknown	0	0%	0	0%
Encyclopedia in home				
Yes	105951	70%	2979	73%
No	21837	14%	542	13%
I Don't Know	20295	13%	527	13%
Omitted	3196	2%	40	1%
Multiple	25	0%	0	0%
Unknown	0	0%	0	0%
Pages read in school and for homework				
5 or fewer	42569	28%	1103	27%
6-10	33717	22%	943	23%
11-15	22450	15%	609	15%
16-20	18014	12%	497	12%
More than 20	31097	21%	890	22%
Omitted	3365	2%	44	1%
Multiple	92	0%	2	0%
Unknown	0	0%	0	0%
Talk about studies at home				
Never or hardly eve	33589	22%	798	20%
Every few weeks	27196	18%	723	18%
About once a week	26128	17%	693	17%
2-3 times a week	32644	22%	922	23%
Every day	28300	19%	907	22%
Omitted	3401	2%	43	1%
Multiple	46	0%	2	0%
Unknown	0	0%	0	0%
Days absent from school last month				
None	64800	43%	1734	42%
1-2 days	52913	35%	1411	35%

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	Charter		Traditional	
3-4 days	19761	13%	580	14%
5-10 days	7545	5%	239	6%
More than 10 days	2959	2%	85	2%
Omitted	3273	2%	37	1%
Multiple	53	0%	2	0%
Unknown	0	0%	0	0%
Mother's education level				
Did not finish h.s.	14613	10%	404	10%
Graduated h.s.	29684	20%	738	18%
Some ed after h.s.	25710	17%	780	19%
Graduated college	55743	37%	1439	35%
I Don't Know	21753	14%	670	16%
Omitted	3557	2%	46	1%
Multiple	244	0%	11	0%
Unknown	0	0%	0	0%
Father's education level				
Did not finish h.s.	15332	10%	423	10%
Graduated h.s.	30398	20%	710	17%
Some ed after h.s.	20427	14%	545	13%
Graduated college	46954	31%	1153	28%
I Don't Know	34150	23%	1197	29%
Omitted	3868	3%	53	1%
Multiple	175	0%	7	0%
Unknown	0	0%	0	0%
Language other than English spoken in home				
Never	86786	57%	1894	46%
Once in a while	28564	19%	922	23%
Half the time	11228	7%	433	11%
All or most of time	20222	13%	765	19%
Omitted	4455	3%	72	2%
Multiple	49	0%	2	0%
Unknown	0	0%	0	0%
Reading is a favorite activity				
Strongly disagree	37705	25%	830	20%
Disagree	54254	36%	1467	36%
Agree	33790	22%	1103	27%
Strongly agree	19268	13%	579	14%
Omitted	6237	4%	108	3%
Multiple	50	0%	1	0%
Unknown	0	0%	0	0%
Read for fun on own				
Never or hardly eve	46454	31%	1032	25%
Once or twice/month	33556	22%	1021	25%
1-2 times a week	35520	23%	1055	26%
Almost every day	30931	20%	902	22%
Omitted	4769	3%	76	2%
Multiple	74	0%	2	0%
Unknown	0	0%	0	0%

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	Charter		Traditional	
Use school/public library for info for own use				
Never or hardly eve	76861	51%	2100	51%
Once/twice a month	44184	29%	1205	29%
Once or twice a wee	20071	13%	558	14%
Every day or almost	6138	4%	175	4%
Omitted	4029	3%	50	1%
Multiple	21	0%	0	0%
Unknown	0	0%	0	0%
Do Eng/lang arts at after-school or tutoring prog				
Yes	26604	18%	1099	27%
No	120344	80%	2920	71%
Omitted	4330	3%	67	2%
Multiple	26	0%	2	0%
Unknown	0	0%	0	0%
Go to book clubs, competitions, fairs for reading				
Yes	33064	22%	1147	28%
No	111689	74%	2818	69%
Omitted	6523	4%	123	3%
Multiple	28	0%	0	0%
Unknown	0	0%	0	0%

