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 how charter schools perform with respect to their academic outcomes for students.

This dissertation has two major goals: 1. To develop new methods, largely graphical in form, to facilitate multilevel or cluster analyses of observational data while accounting for covariate differences between the groups being compared, and 2. to use these new methods using a large archival data base to compare outcomes for students who attend charter schools with their traditional 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) that aim to reduce if not eliminate selection bias in the context of clustered data. Charter schools are, by definition, schools of choice; traditional public schools are, at least by default, also schools of choice. This means that observational data methods are needed to compare these two kinds of schools with one another because

students (or their parents) who choose between these two kinds of schools tend to be systematically different from one another with respect to multiple covariates. That is, comparisons of these two kinds of schools tend to be afflicted by selection bias, or as in this case, the likely systematic differences introduced due to the lack of randomization of students being placed in either of the two groups.. Given well designed observational studies, and appropriate analysis methods, effects of the selection bias may be reduced, if not eliminated. The advent of new methods for observational data analysis will generally result in ways to replace simple comparisons of two independent groups by comparisons that make adjustments for covariate differences. In the present context the new methods do this chiefly using graphical methodologies.

New statistical procedures for observational data analysis 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 development and use in situations where multilevel, or clustered data are of interest, have been limited (Thoemmes & Kim, 2011).

Using data from the 2007 and 2009 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).

INTRODUCTION

Since the opening of the first charter school in Minnesota in 1991, the United States[1] has increasingly embraced charter schools as an option for educational reform. In the last 10 years for which data are available, the number of charter schools grew 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 charter school supporter Arne Duncan's appointment as Secretary of Education by President Barack Obama, charter school growth seems likely to continue in the near future.

In principle, charter schools opt out of bureaucratic rules and union contracts in order to gain administrative autonomy. The standard argument has become that this autonomy will lead to higher student test scores and better academic environments (Wells, 2002) because in the charter framework, teachers, administrators, students and the community that comprise charter schools are free to innovate. Proponents argue that charter schools are more likely than their conventional counterparts to serve as experimental schools where the innovations can inform reform of public education at large. Some charter supporters even envision a time when most traditional public schools will be replaced by charter schools. This is exemplified by the attempted school voucher legislation during the second G.W. Bush Administration.

Clearly charter schools have become a popular vehicle among parents. The Center for Education Reform (2008) reports that 59% of charter schools have waiting lists averaging 198 students. Charter schools seem to have provided an apparent choice to many parents

[1]Though this study focuses on charter schools in the U.S., Canada (Foundations for the Future Charter Academy, 2007), Chile (Larrañaga, 2004), England (Wohlstetter & Anderson, 1994), Germany (Herbst, 2006), and New Zealand (Lander, 2001) also have charter schools.

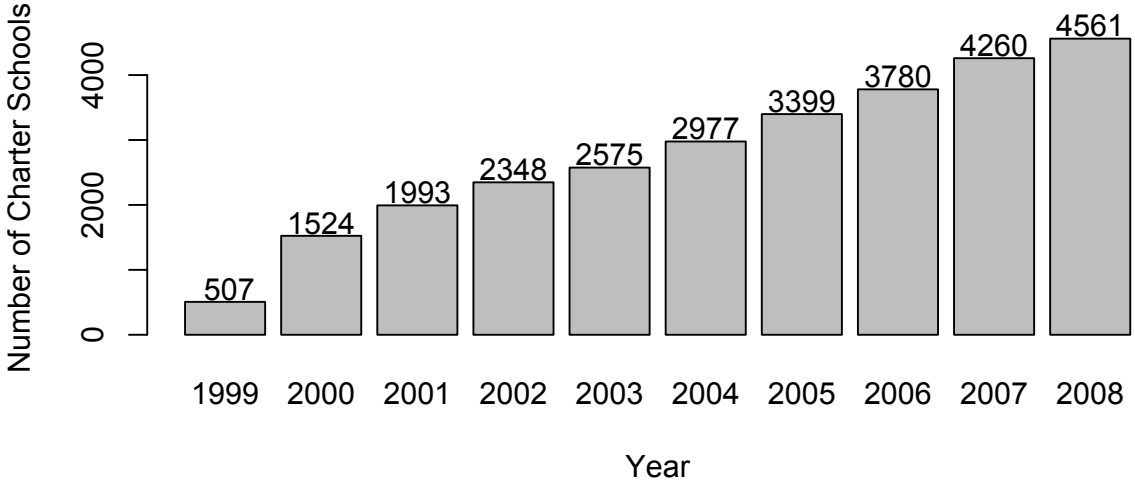

Figure 1: Charter School Growth 1999-2008

and are congruent with the United States individualistic (see e.g., Hofstede & Hofstede, 2004; Maccall, 1847; Swart, 1962) culture.

Whatever the generic arguments supporting charter schools in the U.S., it is clear that sound empirical evidence is needed to evaluate this class of schools in relation to their traditional counterparts. Several studies have shown that charter schools are not only failing to increase student performance, but in fact often perform well below their traditional public school counterparts in terms of achievement test scores (see e.g., Center for Research on Education Outcomes, 2009; Braun et al., 2006; 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 disadvantaged 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

A large number of issues surround the topic charter schools, including their nature or form, their settings and especially their curricula. Given the numbers of current and future generations of students for which decisions about charter schools have central implications, one key concern must certainly be that of comparative outcomes of charter in relation to traditional public schools. Clearly, this issue should be explored using the best and most comprehensive data and methods available. Betts and Hill (2006) identify 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 issue of selection bias[2].

2. The variation in types or kinds of charter schools (and the rules under which they operate in different states).

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

All of these issues are significant, but some are only partially amenable to empirical study, and some must be addressed in future research. We shall in fact focus on only a subset of these issues, and will do so only with respect to one large archival data set. Given the need

[2]Betts and Hill (2006) cite counterfactuals as the issue. Though the issue of counterfactals is an important concept in defining causal inference, it is problematic from a practical viewpoint. Specifically, it is impossible to observe two treatment conditions (or treatment and non-treatment) on the same individual (i.e. "the fundamental problem of causal inference", Holland, 1986).

for evidence regarding the relative performance of charter schools in relation to their conventional public school counterparts, we will focus on how effectively to use a large archival data set to ameliorate the effects of selection bias in the comparison of these two kinds of schools. The limitations of such study should also become clear, and will be discussed in some detail.

As noted above, selection bias will be examined in some detail. However, the central point is easy to state: statistical methods that incorporate propensity scores can provide ways to adjust for manifest selection bias in observational studies. It follows that under certain conditions, treatment comparisons, such as the comparison of charter and conventional public schools, can be clarified by reducing confounding effects through the use of covariates. In idealized conditions, interpretations of observational group comparisons can approach the qualities of randomized experiments with respect to the key goal of supporting causal inferences. To the extent that idealized conditions fail to exist or be reached, results of observational study comparisons will tend to become unclear, which is to say that confounding effects may continue to play a notable role. (While observational study comparisons may fail to provide sound causal evidence the same can be said for for true experiments, that is for studies where random assignments to groups have been employed. Of course the fundamental problem of causal inference remains (Holland, 1986). That is, it is impossible to observe treatment and non-treatment on the same unit of analysis.

The second issue noted above, that the term charter school" means different things in different contexts, is often cited in critiques of national or large-scale charter school studies. The same of course is also true of public schools! However, to suggest that such variations obviate meaningful comparisons of these two fundamentally different kinds of schools would be an extreme judgment, one that when generalized would preclude or at least hinder all school (type) comparisons. It is a key assumption of the proposed dissertation

that meaningful comparisons of charter and public schools does not require that each type be in any sense pure.

Given that the charter school debate is national, and has implications at the Federal level, large scale studies are not only likely to be useful, they are necessary because charter schools are routinely being offered, with few exceptions, as alternatives to traditional public schools, throughout the nation. For the few states that dont currently have charter schools, incentives at the federal level for states to have charter schools have been put forth (e.g. the Race to the Top Initiative). In the case of this work the aim is not to focus on particular charter schools, or types of charter schools, but rather to compare these kinds of schools under one broad umbrella using government sponsored archival data that derives from carefully developed tests. The specific focus is on outcomes for the subjects reading and mathematics, using data aggregated at the level of the states.

Lastly, the roles of environmental, social, community, and cultural factors that contribute to a students academic achievement are often ignored or 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.

Although educators acknowledge that schools, in their various forms, are only part of what contributes to student academic achievement, they are nevertheless important parts and it behooves educators to evaluate school effects quite generally. The particular approach used there is to compare school effects using a class of statistical methods that should make it possible to make clearer, less qualified conclusions, than is usually has been possible.

Research Questions & Objectives

The primary focus of this study is the development of a new set of methods for propensity score analysis with multilevel, or clustered, data. One of these aims is to show how graphics can be used to address research questions in the context of multilevel propensity score analysis; another is to describe and illustrate the key features of a new package of R functions to facilitate multilevel propensity score analyses, vis-à-vis the `multilevelPSA` package in R. Moreover, these new multilevel methods for propensity score analysis will be presented within the context of more traditional methods for propensity score analysis, namely stratification and matching. Not only will this show how these new methods perform with regard to more established methods, they may show with the use of modern graphics, how clusters may vary.

The newly developed multilevelPSA package will be shown to provide an effective means of estimating and visualizing propensity score results with clustered (multilevel) data (these procedures are discussed more fully below; see also Figure 2). Moreover, the use of pre-existing visualization procedures such as loess regression plots, density plots, as well as the PSA balance and assessment plots introduced by Helmreich and Pruzek (2009), can provide critical insight into the analysis and eventual interpretation of results. More succinctly, the presentation of graphics in this study are not merely provided for diagnostic or descriptive purposes, but are a critical component of presenting, analyzing, and interpreting results. For instance, related to research questions two and three below, it is the graphics that will be most revealing in the differences, if any, and not the numerical analyses (though numerical analyses are provided).

Given that charter schools are regularly being offered as solutions for 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 and traditional public schools using the National Assessment of Educational Progress (NAEP) using multiple propensity score methods. More specifically, this study proposes to address the questions:

1. Given appropriate adjustments based on available student data, is there a discernible difference between charter and traditional public schools with regard to math and reading scores at grades 4 and 8?

2. If so, what is the nature and magnitude of this difference for the two outcomes reading and mathematics (for two grade levels)?

3. And finally, how, and how much do identified differences differ between states with differing charter school laws?

METHOD

In this section I outline 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 sound and interpretable empirical evidence, preferably with support for causal inferences, is most desirable.

The *gold standard* of applied scientific 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 traditional public school. The theoretical justification for such a scheme is that any systematic differences between the two groups would be balanced through the randomization process. However, in practice, randomization is rarely feasible, and may not be ethical in the context of comparing charter and traditional public schools. This introduces a phenomenon called selection bias, which refers to systematic covariate

differences between the groups being compared, differences that tend to confound interpretations of comparative results. That is, any comparison of the two groups is likely to be biased given the fact that the units of study, are likely to be systematically different from one another on one or more covariates; such differences, in turn, generally make it impossible to interpret effects due to this confounding.

