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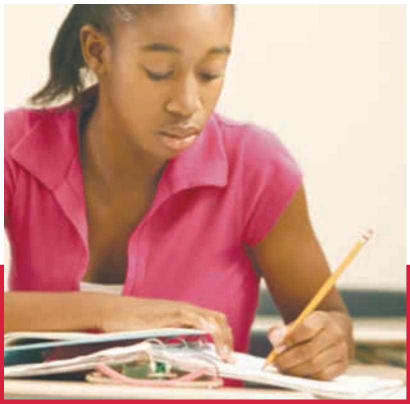
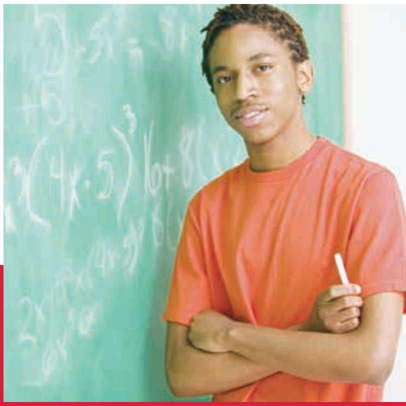
Student Achievement in Massachusetts' Charter Schools



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Center for Education Policy Research

The rapid accumulation of student achievement data represents an untapped national resource, one that holds the promise of breaking longstanding stalemates in the education policy debate. The Center for Education Policy Research works with University-based researchers and policymakers to bring these new data to bear in evaluating policies and drawing implications for reform. To ensure that the research is solving real problems, the Center engages stakeholders in the field directly to frame the research. As a national convener with alumni in leadership positions in districts around the country, the Harvard Graduate School of Education and Harvard University are uniquely placed to play a national leadership role in linking research to critical policy and management concerns.

Acknowledgements

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Mitchell D. Chester, Ed.D.
Commissioner

Dear Colleagues:

Two years ago, the Department of Elementary and Secondary Education, The Boston Foundation, and the Center for Education Policy Research at Harvard University partnered to produce a groundbreaking report, *Informing the Debate: Comparing Boston's Charter, Pilot, and Traditional Schools*. *Informing the Debate* provided evidence of the impact of Boston-based charter schools on student performance. We are pleased to advance this research with this current report, which looks at the impact of charter schools statewide.

The findings are provocative. They suggest that students in Massachusetts' charter middle and high schools often perform better academically than their peers in traditional public schools. The results are particularly large for students at charter middle schools and at schools located in urban areas, two areas where traditional public schools have found it most challenging to improve student performance.

Longer school days, more instructional time on core content, a "no excuses" philosophy, and other structural elements of school organization appear to contribute to the positive results from these schools. Perhaps most importantly, many of these elements could be implemented in traditional public schools, providing us with potential models for improvement across the Commonwealth.

We look forward to continuing to learn from our charter schools about their strategies for success and to working with stakeholders statewide on using school redesign as a potential lever for improving student performance.

Mitchell D. Chester, Ed.D.
Commissioner of Elementary and Secondary Education
Commonwealth of Massachusetts

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I Executive Summary

The question of whether charter schools boost achievement has been at the heart of the education policy debate statewide and nationwide, with special attention to the role that charter schools might play in disadvantaged urban communities. This report evaluates the impact of charter attendance on academic achievement in the Commonwealth of Massachusetts. The evaluation methodology exploits charter school admissions lotteries in an effort to produce credible quasi-experimental estimates of the impact of charter attendance. These estimates constitute "apples-to-apples" comparisons that control for differences in student characteristics across school types.

In earlier work, we used charter school admissions lotteries to evaluate charter school effectiveness in Boston and Lynn, a working-class suburb north of Boston. These studies show the strong effects of charter attendance on Massachusetts Comprehensive Assessment System (MCAS) scores in middle schools and high schools (Abdulkadiroglu et al., 2009a; Abdulkadiroglu, Angrist, Dynarski, Kane & Pathak, 2009b; Angrist, Dynarski, Kane, Pathak & Walters, 2010a, 2010b). Here, we use the same methods to look at the effects of charter school attendance in a wider sample of schools, including some from smaller cities and towns as well as rural areas.

The lottery study is necessarily limited to a sample of schools with more applicants than seats (we call these "oversubscribed" schools), so that lotteries are required to select students (Massachusetts state law requires charter schools to use lotteries when oversubscribed). The lottery sample also is limited to schools with accurate lottery records. As in the Boston study, the lottery analysis is complemented by an observational study that relies on statistical controls for family background and previous achievement. The observational study allows us to look at achievement in a sample that includes all Massachusetts schoolchildren. However, the observational study is not as well controlled as the lottery study, and therefore the observational results should be seen as more speculative.

On the one hand, the lottery study is not likely to be compromised by differences in the prior academic preparation, family background, or motivation of charter students and traditional students. On the other hand, oversubscribed charter schools may not be representative of all charters in the state. The observational study includes almost all charter schools in Massachusetts, including those that are undersubscribed and have poor lottery records. Although the observational study controls for observed differences between charter school attendees and their counterparts in traditional public schools, this approach does not account for unobserved differences that may influence test scores as well as charter school attendance. Fortunately, many of the results reported here are similar across study designs. In such cases, the overall findings can be seen as especially strong.

Summary of Findings

Lottery-based estimates suggest that, as a group, Massachusetts' charter middle schools boost average math scores, but have little effect on average English Language Arts (ELA) scores. The results for high school show strong effects in both subjects. These findings are broadly consistent with our earlier findings for charter schools in Boston and Lynn, though the middle school effects are somewhat smaller.

Most important, the all-state charter sample masks substantial differences by community type, particularly for middle schools. When estimated using admissions lotteries, the results for urban middle schools show large, positive, and statistically significant effects on ELA and math scores, while the corresponding estimates for nonurban middle schools are negative and significant for both ELA and math. The results from the observational study of middle school students are broadly consistent with the lottery results in showing substantial and statistically significant score gains for urban charter students. Moreover, as in the lottery results, the observational estimates for nonurban charter middle schools are negative in the lottery sample, though not as negative as when the estimates are constructed using lotteries.

The state high school sample used in the lottery analysis consists mostly of the Boston-area schools analyzed in our earlier work. It is not surprising, therefore, that the urban high school results for the lottery sample are similar to the substantial positive estimates appearing in our Boston report. We also report estimates for nonurban high schools. The nonurban lottery sample is small and generates imprecise and inconclusive lottery-based results, but the observational estimates for these schools show modest and statistically significant positive effects. Observational estimates for nonurban high schools outside the lottery sample are estimated relatively precisely and come out very close to zero.

Nonurban students have much higher baseline (i.e., pre-charter) scores than do urban students. However, differences in findings between urban and nonurban schools do not appear to be explained by differences in either student ability or the quality of peers that charter students are exposed to in the two settings. Rather, differences in results by community type seem likely to be generated by differences in performance among schools that serve a mostly minority, low-income population and other types of schools. Recent results for a multistate sample similarly suggest that inner-city charter schools boost achievement more than other types of charters, at least on average (Gleason, Clark, Tuttle & Dwoyer, 2010).

In an effort to identify instructional practices that can be linked to school effectiveness, our study includes results from a survey of school administrators. The survey responses show that urban charter schools tend to have longer days; spend more of each day on reading and math instruction; are more likely to identify with the "No Excuses" approach to education; and are more likely to require uniforms, to use merit/demerit discipline systems, and to ask parents and students to sign contracts. These differences in approach may account for the differences in impact. In addition, nonurban charter students may have access to higher-quality alternatives in their local public schools. It also is worth noting that nonurban charters are more likely to emphasize nontraditional subjects such as the performing arts. The benefits of this type of curriculum may not be expressed in higher MCAS scores. Our study design does not allow us to isolate the relative importance of student characteristics, school quality or emphasis, and regular public school quality as drivers of charter effects. We plan to address these questions in future work.

II Introduction

The principal challenge in an evaluation of charter schools is selection bias: students who enroll in charters may differ in ways that are associated with test scores. For example, charter applicants may be relatively motivated students, or they may have better-informed parents. The possibility of bias from this type of nonrandom selection has led academic researchers to exploit charter admissions lotteries as a source of quasi-experimental variation that generates apples-to-apples comparisons.

