Different Paths to College Success: The Impact of Massachusetts' Charter Schools on College Trajectories *

Sarah R. Cohodes†
University of Michigan and NBER

Astrid Pineda
Teachers College Columbia University

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Abstract

The charter school movement encompasses many school models. In Massachusetts in the 2010's, the site of our study, urban charter schools primarily used "No Excuses" practices, whereas nonurban charters had greater model variety. Using randomized admissions lotteries, we estimate the impact of charter schools by locality on college preparation, enrollment, and graduation. Urban charter schools boost all of these outcomes. Nonurban charter schools raise college enrollment and graduation despite reducing state test scores and AP enrollment. Our results suggest that there is more than one path to a college degree and that test score impacts may not predict college outcomes.

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†Corresponding author. Gerald R. Ford School of Public Policy at the University of Michigan, 735 S. State St., Ann Arbor, MI 48109. E-mail: scohodes@umich.edu.

Despite the recent decline in the college wage premium, individuals with a BA still outearn their peers with only a high-school diploma by 75 percent (Bengali et al., 2023; Autor et al., 2023). With much policy and research in the United States focused on college access, we know less about how K–12 educational experiences contribute to college success (Dynarski et al., 2023). This paper uses application lotteries to show the causal effects of one such K–12 educational intervention—charter schools—on college preparation, enrollment, and graduation.

Charter schools are autonomously operated public schools with oversight, curricular, budgetary, and hiring independence from traditional school districts. They are authorized by a state-empowered entity, undergo periodic review and may be subject to closure. When oversubscribed, charter schools admit students via randomized admissions lotteries.

Charter schools are not monolithic in character. Many urban charter schools feature longer school days and school years, a culture of high expectations, frequent teacher observations and feedback, data-driven instruction, use of tutoring, and strict disciplinary practices, practices which are often referred to as "No Excuses" (Angrist et al., 2013; Dobbie and Fryer, 2013). In recent years, many of these schools have moved away from this label and some of the associated practices (Torres, 2022), though at the time students in this study were enrolled in Massachusetts charter schools, most of the urban charters used these practices, as shown in Table 1. Other charter schools operate on the basis of a greater range of educational models and include project-based learning schools, themed schools (arts, language, culture), Montessori schools, and classical learning schools.

Many lottery-based studies have shown that attending urban charter schools, many of which use these high academic press practices, increases students' test scores (see Cohodes and Roy (2023) for a summary of this research). The more limited lottery-based evidence on nonurban charter schools shows mixed impacts on test scores, with findings of some small positive effects (Dynarski et al., 2018) and, in other cases, null or negative effects (Gleason et al., 2010; Angrist et al., 2013). Observational estimates of charter school impacts appear to confirm the lottery-based evidence that urban charter schools boost test scores while nonurban charters do not (CREDO, 2009; Tuttle et al., 2010; CREDO, 2013; Tuttle et al., 2015; Abdulkadiroğlu et al., 2016; Dobbie and Fryer, 2020; Harris, 2020).

This body of evidence has led some to conclude that charter schools are most successful in urban contexts when they adopt "No Excuses" practices (Chabrier et al., 2016; Epple et al., 2016; Cohodes and Parham, 2021). This conclusion is bolstered by lottery-based evidence showing that urban charters that boost test scores also boost college preparation and enrollment and even shape non–test score outcomes such as voting and risky behavior (Angrist et al., 2016; Dobbie and Fryer, 2015; Wong et al., 2014; Davis and Heller, 2019; Cohodes and Feigenbaum, 2021; Demers et al., 2023). However, there is much less evidence on nonurban charter schools and nontest outcomes. The sole lottery-based evidence on college graduation of which we are aware refers to a broad sample of charter schools in a federally funded national evaluation of charter schools (Gleason et al., 2010)

extended to college outcomes (Place and Gleason, 2019). Place and Gleason (2019) find no impact on college enrollment or graduation and no relationship between test scores and college outcomes. This is perhaps because their sample only consists of middle schools, whereas many of the schools in our sample are either high schools or combined middle and high schools. Dobbie and Fryer (2020) use propensity score matching to show that "No Excuses" charter schools improve test scores and four-year college enrollment whereas "other" charter schools decrease both.[1]

This paper builds on Angrist et al. (2013) (APW), which examines the effects of Massachusetts charter schools on test scores across urban and nonurban areas. APW find that urban charter schools generate large test score gains whereas nonurban charters have null or negative effects. In our shared Massachusetts sample, at the time students were enrolled in the 2000's and 2010's, the urban charter schools mostly adhered to "No Excuses" practices and served a primarily minority and economically disadvantaged population. The nonurban schools did not, embracing alternative charter school models and serving primarily white children. APW find that the different practices and student bodies help account for the different test scores trajectories, aligning with the existing literature on charter schools.