Propensity score analysis (Rosenbaum & Rubin, 1983) is a statistical methodology whereby the covariate differences between the two groups are, in large measure, taken into account. This is done through use of a method that uses available covariate information to construct propensity scores for each unit (student); comparisons are then made between the groups, conditional on the derived propensity scores.

In the case of this study the general approach being used is based on archival data, so it is retrospective, not prospective approach (where covariates are defined and measured by the investigator at the outset). In retrospective studies the investigator is limited to covariate data that was collected and included in the archive. Fortunately, in the case of the NAEP archive, extensive covariate information is available, which strengthens the case for using propensity score methods. Furthermore, the general procedure lends itself well to secondary analysis of the available 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 Educations Institute of Education Sciences (IES). The National Assessment of Educational Progress (NAEP) was started in 1971 and has regularly provided national measures of student achievement in many subjects including mathematics, reading, science, writing, history, civics, and the arts since its inception. In 2003 NAEP began assessing charter schools as well as private and public schools. This study will utilize the 2007 and 2009

administration 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 provide valuable insights into the academic differences between charter and traditional 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 to inform broadly about subject-matter achievement, instructional experiences, and school environments for states and regions in the U.S. (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 individual participants. Though not appropriate for assessing individual student achievement, in aggregate the NAEP measures provide statistically and psychometrically sound estimates of large group similarities and differences in student achievement.

In addition to subject area measures, NAEP includes student, teacher, and school questionnaires that provide contextual information about the students environment. 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 answers to items on these questionnaires provide the covariate information that will be used in PSA to adjust for selection bias. Propensity scores will be derived from the covariates to construct student propensity scores (e(x)), these being estimates of the probability of being in the treatment group (i.e. charter school in the context of this study). The complement of each propensity score, 1 - e(x), estimates the probability of

being in a traditional public school, based on available covariates. The responsibility for developing the assessment objectives and test specifications lies with the National Assessment Governing Board that was created by Congress in 1988. The governing board is charged with deciding what are appropriate achievement goals, nationally, and state-by-state, for each age and grade. The following two sections provide the framework for mathematics and reading assessments.

Analysis

Most of the studies conducted using PSA involve analysis in two phases where phase one involves 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, there is little research with regard to situations where data is multilevel. As such, this study will be organized as follows:

1. *Propensity score analysis using stratification.* This method ignores state assignment as a clustering variable. Under this broader method three statistical methods for stratification will be used:

    (a) Full logistic regression. This method will estimate propensity scores using logistic regression with all available covariates.

    (b) Logistic regression with step AIC. The `stepAIC` in the `MASS` package (Venables & Ripley, 2002) will select the best logistic model based upon the Akaike Information Criterion (Akaike, 1974). In this case the best first order interaction terms will be added to the main effect terms in a.

    (c) Conditional inference trees, based on all covariates; missing data will also be accommodated with the tree-based methods.[3]

[3]Random forest methods based on trees would, according to the available literature be more desirable

2. *Propensity score matching.* This method implicitly accounts for clustering. That is, the method used will find matches between treated and control units that first match exactly on state, ethnicity, and gender, then finds a best match based upon the propensity scores estimated using logistic regression. As suggested by Stuart (2010), multiple matched sets will be formed using (charter-to-traditional public school students):

   (a) One-to-one

   (b) One-to-five

   (c) One-to-ten.

   A dependent sample analysis will be performed on the resulting matched pairs (Austin, 2011).

3. *Multilevel propensity score analysis.* This method will utilize the same stratification methods as described in method one above, namely:

   (a) Full logistic regression.

   (b) Logistic regression with step AIC.

   (c) Conditional inference trees.

   However, where this method differs from method one is that separate models will be estimated for each state separately. Results from each state are then aggregated to provide an overall, national estimate of the differences between charter and traditional public school. Moreover, this method provides an approach whereby

that simple trees, but the large number of 'clusters' (states) and the relatively large sample size here make this option too time-consuming to consider.

differences between meaningful subgroups (states in this study) can be explored, especially with the use of graphics as described below.

It is generally recommended that multiple methods for the estimation of propensity scores be used (see e.g. Stuart & Rubin, 2008; Stuart, 2010). The choices of methods for this study were chosen first to provide estimations disregarding clustering, to utilize clustering implicitly, and to utilize clustering explicitly. Then secondly, within each of these three approaches with respect to clustering, multiple methods are used in accordance to the recommendations provided by Stuart and Rubin (2008) and Stuart (2010).

Visualizing Multilevel PSA

Given the large amount of data that needs to be summarized, the use of graphics will be an integral component of representing the results. The `multilevelPSA`[4] package provides a number of graphing functions that extend the framework introduced by Helmreich and Pruzek (2009) for multilevel PSA. Figure 2 represents a multilevel PSA assessment plot with annotations. In this graphic, the x-axis corresponds to traditional public school grade 8 NAEP scores and the y-axis corresponds to charter school grade 8 NAEP scores. Each colored circle (a) is a state with its size corresponding the number of students within each state. Each state is projected to the lower left, parallel to the unit line, such that a tick mark is placed on the line with slope -1 (b). These tick marks represent the distribution of differences between charter and traditional public schools across states. Differences are aggregated (and weighted by size) across states. For grade 8 math, the overall adjusted mean for charter school students is 278 and the overall adjusted mean for traditional public school student is 278 and represented by the horizontal (c) and vertical (d) blue lines, respectively. The dashed blue line parallel to the unit line (e)

[4]The `multilevelPSA` package was written by the author and is available from `http://github.com/jbryer/multilevelPSA`.

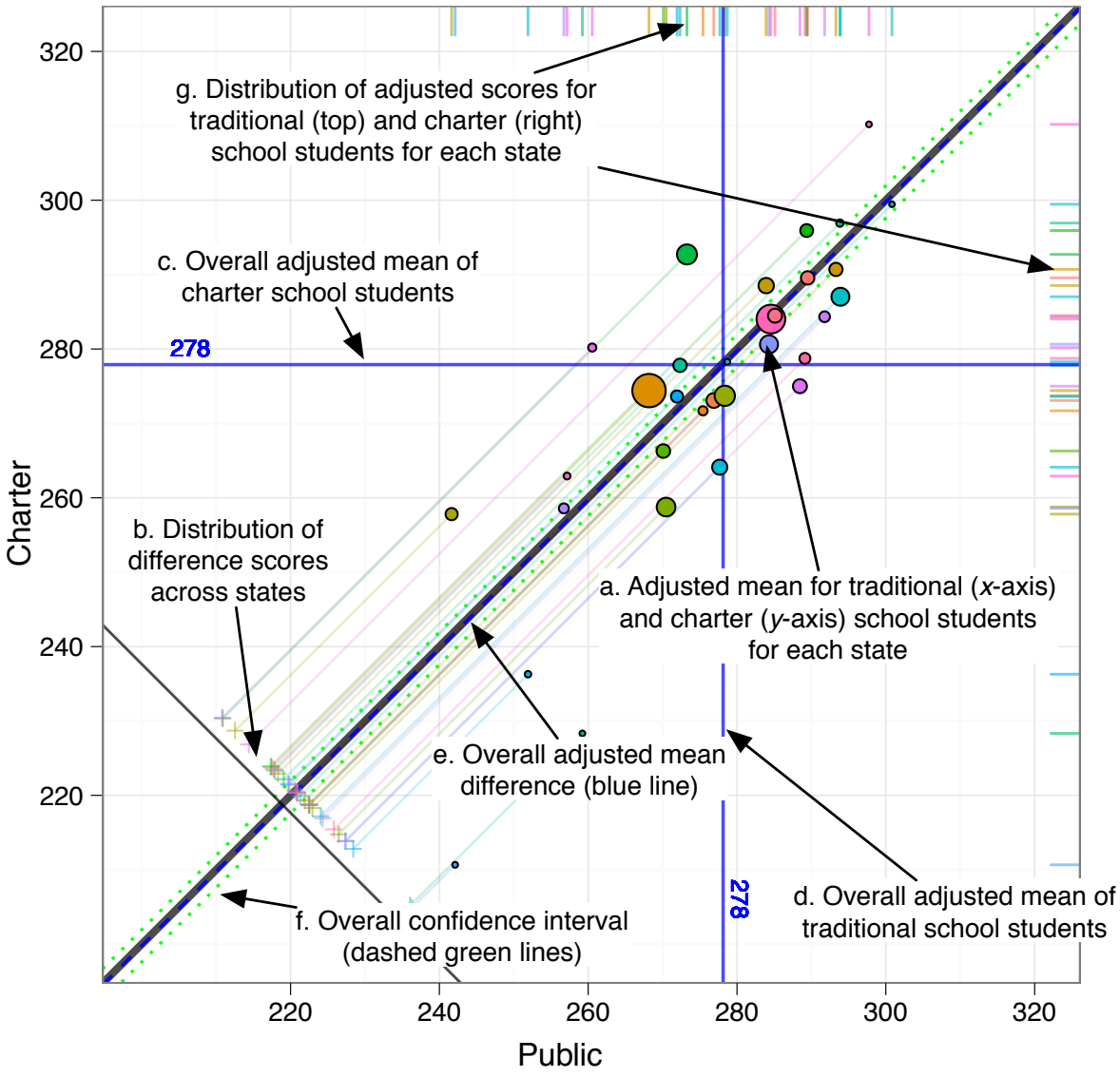

Figure 2: Multilevel PSA Assessment Plot

corresponds to the overall adjusted mean difference and likewise, the dashed green lines (f) correspond to the confidence interval. Lastly, rug plots along the right and top edges of the graphic (g) correspond to the distribution of each state's overall mean charter and traditional public school NAEP scores, respectively.

Figure 2 represents a large amount of data and allows provides much greater insight into the data and results. The figure provides overall results that would be present in a traditional table, for instance the fact that the green dashed lines span the unit line (i.e. y = x) indicates that there is a non-significant difference between the two groups. However additional information is difficult to convey in tabular format. For exmaple, the rug plots indicate that the variance in the performance of charter schools is much greater than that of traditional public schools. We can also observe that most states cluster near the overall mean (i.e. where the vertical and horizontal blue lines intersect), but there are a few states that perform well below the rest of the states (namely those located towards the bottom left of the figure). These are of particular interest due to the fact that theese states are among those with the greatest difference in favor of charter schools. That is, the states where charter schools are performing substantially better than their traditional public school counterparts are overall performing substaintly worse than other states.

Figure 3 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 strata within each state. The graphic also provides confidence intervals for each state as well as the overall adjusted mean difference (the vertical blue line) and confidence interval (the vertical green lines).