Table 13: Grade 8 Reading Unadjusted NAEP Score

	Charter Schools						Public Schools					
	n	mean	sd	median	min	max	n	mean	sd	median	min	max
Overall	4088	256.27	32.94	258.06	122.77	350.97	151304	261.65	31.88	264.69	73.88	395.38
Arkansas	96	256.04	41.63	256.14	122.77	339.36	2739	256.81	34.43	260.57	126.56	342.91
Canal zone	500	248.96	35.63	252.66	126.10	345.55	6684	247.48	35.33	250.24	96.30	358.39
Connecticut	148	276.04	28.27	283.61	163.67	341.03	2607	264.17	30.14	266.49	124.53	356.84
D.C.	792	245.50	29.44	246.59	148.27	330.85	826	241.77	37.62	241.67	124.79	340.51
Florida	195	273.34	30.08	275.57	190.41	340.18	2557	264.75	27.37	267.22	166.92	332.18
Idaho	281	268.82	26.71	271.59	192.71	331.07	3928	262.15	31.40	264.16	133.45	349.50
Illinois	86	247.23	31.37	250.03	159.75	307.27	3397	258.36	31.06	259.82	119.83	343.14
Iowa	172	256.51	32.18	257.96	173.44	331.34	2693	254.25	31.71	257.49	133.60	337.56
Kansas	86	284.32	25.90	289.36	194.44	341.67	2879	263.96	30.26	267.31	116.64	336.22
Kentucky	107	248.44	23.29	250.67	198.59	300.52	3996	259.71	32.04	262.56	144.33	349.01
Louisiana	77	253.69	20.75	256.41	207.58	294.13	2579	266.40	28.59	268.56	140.72	337.32
Michigan	89	250.34	27.67	250.06	170.25	333.93	2514	253.14	31.67	255.03	111.28	348.55
Mississippi	77	247.56	21.96	245.11	196.99	290.06	3095	262.49	32.50	263.18	115.34	352.86
Missouri	56	276.37	29.72	272.99	182.71	343.64	3557	269.19	31.68	271.05	132.08	350.95
Montana	162	244.84	30.73	244.12	154.60	319.40	3174	255.36	34.99	258.19	113.45	349.25
Nebraska	78	272.22	39.25	280.31	174.13	350.97	2803	269.01	29.01	272.52	117.90	350.65
Oregon	90	266.50	37.32	272.90	170.18	344.88	4374	257.97	34.14	261.08	98.30	357.58
Rhode Island	87	253.08	28.29	255.80	193.19	304.42	3267	262.96	31.65	265.72	112.27	344.09
Tennessee	118	255.62	30.19	254.58	191.20	320.67	3429	263.73	32.48	266.63	145.83	358.89
Washington	131	265.94	34.58	271.95	147.12	335.37	5602	257.67	31.76	260.22	102.43	341.04
West Virginia	118	275.83	27.11	277.67	189.22	326.77	2712	263.53	30.14	266.53	143.86	340.59
DoDEA/DDESS	216	245.73	31.56	246.19	159.34	337.02	3181	262.14	32.15	266.18	119.62	339.34