With a longer time horizon and more cohorts and schools, we return to APW's diverse sample of charter schools and report several novel findings. First, we replicate their test score results, finding that urban charters boost standardized test scores and nonurban charters driving them downward. Next, we find that urban and nonurban charters also diverge in their college preparation impacts. Urban charters increase Advanced Placement (AP) test-taking and scores and SAT scores while increasing time to high-school graduation, confirming the results for Boston found in Angrist et al. (2016). Nonurban charters decrease AP test-taking. These findings align with APW's test score results.

The nature of the divergences shifts when we turn to college outcomes, however. First, both urban and nonurban charter schools boost four-year college enrollment, by 8 and 10 percentage points, respectively. Next, we turn to college graduation and present some of the first lottery-based estimates of charter school impacts on degree attainment. Here, we find that attending an urban charter school raises attainment of any degree by 4.6 percentage points from the comparison mean of 24 percent and BA completion by 4.1 percentage points from a comparison of 22 percent. Nonurban charter schools increase attainment of any degree by 11 percentage points from a comparison mean of 52 percent and BA attainment by 11 percentage points over a comparison rate of 47 percent. In short, both urban and nonurban charter schools lift degree attainment, but nonurban charter schools—the same schools that negatively impact test scores—induce very large gains.

This paper makes two main contributions. First, we add to the evidence on charter schools

[1]Observational work from Florida shows that charter schools initially decrease scores (Sass, 2006) but increase college persistence (Sass et al., 2016), but it does not differentiate by location type or model. Hitt et al. (2018) use vote-counting methods to assess the correlation between achievement and attainment impacts in school choice programs across studies, finding little alignment. However, they do not focus on charters alone, and only consider whether each study's findings are positive or negative and not their magnitude.

by presenting lottery-based estimates of their impacts on college graduation from a diverse sample of schools. The findings expand our so far limited knowledge of the impact of different charter school models on college outcomes. Second, we demonstrate that the test score gains and declines induced by charter school attendance do not always align with the schools' impacts on students' life trajectories. Standardized test scores provide a measure of student learning that is useful to families and schools and for government accountability ratings, but—for the most part—scores correlate with but are not directly connected to life outcomes such as college graduation and earnings. Researchers often use standardized test scores as a proxy for other outcomes that we care about (Krueger, 2003; Chetty et al., 2011; Hanushek, 2011; Chetty et al., 2014; Ganimian et al., 2021), but had we done so for our sample of Massachusetts charter schools, we would have come to the wrong conclusion about the schools' impacts on attainment. Now that sufficient time has passed for APW's sample of students to have completed their education, we can measure their longer-term outcomes directly and do so in the remainder of this paper.

1 Data and Descriptive Statistics

Below, we describe our data sources and sample criteria. We then describe the population of schools and students in Massachusetts and how it differs by locality.

1.1 Data and Sample

Massachusetts charter school records from randomized admissions lotteries in 2002–2014, corresponding to cohorts projected to graduate high school in 2006–2018, form the basis of our investigation into charter school impacts. We include schools with admission in the middle-school grades or later, as students admitted for elementary school are not yet old enough for us to observe their longer-term outcomes. Our sample, based on APW's but with a few additional schools with students old enough for their college outcomes to be observed, includes 15 urban charter schools and 9 nonurban charter schools. We define schools as urban if they are in towns where the school district participates in the Massachusetts Urban Superintendents Network and as nonurban otherwise. The sample covers all Massachusetts charter schools that offered admission for middle- or high-school grades at the time of the initial lottery record collection (2009–2010) and for which there are extant records of lotteries with more applicants than seats available, with the additions noted above (Appendix Table A.1). All students in the sample are old enough to be observed 5 years after their projected high-school graduation, with one fewer cohort available for observation at 6 years after projected high-school graduation.