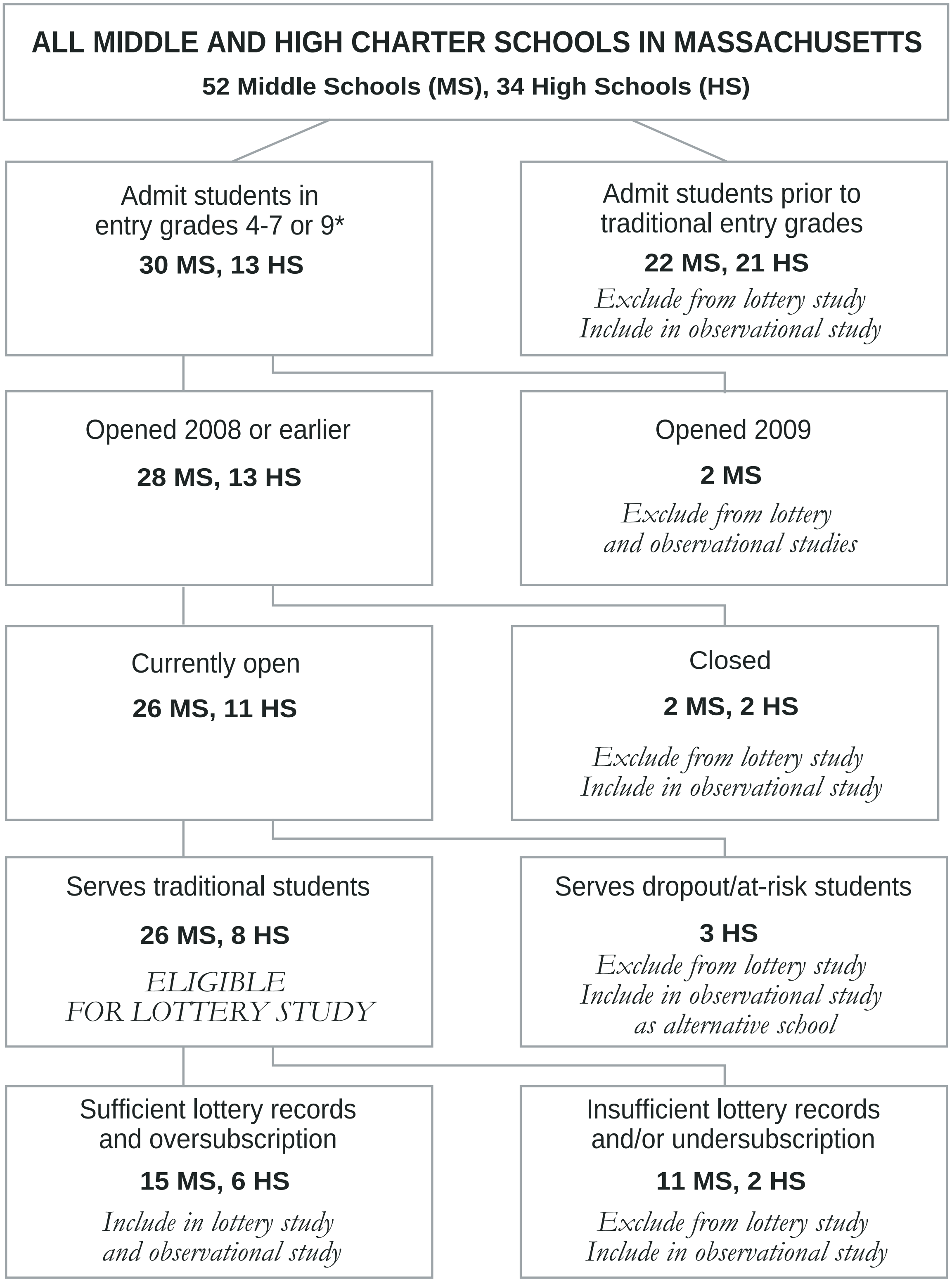
In a series of recent studies using lotteries, we evaluated the achievement effects of attendance at a set of Boston charter schools and a KIPP middle school in Lynn, Massachusetts (Abdulkadiroglu et al., 2009a, 2009b; Angrist et al., 2010a, 2010b). These studies show significant positive effects for oversubscribed schools. Boston middle school charters appear to increase student achievement over traditional Boston public schools by about 0.2 standard deviations (σ) per year in English Language Arts (ELA) and about 0.4σ per year in mathematics. For high school students, attendance at a Boston charter school increases student achievement by about 0.2σ per year in ELA and 0.32σ per year in math.[1] Estimates for the KIPP middle school in Lynn are in line with the Boston results.

This study expands and updates the sample of Boston and Lynn schools to include other schools from around the state. As in our earlier work, we use two methods to estimate the effects of charter attendance. First, we take advantage of the random assignment of students in charter school admission lotteries to compare students who were offered a seat in oversubscribed charter lotteries with those who were not; we refer to this as the "lottery study." The lottery study controls for both observed and unobserved differences in student background, but is necessarily limited to schools that are oversubscribed and have good lottery records. Therefore, we also compare charter students to those in traditional public schools using statistical controls such as prior achievement to adjust for observed differences; we refer to this as the "observational study." The observational study includes all charter schools serving traditional students, but the observational results may be influenced by selection bias. In both the lottery and observational studies, separate results for charter schools located in urban areas and charter schools located outside of urban areas are reported in an effort to determine whether charter effects differ by community type.

This report is organized as follows. Section II describes Massachusetts' charter schools, participation in the lottery study sample, and student demographics and test scores; Section III describes the econometric methods used in the lottery study; Section IV reports the lottery findings; and Section V reviews the observational results. We conclude in Section VI.

[1] Other lottery studies look at schools in Chicago (Hoxby & Rockoff, 2004), New York City (Hoxby, Murarka & Kang, 2009), and the Harlem Children's Zone (Dobbie & Fryer, 2009). These studies report effects similar to our Boston and Lynn results. A recent national study using admissions lotteries found no effects for a sample of charter schools on average, but strong positive results for charter schools in urban communities (Gleason et al., 2010).

Figure 1: School Participation in Lottery and Observational Studies



Notes: Schools are counted as a middle school or high school if they enroll students in middle and/or high school grades. Thus, a school is counted twice if it enrolls both middle and high school grades.

* There is an exception to the 9th grade entry criteria for high school. Two schools with lotteries at the middle school entry point which also enroll students in the high school grades are included in the lottery analysis of 10th grade outcomes.

III School Participation, Data, and Descriptive Statistics

School Participation

The analysis here only covers middle schools and high schools (middle schools are defined as schools that students enter in grades 4 -7, while high schools typically start in 9th grade). We focused on middle schools and high schools for two reasons. First, data for elementary school lotteries were less widely available; second, elementary schools are not well suited to our observational study design, which relies on students' earlier test scores to control for differences between charter students and traditional public school students. No early score data are available for elementary school charter applicants.

Figure 1 and Table 1 summarize school participation (see also Appendix Table A1 for additional notes). Of the 30 middle schools and 13 high schools[2] that might have been included in the lottery study, we excluded two middle schools that opened in 2009, three alternative high schools, and two middle schools and two high schools that had closed. We surveyed the remaining 26 middle schools and eight high schools to determine if and when they were oversubscribed. Ultimately, 22 of these 32 schools had usable lottery records for at least one school year. These include 15 middle schools and six high schools. Eleven of the middle schools were undersubscribed or had insufficient records, with most of these schools located outside of Boston. Two high schools were undersubscribed or had insufficient records (one in Boston and one in Chelsea).

Nine of the lottery-study participating middle schools are in urban areas, with seven of these in Boston, one inside I-495, and one near the Rhode Island border. The other six are in nonurban areas, with three in the center of the state, one on Cape Cod, one inside I-495, and one near the New Hampshire border. Four participating high schools are in Boston. One nonurban lottery-study participating high school is on Cape Cod and the other near Springfield.

Charter schools covered by the observational study include all those operating between 2002 and 2009, except two middle schools that opened in the fall of 2009. Two middle schools and two high schools that closed before 2009 contribute observational data when open. Three high schools that enroll dropout and other at-risk students are included in the observational study as alternative schools.

Data

The Massachusetts Department of Elementary and Secondary Education provided data on all students enrolled in Massachusetts' public schools from the school year beginning fall 2001 through the school year beginning fall 2008. The data include student race/ethnicity, gender, special education status, limited English proficiency status, free/reduced-price lunch status, town of residence, and school(s) of attendance, as well as raw and scaled scores on MCAS exams. For the purposes of this project, raw MCAS scores were standardized by subject, grade level, and year. (The resulting scores have a mean of zero and a standard deviation of one for each year, subject, and grade level.)

Students were assigned to a single school for each year they appear in the data even if they attended more than one school in a given year. Typically, students appearing on the roster of more than one school were assigned to the school they attended longest, though students with any time in a charter school in a given year are coded as having been a charter student for the year. This conservative assignment rule ensures that charter schools "take responsibility" for partial-year students as well as those who attended for the full school year.[3]

The lottery study matches applicant records from the 15 participating middle schools and 6 participating high schools to the state database using name, year, and grade. When available, information on each applicant's birthday, town of residence, race/ethnicity, and gender was used to break ties. Ninety-five percent of applicants were successfully matched. Applicants were excluded from the lottery analysis if they were disqualified from the lottery they entered (typically, this was for applying to the wrong grade level). We also dropped siblings of current students, late applicants, and out-of-area applicants.[4] Students missing baseline demographic information in the state database were dropped as well. Some analyses exclude students without a baseline test score.