Appendix E

Covariate Missingness

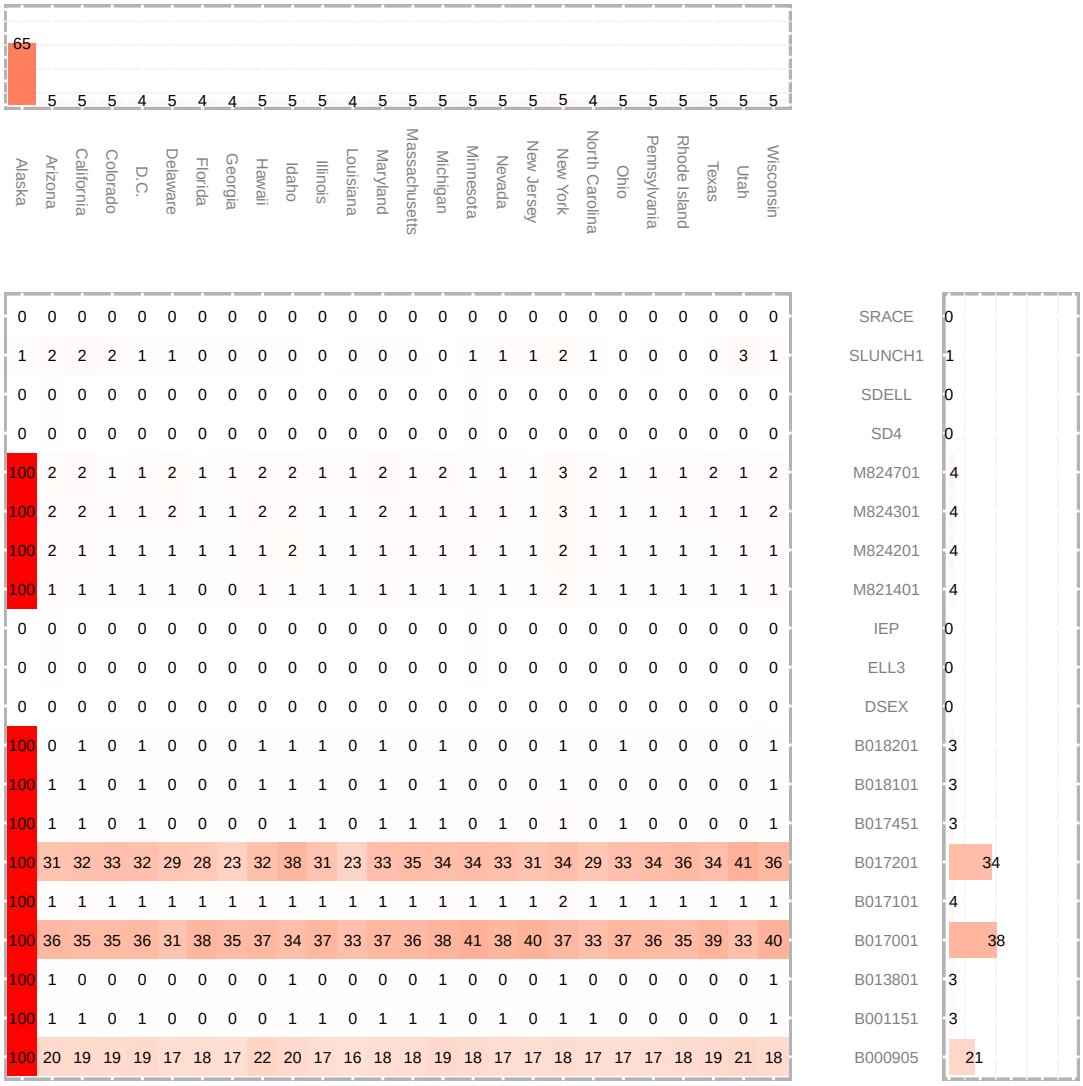

Figure 12: Covariate Missingness for Grade 4 Math

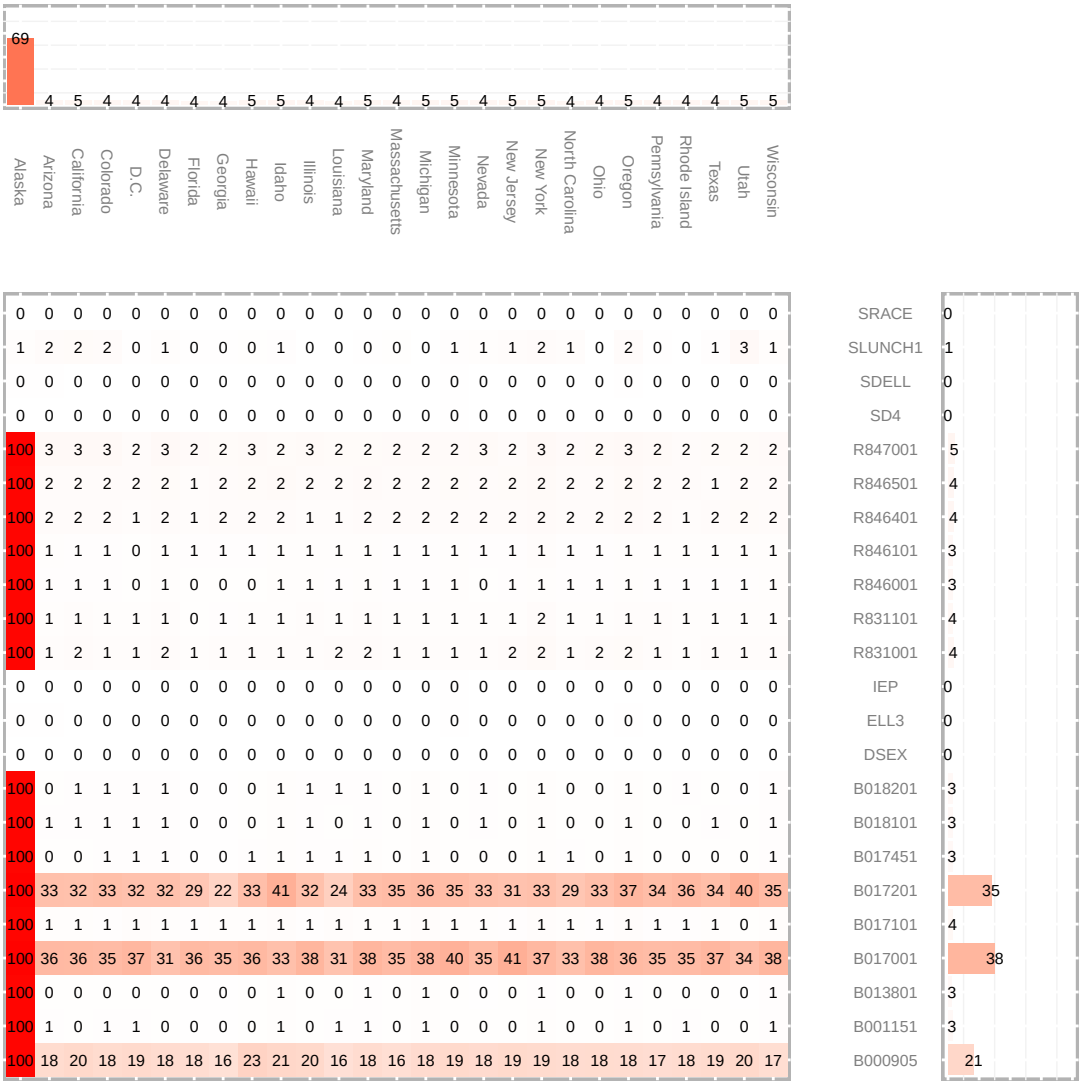

Figure 13: Covariate Missingness for Grade 4 Reading

Figure 14: Covariate Missingness for Grade 8 Math

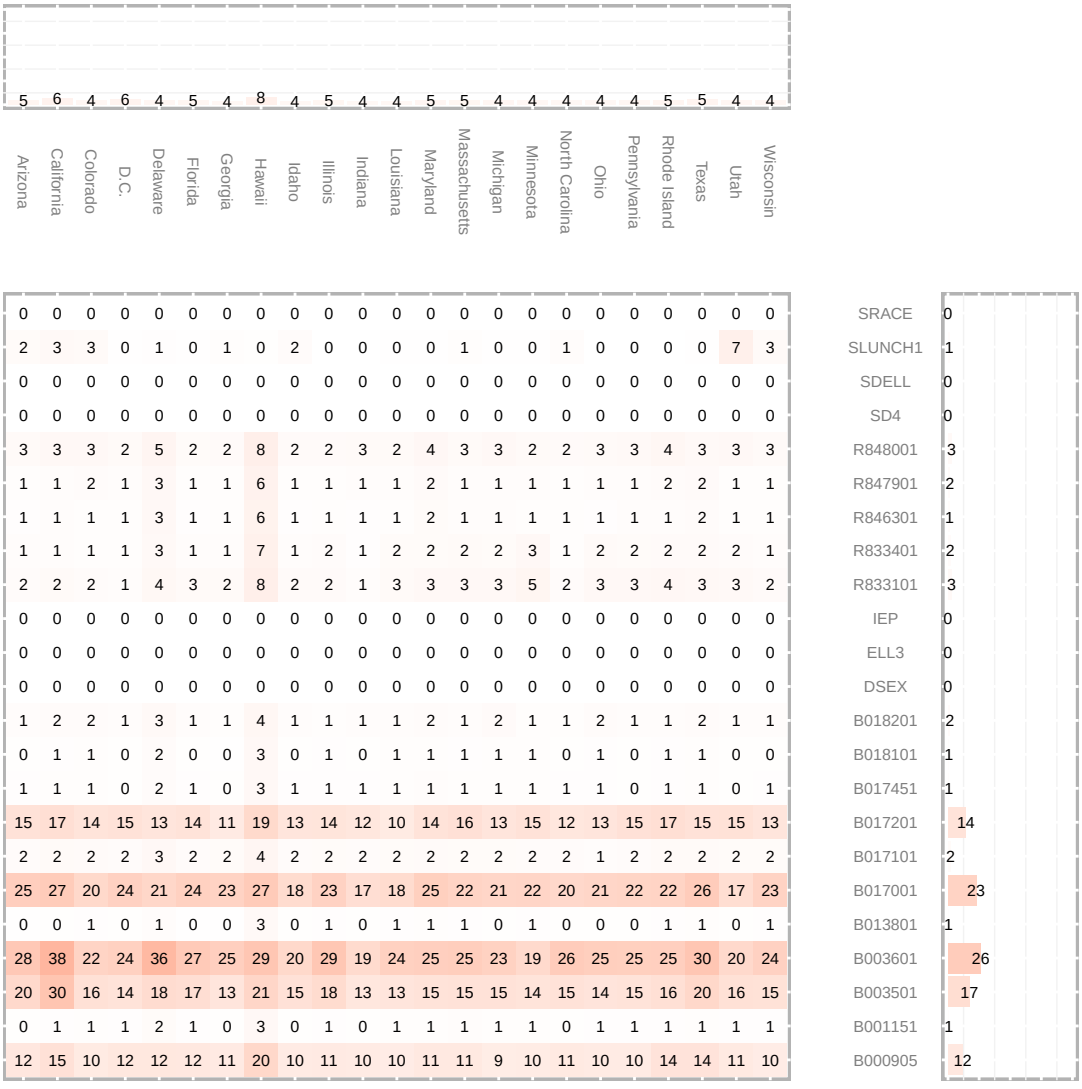

Figure 15: Covariate Missingness for Grade 8 Reading

Appendix F

Logistic Regression Full Model

Appendix G

Logistic Regression Step AIC Model

Appendix H

Conditional Inference Trees

Appendix I

Heat Maps of Relative Importance of Covariates Identified from Conditional Inference Tree Analysis