The lottery records include students' names and dates of birth alongside lottery information (application grade, sibling status, town of residence, late application, admissions offers, and waitlist status). We exclude students who are omitted from randomization due to the lottery procedure:

namely, guaranteed-admission siblings and late and out-of-area applicants. We use the lotteries for entry grades, as these have the greatest number of open seats and a standard open admission process (some charter schools use waitlists from the previous year for later grades). We create indicators both for admission on the day of the lottery (initial offers) and offers extended from the randomized waitlist (waitlist offers). The sample includes students present in the Massachusetts data at baseline, excluding students who applied to charter schools from private schools to ensure that we have baseline demographic information for all students.

We use name, date of birth, town of residence, and application cohort to match the lottery records to state administrative data from the Massachusetts Department of Elementary and Secondary Education (DESE). These records include student information such as school enrollment, gender, race, special education status, English learner status, subsidized lunch status, days of attendance, suspensions, and high-school graduation status from the Student Information Management System (SIMS) and achievement scores from the Massachusetts Comprehensive Assessment System (MCAS). DESE also provided information on AP and SAT exams from the College Board and college enrollment and graduation records from the National Student Clearinghouse (NSC).

Our key outcomes include MCAS scores two years after the charter school lottery, AP and SAT test-taking and scores, high school graduation, and college enrollment and degree attainment. We describe relevant details for each of these outcomes here. We standardize MCAS scores by subject, grade, and year to have mean zero and standard deviation one for the entire state.[2] AP and SAT outcomes are available for the class of 2007 and later. Students who were present in 11th or 12th grade but did not take SAT or AP exams are marked as zero for each national test outcome they do not participate in and missing if not present. High school graduation is measured for students that appear in 9th grade. For college indicators, we mark students as zeroes if they were sent to the NSC but do not have college records, otherwise they are missing. We report college outcomes within timeframes of expected high-school graduation, where the expected high-school graduation year is based on the year and grade of the charter school lottery. Thus, an outcome such as bachelor's attainment within 6 years indicates that a student obtained a bachelor's within 6 years of her expected high-school graduation based on when she applied to a charter school.

1.2 Schools

In addition to diverging from their traditional public school counterparts, urban and nonurban charter schools diverge in their characteristics and practices from each other. Table 1 compares school characteristics for the charter schools in the lottery sample and other public schools. We measure school characteristics in the early 2010's, the point at which most students in our sample matriculated. Urban charter schools have the lowest share of teachers with formal credentials (59

[2]MCAS scores exclude middle-school scores from 2015 and 2016, when districts could select the MCAS or PARCC exam.

percent licensed in their subject), followed by nonurban charters (71 percent), in contrast to public schools, where almost all teachers are licensed in their subject. All urban charter schools receive federal Title 1 funds for serving a high-poverty student body, as do about two-thirds of nonurban charters. Among traditional schools, 77 percent of urban schools and 41 percent of nonurban schools receive Title 1. The student–teacher ratio is lower in charter schools (12:1 or 11:1 in charters and 14:1 or 13:1 in other public schools). Charter schools are also small schools, with approximately 430 students per school. This compares to 660 students at urban public schools and over 2,000 students per school in nonurban areas, which tend to have large comprehensive high schools. Per-pupil expenditures (in 2014 dollars) are slightly higher in urban charters ($16,250) than in urban traditional schools ($15,660) and lower in nonurban charters ($11,981) than in nonurban traditional schools ($14,410).

For the charter schools only, we have responses to a survey on school practices (Panel B). Urban charters have longer school days and school years, use tutoring, frequent teacher observations, and frequent checks for student understanding, and have a culture of high expectations. Nonurban charters are less likely to deploy these practices, though half of the nonurban charters use frequent checks for student understanding and 75 percent use differentiated instruction (even higher than the 69 percent for urban charters). They also focus less on academic expectations. We do not have school district information on length of the school day and year since it is determined by district-level collective bargaining agreements, but we note that the state requires school districts to operate a minimum of 180 days a year for at least 5.5 hours a day. We can observe disciplinary information via administrative records and see that urban areas have higher disciplinary rates. However, relative to traditional public schools, urban charters use discipline to a greater extent, whereas nonurban charters have fewer disciplinary incidents.