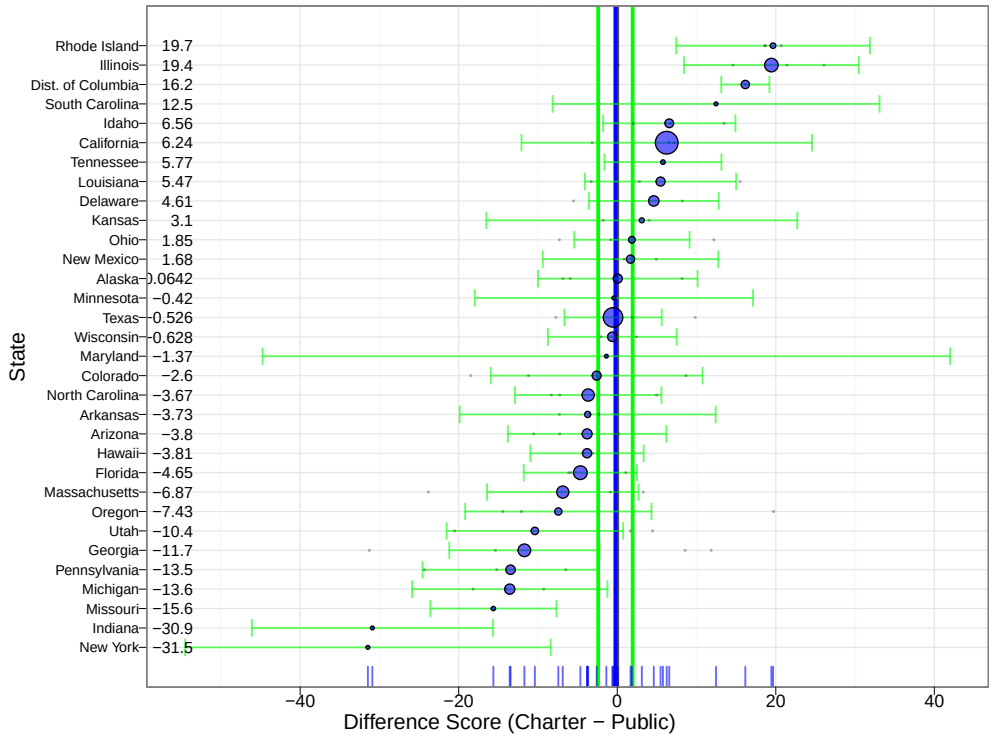

Figure 3: Multilevel PSA Difference Plot: Grade 8 Math

(PRELIMINARY) RESULTS

The tables and figures in this section represent the preliminary results of the analysis outlined in the methods section. Though these results will likely differ than the results reported in the final dissertation, they provide sufficient approximations.

Figure 4 provides a summary of all the results across the four dependent variables. This graphic displays the mean adjusted differences as blue dots with the confidence interval in green. Therefore, any instance where the confidence interval does not cross zero (as represented by the vertical black line) indicates there is a statistical significant difference. Tables 10, 11, and 12 in Appendix K provide the overall numerical results, that provide the basis for Figure 4, for each dependent variable (i.e. math and reading at grades 4 and 8) using stratification, matching, and multilevel PSA, respectively.

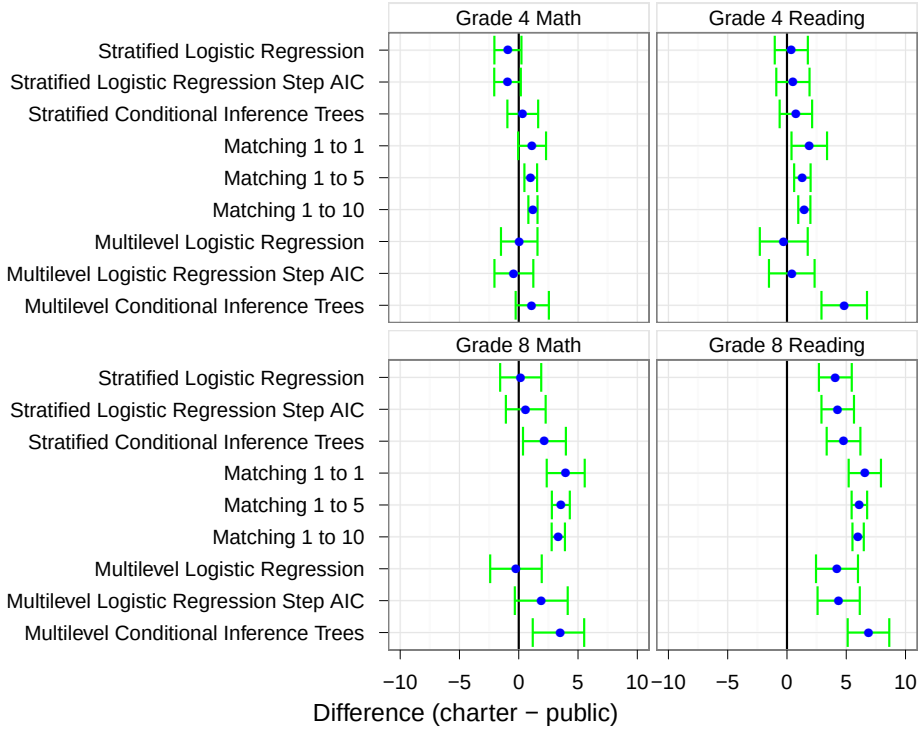

Figure 4: Summary of Overall Results

Examining Figure 4, I see there is general agreement across the nine different methods used. That is, given the various approaches to adjusting selection bias with the available student information provides consistent conclusions. Specifically, these results suggest there is no statistical difference between charter and traditional public school students in grade 4 math and reading. Grade 8 math provides mixed results whereby five of the nine methods have confidence intervals that do not span zero. For grade 8 reading however, there is a clear statistical difference as all nine methods result in confidence intervals that do not span zero (effect size $\leq .20$).

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Appendix A

Charter Schools & Student Enrollment by State

Table 1: Charter Schools & Student Enrollment by State

	Law	Totals for Charter Schools[b]			NAEP Students	
State	Enacted	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

Charter Schools & Student Enrollment by State (cont.)

State	Law Enacted	Totals for Charter Schools[b] Operating	Closed	Students	NAEP Students Charters	Publics
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
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 Maps of Number of Charter Schools by State in 2009

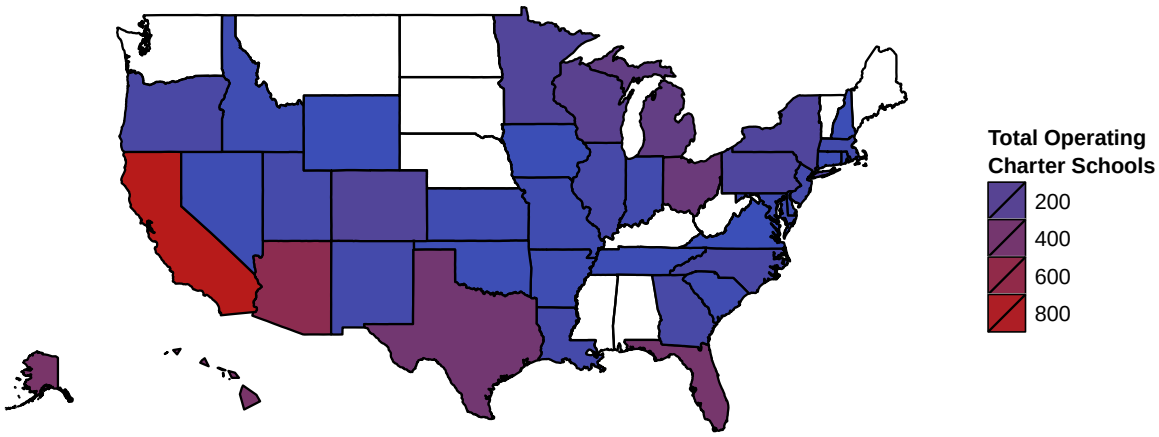

Figure 5: Thematic Map of Number of Operating Charter Schools by State in 2009

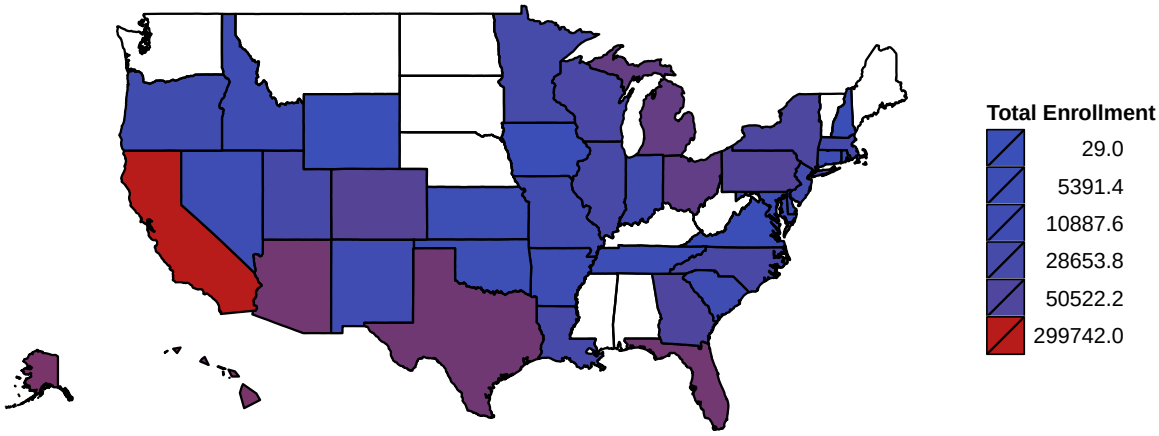

Figure 6: Thematic Map of Charter School Enrollments by State in 2009

Appendix C

NAEP Student Background Questionnaire

Core Questions

- Are you Hispanic or Latino? [No, I am not Hispanic or Latino; Yes, I am Mexican, Mexican American, or Chicano; Yes, I am Puerto Rican or Puerto Rican American; Yes, I am Cuban or Cuban American; Yes, I am from some other Hispanic or Latino background]
- Which of the following best describes you? [White; Black or African American; Asian; American Indian or Alaska Native; Native Hawaiian or other Pacific Islander]
- Does your family get a newspaper at least four times a week?
- Does your family get any magazines regularly?
- About how many books are there in your home?
- Is there a computer at home that you use?
- Is there an encyclopedia in your home? It could be a set of books, or it could be on the computer.
- About how many pages a day do you have to read in school and for homework?
- How often do you talk about thinks you have studied in school with someone in your family?
- How many days were you absent from school in the last month?
- How far in school did your mother go? [Grade 8 Only]
- How far in school did your father go? [Grade 8 Only]
- How often do people in your home talk to each other in language other than English?