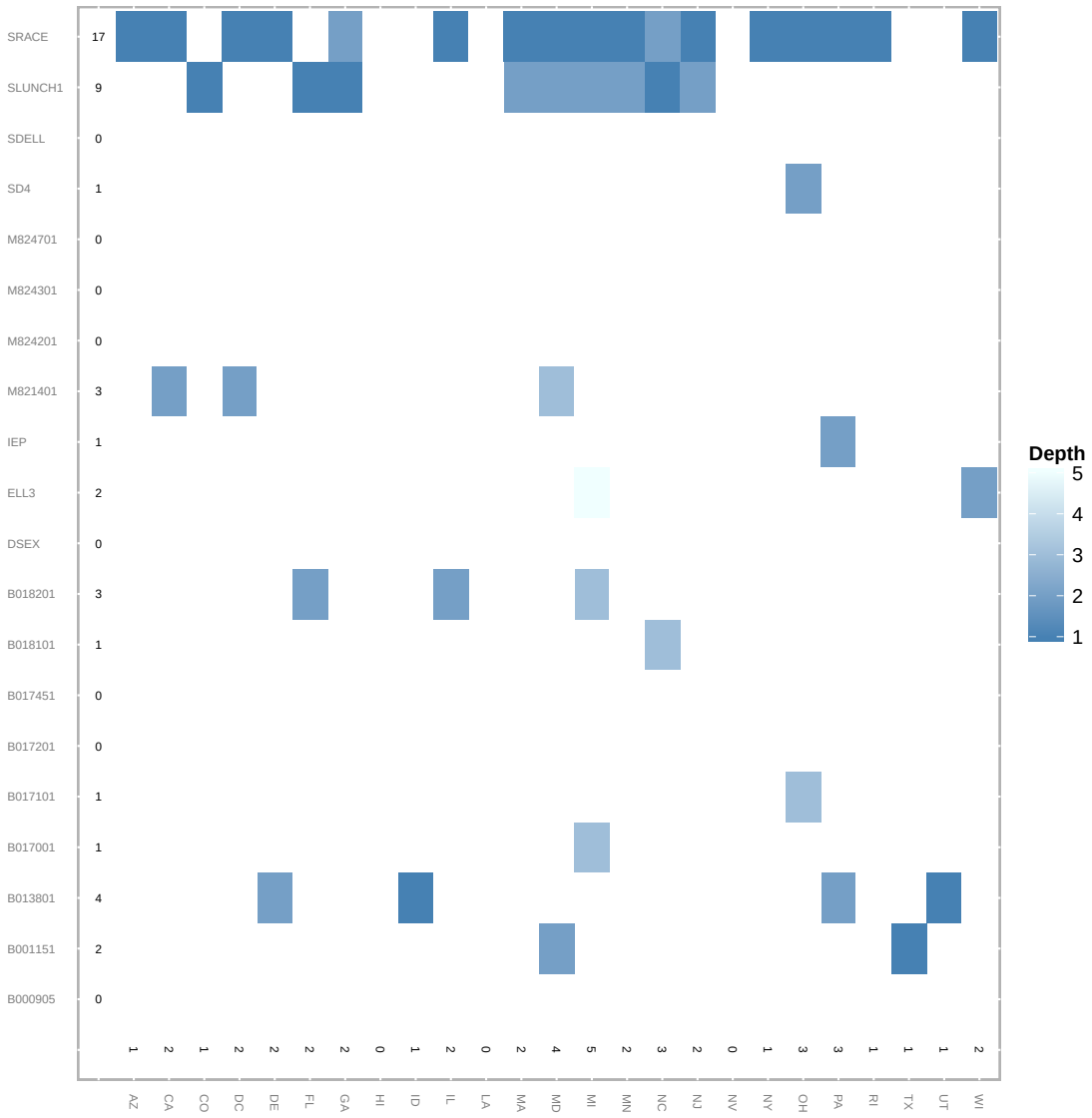

Figure 16: Heat Map of Relative Importance of Covariates for Phase I: Grade 4 Math