1.3 Students

Table 1 also presents descriptive statistics for charter lottery applicants (Columns 1 and 2) and students who attended public schools in Massachusetts in 9th grade and were projected to graduate between 2006 and 2018 (Columns 3 and 4) in Panel C. We see important differences across urban and nonurban areas. In urban areas, Black and Latino/a students comprise 20 and 32 percent of the public school student population (Column 3), respectively, and 52 and 28 percent of lottery applicants (Column 3). Sixty-four percent of urban students in noncharter public schools and 74 percent of lottery applicants receive free or reduced-price lunch. Urban students and lottery applicants also have low average baseline scores: 0.36σ and 0.43σ below the state average in math and 0.41σ and 0.43σ below the average in English language arts (ELA). Regarding test scores, lottery applicants are representative of urban students overall.

In contrast, most students in nonurban areas are white: 84 percent of nonurban public school students and 90 percent of lottery applicants are white. Students in nonurban locations are of more

affluent backgrounds and have better baseline academic outcomes. Twenty percent of public school students in nonurban areas and 11 percent of charter school applicants receive subsidized lunch. Nonurban students and lottery applicants score 0.15σ and 0.36σ above the state average in math and 0.16σ and 0.43σ above the average in ELA.

2 Empirical Framework

To estimate the impact of urban and nonurban charter schools on educational attainment and other outcomes, we take advantage of the natural experiment created by charter school lotteries. We use randomized lottery offers as instruments for charter school attendance at each type of charter school in a two-stage least squares (2SLS) strategy with multiple endogenous variables. We link charter school attendance to outcomes with an equation of the following form:

$$y_i = \sum_j \delta_j d_{ij} + X_i'\Gamma + \rho^u C_i^u + \rho^n C_i^n + \epsilon_i, \tag{1}$$

where y_i is an educational outcome for student i, such as degree attainment. Charter attendance is represented by type with C_i^u and C_i^n, which are indicator variables for attendance prior to when y_i occurs at an urban (u) or nonurban (n) charter school with a lottery. The effect of attending an urban or nonurban charter is thus captured by ρ^u and ρ^n, respectively. A vector of baseline characteristics, X_i, increases statistical precision and includes indicators for gender, race, special education, English learner status, and subsidized lunch status and a set of year of birth fixed effects. Key to our estimation strategy is the inclusion of "risk sets," indicated by d_{ij}, which are lottery fixed effects that account for the set of charter schools applied to by each student and include the year and grade of application. The risks sets thus account for different probabilities of charter school attendance conditional on the number of schools applied to or a school's popularity. We use robust standard errors.

Charter school lottery offers serve as instruments for charter school attendance, coded as mutually exclusive indicator variables: Z_{i1} represents a random offer for a charter seat on the day of the lottery (initial offer) and Z_{i2} represents an offer for a charter seat from the randomized waitlist (waitlist offer). In a few cases, schools reported only initial or waitlist offer information; in such situations we include the school but only make use of the single source of offer variation. Thus, the first stage of our 2SLS framework is:

$$C_i^k = \sum_j \mu_j d_{ij} + X_i'\beta + \pi_1^u Z_{i1}^u + \pi_2^u Z_{i2}^u + \pi_1^n Z_{i1}^n + \pi_2^n Z_{i2}^n + \eta_i; k \in u, n, \tag{2}$$

where C_i^k indicates attendance at a charter school of k type, where $k \in u, n$, and is estimated as a function of the risk sets described above, the same vector of student characteristics, and the

randomized lottery offers. The effect of lotteries on attendance is captured by π_1^k for the initial offer and π_2^k for the waitlist offer. Reduced form estimates of the effect of lottery offers on student outcomes can be represented in a similar setup as Equation 2, substituting y_i as the outcome variable.