Grade 4 Math Related Questions

- Use computer at school for math
- Use computer to practice or drill on math

- Use computer to play math games
- Kind of calculator you normally use
- Use calculator for math tests-student
- Difficulty of this math test
- Effort on this math test
- Importance of success on this math test
- The math work is too hard
- I have done a good job on my homework
- I have done a good job in class
- The math work is too easy
- I like what we do in math class

Grade 4 Reading Related Questions

- Learn a lot when reading books
- Reading is a favorite activity
- Writing stories or letters is a favorite activity
- Writing helps share ideas
- Read for fun on own
- Talk with friends about what you read
- Write e-mails to friends or family
- Read stories or poems for fun
- Read to learn about real things
- Read stories on Internet for fun
- Class discussion about something class has read
- Work in groups to talk about something read

- Write in journal about something read
- Write a book report
- Make presentation to class about something read
- Do school project about something read
- Read books or magazines for reading
- Read books or magazines for science
- Read books or magazines for social studies/history
- Read books or magazines for math
- Write long answers on reading tests
- Read own books for reading assignment
- Difficulty of this reading test
- Effort on this reading test
- Importance of success on this reading test

Grade 8 Math Related Questions

- Use computer at school for math
- Use computer to practice or drill on math
- Use computer to play math games
- Kind of calculator you normally use
- Use calculator for math tests-student
- Difficulty of this math test
- Effort on this math test
- Importance of success on this math test
- Time per day on computer for math work
- Use spreadsheet program for math assignments

- Use program to drill on math facts
- Use program for new lessons on problem-solving
- Use Internet to learn things for math class
- Use calculator program for math class
- Using graphing program for charts for math class
- Use statistical program for math class
- Use word processing program for math class
- Use drawing program for math class
- Use basic four-function calculator in math class
- Use scientific calculator in math class
- Use graphing calculator in math class
- Have clear understanding what teacher asking to do
- The math work is too easy
- The math work is boring
- I have done a good job on my homework
- I have done a good job on my classwork
- The math work is challenging
- The math work is engaging and interesting
- I am learning

Grade 8 Reading Related Questions

- Write long answers on reading tests
- Learn a lot when reading books
- Reading is a favorite activity
- Writing stories or letters is a favorite activity

- Writing helps share ideas
- Read for fun on own
- Talk with friends about what you read
- Write e-mails to friends or family
- Read comic books or joke books outside school
- Read fiction books or stories outside school
- Read plays outside school
- Read poems outside school
- Read biographies/autobiographies outside school
- Read books on science outside school
- Read books on technology outside school
- Read books on other countries outside school
- Read books on history outside school
- Read other non-fiction books outside school
- Read newspaper articles or stories outside school
- Read magazine articles or stories outside school
- Read Internet articles or stories outside school
- Class discussion about something class has read
- Work in groups to talk about something read
- Write in journal about something read
- Write report or paper about something read
- Make presentation to class about something read
- Done project about something read
- Read other than textbook for English class
- Read other than textbook for science class

- Read other than textbook for social studies class
- Read other than textbook for math class
- Explain understanding of what you read
- Discuss interpretation of what you read
- Difficulty of this reading test
- Effort on this reading test
- Importance of success on this reading test

Appendix D

Descriptive Statistics

Table 2: Descriptive Statistics: Grade 4 Math Student Variables

	Public Schools		Charter Schools	
	gender			
Male	72662	51%	1681	50%
Female	70622	49%	1666	50%
Unknown	35	0%	0	0%
	race			
White	78078	54%	1207	36%
Black	24605	17%	1376	41%
Hispanic	28206	20%	577	17%
Asian American	7515	5%	96	3%
American Indian	3108	2%	47	1%
Other	1807	1%	44	1%
Unknown	0	0%	0	0%
	iep			
Yes	16607	12%	311	9%
No	126697	88%	3036	91%
Unknown	15	0%	0	0%
	ell			
Yes	16091	11%	252	8%
No	127200	89%	3095	92%
Unknown	28	0%	0	0%
	lunch			
Not eligible	74755	52%	1393	42%
Reduced	9728	7%	197	6%
Free	57825	40%	1582	47%
Unknown	1011	1%	175	5%
	books			
0-10	17170	12%	405	12%
11-25	30527	21%	684	20%
26-100	46980	33%	1061	32%
>100	45043	31%	1083	32%
Unknown	3599	3%	114	3%
	birthyear			
1993	40	0%	0	0%
1994	289	0%	7	0%

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	Charter Schools		Public Schools	
1995	3914	3%	70	2%
1996	51306	36%	1033	31%
1997	87408	61%	2205	66%
1998	251	0%	29	1%
1999	108	0%	3	0%
2000	3	0%	0	0%
Unknown	0	0%	0	0%
	newspapers			
yes	44064	31%	1003	30%
no	46298	32%	1143	34%
Unknown	52957	37%	1201	36%
	magazines			
yes	84482	59%	1930	58%
no	31141	22%	701	21%
Unknown	27696	19%	716	21%
	computer			
yes	119361	83%	2810	84%
no	19877	14%	411	12%
Unknown	4081	3%	126	4%
	encyclopedia			
yes	72434	51%	1761	53%
no	23257	16%	490	15%
Unknown	47628	33%	1096	33%
	pagesread			
<5	29967	21%	800	24%
5-10	26429	18%	678	20%
11-15	19560	14%	449	13%
16-20	20369	14%	447	13%
>20	43341	30%	858	26%
Unknown	3653	3%	115	3%
	talkstudies			
Never	25156	18%	604	18%
1-2 per month	18463	13%	431	13%
1 per week	16051	11%	359	11%
2-3 times per week	28174	20%	553	17%
Every day	51862	36%	1288	38%
Unknown	3613	3%	112	3%
	daysabsent			
None	69196	48%	1504	45%
1-2	42220	29%	949	28%

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	Charter Schools		Public Schools	
3-4	17372	12%	461	14%
5-10	7004	5%	174	5%
>10	3943	3%	149	4%
Unknown	3584	3%	110	3%
		langinhome		
Never	71636	50%	1569	47%
Once in a while	31552	22%	785	23%
Half the time	10935	8%	296	9%
All or most of the time	25557	18%	588	18%
Unknown	3639	3%	109	3%

Table 3: Descriptive Statistics: Grade 4 Math Scores by State

	Charter Schools						Public Schools					
	n	mean	sd	median	min	max	n	mean	sd	median	min	max
Overall	3347	233.09	28.81	234.25	127.15	313.10	143319	238.04	27.94	239.86	105.92	336.74
Alaska	96	248.66	28.59	252.18	171.68	310.14	2861	238.77	28.86	241.24	132.44	315.60
Arizona	244	233.47	28.73	235.46	127.15	296.09	3294	231.87	30.99	233.85	105.92	327.46
Arkansas	20	245.97	21.14	248.87	196.54	276.03	3087	237.70	26.85	239.32	134.61	305.83
California	276	226.95	29.27	228.80	160.57	296.81	9602	227.17	31.72	228.37	114.90	327.37
Colorado	176	251.14	24.70	254.54	173.59	303.78	3195	239.46	28.61	241.33	117.05	322.84
Connecticut	9	241.58	20.00	238.28	218.62	275.62	3198	243.22	28.31	245.82	108.81	325.12
Delaware	186	237.21	20.66	238.58	180.13	290.34	3111	242.21	23.41	242.86	161.25	313.35
Dist. of Columbia	376	214.20	27.89	215.33	132.74	294.06	1560	213.79	31.95	212.67	124.08	316.65
Florida	216	248.04	20.56	249.88	193.11	288.81	4971	241.68	24.92	242.52	138.45	317.76
Georgia	81	229.24	24.25	230.31	166.06	281.96	4667	231.41	27.24	231.09	128.42	322.00
Hawaii	79	242.36	19.99	244.03	186.62	291.17	3364	234.29	30.00	236.98	118.25	316.46
Idaho	120	257.56	23.91	260.58	184.00	297.52	3464	240.54	25.65	242.24	145.46	310.83
Illinois	91	224.57	19.50	223.46	181.67	271.27	4782	231.36	29.82	231.94	121.28	316.82
Indiana	9	193.44	19.40	194.96	152.18	213.88	3131	245.59	25.00	247.08	120.78	336.74
Iowa	4	230.07	18.44	226.29	212.35	255.36	3023	242.76	24.99	244.53	120.93	315.95
Louisiana	157	236.79	25.71	236.10	178.70	295.55	2886	230.26	25.13	230.64	142.70	302.89
Maryland	22	214.61	19.49	217.25	158.19	257.62	3570	240.68	29.14	241.44	153.03	326.72
Massachusetts	58	232.12	20.78	232.36	182.92	279.23	4084	246.74	26.09	248.13	149.06	320.80
Michigan	342	225.82	28.71	225.91	148.98	298.83	2995	239.41	27.63	242.01	134.29	316.89
Minnesota	33	250.06	23.79	249.35	202.82	304.24	3538	246.26	26.83	248.77	116.79	317.13
Missouri	29	202.01	25.97	200.61	147.55	255.00	3168	240.12	26.02	241.56	146.54	318.74
Nevada	28	226.90	28.63	233.98	147.17	270.87	4005	231.03	28.32	233.32	130.20	312.34
New Hampshire	5	244.07	12.22	246.95	227.90	258.95	3343	248.51	23.91	250.00	147.79	324.29
New Jersey	34	225.05	20.64	221.87	178.65	264.08	3306	248.15	25.70	249.85	157.81	321.31
New Mexico	3	173.61	6.41	171.26	168.71	180.86	3149	228.02	27.68	229.53	126.99	310.59
New York	20	233.30	16.80	231.55	203.43	263.35	4568	240.78	27.02	242.46	122.86	331.88
North Carolina	78	257.74	22.52	259.24	187.51	292.10	5480	240.30	26.37	240.93	124.66	319.32
Ohio	122	223.41	22.45	225.62	166.82	268.12	3720	237.86	28.20	239.37	120.25	311.48
Oklahoma	5	197.63	18.58	192.62	178.83	218.80	3220	237.31	23.71	238.55	124.41	311.19
Oregon	14	239.03	31.96	242.63	173.87	275.80	3486	235.54	27.50	237.30	127.15	314.33
Pennsylvania	98	244.60	29.57	246.79	157.89	296.81	3381	244.27	27.55	247.56	126.32	321.62
Rhode Island	30	230.02	25.71	225.69	177.33	293.88	3070	235.25	27.73	237.93	129.90	303.57
South Carolina	7	233.80	24.04	243.01	203.14	269.53	3560	237.56	28.14	239.44	115.53	316.96
Tennessee	9	211.69	17.60	213.20	187.58	240.25	3237	233.45	26.21	235.39	115.24	311.24
Texas	129	220.51	22.42	218.67	164.33	278.31	8746	239.69	24.51	239.55	128.55	314.11
Utah	76	249.71	25.83	255.54	183.80	294.22	3618	239.43	26.44	242.26	126.79	308.68
Wisconsin	57	220.93	30.40	211.70	153.62	290.65	3170	245.18	26.60	248.06	148.39	319.55
Wyoming	8	274.94	23.59	277.09	244.79	313.10	2709	243.88	23.41	245.60	145.86	318.65