Descriptive Statistics

Table 2 shows descriptive statistics for students enrolled in traditional public schools, students enrolled in charter schools, and the sample of

[2] Two of the high schools are middle schools that enroll students in the high school grades and have historical lottery records that include the 10th grade outcome in our time frame (2002-2009).

[3] If a student attended more than one charter, the student was assigned to the charter he or she attended the longest.

[4] Charter schools typically give priority to students in the local school district (or sometimes region) in which they are located. Our applicant risk sets (discussed in the next section) distinguish between in-area and out-of-area applicants for schools that take substantial numbers of both. At schools with fewer than five out-of-area applicants, those out-of-area were dropped.

students who applied to oversubscribed charters participating in the lottery study. Traditional schools are defined as those that are not charters, alternative, special education, exam, or magnet schools; in this case, they include Boston's pilot schools. For each group, the table shows demographic characteristics, program participation rates, and average baseline test scores for students in schools across the state, schools in urban areas, and schools in nonurban areas.

Traditional urban students look very different from traditional students in the rest of the state. Specifically, urban students are much more likely to be African American or Hispanic, to be English language learners (or limited English proficient, LEP), to participate in special education, and to receive a subsidized lunch. Urban students also have much lower baseline test scores than other public school students (baseline scores are from 4th grade for middle schoolers and 8th grade for high schoolers).

Charter school students who live in urban and nonurban areas are more similar to their peers in regular public schools than to one another. However, there are important differences by charter status as well. In urban middle school charters, for example, charter students are more likely to be African American and less likely to be Hispanic or LEP, and less likely to participate in special education or to qualify for a subsidized lunch. Applicants to urban middle school charters have slightly higher baseline scores than their traditional school counterparts, as do nonurban charter applicants. Similar patterns appear in the high school sample. Differences in baseline characteristics by charter status underline the importance of appropriate comparisons when determining charter school impacts. In the lottery study, we examine students with similar backgrounds by comparing randomly selected winners and losers among applicants, while the observational study adjusts for background differences using an array of control variables, including baseline scores.

IV Statistical Methods for the Lottery Study

Massachusetts state law requires charter schools to admit students based on a public lottery when there are more applicants than seats. As part of the lottery admissions process, applicants are randomly assigned sequence numbers. Applicants with the lowest sequence numbers are admitted immediately, while the rest go on a waiting list.[5] Since applicant sequencing is random, those offered a seat should be similar to those with higher numbers who do not receive an offer. Specifically, applicants who do and do not receive offers should have similar measured characteristics (such as previous test scores). Moreover, these two groups also should have similar unobserved characteristics (such as factors related to motivation or family background).

In practice, the lottery analysis is complicated by the fact that not all students offered a seat will enroll in one of the charter schools to which they were admitted (applicants may move or change their minds, for example). At the same time, some applicants who are not offered a seat ultimately will end up attending a charter school, usually by reapplying in the following year. Consequently, the time that students spend attending charter schools, while highly correlated with lottery offers, is determined by other factors as well. We therefore use an econometric technique called "Instrumental Variables," or IV (also called "two-stage least squares," or 2SLS), to adjust for the gap between randomized lottery offers and actual charter attendance. The specifics of this method are detailed below. Briefly, 2SLS takes the difference in test scores between winners and losers and divides it by the corresponding win-loss difference in the average time spent attending a charter school.

The effects of charter attendance are modeled as a function of years spent attending a charter school. The causal relationship of interest is captured by using equations like this one for the MCAS scores, y_{igt}, of student i taking a test in year t in grade g:

Equation 1

$$y_{igt} = a_t + \beta_g + \sum_j \delta_j d_{ij} + \gamma' X_i + \rho S_{igt} + \varepsilon_{igt}.$$

The variable, S_{igt}, is the years spent in a charter school as of the test date, counting any repeated grades, and counting time in all charter schools, not just the oversubscribed charters. The causal effect of years spent in a charter school is ρ. The terms a_t and β_g are year-of-test and grade-of-test effects; X_i is a vector of demographic controls with coefficient γ; and ε_{igt} is an error term that reflects random fluctuation in test scores. The dummies d_{ij} are indicators for lottery-specific risk sets – these dummies allow for differences in the probability of admission created by applications to more than one charter school lottery.[6]

Because students and parents selectively choose schools, ordinary least squares (OLS) estimates of equation (1) may not capture the causal effects of charter attendance. Specifically, OLS estimates may be biased by correlation between school choice and unobserved variables related to ability, motivation, or family background. We therefore use an instrumental variables strategy that exploits the partial random assignment of S_{igt} in school-specific lotteries to estimate the causal effects of charter school attendance.

IV estimation involves three components: the first-stage, which links random assignment to years in charter; the reduced form, which links random assignment to outcomes (test scores); and the ratio of these two, which captures the causal effect of interest.

The first stage is:

Equation 2

$$S_{igt} = \lambda_t + \kappa_g + \sum_j \mu_j d_{ij} + \Gamma' X_i + \pi Z_i + \eta_{igt},$$

where λ_t and κ_g are year-of-test and grade effects in the first stage. The first-stage effect is the coefficient, π, on the instrumental variable, Z_i. The charter instrument is a dummy variable for having been offered a seat at one of the schools in the applicant's charter risk set.

For a given charter applicant, the charter risk set is the list of all lotteries to which the student applied in a given year and the entry grade among the lottery sample charters. Students who did not apply to any of the lottery sample charter schools are not in any charter risk set; we therefore

[5] Siblings of currently enrolled students are typically offered slots automatically. Some schools run separate lotteries for those who reside outside the district or region where the charter school is located.

[6] Other control variables include year-of-birth dummies. Some models also include demographic controls and/or baseline test scores. Standard errors are clustered to allow for correlation by year and school in the high school analysis. The middle school analysis clusters in two dimensions: student identifier and school by grade and by year. For details, see our Boston study (Abdulkadiroglu et al., 2009a).

cannot include them in the lottery-based analysis. Charter risk sets also vary by grade of entry and by year of application (the entry cohort).[7]

The IV reduced form is obtained by substituting for years in charter in equation (1) using the first stage, equation (2). The reduced form measures the direct impact of the instrument on outcomes. (In clinical trials with noncompliance, this is sometimes called the "intention-to-treat" effect.) The causal effect of interest in equation (1), ρ, is the ratio of the reduced form effect of the instrument to the first stage effect of the instrument, as estimated in equation (2). The procedure by which this ratio is computed in practice is commonly referred to as two-stage least squares (2SLS).

Some of the estimates discussed in this report allow for the separate effects of charter attendance at schools in and out of urban areas. These estimates are constructed using two instruments, one indicating random offers of an urban charter seat and one indicating random offers of a nonurban charter seat. The causal variables of interest in this case separately count the years in urban charters and the years in nonurban charters. This method therefore distinguishes the effect of attending an urban charter school from the effect of attending a charter school in the rest of the state.

[7] As described above, the charter school risk set is the set of charters to which an applicant applied. To illustrate, a student who applied to charter school A and no others would be put in one risk set; a student who applied to charter school B and no others would be put in another risk set; and a student who applied to charter schools A and B would be placed in a third risk set. By controlling for the risk set, or combinations of charter schools applied to, we are in essence making comparisons within groups of students who have applied to the same schools. This is important, since students who apply to more charter schools have a greater chance of receiving an offer at a school simply because they have entered more lotteries.

Covariate Balance and Attrition

The validity of the lottery-based estimates reported here turns in part on the quality of the lottery data collected from individual schools. As a check on the lottery data, we compared the characteristics of those offered and not offered a seat, groups we refer to by the shorthand terms of "winners" and "losers." (This comparison excludes students whom the admissions process does not randomize, such as siblings and late applicants.) Table 3 reports regression-adjusted differences by win/loss status, where a win means students were offered a spot in a charter within the relevant risk set. The regressions used to construct these estimates control for applicant risk sets (year of application and the set of charters applied to).

Table 3 shows only two significant differences between lottery winners and losers. In middle school lotteries with students who have baseline test score data, winners are 0.9 percentage points more likely to be Asian; and in high school lotteries with students who have baseline score data, winners have a baseline ELA score that is .09 standard deviations lower than that of losers. These isolated small differences seem likely to be chance findings. This conclusion is reinforced by F statistics at the bottom of each column, which test the joint hypothesis that all differences in background characteristics and baseline test scores in the column are zero. None of these tests lead to rejection at conventional significance levels.

A second potential threat to the validity of lottery-based estimates is the differential loss to follow-up between winners and losers (also called differential attrition). Students in our study are lost to follow-up if they are missing the MCAS score data we use to measure charter achievement effects. This usually happens when a student moves out of state or to a private school. Attrition can bias lottery-based estimates if different types of students are more likely to leave the sample depending on lottery results. For instance, losers might be more likely to leave than winners, and highly motivated students might be more likely to opt for private school if they lose. We therefore compare the likelihood that winners and losers have an outcome test score in our data. There are no statistically significant differences in follow-up rates in the lottery sample schools, a result documented in Appendix Table A3. It therefore seems unlikely that differential attrition has an impact on the lottery-based results.