The first-stage results are reported in Panel A of Table 2. Among charter school applicants, urban students are 48 percentage points more likely to have ever attended a charter school if they received an initial offer and 34 percentage points more likely to attend if they received a waitlist offer than students not offered a seat. Nonurban applicants are 60 and 41 percentage points more likely to have attended a charter school if they received an initial or waitlist offer to attend. Urban students who received an offer for a charter seat spent approximately one and a half more years in a charter than students not offered a seat. Nonurban students who received a charter offer spent between 2 and almost 3 more years in a charter than students who did not receive an offer.

We demonstrate in Appendix Table A.2 that the characteristics of students offered seats in the lottery are very similar to not-offered students in both the urban and nonurban contexts, offering a check on lottery randomization. Match rates to the SIMS data are above 99 percent and are very similar across lottery offers (Appendix Table **??**).

There is some differential attrition. Students offered seats in the lottery are slightly more likely to have test score outcomes than those not offered seats in the lottery by 1.5–2 percentage points for the urban scores and 4 percentage points for nonurban initial offers for both subjects (Table 2, Panel B). This is not surprising, since winning the lottery makes it more likely a student enrolls in a charter school (and thus not a private school or out-of-state). Nonurban offered students are also more likely to be present in the data in 9th and 12th grade with a 5 and 3 percentage point differential respectively on the initial offer indicator.

Given the differential attrition, we report Lee (2009) bounds for the test score and high school outcomes. By locality, we calculate the lower bound by dropping the fraction of the highest-scoring lottery winners until the response rates among lottery winners and losers are equal. To estimate the upper bound, we drop instead the fraction of lowest-scoring lottery winners.[3] For binary outcomes we conduct a similar procedure but randomly select cases to drop among the offered group those with the one (lower bound) or zero (upper bound) value. This bounding exercise shows little scope for the modest differential attrition to explain the MCAS or high school—AP, SAT, and high-school graduation—results. We note that our analysis is concerned primarily with college outcomes. For these outcomes there is no differential attrition and we have almost complete sample coverage (94%). We thus do not present bounds for college outcomes.

The control complier mean (CCM) is our preferred indicator for the counterfactual comparison. The CCM is the average value of the outcome for compliers without charter school offers. These are students who do not attend a charter when they do not receive an initial or waitlist offer in the

[3]To avoid commingling noncompliance and attrition, we estimate these bounds on the reduced form.

first charter school lottery they apply to. We estimate the CCM for each charter type k as follows (Katz et al., 2001; Abadie, 2002):

$$y_i * \left(1 - C_i^k\right) = \sum_j \lambda_j d_{ij} + X_i'\alpha + \tau \left(1 - C_i^k\right) + \nu_i \tag{3}$$

where τ is the estimate of the CCM and (1-C_i^k) is instrumented by Z_{i1}^k and Z_{i2}^k, with risk sets and demographics accounted for as in Equation 2.

3 Results

3.1 Standardized Test Scores

MCAS math and ELA scores serve as our benchmark to compare our findings to those of previous studies. Similarly to APW, we find that attending an urban charter school boosts standardized test scores whereas attending a nonurban charter reduces them. To combine test scores across grade levels, in Table 3, we estimate the impact on MCAS scores two years after the charter school lottery, typically 6th or 7th grade for students entering charter middle schools and 10th grade for those entering charter high schools.

After two years, urban charters increase scores by almost half a standard deviation (σ) in math (0.48σ) and 0.32σ in ELA. These results align with the per-year effects found in APW of 0.33σ for middle-school math, 0.15σ for middle-school ELA, 0.34σ for high-school math, and 0.26σ for high-school ELA, though the comparison is inexact because of the different parameterizations. The urban results are on also par with those reported for Boston (Abdulkadiroğlu et al., 2011; Angrist et al., 2016; Walters, 2018; Cohodes et al., 2021; Setren, 2021; Cohodes and Feigenbaum, 2021). After a student spends two years in a nonurban charter school, test scores drop by -0.12σ in math and -0.14σ in ELA. The corresponding per-year middle-school estimates from APW are -0.12σ for math and -0.14σ for middle-school ELA, with negative but not statistically significant impacts on high-school tests.

We also present Lee bounds on the reduced form estimates to address the differential attrition concern in Table 3. Findings from this exercise suggest that, even in the presence of nonrandom attrition, the overarching test score patterns remain consistent with our main results. The bounds for MCAS scores in urban areas are very tight, which is not surprising given the minor differential attrition for the MCAS there. The nonurban upper bound is zero rather than negative, however, implying that if the MCAS differential attrition is fully due to nonrandom selection into the sample then we would not find negative nonurban MCAS effects.