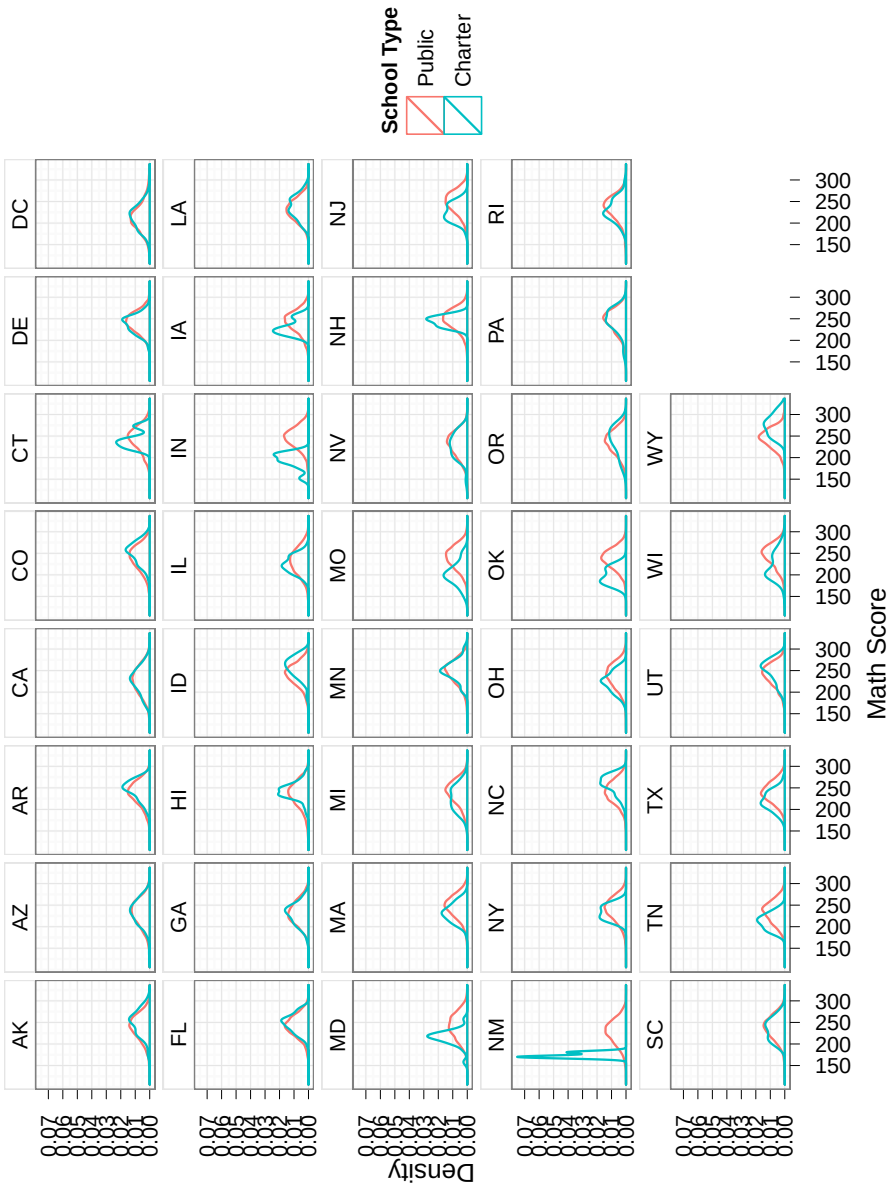

Figure 7: Density Distribution of Grade 4 Math Scores by State

Appendix E

Covariate Missingness

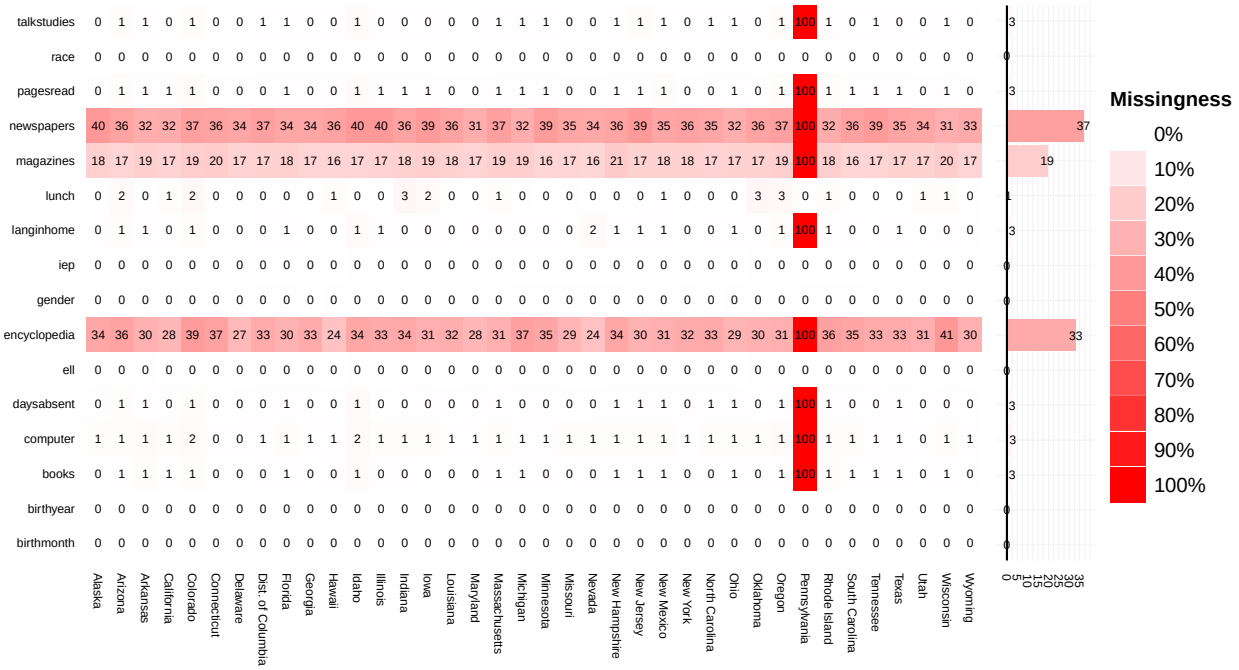

Figure 8: Covariate Missingness for Grade 4 Math

Appendix F

Logistic Regression Full Model

Table 4: Logistic Regression Level 1 Summary: Grade 4 math

	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Alaska	7	251.69	12.92	989	230.40	0.91	21.30
Alaska	11	243.73	11.19	567	234.07	1.24	9.66
Alaska	78	249.08	3.07	1096	251.09	0.73	-2.01
Arizona	20	218.25	4.99	794	224.32	1.17	-6.07
Arizona	222	234.86	1.94	2381	235.32	0.60	-0.46
Arkansas	4	241.24	15.43	433	253.39	0.94	-12.15
Arkansas	4	252.13	8.36	193	253.01	1.62	-0.88
Arkansas	12	245.50	5.87	133	249.91	2.13	-4.41
California	10	221.76	9.11	827	222.99	1.22	-1.23
California	165	227.95	2.39	6695	229.10	0.39	-1.15
California	101	225.82	2.69	2080	222.62	0.64	3.20
Colorado	32	240.62	5.31	918	228.89	0.92	11.72
Colorado	144	253.48	1.90	2150	245.43	0.58	8.05
Connecticut	6	245.19	9.24	55	227.68	3.17	17.52
Delaware	40	248.90	2.78	1165	248.66	0.65	0.24
Delaware	145	233.93	1.69	1727	238.87	0.56	-4.93
Dist. of Columbia	376	214.20	1.44	1555	213.74	0.81	0.46
Florida	6	229.13	5.84	695	226.66	0.97	2.47
Florida	45	239.46	3.04	2031	239.53	0.55	-0.07
Florida	165	251.07	1.54	2241	248.32	0.47	2.75
Georgia	19	235.92	7.36	2349	235.12	0.58	0.80
Georgia	27	229.93	4.38	1317	229.37	0.72	0.56
Georgia	35	225.07	3.38	539	225.12	1.08	-0.05
Hawaii	9	233.92	8.54	1254	229.08	0.82	4.84
Hawaii	15	246.91	6.30	929	238.42	0.92	8.49
Hawaii	54	243.32	2.26	757	247.66	0.99	-4.34
Idaho	28	256.70	4.19	1130	243.43	0.70	13.27
Idaho	89	258.91	2.50	1275	249.12	0.64	9.79
Illinois	6	221.80	8.61	604	220.57	1.20	1.22
Illinois	24	219.03	4.76	1133	219.02	0.78	0.01
Illinois	60	226.93	2.27	891	214.41	0.78	12.51
Indiana	7	192.21	8.25	56	220.26	3.24	-28.05
Iowa	4	230.07	9.22	17	240.43	6.29	-10.35

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Louisiana	5	247.46	10.87	589	235.04	0.96	12.41
Louisiana	18	235.47	5.20	878	234.11	0.84	1.36
Louisiana	134	236.57	2.27	1382	225.71	0.68	10.85
Maryland	4	215.36	5.68	678	234.03	1.05	-18.67
Maryland	8	215.15	5.48	336	226.60	1.49	-11.45
Maryland	9	212.58	8.93	151	223.72	2.13	-11.15
Massachusetts	7	246.67	11.07	1325	247.03	0.73	-0.37
Massachusetts	10	225.57	7.55	392	235.81	1.29	-10.24
Massachusetts	39	231.15	2.64	392	234.89	1.05	-3.75
Michigan	14	249.97	7.42	520	248.99	1.00	0.98
Michigan	328	224.79	1.56	2420	237.49	0.57	-12.70
Minnesota	11	253.55	8.34	1882	249.77	0.59	3.78
Minnesota	13	250.22	7.21	482	244.53	1.25	5.69
Minnesota	9	245.57	5.31	152	239.14	2.30	6.43
Missouri	26	199.23	4.90	161	219.72	1.77	-20.48
Nevada	9	224.35	8.06	1709	230.26	0.70	-5.90
Nevada	12	226.30	10.06	457	234.81	1.26	-8.51
Nevada	6	236.05	9.83	117	230.32	2.64	5.72
New Jersey	4	234.57	9.00	348	234.79	1.32	-0.22
New Jersey	7	229.02	9.25	419	236.38	1.18	-7.36
New Jersey	23	222.19	4.18	308	236.33	1.28	-14.15
New York	5	232.09	7.25	266	230.84	1.46	1.25
New York	11	232.49	5.37	142	231.51	1.87	0.98
North Carolina	13	245.21	7.59	1626	240.31	0.64	4.90
North Carolina	14	256.95	6.68	965	255.17	0.77	1.78
North Carolina	49	261.52	2.78	594	253.26	0.86	8.26
Ohio	14	240.94	5.13	1636	250.50	0.58	-9.56
Ohio	27	232.63	4.05	1012	237.13	0.80	-4.50
Ohio	81	217.31	2.33	1011	217.09	0.81	0.22
Oregon	7	228.47	13.59	54	230.51	3.66	-2.05
Pennsylvania	4	228.45	6.72	623	239.89	1.08	-11.43
Pennsylvania	48	245.15	4.33	1681	247.83	0.67	-2.69
Pennsylvania	46	245.44	4.45	840	242.79	0.97	2.65
Rhode Island	9	243.08	9.24	1593	241.33	0.62	1.75
Rhode Island	4	236.79	10.48	280	235.65	1.73	1.14
Rhode Island	15	220.68	5.10	129	217.75	2.98	2.94
Tennessee	4	206.64	8.92	74	219.33	3.04	-12.70
Tennessee	5	215.73	8.19	73	216.15	3.05	-0.43
Texas	19	225.34	5.12	3172	239.87	0.42	-14.53