Estimated Charter Effects

Table 4 reports first stage, reduced form, and 2SLS estimates for three groups of schools with oversubscribed lotteries: charter middle schools and high schools statewide, charter schools located in urban areas, and charter schools in nonurban areas. The first stage estimates capture the difference in years of attendance at a charter school between winners and losers. Reduced form estimates capture the analogous difference in test scores. The 2SLS estimates, computed as the ratio of reduced form to first stage estimates, capture the average causal effect of a year's attendance at a charter school.[8]

Among applicants to charter middle schools, students who win a charter school lottery spend about 0.9 more years in charter schools before taking the MCAS than students who are not offered a seat in the lottery. In high school, applicants who win the lottery spend about half a year more attending a charter school than applicants who lose the lottery before taking the MCAS test. These results can be seen in the first column of Table 4. There is little difference in first stage effects at urban and nonurban schools, as can be seen by comparing the first stage estimates in columns 4 and 7. Overall, the first stage estimates are similar to those reported in our Boston study (Abdulkadiroglu et al., 2009a).

Although high school students attend school for two years before their 10th grade MCAS test, the high school first stage is well below two. This is not entirely unexpected: some winners never attend a charter school and thus contribute zero years of charter attendance to the first stage, while other winners attend for only one year. At the same time, some losers ultimately go to a charter school for at least part of their high school careers.

Middle school lottery winners outscore lottery losers by about 0.24σ in math. By contrast, the reduced form estimate shows no significant effect on middle school ELA scores. These estimates appear in column 2 of Table 4. High school lottery winners outperform lottery losers by about 0.13σ in ELA, 0.18σ in math, 0.18σ in writing composition, and 0.15σ in writing topic development. These estimates, like the middle school math effect, are statistically significantly different from zero.

[8] The estimates reported in Table 4 are from models that include controls for risk sets and student demographic characteristics (male, African American, Hispanic, Asian, other race, special education, limited English proficiency, free/reduced-price lunch, and a female by minority interaction). Similar results are obtained from models that add controls for baseline scores.

2SLS estimates of the causal effect of attending a charter school are reported in column 3 of Table 4. Because the middle school first stage is close to one, the middle school 2SLS estimates differ little from the corresponding reduced form estimates. Across the state, the 2SLS estimates imply that math scores increase by about 0.25σ for each year of attendance at a lottery sample middle school charter, with no difference in ELA results.

Although the high school reduced form effects are smaller than the corresponding middle school reduced form estimates, the high school first stage also is smaller. Together, the high school first stage and reduced forms are generally somewhat larger effects than those found for middle schools. Specifically, the ELA and math score gains generated by time spent in charter high schools are on the order of 0.26σ per year for ELA and 0.37σ per year for math. Writing gains also are estimated to be substantial.

The estimates for the pooled state sample mask considerable heterogeneity by school type for middle schools. Urban charter middle schools generate significant gains of about 0.12σ in ELA and 0.36σ in math per year. At the same time, the results for nonurban middle schools show clear negative effects. Specifically, these results show charter students at nonurban middle schools losing ground relative to their public school peers at a rate of 0.19σ in ELA and 0.13σ in math. Not surprisingly, the high school lottery results for urban schools are similar to the statewide results (all but two of the high schools in the state sample are urban). On the other hand, lottery estimation generates no significant effects of attendance at the nonurban charter high schools. It is important to note, however, that there also is heterogeneity within the urban and nonurban groups. For each subsample, the 2SLS effects reported here are average effects that reflect outcomes in a variety of schools, some positive, some negative.

Models for Subgroups

In an inquiry motivated in part by the striking differences in charter effects by school type, we looked separately at charter effects in demographic subgroups defined by race/ethnicity and free lunch eligibility. Urban schools serve a mostly low-income minority population, while there are relatively few non-White and low-income students at other schools. The difference in effects generated by urban and nonurban charters may therefore be explained in part by differences in the populations served at these two types of schools.

Urban middle schools generate much larger positive effects for non-Whites and free lunch-eligible applicants than for White applicants (in fact, the ELA estimate for White middle schoolers is essentially zero). These results, which can be seen in Table 5, suggest that the overall positive effects found for urban charters are indeed partly accounted for by their success with poor minority students. At the same time, nonurban charters do not seem to be raising scores for the same type of student. This suggests that something about the schools themselves rather than the student body composition drives large urban charter gains; however, it should be noted that the nonurban minority sample is small. The picture for high school is more consistent across school settings, with both urban and non-urban schools generating big gains for poor students who qualify for a subsidized lunch (though the nonurban subsidized lunch sample is quite small).

Ability Interactions and Peer Effects

To address the question of whether charter schools cater to a relatively high-achieving group, we interacted the charter school attendance variable with achievement scores from tests prior to the charter school lotteries. We also looked at possible peer effects by allowing for interactions with the average score of applicant peers in each student's risk set. The results of this analysis appear in Table 6 (Abdulkadiroglu et al., 2009b, discuss statistical models with interaction terms in detail). The effects of urban charter middle school attendance are magnified for students with lower baseline scores, while the interactions for high school students are nearly all insignificant, a result shown in column 2 of Table 6. Negative own-achievement interactions in middle school weigh against the view that charter middle schools focus on high-achieving applicants. The own-achievement interaction for writing composition in nonurban high schools is also negative.

There also is little evidence of a peer effect due to the grouping together of high-achieving students. In fact, middle school applicants from risk sets with lower average baseline scores benefit more from charter school attendance than do high achievers, as can be seen in columns 6 and 8 of Table 6. The absence of strong positive interactions with peer ability weighs against the view that high-achieving peers contribute to the success of urban charters, a finding that echoes the results from similar models in our Boston study.

School Characteristics

In a recent multistate lottery study, Gleason et al. (2010) estimate separate charter school effects in schools with a majority non-White student population, schools with a majority economically disadvantaged population (using free/reduced-price lunch status), and schools located in urban areas. Like our study, this one finds that urban charter schools boost achievement more than other types of charters, at least on average.

These results naturally raise the question of which practices contribute to charter school success. In an effort to shed some light on this question, we surveyed school leaders in the sample of schools participating in the lottery study. The survey results, summarized in Table 7, show that urban charter schools tend to have longer days and school years, with instructors who spend considerably more time on reading and math instruction. Over the course of the school year, urban charter schools spend 136 more hours in math instruction and 156 more hours in reading instruction than nonurban schools. This is not surprising since many urban charter leaders reported that their schools schedule double periods or double blocks for reading and math. In contrast, the Boston Public Schools' teachers' contract limits the school day to 400 minutes and the school year to 180 days (Stutman, 2010).

Most urban charter schools also identify with a No Excuses philosophy, while none of the nonurban schools subscribe to this approach. Urban charter schools are more likely than nonurban charter schools to use student and parent contracts, to require students to wear uniforms, and to use some type of merit/demerit discipline system. It also is worth noting that average per-pupil spending is higher at urban schools (though class size also is larger, and teachers are younger and thus presumably less experienced). These differences in approach may explain some of the differences in achievement gains across settings.

VI Results from the Observational Study

The observational analysis includes students from all operating charter schools in the state that enroll traditional students; this allows us to compare results for charter schools included in the lottery sample to results for charter schools that either were undersubscribed or had poor records. Three charter high schools that enroll dropout and at-risk students are included in the observational analysis as alternative schools. The observational analysis is of interest for two reasons. First, we can determine whether a research design that relies on statistical controls replicates the lottery findings when applied to the same sample. Where the replication is successful, it seems reasonable to conclude that statistical controls eliminate selection bias, an interesting finding in its own right. However, a good match between lottery and observational estimates also is useful; we can use the observational approach to look at nonlottery schools in the hope that the observational estimates for nonlottery schools also are uncontaminated by selection bias. This allows us to explore the possible differences in effectiveness between lottery-sample charter schools and other charter schools.[9]

Our observational approach relies on a combination of matching and regression models to control for differences between charter students and students attending traditional public schools. The observational sample begins with almost all charter students in the state (that is, those enrolled in a charter school serving traditional students at the time they were tested). Charter students are then grouped into cells defined by baseline year and school, gender, race, limited English proficiency status, special education status, and subsidized lunch status. Finally, we match the charter students in each cell to the sample of noncharter students with the same characteristics. The matched sample of middle school students includes about 13,000 in charters and 62,000 in the comparison group (some students contribute multiple grades of outcomes to the observational analysis). The matched sample of high school students includes about 4,000 in charters and 35,000 in the comparison group.