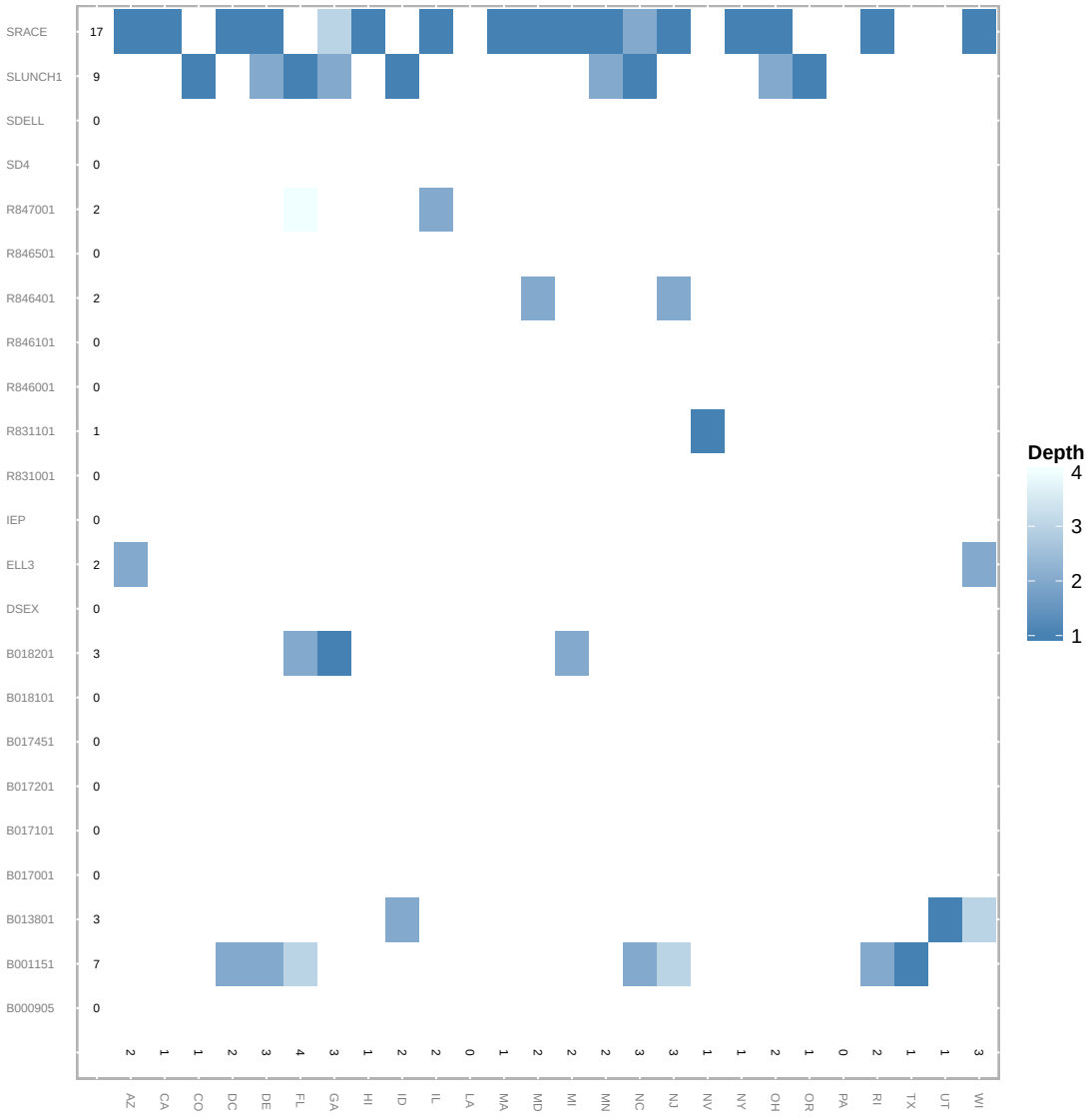

Figure 17: Heat Map of Relative Importance of Covariates for Phase I: Grade 4 Reading