Notably, the test score gains and losses occur at very different points in the statewide test score distribution. Comparison (traditional) urban students score approximately a third of standard deviation below the state mean, whereas traditional nonurban students score almost half a

standard deviation above the state mean. Thus, the test score gains in urban charters shift the full distribution of scores rightward from below the state average to at or above the state average in two years, whereas nonurban charter students, despite their performance being lower than that of traditional nonurban students, still perform above the state mean (Appendix Figure B.1 shows the distribution of test scores).

3.2 College Preparation

AP classes and their associated tests are one mechanism for high-school students to complete college-level work. In Panel B of Table 3, we estimate the impact of charter attendance on the student's likelihood of taking any AP and AP scores. In urban areas, approximately 33 percent of comparison students take at least one AP; charter attendance increases this share to 49 percent. There is also a boost in the share of urban charter students scoring 3 or more on any APs (a typical cutoff to receive college credit) from 11 to 15 percent. In nonurban areas, the share of comparison students taking at least one AP is much higher at 51 percent; charter attendance *decreases* this to 22 percent. Nonurban charter attendance reduces the share of students scoring above the 3+ threshold. This is driven by nonurban charters' reduced AP offering: students attending a nonurban charter school are 41 percentage points less likely to have had access to an AP class than the comparison group (Appendix Table B.2). We do not observe differences in AP scores for urban and nonurban charter students after we condition the AP score results on their taking at least one AP. This means that the AP score differences are due to test-taking rather than to a change in performance. Urban charters actively boost a college preparatory curriculum via AP classes whereas nonurban charters do not emphasize such classes.

Taking, and scoring well on, the SAT test is another milestone on the path to college, as many colleges require the exam. As shown Table 3, urban charter attendance increases SAT taking by about 4 percentage points, up from 62 percent for comparison students. Nonurban charter attendance does not change the rate of SAT-taking with 75 percent of nonurban students in the sample taking the SAT. Urban charter attendance boosts the test scores of takers by 39 points (out of 1600), with little difference in nonurban scores.[4]

APs and SATs are helpful for being admitted to and preparing for college; high-school students must also progress through high school and graduate. We display treatment estimates for high-school graduation in Table 3 with details on high-school progress, attendance, and suspensions in Appendix Tables B.3 andB.4. Here, the findings diverge from those on test scores. Urban students are less likely to graduate high-school on time, with an 7-percentage-point decrease in high-school graduation in four years. Urban charter students do catch up, with little difference in graduation rates vis-à-vis their peers' at a 5- or 6-year horizon. This is consistent with Angrist et al. (2016),

[4]We display SAT reasoning scores (math and verbal, summing to 1600) since all cohorts take these two SAT subsections and only a few take the exam scored out of 2400.

which suggests that many Boston charter students take five years to graduate in order to complete high school requirements, and our finding that urban charter attendance increases the likelihood that students repeat 9th or 10th grade by 4 percentage points (Appendix Table B.3). Nonurban charter students graduate at the same rates and within the same timeframe as their peers.

Since there is modest differential attrition in presence in high school in the nonurban areas, we present Lee bounds for AP, SAT, and high school graduation as well. The bounds for these outcomes are quite tight and the small differences in appearance in the data do not affect our conclusions.

Overall, our findings suggest that attending an urban charter school boosts several measures of college preparation: urban charters increase the number of APs that students take and their SAT scores, though there are negative impacts on high-school graduation, which diminish over time. These estimates are similar to those previously reported for Boston charters (Angrist et al., 2016; Setren, 2021; Cohodes and Feigenbaum, 2021). For the first time, we present evidence on nonurban charter attendance and college preparation: for the most part nonurban charter attendees,perform similarly to their comparison peers except that they take fewer APs, given their schools' lower AP course offerings.