The observational estimates come from a regression model of the following form:

where y_{igt} is the test score of student i from the sending school s, tested in grade g and year t, and S_{igt}, E_{igt}, and ALT_{igt} denote years spent attending a charter, exam/magnet, or special education/alternative school, with corresponding effects ρ_c, ρ_e, and ρ_{alt}. All observational specifications control for baseline test scores, and include a sending school fixed effect, denoted by μ_s in equation (3).

Observational estimates for middle schools in the urban lottery sample are strikingly similar to the lottery results. This can be seen by comparing the estimates in columns 1 and 2 in Table 8 (compare 0.12σ to 0.17σ for ELA, and 0.33σ to 0.32σ for math). The match across designs is not as good for urban high schools, but the observational and lottery results in the nonlottery sample are broadly consistent in that both show substantial positive effects. Most important, the observational results for schools in the lottery sample strongly suggest that these schools generate larger achievement gains than other urban charters. This is further evidence of the importance of school-level heterogeneity in charter attendance effects.

Among estimates of attendance effects at nonurban charter schools, the match between lottery estimates and observational results is not as good as for urban schools, even when the two research designs use the same sample (as can be seen in columns 4 and 5 of Table 8). Specifically, the observational results for the nonurban middle schools in the lottery sample are smaller in magnitude than the lottery estimates showing large, significant negative effects. At the same time, the observational results for nonurban middle school charters in the lottery sample are broadly consistent with the lottery results in that they also show evidence of negative effects. The lottery results for nonurban charter high schools include no significant effects. On the other hand, the observational estimates for these schools are positive and significantly different from zero, though much more modest than the corresponding effects for urban high schools. Observational estimates for nonurban charter high schools outside the lottery sample are virtually zero.

Equation 3

$$y_{isgt} = a_t + \beta_g + \mu_s + \gamma' X_i + \rho_c C_{igt} + \rho_e E_{igt} + \rho_{alt} ALT_{igt} + \varepsilon_{igt},$$

[9] The observational study includes students attending any school with middle school or high school grades, and not just those that fit the definition of a middle school or high school for the purposes of the lottery study.

VII Conclusions

Comparisons of charter lottery winners and losers show mostly significant positive effects of charter attendance at oversubscribed middle schools and high schools. The middle school results reported here are moderately smaller than our earlier findings for Boston and Lynn, while the high school results are similar. A more nuanced analysis shows that positive estimates in the statewide sample come primarily from urban charters, which include the set of Boston schools and the KIPP middle school we previously analyzed. On average, schools outside of urban areas are much less likely to have produced achievement gains; in fact, their students may be lagging their noncharter peers.

Differences in impact by community type do not appear to be explained by student demographics. Although urban charter schools do especially well with minority and low-income students, these schools also produce significant gains on most outcomes for Whites as well. By contrast, estimates for nonurban middle schools fail to show significant gains for any demographic subgroup, with some negative effects on Whites in these schools. An analysis that interacts charter attendance with students' baseline scores shows that urban charter schools boost achievement most for students who start out with the lowest scores. Interactions with the baseline score of peers offer little evidence of positive peer effects; in fact, among middle schools, the charters that boost achievement most enroll the weakest students.

As in our earlier work with Boston charters, we use an observational study design to examine charter attendance effects in a wider sample of schools. When estimated using the same sample, observational and lottery estimates are similar for urban charters, especially for middle schools. The results also suggest, however, that the oversubscribed schools that make up our urban lottery sample are considerably more effective than schools that are not oversubscribed or that have insufficient lottery records. This also seems to be true for nonurban high schools, where observational estimates for the lottery sample generate modest positive effects. This set of findings constitutes an important caution: our lottery estimates capture effects for a particular group of schools – specifically, schools in high demand. The impact of attendance at other types of charter schools may differ.

Another key distinction in our analysis is the distinction between charter schools in urban and nonurban settings. The differences in charter effectiveness by community type documented here may be due to differences in either the quality of the surrounding public schools or the pedagogical approach. Suburban charter applicants clearly come from relatively high-achieving public school districts. Moreover, our survey of school leaders shows important differences in practice between urban and nonurban charter schools. Among other pedagogical differences, urban charter schools largely embrace the No Excuses model and devote considerably more time to math and reading instruction than do nonurban charter schools. These factors may explain community-related differences in impact, though other differences may be equally important. In future work, we hope to isolate the practices that allow effective charters to boost achievement. We also plan to look at outcomes other than test scores, such as post-secondary educational attainment and earnings.

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Table 1: School Participation

	All Charters (1)	Charters Included in Observational Study (2)	Middle (Entry in 4-7) and High (Entry in 9) School Charters* (3)	Charters Eligible for Lottery Study (4)	Charters Included in Lottery Study (5)
Middle Schools					
Urban	33	31	19	16	9
Boston	13	12	11	8	7
Non-Boston	20	19	8	8	2
Nonurban	19	19	11	10	6
Total (Urban and Nonurban)	52	50	30	26	15
High Schools					
Urban	23	20	8	6	4
Boston	10	9	7	5	4
Non-Boston	13	11	1	1	0
Nonurban	11	11	5	2	2
Total (Urban and Nonurban)	34	31	13	8	6

Notes: This table reports the number of middle and high charter schools in Massachusetts and their participation in the observational and lottery studies. The numbered notes below describe the schools included in each column. Columns (3)-(5) exclude middle schools that have their main admissions lottery in elementary school (e.g., K-8 schools) and high schools that hold their main admissions lotteries in elementary or middle school (e.g.,K-12 or 6-12 schools). MATCH Charter Public High School is counted twice: once as a middle school and once as a high school (lotteries from each level participate in the lottery study). Edward Brooke Charter School is counted as a middle school (it became K-8 in 2006, only lotteries from the middle grades participate in the lottery study). "Urban" towns are defined by the Massachusetts Department of Elementary and Secondary Education as the towns where the district superintendents participate in the Massachusetts Urban Superintendents Network. These towns include: Boston, Brockton, Cambridge, Chelsea, Chicopee, Everett, Fall River, Fitchburg, Framingham, Haverhill, Holyoke, Lawrence, Leominster, Lowell, Lynn, Malden, New Bedford, Pittsfield, Quincy, Revere, Somerville, Springfield, Taunton, and Worcester.

1. Middle and high charter schools in Massachusetts, including schools opened in 2009 (which is too recent to have MCAS outcomes), alternative charter schools, and closed schools.
2. Middle and high charter schools in Massachusetts, including closed schools but excluding schools opened in 2009 (which is too recent to have MCAS outcomes) and alternative charter schools.
3. Middle and high charter schools in Massachusetts with the designated entry grades (in 4-7 and 9)*, including schools opened in 2009, alternative schools, and closed schools.
4. Middle and high charter schools in Massachusetts with the designated entry grades, excluding schools opened in 2009, alternative charter, and closed schools.
5. Middle and high charter schools that are included in column (4), excluding schools that are undersubscribed or have insufficient lottery records.

* There is an exception to the 9th grade entry criteria for high school. Two schools with lotteries at the middle school entry point which also enroll students in the high school grades are included in the lottery analysis of 10th grade outcomes.

Table 2: Descriptive Statistics

	Traditional School Students			Charter Students			Applicants in the Oversubscribed Lottery Sample		
	Statewide (1)	Urban (2)	Nonurban (3)	Statewide (4)	Urban (5)	Nonurban (6)	Statewide (7)	Urban (8)	Nonurban (9)
I. Middle School (5th, 6th, 7th, and 8th grades)									
Female	48.7%	48.5%	48.7%	49.3%	50.0%	48.4%	50.1%	49.4%	52.0%
African American	7.4%	18.9%	2.9%	23.4%	38.7%	6.6%	37.4%	51.6%	2.1%
Hispanic	11.3%	31.0%	3.5%	16.7%	27.1%	5.3%	16.2%	21.6%	2.9%
Special Education	16.8%	19.1%	15.9%	15.3%	15.1%	15.6%	18.2%	18.3%	18.1%
Subsidized Lunch	29.4%	67.8%	14.2%	43.7%	62.6%	23.0%	51.4%	68.2%	9.4%
Limited English Proficiency	5.1%	14.2%	1.6%	5.1%	7.7%	2.3%	6.6%	9.1%	0.5%
Baseline Math Score	0.028	-0.453	0.215	-0.151	-0.441	0.169	-0.199	-0.408	0.321
Baseline ELA Score	0.034	-0.476	0.232	-0.124	-0.400	0.180	-0.191	-0.420	0.379
Years in Charter	0.001	0.001	0.001	2.145	2.174	2.113	1.274	1.403	0.958
Number of Students	387,448	109,939	277,509	18,622	9,771	8,851	3,882	2,753	1,129
Number of Schools	624	247	377	50	31	19	15	9	6
II. High School (10th grade)									
Female	49.6%	50.4%	49.4%	55.4%	56.2%	53.9%	54.9%	55.4%	49.1%
African American	7.3%	21.0%	3.1%	31.6%	46.1%	5.3%	56.2%	60.9%	4.3%
Hispanic	9.6%	26.9%	4.3%	11.8%	16.8%	2.7%	22.2%	24.2%	0.4%
Special Education	15.7%	16.4%	15.4%	12.8%	12.4%	13.5%	16.6%	16.8%	15.0%
Subsidized Lunch	24.9%	59.5%	14.4%	39.1%	52.6%	14.9%	65.8%	70.4%	15.4%
Limited English Proficiency	3.2%	9.2%	1.3%	1.3%	1.7%	0.6%	2.9%	3.2%	0.4%
Baseline Math Score	0.090	-0.397	0.235	-0.052	-0.208	0.227	-0.234	-0.281	0.266
Baseline ELA Score	0.113	-0.363	0.250	0.027	-0.132	0.315	-0.215	-0.267	0.285
Years in Charter	0.002	0.006	0.001	1.950	1.964	1.926	0.682	0.616	1.402
Number of Students	369,879	86,000	283,879	5,533	3,560	1,973	2,804	2,570	234
Number of Schools	395	96	299	31	20	11	6	4	2