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Texas	37	229.58	3.86	1536	235.41	0.54	-5.83
Texas	70	214.56	2.47	1075	226.00	0.65	-11.44
Utah	12	249.95	7.67	977	239.68	0.81	10.26
Utah	28	254.61	4.43	1618	243.56	0.61	11.05
Utah	36	245.81	4.56	530	244.48	1.09	1.33
Wisconsin	12	256.87	5.12	1952	251.29	0.53	5.58
Wisconsin	6	242.42	11.78	290	235.29	1.69	7.13
Wisconsin	38	206.92	3.54	297	219.07	1.61	-12.16

Table 5: Logistic RegressionLevel 2 Summary: Grade 4 math

State	n	Public	Charter	Diff	Confidence Interval	
Alaska	2748	240.01	248.90	8.89	-2.52	20.29
Arizona	3417	232.70	230.91	-1.79	-7.20	3.61
Arkansas	779	252.65	244.79	-7.86	-20.11	4.39
California	9878	227.15	226.96	-0.20	-6.67	6.27
Colorado	3244	240.59	249.71	9.12	3.49	14.76
Connecticut	61	227.68	245.19	17.52	-2.04	37.07
Delaware	3077	242.70	239.80	-2.91	-6.20	0.39
Dist. of Columbia	1931	213.74	214.20	0.46	-2.78	3.70
Florida	5183	241.87	243.45	1.58	-2.90	6.07
Georgia	4286	231.98	232.59	0.61	-5.48	6.70
Hawaii	3018	236.99	240.51	3.52	-3.65	10.68
Idaho	2522	246.51	257.89	11.39	6.51	16.26
Illinois	2718	217.76	222.41	4.65	-2.03	11.34
Indiana	63	220.26	192.21	-28.05	-45.77	-10.33
Iowa	21	240.43	230.07	-10.35	-33.72	13.01
Louisiana	3006	230.06	238.39	8.33	0.26	16.40
Maryland	1186	230.49	214.93	-15.56	-23.57	-7.55
Massachusetts	2165	242.53	239.66	-2.87	-11.88	6.13
Michigan	3282	239.36	228.88	-10.48	-18.00	-2.96
Minnesota	2549	248.08	252.40	4.32	-3.87	12.51
Missouri	187	219.72	199.23	-20.48	-30.77	-10.20
Nevada	2310	231.19	225.37	-5.81	-16.59	4.97
New Jersey	1109	235.86	228.74	-7.12	-16.11	1.87
New York	424	231.08	232.23	1.15	-8.02	10.32
North Carolina	3261	247.33	251.95	4.63	-2.28	11.54
Ohio	3781	237.18	231.83	-5.34	-9.95	-0.74
Oregon	61	230.51	228.47	-2.05	-30.21	26.11
Pennsylvania	3242	244.92	242.00	-2.92	-8.99	3.15
Rhode Island	2030	238.86	240.61	1.75	-8.24	11.74
Tennessee	156	217.74	211.18	-6.56	-19.26	6.13
Texas	5909	235.99	224.38	-11.61	-16.14	-7.08
Utah	3201	242.53	251.61	9.09	2.51	15.67
Wisconsin	2595	245.31	248.77	3.47	-5.38	12.31

Appendix G

Logistic Regression Step AIC Model

Table 6: Logistic Regression Step AIC Level 1 Summary: Grade 4 math

	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Alaska	7	272.74	6.82	906	234.25	0.89	38.49
Alaska	9	215.63	8.08	307	217.35	1.83	-1.72
Alaska	80	250.27	3.00	1311	251.15	0.64	-0.88
Arizona	20	214.02	6.33	638	222.31	1.29	-8.29
Arizona	223	235.33	1.89	2532	235.25	0.59	0.08
Arkansas	4	253.75	12.04	466	250.11	0.98	3.64
Arkansas	6	244.60	10.07	213	251.55	1.62	-6.95
Arkansas	10	243.69	6.15	147	252.48	1.90	-8.79
California	4	227.02	16.18	359	228.60	1.81	-1.58
California	224	227.28	1.99	8466	228.05	0.34	-0.77
California	48	225.40	3.94	777	216.94	1.03	8.45
Colorado	26	239.33	6.17	948	224.26	0.88	15.08
Colorado	150	253.19	1.87	2247	245.87	0.57	7.32
Connecticut	6	238.97	6.96	97	222.65	2.60	16.32
Delaware	36	251.54	2.85	1160	250.66	0.63	0.88
Delaware	147	233.80	1.64	1763	237.81	0.55	-4.01
Dist. of Columbia	376	214.20	1.44	1557	213.76	0.81	0.44
Florida	9	228.77	5.94	709	224.87	0.95	3.90
Florida	38	236.09	3.05	1657	236.34	0.56	-0.25
Florida	169	251.76	1.50	2596	249.75	0.45	2.00
Georgia	27	241.13	4.46	2457	236.60	0.57	4.54
Georgia	22	227.31	5.59	1178	226.90	0.72	0.41
Georgia	32	220.53	3.52	434	221.05	1.20	-0.52
Hawaii	12	238.35	8.01	1541	231.32	0.72	7.03
Hawaii	16	247.12	6.07	539	238.34	1.30	8.78
Hawaii	50	242.00	2.32	892	243.98	0.94	-1.98
Idaho	26	252.70	4.39	1006	242.82	0.75	9.88
Idaho	91	259.04	2.53	1483	248.78	0.59	10.26
Illinois	9	223.68	7.69	567	221.76	1.22	1.92
Illinois	23	226.56	3.84	985	222.21	0.83	4.34
Illinois	58	223.78	2.60	1060	211.21	0.72	12.57
Indiana	7	192.21	8.25	84	217.71	2.48	-25.50
Iowa	4	230.07	9.22	503	229.18	1.12	0.89

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Louisiana	8	244.00	9.31	701	234.77	0.89	9.23
Louisiana	9	238.24	8.52	709	232.97	0.96	5.27
Louisiana	140	236.28	2.18	1430	226.68	0.67	9.60
Maryland	11	212.37	8.02	960	234.03	0.94	-21.66
Maryland	8	213.64	2.95	389	223.28	1.30	-9.64
Massachusetts	8	245.06	8.83	976	244.91	0.89	0.16
Massachusetts	8	217.83	6.85	289	235.81	1.53	-17.97
Massachusetts	39	231.15	2.64	440	235.02	0.96	-3.88
Michigan	5	248.24	21.54	146	239.40	1.94	8.84
Michigan	337	225.49	1.54	2795	239.54	0.53	-14.06
Minnesota	22	246.47	5.02	1983	246.18	0.61	0.29
Minnesota	8	266.15	6.17	307	258.52	1.33	7.63
Missouri	25	198.28	5.00	184	218.69	1.73	-20.41
Nevada	13	221.33	5.70	1689	230.16	0.69	-8.83
Nevada	8	232.84	15.32	382	241.49	1.29	-8.65
Nevada	4	234.37	13.46	46	228.53	4.03	5.84
New Hampshire	5	244.07	5.47	3343	248.51	0.41	-4.43
New Jersey	6	233.94	11.01	364	236.87	1.27	-2.93
New Jersey	4	215.92	7.53	328	235.46	1.34	-19.54
New Jersey	24	224.35	4.02	400	235.30	1.14	-10.95
New York	7	234.88	6.92	617	231.26	0.96	3.61
New York	4	233.02	7.09	304	226.21	1.46	6.81
New York	9	232.20	6.15	183	224.58	1.72	7.62
North Carolina	5	251.62	10.95	2200	230.28	0.52	21.34
North Carolina	9	239.19	8.35	1507	242.31	0.69	-3.11
North Carolina	20	257.05	5.68	988	254.82	0.72	2.23
North Carolina	44	262.53	2.82	559	250.06	0.95	12.47
Ohio	15	242.33	4.97	1794	249.86	0.55	-7.54
Ohio	25	229.49	4.12	790	236.36	0.93	-6.87
Ohio	82	218.10	2.36	1059	217.59	0.79	0.50
Oregon	6	247.15	10.97	1431	237.94	0.66	9.20
Oregon	6	221.30	13.66	50	223.67	4.01	-2.37
Pennsylvania	8	242.20	13.27	574	244.93	1.07	-2.73
Pennsylvania	53	247.42	3.65	1904	247.59	0.61	-0.17
Pennsylvania	37	241.08	5.30	671	237.16	1.20	3.92
Rhode Island	9	233.66	11.11	1487	241.47	0.65	-7.81
Rhode Island	15	220.59	5.09	129	210.02	2.92	10.57
Tennessee	5	214.32	9.31	208	219.68	1.60	-5.36
Texas	7	216.28	7.21	4304	243.17	0.40	-26.89

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Texas	18	231.16	5.54	1984	243.33	0.48	-12.17
Texas	31	225.53	4.12	1302	235.24	0.58	-9.71
Texas	73	216.16	2.49	1156	225.47	0.64	-9.30
Utah	57	249.06	3.37	2596	243.25	0.49	5.80
Utah	16	251.55	7.12	298	242.13	1.51	9.43
Wisconsin	11	254.53	5.10	2001	252.46	0.52	2.07
Wisconsin	4	252.19	13.46	352	238.03	1.34	14.16
Wisconsin	39	206.80	3.45	303	218.11	1.65	-11.31
Wyoming	8	274.94	8.34	1188	250.35	0.62	24.59

Table 7: Logistic Regression Step AIC Level 2 Summary: Grade 4 math

State	n	Public	Charter	Diff	Confidence Interval	
Alaska	2620	241.19	253.92	12.73	5.41	20.06
Arizona	3413	232.76	231.22	-1.54	-8.16	5.09
Arkansas	846	250.92	249.52	-1.41	-12.58	9.76
California	9878	227.14	227.11	-0.03	-11.07	11.01
Colorado	3371	239.62	249.18	9.56	3.16	15.96
Connecticut	103	222.65	238.97	16.32	1.58	31.07
Delaware	3106	242.76	240.63	-2.13	-5.45	1.20
Dist. of Columbia	1933	213.76	214.20	0.44	-2.80	3.67
Florida	5178	241.91	243.44	1.53	-3.01	6.07
Georgia	4150	232.05	234.82	2.77	-2.53	8.08
Hawaii	3050	236.51	241.07	4.56	-2.27	11.40
Idaho	2606	246.42	256.53	10.11	5.05	15.16
Illinois	2702	217.56	224.79	7.23	1.27	13.20
Indiana	91	217.71	192.21	-25.50	-42.61	-8.39
Iowa	507	229.18	230.07	0.89	-17.36	19.14
Louisiana	2997	230.10	238.57	8.47	0.05	16.90
Maryland	1368	230.91	212.74	-18.17	-26.70	-9.64
Massachusetts	1760	240.68	236.68	-4.00	-11.62	3.62
Michigan	3283	239.54	226.53	-13.00	-34.27	8.26
Minnesota	2320	247.86	249.14	1.29	-6.64	9.21
Missouri	209	218.69	198.28	-20.41	-30.85	-9.97
Nevada	2142	232.18	223.73	-8.45	-22.58	5.67
New Hampshire	3348	248.51	244.07	-4.43	-15.18	6.32
New Jersey	1126	235.86	225.01	-10.85	-20.07	-1.62
New York	1124	228.74	233.91	5.17	-2.62	12.97
North Carolina	5332	240.58	250.35	9.77	2.31	17.24
Ohio	3765	237.16	232.21	-4.95	-9.53	-0.38
Oregon	1493	237.41	246.18	8.77	-8.87	26.40
Pennsylvania	3247	244.84	245.11	0.26	-9.44	9.97
Rhode Island	1640	238.71	232.52	-6.20	-18.53	6.14
Tennessee	213	219.68	214.32	-5.36	-23.98	13.26
Texas	8875	239.56	221.01	-18.56	-23.62	-13.49
Utah	2967	243.13	249.32	6.19	-1.69	14.06
Wisconsin	2710	246.23	248.20	1.97	-7.81	11.75
Wyoming	1196	250.35	274.94	24.59	8.18	41.00