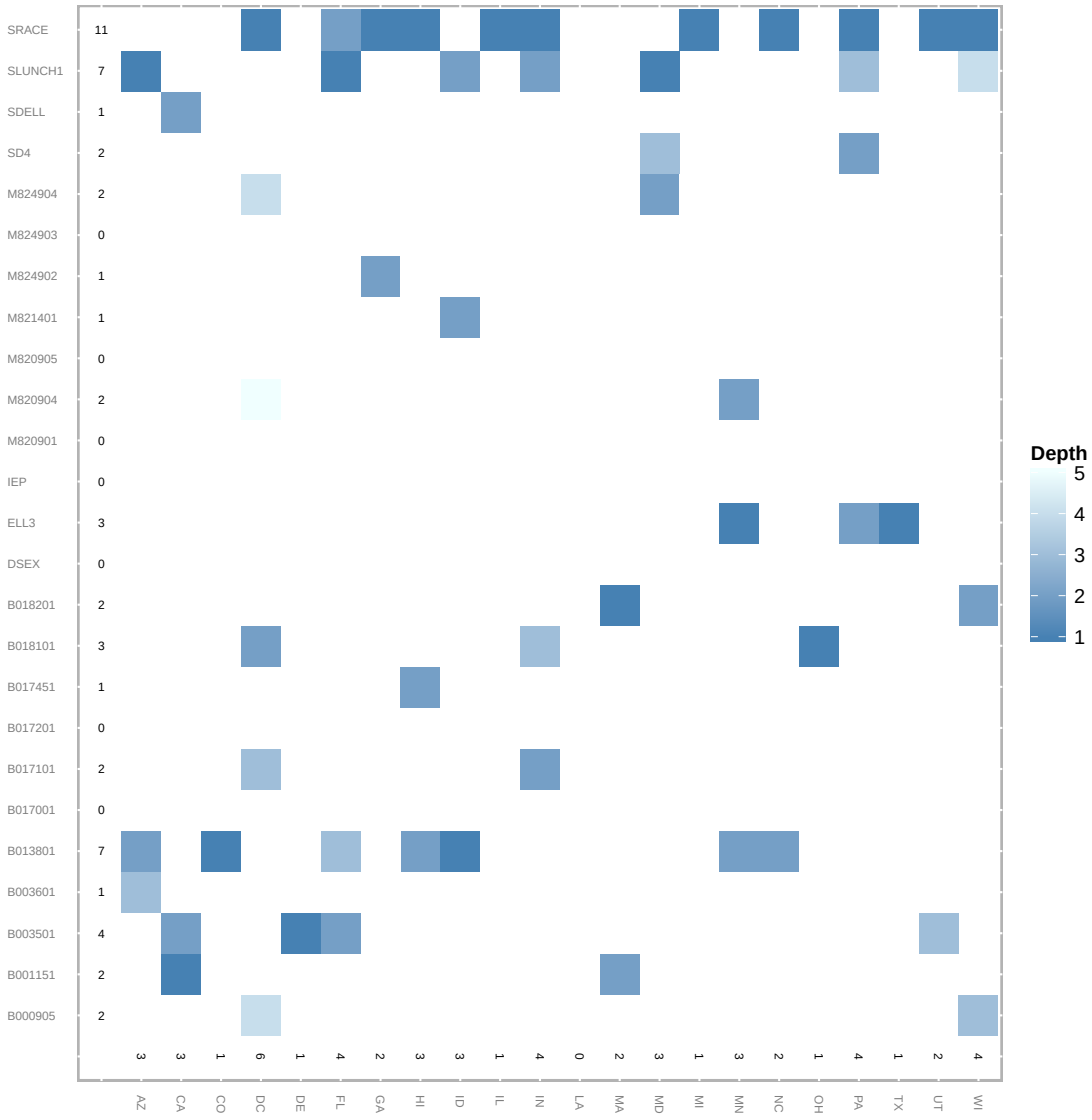

Figure 18: Heat Map of Relative Importance of Covariates for Phase I: Grade 8 Math