Notes: The table reports sample means in baseline years by school type in each column. The numbered notes below describe each sample. Demographic characteristics are taken from grade 4 for middle school students and grade 8 for high school students. All students must be enrolled in a Massachusetts public school in the baseline year. Students must have at least one MCAS score to be included in the table. Two middle schools that extend to the high school grades are included in the applicant sample.

1. Massachusetts students, excluding students attending exam/magnet, pilot, alternative, special education, or charter schools from 2004-2009.
2. Students enrolled in urban schools, excluding students attending exam/magnet, pilot, alternative, special education, or charter schools from 2004-2009.
3. Students enrolled in Massachusetts public schools, excluding students attending urban schools, exam/magnet, pilot, alternative, special education, or charter schools from 2004-2009.
4. Students enrolled in charter schools from 2004-2009.
5. Students enrolled in charter schools located in urban areas from 2004-2009.
6. Students enrolled in charter schools located in Massachusetts but not in urban areas from 2004-2009.
7. Charter applicant cohorts in randomized lotteries: middle school students in 2002-2008, and high school students in 2002-2007.
8. Charter applicant cohorts in randomized lotteries of charters located in urban areas: middle school students in 2002-2008, and high school students in 2002-2007.
9. Charter applicant cohorts in randomized lotteries of charters located in Massachusetts but not in urban areas: middle school students in 2002-2008, and high school students in 2002-2007.

Covariate Balance between Lottery Winners and Lottery Losers

Table 3: Covariate Balance between Lottery Winners and Lottery Losers

	Middle School		High School	
	All Lotteries	Lotteries with Baseline Scores	All Lotteries	Lotteries with Baseline Scores
	(1)	(2)	(3)	(4)
Hispanic	-0.004	0.001	0.002	-0.014
	(0.013)	(0.013)	(0.019)	(0.021)
African American	0.012	0.006	0.006	0.020
	(0.015)	(0.015)	(0.021)	(0.023)
White	-0.004	-0.005	-0.007	-0.006
	(0.013)	(0.014)	(0.011)	(0.012)
Asian	0.008	0.009*	0.001	-0.004
	(0.005)	(0.005)	(0.008)	(0.008)
Female	0.025	0.028	0.002	0.011
	(0.018)	(0.019)	(0.022)	(0.023)
Subsidized Lunch	0.009	0.010	0.025	0.010
	(0.015)	(0.016)	(0.019)	(0.021)
Special Education	-0.010	-0.011	0.002	0.003
	(0.014)	(0.015)	(0.017)	(0.018)
Limited English Proficiency	-0.013	-0.008	0.009	0.007
	(0.008)	(0.009)	(0.008)	(0.007)
Baseline ELA Score	-	-0.021	-	-0.087**
		(0.036)		(0.039)
Baseline Math Score	-	0.017	-	-0.059
		(0.035)		(0.042)
Baseline Writing Composition Score	-	-	-	0.012
				(0.041)
Baseline Writing Topic Score	-	-	-	-0.061
				(0.040)
p-value, from F-test	0.261	0.263	0.926	0.227
N	4,646	4,256	3,476	2,830

Notes: This table reports coefficients on regressions of the variable indicated in each row on an indicator variable equal to one if the student won the lottery. Regressions include dummies for (combination of schools applied to)*(year of application)*(location risk set) and baseline grade and exclude students with sibling priority or late applications. Samples in columns (1) and (3) are restricted to students from cohorts where we should observe at least one test score. Samples in columns (2) and (4) are restricted to students who also have baseline test scores. F tests are for the null hypothesis that the coefficients on winning the lottery in all regressions are all equal to zero. These test statistics are calculated for the subsample that has non-missing values for all variables tested.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Lottery Estimates of Charter Effects

Level	Subject		Statewide First Stage (1)	Statewide Reduced Form (2)	Statewide 2SLS (3)	Urban First Stage (4)	Urban Reduced Form (5)	Urban 2SLS (6)	Nonurban First Stage (7)	Nonurban Reduced Form (8)	Nonurban 2SLS (9)
Middle School											
	ELA		0.933***	0.044	0.047	0.949***	0.111***	0.115***	0.917***	-0.174***	-0.189***
			(0.050)	(0.035)	(0.036)	(0.062)	(0.041)	(0.041)	(0.084)	(0.053)	(0.059)
		N		8,500			6,313			2,187	
	Math		0.929***	0.235***	0.253***	0.936***	0.339***	0.361***	0.944***	-0.127**	-0.131**
			(0.049)	(0.040)	(0.040)	(0.061)	(0.045)	(0.044)	(0.085)	(0.060)	(0.066)
		N		8,754			6,596			2,158	
High School											
	ELA		0.509***	0.132**	0.259***	0.503***	0.136**	0.270***	0.896***	-0.051	-0.047
			(0.109)	(0.053)	(0.077)	(0.112)	(0.054)	(0.078)	(0.067)	(0.154)	(0.169)
		N		2,709			2,499			210	
	Math		0.508***	0.186***	0.367***	0.502***	0.197***	0.390***	0.898***	-0.284	-0.303
			(0.109)	(0.069)	(0.093)	(0.112)	(0.070)	(0.094)	(0.066)	(0.219)	(0.234)
		N		2,673			2,466			207	
	Writing Topic		0.514***	0.172***	0.334***	0.508***	0.181***	0.355***	0.895***	-0.207	-0.218
			(0.109)	(0.061)	(0.092)	(0.112)	(0.061)	(0.093)	(0.067)	(0.324)	(0.355)
		N		2,682			2,473			209	
	Writing Composition		0.514***	0.148**	0.288***	0.508***	0.154**	0.303***	0.895***	-0.126	-0.129
			(0.109)	(0.062)	(0.097)	(0.112)	(0.063)	(0.099)	(0.067)	(0.286)	(0.316)
		N		2,682			2,473			209	

Notes: This table reports estimates of the effects of years in charter school on test scores, controlling for demographic characteristics. The sample is restricted to students with baseline demographic characteristics who attended a Massachusetts public school when tested and excludes students with sibling priority or late applications. All models control for sex, race, special education, limited English proficiency, subsidized lunch status, and a female by minority dummy. Regressions include year of test, year of birth, and risk set dummies. The risk set dummies are: (combination of schools applied to)*(year of application)*(location risk set). Middle school regressions pool 4th, 5th, 6th, 7th, and 8th grade outcomes that occur after charter entry grade and include dummies for grade level and baseline grade. Reported N's count the number of student by grade observations that contribute to the regression (up to five grade outcomes for middle school). Robust standard errors are reported for high school estimates. Middle school standard errors cluster on student identifier and school by year by grade.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table

5

2SLS Estimates for Subgroups

Table 5: 2SLS Estimates for Subgroups

		Urban					Nonurban				
		All	African American Students	Hispanic Students	White Students	Students with Subsidized Lunch	All	African American Students	Hispanic Students	White Students	Students with Subsidized Lunch
Level	*Subject*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Middle School											
	ELA	0.117***	0.196***	0.166***	-0.003	0.190***	-0.175***	-0.187	0.182	-0.177***	-0.047
		(0.034)	(0.056)	(0.055)	(0.057)	(0.038)	(0.045)	(0.508)	(0.311)	(0.045)	(0.135)
	N	5,995	2,903	1,256	1,435	4,014	2,116	45	66	1,906	190
	Math	0.331***	0.460***	0.408***	0.111*	0.364***	-0.192***	-0.239	-0.427	-0.177***	-0.098
		(0.036)	(0.056)	(0.061)	(0.060)	(0.040)	(0.049)	(0.456)	(0.481)	(0.043)	(0.124)
	N	6,177	2,992	1,300	1,474	4,126	1,850	44	55	1,658	174
High School											
	ELA	0.328***	0.306***	0.382**	0.093	0.328***	0.124	-	-	0.014	0.555***
		(0.069)	(0.072)	(0.154)	(0.377)	(0.075)	(0.200)	-	-	(0.250)	(0.113)
	N	2,151	1,309	555	167	1,568	167	-	-	155	24
	Math	0.385***	0.397***	0.209	0.574*	0.284***	-0.134	-	-	-0.150	0.228
		(0.068)	(0.080)	(0.145)	(0.304)	(0.085)	(0.725)	-	-	(0.709)	(0.139)
	N	2,410	1,499	591	190	1,749	169	-	-	157	22
	Writing Topic	0.375***	0.477***	-0.055	0.404	0.327***	0.293	-	-	0.242	0.602***
		(0.097)	(0.110)	(0.210)	(0.456)	(0.110)	(0.580)	-	-	(0.627)	(0.141)
	N	2,103	1,276	543	167	1,533	166	-	-	154	23
	Writing Composition	0.246**	0.278**	0.129	0.452	0.148	-0.300	-	-	-0.401	0.067
		(0.101)	(0.114)	(0.248)	(0.381)	(0.119)	(0.626)	-	-	(0.682)	(0.318)
	N	2,103	1,276	543	167	1,533	166	-	-	154	23