Appendix H

Conditional Inference Trees

Table 8: Conditional Inference Trees Level 1 Summary: Grade 4 math

	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Alaska	86	250.01	3.03	1626	247.48	0.64	2.53
Alaska	10	237.02	10.14	1235	227.30	0.82	9.72
Arizona	6	218.57	13.00	80	227.58	2.65	-9.01
Arizona	23	215.36	5.85	71	210.36	3.55	5.01
Arizona	17	218.38	5.64	542	201.51	1.22	16.87
Arizona	81	240.26	2.67	1734	245.96	0.61	-5.70
Arizona	34	230.44	3.57	477	222.57	1.11	7.86
Arizona	83	237.27	3.66	390	227.53	1.43	9.74
Arkansas	20	245.97	4.73	1320	249.09	0.66	-3.11
California	48	225.40	3.94	784	216.80	1.03	8.60
California	228	227.27	1.97	8818	228.09	0.34	-0.82
Colorado	132	254.86	1.97	1874	249.88	0.56	4.98
Colorado	44	239.98	4.12	1321	224.66	0.76	15.31
Connecticut	7	240.00	5.97	410	220.50	1.36	19.50
Delaware	72	229.20	2.35	451	224.68	0.93	4.52
Delaware	43	232.84	2.65	525	234.12	0.89	-1.29
Delaware	71	247.98	2.21	2135	247.90	0.48	0.08
Dist. of Columbia	52	208.22	3.32	315	203.32	1.46	4.89
Dist. of Columbia	289	213.18	1.63	1001	209.69	0.88	3.49
Dist. of Columbia	23	219.81	5.10	108	221.19	2.91	-1.38
Dist. of Columbia	12	253.90	7.32	136	262.38	2.64	-8.48
Florida	95	251.49	1.99	2182	250.76	0.50	0.72
Florida	37	234.85	3.33	1704	232.95	0.57	1.90
Florida	50	254.10	2.92	330	246.74	1.22	7.36
Florida	34	243.86	2.97	755	232.90	0.88	10.96
Georgia	4	201.29	13.80	1726	248.47	0.57	-47.18
Georgia	19	220.46	4.22	1514	217.71	0.57	2.75
Georgia	45	236.51	3.80	1115	227.02	0.71	9.48
Georgia	13	225.52	4.28	312	219.23	1.57	6.29
Hawaii	34	243.13	2.96	646	241.32	1.14	1.80
Hawaii	34	238.82	3.64	1503	233.45	0.78	5.38
Hawaii	11	250.91	6.90	1215	231.59	0.86	19.32
Idaho	37	250.86	4.00	1148	244.23	0.65	6.63

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Idaho	18	256.43	5.54	1093	229.15	0.76	27.28
Idaho	65	261.69	2.88	1223	247.25	0.74	14.44
Illinois	66	224.22	2.38	1260	213.45	0.68	10.77
Illinois	24	225.18	4.21	1379	221.58	0.73	3.60
Indiana	8	192.00	7.15	312	225.45	1.32	-33.46
Iowa	4	230.07	9.22	800	229.43	0.88	0.64
Louisiana	11	251.04	5.51	1074	237.85	0.68	13.19
Louisiana	18	266.08	4.46	235	245.70	1.58	20.38
Louisiana	113	233.59	2.23	1131	222.22	0.69	11.36
Louisiana	14	214.55	5.12	334	215.82	1.25	-1.27
Maryland	20	214.17	4.55	1549	225.18	0.66	-11.01
Massachusetts	7	255.32	8.73	2694	256.54	0.41	-1.21
Massachusetts	29	231.36	3.44	455	229.23	1.09	2.12
Massachusetts	22	225.75	3.93	935	227.02	0.77	-1.27
Michigan	22	225.09	5.30	117	232.16	2.61	-7.06
Michigan	121	243.66	2.39	2432	244.43	0.50	-0.77
Michigan	199	215.05	1.77	446	213.99	1.30	1.06
Minnesota	33	250.06	4.14	3538	246.26	0.45	3.80
Missouri	20	208.03	5.80	509	220.73	1.06	-12.70
Missouri	9	188.63	7.25	57	205.23	3.15	-16.60
Nevada	28	226.90	5.41	4005	231.03	0.45	-4.13
New Hampshire	5	244.07	5.47	3343	248.51	0.41	-4.43
New Jersey	34	225.05	3.54	1207	233.52	0.71	-8.47
New York	4	230.29	8.50	3558	244.87	0.44	-14.58
New York	16	234.05	4.31	1010	226.34	0.77	7.72
North Carolina	14	259.92	5.33	483	238.70	1.09	21.21
North Carolina	17	269.47	4.27	215	249.16	1.68	20.31
North Carolina	19	264.48	5.04	1940	255.46	0.51	9.02
North Carolina	23	245.36	4.53	780	239.46	0.81	5.91
North Carolina	5	243.04	9.97	2062	225.80	0.51	17.24
Ohio	20	234.63	4.29	794	245.69	0.90	-11.06
Ohio	11	231.65	6.32	468	236.60	1.13	-4.95
Ohio	8	248.37	5.69	1422	249.51	0.64	-1.14
Ohio	74	217.06	2.48	1026	216.44	0.77	0.62
Ohio	9	218.41	6.49	10	217.83	10.02	0.58
Oklahoma	4	202.33	8.85	334	220.65	1.23	-18.31
Oregon	6	221.30	13.66	134	221.52	2.53	-0.22
Oregon	8	252.33	8.84	3352	236.10	0.47	16.23
Pennsylvania	74	252.31	2.51	2923	247.52	0.46	4.79

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	Charter Schools			Public Schools			
State	n	Score	SE	n	Score	SE	Diff
Pennsylvania	5	206.36	19.34	16	206.29	9.61	0.07
Pennsylvania	19	224.64	8.39	442	224.19	1.61	0.46
Rhode Island	12	217.17	5.28	216	204.35	2.15	12.82
Rhode Island	15	234.39	6.23	2768	237.53	0.49	-3.13
South Carolina	7	233.80	9.09	3560	237.56	0.47	-3.76
Tennessee	9	211.69	5.87	831	213.92	0.84	-2.24
Texas	6	231.56	10.44	2715	255.53	0.41	-23.98
Texas	5	214.72	3.48	2162	228.11	0.47	-13.38
Texas	36	227.32	3.89	2338	239.32	0.43	-12.00
Texas	82	217.07	2.40	1531	228.50	0.58	-11.43
Utah	76	249.71	2.96	3178	242.01	0.45	7.70
Wisconsin	17	253.49	5.52	2808	248.30	0.46	5.18
Wisconsin	39	206.80	3.45	236	210.97	1.71	-4.17
Wyoming	8	274.94	8.34	2709	243.88	0.45	31.06

Table 9: Conditional Inference Trees Level 2 Summary: Grade 4 math

State	n	Public	Charter	Diff	Confidence Interval	
Alaska	2957	238.98	244.54	5.56	-4.86	15.98
Arizona	3538	231.71	233.80	2.09	-3.50	7.68
Arkansas	1340	249.09	245.97	-3.11	-12.48	6.25
California	9878	227.14	227.11	-0.03	-4.47	4.42
Colorado	3371	239.67	248.83	9.16	4.59	13.73
Connecticut	417	220.50	240.00	19.50	7.46	31.54
Delaware	3297	241.84	242.39	0.55	-2.32	3.43
Dist. of Columbia	1936	213.29	215.80	2.51	-2.66	7.69
Florida	5187	241.77	244.93	3.16	0.25	6.07
Georgia	4748	231.30	217.74	-13.56	-21.22	-5.89
Hawaii	3443	234.34	243.98	9.64	4.08	15.19
Idaho	3584	240.64	256.48	15.84	10.92	20.75
Illinois	2729	217.63	224.71	7.08	2.24	11.93
Indiana	320	225.45	192.00	-33.46	-47.75	-19.16
Iowa	804	229.43	230.07	0.64	-17.54	18.82
Louisiana	2930	229.28	240.59	11.32	6.76	15.88
Maryland	1569	225.18	214.17	-11.01	-20.02	-2.00
Massachusetts	4142	246.53	245.69	-0.84	-7.55	5.87
Michigan	3337	238.03	237.36	-0.68	-5.09	3.74
Minnesota	3571	246.26	250.06	3.80	-4.37	11.96
Missouri	595	219.01	205.88	-13.13	-22.81	-3.46
Nevada	4033	231.03	226.90	-4.13	-14.77	6.51
New Hampshire	3348	248.51	244.07	-4.43	-15.18	6.32
New Jersey	1241	233.52	225.05	-8.47	-15.55	-1.39
New York	4588	240.73	231.13	-9.60	-18.97	-0.22
North Carolina	5558	240.36	253.55	13.19	7.68	18.69
Ohio	3842	237.47	234.26	-3.20	-9.31	2.90
Oklahoma	338	220.65	202.33	-18.31	-35.88	-0.74
Oregon	3500	235.52	251.09	15.57	-0.58	31.72
Pennsylvania	3479	244.18	248.37	4.19	-11.08	19.46
Rhode Island	3011	235.01	233.09	-1.93	-10.22	6.37
South Carolina	3567	237.56	233.80	-3.76	-21.60	14.07
Tennessee	840	213.92	211.69	-2.24	-13.87	9.40
Texas	8875	239.59	223.68	-15.91	-21.76	-10.05
Utah	3254	242.01	249.71	7.70	1.82	13.57
Wisconsin	3100	244.99	249.34	4.35	-2.26	10.97
Wyoming	2717	243.88	274.94	31.06	14.68	47.44