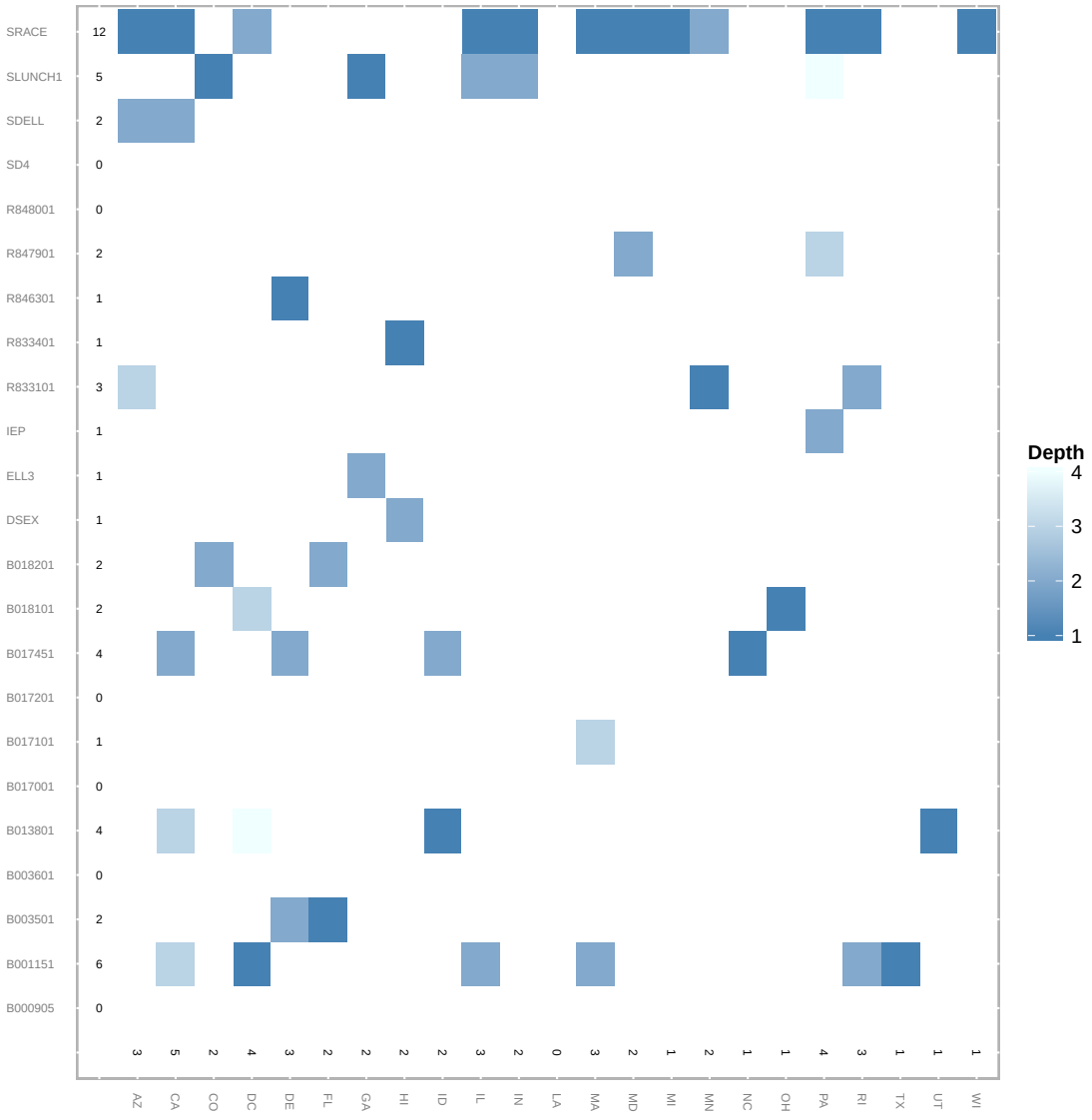

Figure 19: Heat Map of Relative Importance of Covariates for Phase I: Grade 8 Reading

Appendix J

Distribution of NAEP Scores for Matched vs. Unmatched Public School Students

The figures in this appendix represent the distributions of matched and unmatched public school students as identified by the full logistic regression model. These models were chosen since they resulted in the largest number of unmatched public school students vis-à-vis stratification. It should be noted that for some states there may be only one density line. This indicates that all public school students within that state were either all matched or all not matched.

Appendix K

multilevelPSA R Package

The `multilevelPSA` R package was developed, in part, to conduct the analysis for this dissertation. It is available from the Comprehensive R Archive Network (CRAN) at `http://cran.r-project.org/web/packages/multilevelPSA`. The latest version can be installed using the `install.packages` function in R:

```
> install.packages('multilevelPSA', repos='http://cran.r-project.org')
```

The following list provides brief descriptions of the key functions in the `multilevelPSA` package. More information is available vis-à-vis the R help system.

`getPropensityScores` Returns a data frame with two columns corresponding to the level 2 variable and the fitted value from the logistic regression.

`getStrata` Returns a data frame with two columns corresponding to the level 2 variable and the leaves from the conditional inference trees.

`loess.plot` Loess plot with density distributions for propensity scores and outcomes on top and right, respectively.

`missing.plot` Returns a heat map graphic representing missingness of variables grouped by the given grouping vector.

`mlpsa` This function will perform phase II of the multilevel propensity score analysis.

`plot.mlpsa` Creates the multilevel assessment plot.

`mlpsa.circ.plot` Plots the results of a multilevel propensity score model.

`mlpsa.ctree` Estimates propensity scores using the recursive partitioning in a conditional inference framework.

`mlpsa.difference.plot` Creates a graphic summarizing the differences between treatment and comparison groups within and across level two clusters.

`mlpsa.distribution.plot` Plots distribution for either the treatment or comparison group.

`mlpsa.logistic` Estimates propensity scores using logistic regression.

`psrange` Estimates models with increasing number of comparison subjects starting from 1:1 to using all available comparison group subjects.

`plot.psrange` Plots the results of `psrange`.

`tree.plot` Heat map representing variables used in a conditional inference tree across level 2 variables.