Notes: This table reports estimates of the effects of years in charter school on test scores analogous to those reported in the 2SLS lottery results in Table 4 except that the specifications here control for baseline test score in addition to baseline demographics. Baseline test score includes the same subject prior test score and a set of interactions of that test score and baseline grade. The sample is restricted to the relevant subgroup for columns (2)-(5) and (7)-(10). Middle school regressions pool 4th, 5th, 6th, 7th, and 8th grade outcomes that occur after charter entry grade and include dummies for grade level and baseline grade. Reported N's count the number of student by grade observations that contribute to the regression (up to five grade outcomes for middle school). Robust standard errors are reported for high school estimates. Middle school standard errors cluster on student identifier and school by year by grade. Results are not reported for subgroups of five or fewer students.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Interaction Models

Level	Subject		Own Baseline Score				Peer Mean Baseline Score			
			Urban		Nonurban		Urban		Nonurban	
			Main Effect	Interaction	Main Effect	Interaction	Main Effect	Interaction	Main Effect	Interaction
Level	*Subject*		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Middle School										
	ELA		0.102***	-0.089***	-0.140**	-0.060	-0.001	-0.544***	-0.029	-0.254
			(0.033)	(0.030)	(0.059)	(0.061)	(0.055)	(0.180)	(0.192)	(0.324)
		N	5,995		2,116		5,995		2,116	
	Math		0.322***	-0.111***	-0.170***	-0.045	0.166***	-0.886***	0.108	-0.568*
			(0.034)	(0.030)	(0.054)	(0.039)	(0.048)	(0.183)	(0.168)	(0.314)
		N	6,177		1,850		6,177		1,850	
High School										
	ELA		0.326***	0.002	0.128	0.027	0.316***	-0.760	-0.296	0.813
			(0.068)	(0.095)	(0.149)	(0.092)	(0.073)	(0.563)	(1.826)	(3.604)
		N	2,151		167		2,151		167	
	Math		0.386***	0.061	-0.169	0.024	0.379***	0.463	-0.608	0.787
			(0.067)	(0.068)	(0.727)	(0.058)	(0.066)	(0.297)	(2.155)	(2.946)
		N	2,410		169		2,410		169	
	Writing Topic		0.377***	-0.007	0.316	-0.072	0.380***	-0.406	0.265	-2.677
			(0.098)	(0.092)	(0.588)	(0.068)	(0.101)	(0.743)	(0.564)	(4.046)
		N	2,103		166		2,103		166	
	Writing Composition		0.252**	0.049	-0.237	-0.139**	0.251**	-0.420	-0.153	-1.140
			(0.100)	(0.088)	(0.549)	(0.057)	(0.100)	(0.777)	(0.813)	(4.497)
		N	2,103		166		2,103		166	

Notes: This table reports 2SLS estimates from models that include interaction terms. Columns (1)-(4) interact years in urban and nonurban charter schools with a student's own baseline test score, and add baseline score interacted with the urban and nonurban offer dummies to the instruments. Columns (5)-(8) interact years in each type of charter school with the baseline mean of the members of a student's risk set, and add baseline score in the risk set interacted with the offer dummies to the instruments. The interacting variables are demeaned so that the main effects are evaluated at the mean, and all specifications include main effects of the interacting variable. All models control for sex, race, special education, limited English proficiency, subsidized lunch status, a female by minority dummy, baseline test scores, and a set of interactions between baseline test score and baseline grade. Regressions include year of test, year of birth, and risk set dummies. Middle school regressions pool 4th, 5th, 6th, 7th, and 8th grade outcomes that occur after charter entry grade and include dummies for grade level and baseline grade. Reported N's count the number of student by grade observations that contribute to the regression (up to five grade outcomes for middle school). Robust standard errors are reported for high school estimates. Middle school standard errors cluster on student identifier and school by year by grade.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7

School Characteristics

Table 7: School Characteristics

School Characteristic	Statewide (1)	Urban (2)	Nonurban (3)
Time in School			
Days Per School Year	186.90	190.38	180.43
Average Minutes Per Day	456.00	477.77	415.57
Have Saturday School	40.0%	61.5%	0.0%
Average Minutes of Math Instruction Per Day	80.88	94.92	54.79
Average Minutes of Reading/ELA Instruction Per Day	84.88	101.08	54.79
Affiliation and Philosophy			
Affiliated with a CMO or Network	35.0%	30.8%	42.9%
Identify as "No Excuses"	40.0%	61.5%	0.0%
Identify as "No Excuses" or Somewhat "No Excuses"	50.0%	76.9%	0.0%
Have a Parent Contract	77.8%	100.0%	42.9%
Have a Student Contract	72.2%	90.9%	42.9%
Have Uniforms	80.0%	92.3%	57.1%
Have a Merit/Demerit Based Reward and Punishment System	40.0%	61.5%	0.0%
Funding			
Average Per-Pupil-Expenditure	$12,271	$13,869	$11,285
Percentage of Funds from Nongovernmental Sources	5.5%	7.08%	2.46%
Title I Eligible	80.0%	100.0%	42.9%
Staff (From Massachusetts Department of Elementary and Secondary Education)			
Number of Teachers	19.3	17.7	22.0
Student/Teacher Ratio	16.5	19.6	11.2
Proportion of Teachers Licensed to Teach in Assignment	49.5%	50.7%	47.5%
Number of Teachers in Core Academic Areas	17.0	14.8	20.4
Core Academic Teachers Identified as Highly Qualified	75.5%	73.9%	78.3%
Proportion of Teachers 32 and Younger	58.7%	72.2%	37.6%
Proportion of Teachers 49 and Older	11.6%	5.1%	22.0%
Staff (Self-Reported)			
Number of Teachers Who Left Voluntarily Last Year	2.11	1.77	2.43
Number of Teachers Who Left Involuntarily Last Year	1.47	1.46	1.29
Require Staff to Take Calls/Emails after Hours	10.0%	7.7%	14.3%
Have Unpaid Tutors/Volunteers	75.0%	69.2%	85.7%
Have Paid Tutors	15.0%	23.1%	0.0%
Number of Schools Participating in Survey	19	12	7

Notes: Charter school leaders or their designated respondents completed a survey from which the school characteristics are summarized. Only schools that participated in the lottery portion of this study responded to the survey. Responses may not be representative of all charter schools in the state or community type. Staff characteristics from the Massachusetts DESE are available at the website at:

http://profiles.doe.mass.edu/state_report/teacherdata.aspx.

Teachers licensed in teaching assignment is the percent of teachers who are licensed with Provisional, Initial, or Professional licensure to teach in the area(s) in which they are teaching. Core classes taught by highly qualified teachers is the percent of core academic classes (defined as English, reading or language arts, mathematics, science, foreign languages, civics and government, economics, the arts, history, and geography) taught by highly qualified teachers (defined as teachers not only holding a Massachusetts teaching license, but also demonstrating subject matter competency in the areas they teach). For more information on the definition and requirements of highly qualified teachers, see:

http://www.doe.mass.edu/nclb/hq/hq_memo.html.