Appendix I

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

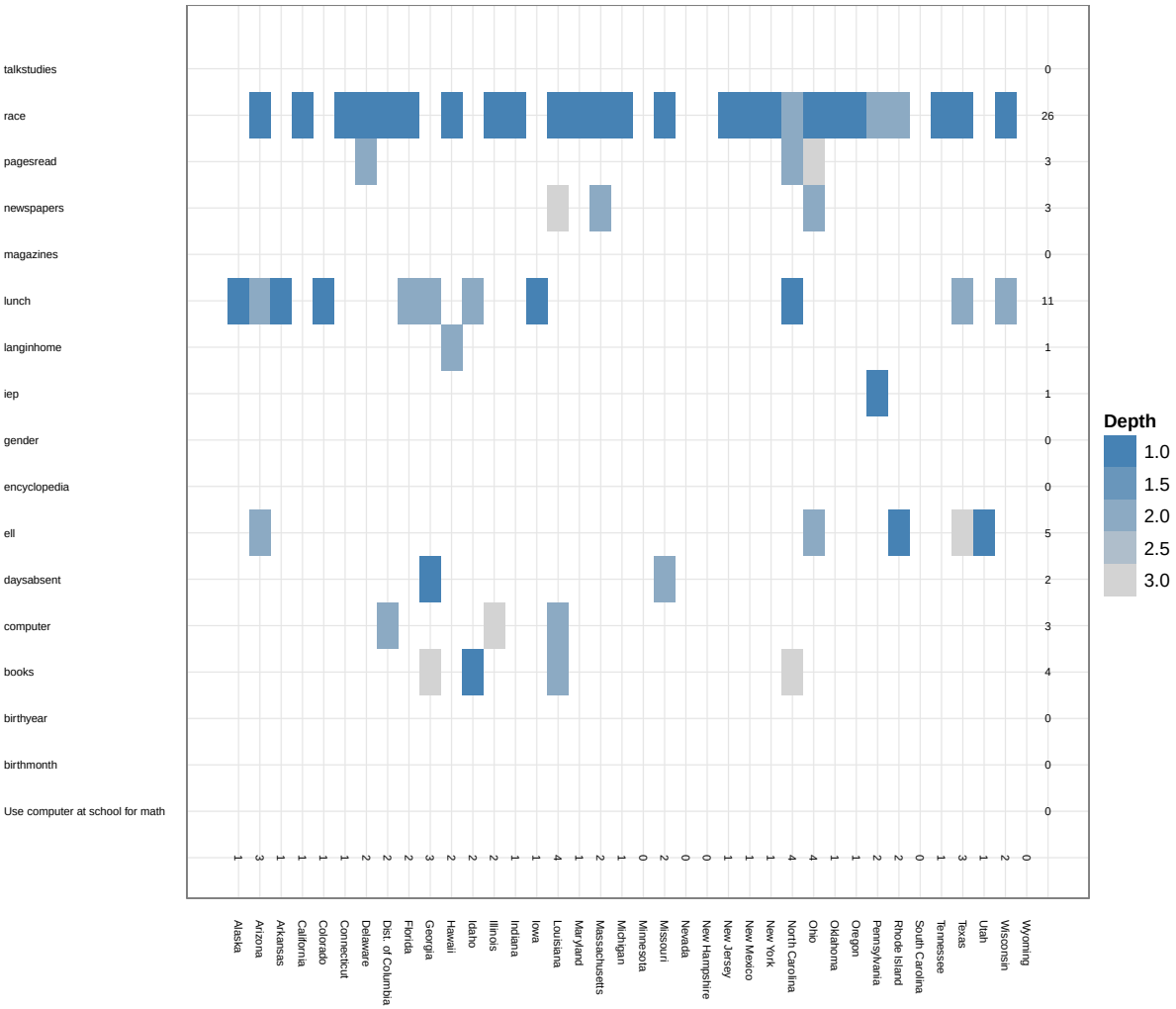

Figure 9: Heat Map of Relative Importance of Covariates for Phase I: Grade 4 Math

Appendix J

Distribution of NAEP Scores for Matched vs. Unmatched Traditional 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 traditional 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 traditional public school students within that state were either all matched or all not matched.

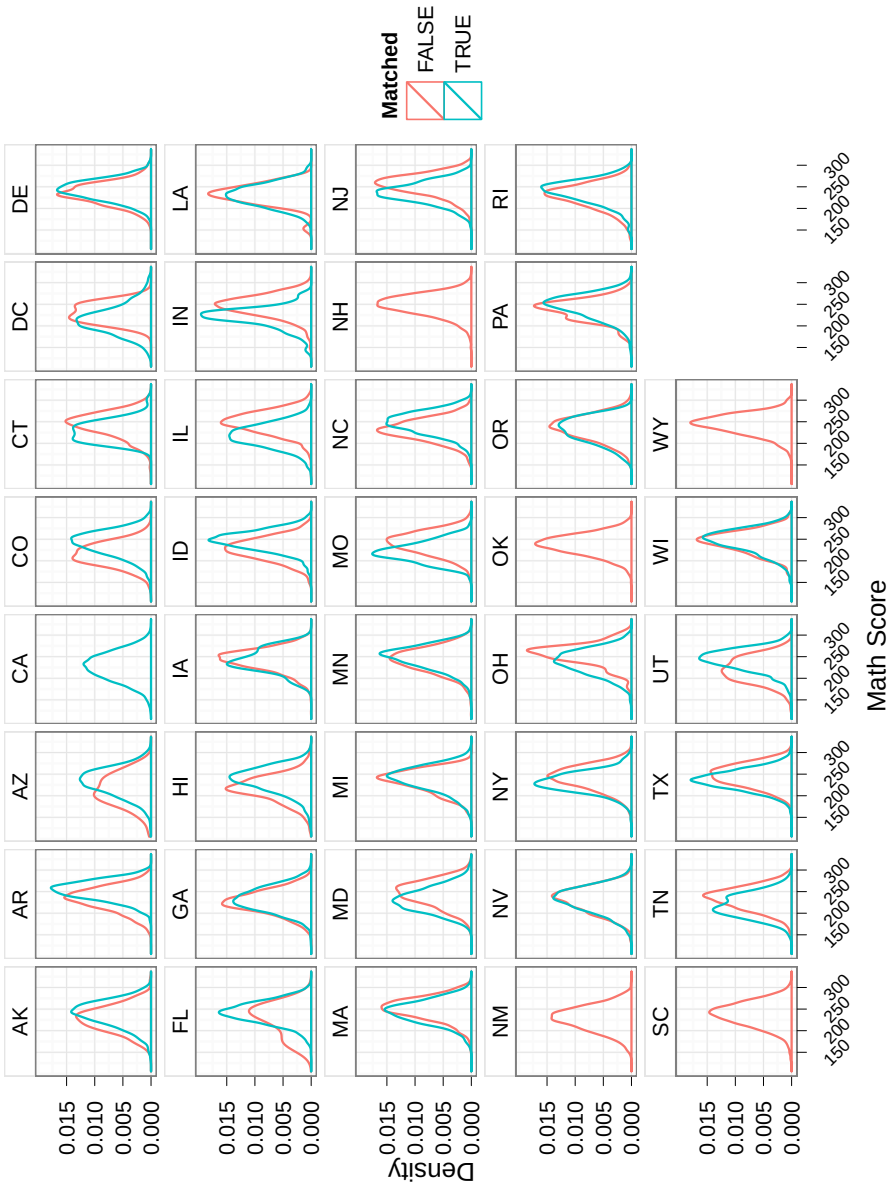

Figure 10: Density Distribution of Grade 4 Math: Matched vs. Unmatched Traditional Public School Students

Appendix K

Tables of Overall Results

Table 10: Summary Propensity Score Analysis using Stratification

	Adjusted Mean		x				
	Public	Charter	Diff	ATE	n	95% CI	
			Grade 4 Math				
Logistic Regression	237.95	237.38	-0.57	-0.57	146656.00	-1.72	0.57
Logistic Regression Step AIC	237.96	237.35	-0.60	-0.60	146656.00	-1.73	0.52
Conditional Inference Trees	237.93	238.27	0.34	0.34	146638.00	-0.96	1.64
			Grade 4 Reading				
Logistic Regression	218.27	218.96	0.70	0.70	141352.00	-0.71	2.11
Logistic Regression Step AIC	218.26	219.22	0.96	0.96	141352.00	-0.44	2.37
Conditional Inference Trees	218.26	219.01	0.75	0.75	141340.00	-0.62	2.12
			Grade 8 Math				
Logistic Regression	278.77	279.10	0.33	0.33	97563.00	-1.40	2.06
Logistic Regression Step AIC	278.77	279.54	0.77	0.77	97563.00	-0.91	2.46
Conditional Inference Trees	278.72	280.89	2.17	2.17	97521.00	0.36	3.98
			Grade 8 Reading				
Logistic Regression	259.80	262.82	3.02	3.02	105486.00	1.55	4.49
Logistic Regression Step AIC	259.80	262.67	2.87	2.87	105486.00	1.36	4.38
Conditional Inference Trees	259.75	265.39	5.65	5.65	105468.00	4.36	6.93

Table 11: Summary of Propensity Score Matching

M	Charter	Public	Diff	ES	95% CI	
			Grade 4 Math			
1	233.10	231.92	1.17	0.04	-0.01	2.36
5	233.94	232.88	1.06***	0.04	0.53	1.60
10	235.58	234.40	1.18***	0.04	0.79	1.57
			Grade 4 Reading			
1	213.33	212.09	1.24	0.04	-0.26	2.74
5	214.35	213.06	1.29***	0.04	0.60	1.99
10	215.89	214.45	1.44***	0.04	0.93	1.95
			Grade 8 Math			
1	273.64	269.94	3.70***	0.10	2.11	5.29
5	276.14	272.56	3.58***	0.10	2.83	4.34
10	277.42	274.11	3.31***	0.09	2.75	3.87
			Grade 8 Reading			
1	259.93	254.63	5.30***	0.16	3.92	6.68
5	261.50	255.63	5.87***	0.17	5.21	6.52
10	262.22	256.76	5.46***	0.16	4.97	5.94

*$p < .05$; **$p < .01$; ***$p < .001$

Table 12: Summary of Multilevel PSA

	Adjusted Mean						
	Public	Charter	Diff	ATE	n	95% CI	
			Grade 4 Math				
Logistic Regression	236.51	236.55	3.40	0.04	83241	-1.50	1.58
Logistic Regression Step AIC	237.25	236.83	4.22	-0.41	95290	-2.05	1.23
Conditional Inference Trees	236.70	237.78	3.89	1.10	118812	-0.26	2.54
			Grade 4 Reading				
Logistic Regression	217.14	216.87	4.65	-0.27	80465	-2.29	1.75
Logistic Regression Step AIC	217.05	217.46	4.71	0.41	86885	-1.52	2.33
Conditional Inference Trees	216.09	220.92	5.99	4.83	108938	2.91	6.75
			Grade 8 Math				
Logistic Regression	278.13	277.90	5.31	-0.23	61795	-2.41	1.94
Logistic Regression Step AIC	278.62	280.52	6.07	1.90	69535	-0.33	4.13
Conditional Inference Trees	277.61	281.11	5.28	3.50	80594	1.48	5.52
			Grade 8 Reading				
Logistic Regression	258.97	263.19	4.14	4.22	71270	2.45	5.99
Logistic Regression Step AIC	259.25	263.61	4.25	4.36	77513	2.58	6.14
Conditional Inference Trees	258.10	264.97	4.37	6.87	84352	5.12	8.63