Table 8: Observational Estimates for Charters in the Lottery Study and Other Charters

			Urban			Nonurban		
			Lottery Study	Observational Study		Lottery Study	Observational Study	
Level	Subject		With Baseline Scores (1)	Charters in Lottery Study (2)	Other Charters (3)	With Baseline Scores (4)	Charters in Lottery Study (5)	Other Charters (6)
Middle School								
	ELA		0.117***	0.173***	0.050***	-0.175***	-0.038**	-0.020***
			(0.034)	(0.017)	(0.010)	(0.045)	(0.016)	(0.007)
		N	5,995	48,575		2,116	84,383	
	Math		0.331***	0.319***	0.080***	-0.192***	-0.096***	-0.018***
			(0.036)	(0.022)	(0.014)	(0.049)	(0.024)	(0.006)
		N	6,177	52,038		1,850	87,338	
High School								
	ELA		0.328***	0.192***	0.054***	0.124	0.075***	-0.013
			(0.069)	(0.024)	(0.020)	(0.200)	(0.016)	(0.021)
		N	2,151	10,439		167	21,909	
	Math		0.385***	0.193***	0.033	-0.134	0.059***	-0.009
			(0.068)	(0.045)	(0.020)	(0.725)	(0.013)	(0.014)
		N	2,410	12,410		169	26,705	
	Writing Topic		0.375***	0.205***	0.046**	0.293	0.088***	-0.026
			(0.097)	(0.035)	(0.022)	(0.580)	(0.025)	(0.025)
		N	2,103	10,280		166	21,774	
	Writing Composition		0.246**	0.200***	0.039*	-0.300	0.073*	0.011
			(0.101)	(0.033)	(0.020)	(0.626)	(0.039)	(0.021)
		N	2,103	10,280		166	21,774	

Notes: Columns (1) and (4) report 2SLS coefficients from Table 5 columns (1) and (6). Columns (2), (3), (5), and (6) estimate the effect of years spent in different types of schools. The reference category is traditional schools. Charter coefficients are estimated separately for years spent in charter schools that participate in the lottery study and for other charter schools. The sample is restricted to students with baseline demographic characteristics who attended a Massachusetts public school when tested. All models control for sex, race, special education, limited English proficiency, subsidized lunch status, and a female by minority dummy. Regressions also include year of test, year of birth, and sending school dummies. Middle school regressions pool 6th, 7th, and 8th grade outcomes and include dummies for grade level. Reported N's count the number of student by grade observations that contribute to the regression (up to three grade outcomes for middle school). Robust standard errors are reported for high school estimates. Middle school standard errors cluster on student identifier and school by year by grade. For a given school level and test, columns (2), (3), (5), and (6) report coefficient estimates from the same regression.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table

A.1 Charter Schools that Participate in the Lottery Study

Table A.1: Charter Schools that Participate in the Lottery Study

	Application Years in Lottery Study (1)	Application Years with Initial Offer Data (2)	Outcome Years (3)	Grade Range (4)	Location (5)	School Leader Identifies School as "No Excuses" (6)	School Year More than 182 Days (7)	Day Length Greater than 450 Minutes (8)	Has Area of Special Focus (College Prep or Not College Prep) (9)	Volunteer or Tutor Type (10)
I. Middle School (4th, 5th, 6th, 7th, and 8th grades)										
Charter Schools Located in Urban Areas										
Academy of the Pacific Rim Charter Public School	2005-2008	2005-2008	2006-2009	5-12	Boston	No	Yes	Yes	College Prep	Parents
Boston Collegiate Charter School	2002-2008	2002-2008	2003-2009	5-12	Boston	Yes	Yes	No	No	Community
Boston Preparatory Charter Public School	2005-2008	2005-2008	2006-2009	6-11	Boston	Yes	Yes	Yes	College Prep	Community
Edward Brooke Charter School	2006-2008	2006-2008	2007-2009	K-8	Boston	Yes	Yes	Yes	No	N/A
Excel Academy Charter School	2008	2008	2009	5-8	Boston	Yes	Yes	Yes	No	Community
MATCH Charter Public Middle School	2008	2008	2009	6-7	Boston	Yes	Yes	Yes	No	N/A
Roxbury Preparatory Charter School	2002-2008	2006-2007	2003-2009	6-8	Boston	Yes	No	Yes	College Prep	Community
KIPP Academy Lynn Charter School	2005-2008	-	2006-2009	5-8	Lynn	Yes	Yes	Yes	No	Community
Global Learning Charter Public School	2006-2007	2006-2007	2007-2009	5-12	New Bedford	No	No	No	Not College Prep	Parents and Community
Charter Schools Located Outside of Urban Areas										
Francis Parker Charter Essential School	2006-2008	2006-2008	2007-2009	7-12	Devins	No	No	No	Not College Prep	Parents
Four Rivers Charter School	2003-2008	2003-2008	2004-2009	7-12	Greenfield	No	No	No	College Prep	N/A
Marblehead Community Charter School	2005-2007	2005-2007	2006-2009	4-8	Marblehead	No	No	No	Not College Prep	Parents and Community
Cape Cod Lighthouse Charter School	2007-2008	2007-2008	2008-2009	6-8	Orleans	No	No	No	Not College Prep	Parents
Pioneer Valley Performing Arts Charter Public School	2006-2008	2006-2008	2007-2009	7-12	South Hadley	No	No	Yes	Not College Prep	Parents and Community
Innovation Academy Charter School	2007-2008	2007-2008	2008-2009	5-11	Tyngsboro	No	No	No	Not College Prep	Parents
II. High School (10th grade)										
Charter Schools Located in Urban Areas										
Boston Collegiate Charter School	2002-2003	2002-2003	2008-2009	5-12	Boston	Yes	Yes	No	No	Community
City On A Hill Charter Public School	2002, 2004-2007	2002, 2004-2007	2004, 2006-2009	9-12	Boston	Somewhat	Yes	No	No	Paid Tutors
Codman Academy Charter Public School	2004	2004	2006	9-12	Boston	Somewhat	Yes	Yes	Not College Prep	Community
MATCH Charter Public High School	2002-2007	2002-2007	2004-2009	9-12	Boston	Yes	Yes	Yes	No	Paid Tutors
Charter Schools Located Outside of Urban Areas										
Four Rivers Charter School	2003-2005	2003-2005	2007-2009	7-12	Greenfield	No	No	No	College Prep	N/A
Sturgis Charter Public School	2004, 2006	2004, 2006	2006, 2008	9-12	Hyannis	No	No	No	Not College Prep	Parents

Table A.2: Sample Selection

	Middle School (1)	High School (2)
A. Charter Lottery Sample		
Application cohorts	**2002-2007**	**2002-2006**
Applications to charter in entry grades	7,225	5,613
Excluding applications not matched to state dataset	6,276	5,338
Excluding applications with sibling priority	6,238	5,319
Excluding late applicants	6,213	5,313
Excluding out of area applications	6,204	5,311
Transforming applications into one observation per student	5,769	4,178
Excluding students with no follow-up test score	5,094	3,220
Excluding students not in MA public schools at baseline (this also drops those without baseline demographics)	4,348	2,724
Excluding students with no baseline test scores	4,098	2,646
Number of follow-up ELA scores for students in MA charter schools at baseline	8,111	2,318
Number of follow-up math scores for students in MA charter schools at baseline	8,027	2,579
B. Regression Sample		
Baseline years	**2002-2007**	**2002-2007**
Students in MA public school or MA charter school and demographics at baseline	487,174	619,318
Matched students*	81,743	39,876
Excluding students with no baseline test scores	81,743	39,872
Number of follow-up ELA scores for students in MA public school or MA charter school at baseline and outcome	132,958	32,348
Number of follow-up math scores for students in MA public school or MA charter school at baseline and outcome	139,376	39,115

*The matched student sample is created by grouping charter students into cells defined by baseline year and school, gender, race, limited English proficiency status, special education status, and subsidized lunch status. These cells of students are then matched to the sample of non-charter students with the same characteristics. Students of either charter or noncharter enrollment with no matches are dropped from the sample. By definition, students in the matched sample must have demographics and a test score at outcome.

Table

A.3 Attrition

Table A.3: Attrition

Level	Subject	Proportion of Non-Offered with MCAS	Differential	
			Demographic Controls	Demographics and Baseline Scores
		(1)	(2)	(3)
Middle School				
	ELA	0.829	0.007	0.006
			(0.005)	(0.005)
	N	3,251	9,014	8,578
	Math	0.856	0.004	0.006
			(0.005)	(0.005)
	N	3,245	8,949	8,186
High School				
	ELA	0.768	0.001	-0.002
			(0.011)	(0.011)
	N	1,266	2,864	2,443
	Math	0.756	0.004	0.002
			(0.012)	(0.012)
	N	1,266	2,864	2,759
	Writing Topic and Writing Composition	0.756	0.004	-0.001
			(0.012)	(0.013)
	N	1,266	2,864	2,408

Notes: This table reports coefficients on regressions of an indicator variable equal to one if the outcome test score is nonmissing on an indicator variable equal to one if the student won the lottery. Regressions in columns (2) and (3) include dummies for (combination of schools applied to)*(year of application)*(location risk set) as well as demographic variables, year of birth dummies, year of baseline, and baseline grade dummies. Regressions in column (3) add baseline test scores. Middle school regressions pool grades and include grade dummies, and cluster standard errors at the student level. Sample is restricted to students who participated in an effective lottery from cohorts where we should observe follow-up scores. High school students who take Writing Topic exam must also take Writing Composition.

* significant at 10%; ** significant at 5%; *** significant at 1%

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