3.3 College Enrollment

College preparation in high school is an important precursor to college, but college enrollment, persistence, and graduation show whether students succeed outside secondary education. Within a year of projected high-school graduation, both urban and nonurban charter students enroll in four-year college at greater rates than their peers, as shown in Figure 1 and Table 4. Additionally, both types divert enrollments from two-year institutions, such that initial enrollment in any post-secondary institution remains flat in both localities (Appendix Table B.5). Urban charter attendance boosts immediate four-year enrollment to 45 percent from 39 percent; nonurban charter attendance boosts enrollment to 62 percent from 53 percent. The decline in two-year college enrollment due to urban charter attendance is 4 percentage points and that due to nonurban charter attendance 7 percentage points. These college enrollment gains are similar to those found for Boston (Angrist et al., 2016; Setren, 2021; Cohodes and Feigenbaum, 2021). By the second year after projected high-school graduation, an interval that allows for late high-school graduation, there is little difference in enrollment at two-year institutions, and four-year college enrollment increases by 8 and 10 percentage points for urban and nonurban charters, respectively. Since two-year enrollment changes little and four-year enrollment rises, enrollment in any college increases for both charter types in the second year after projected high-school graduation, as shown in Table 4. With no differential attrition in the college data, we do not present bounds for these or other college outcomes.

Following the time trend in Figure 1 into the 3rd and 4th years after expected high-school

graduation, urban charters boost four-year college enrollment of 5 to 7 percentage points, with counterfactual attendance decreasing over time as students drop out. In the 5th and 6th years after high-school graduation, urban charters increase enrollment, though the interpretation of this outcome is ambiguous: If it represents progress toward a degree, enrollment could be beneficial; if it represents a delay in joining the workforce, it could be detrimental. The decrease in control complier enrollment is now due in part to graduation from college. Nonurban charters boost four-year enrollment in the 3rd and 4th years by 10 to 13 percentage points, with lower dropout among the counterfactual students. Nonurban charter students are also more likely to be enrolled in the 5th and 6th years after projected high-school graduation by 4 to 6 percentage points, though only the 6th year difference is statistically significant. Urban and nonurban charters increase both initial college enrollment and persistence through college.

3.4 Degree Attainment

Both urban and nonurban charter school attendance increases the likelihood that a student obtains any degree, in particular a bachelor's from a four-year institution. In the 4th year after projected high-school graduation, which corresponds to on-time high-school progress and on-time college progress, urban charters increase BA receipt by 3 percentage points and nonurban charters by 6.5 percentage points. Urban charters boost two-year attainment by a small amount, whereas nonurban schools decrease it, meaning that both school types increase receipt of a degree of any type by 4 to 6 percentage points (Figure 1 and Appendix Table B.6).

As time goes on, urban charter attendance increases the BA boost to 4.1 percentage points by the 6th year after projected high-school graduation and the gains in attainment of any degree to 4.6 percentage points. The nonurban edge increases to an even greater extent over time, with a bump of 11.4 percentage points for BA attainment (11.1 percentage points for any degree) in the 6th year after projected high-school graduation (Table 4). By the 6th year, 22 percent of urban control compliers graduate with a BA, with urban charter attendance increasing this to 26 percent, an increase of 19 percent of the comparison mean. By the 6th year, 47 percent of the nonurban control compliers graduate college, with the charter effect boosting this outcome for treated compliers to 59 percent, a 24 percent increase over the mean.

Charter attendees are more likely to enroll and graduate from four-year institutions in both urban and nonurban areas. However, 6 years after graduating from high school, the college edge from nonurban charter attendance is more than twice as large as that from urban charter attendance. Notably, the nonurban charter effect is even larger for college graduation outcomes than for college enrollment outcomes.

3.5 College Quality

College quality can increase college graduation and earnings (Hoekstra, 2009; DeAngelo et al., 2011; Cohodes and Goodman, 2014; Zimmerman, 2014; Goodman et al., 2017; Ge et al., 2022; Black et al., 2023). Thus, we investigate both the impact of charter attendance on college quality and the extent to which college quality accounts for the observed boost in college graduation. As shown in Table 4, urban charter attendance increases both four-year college enrollment and BA attainment in fairly equal measure at highly competitive institutions and competitive institutions. Nonurban charter attendance boosts college enrollment primarily at highly competitive institutions and graduation at highly competitive and competitive institutions. We summarize the shifts in college quality with two measures: earnings of recent graduates of the college from Chetty et al. (2020), which we label College Quality, and 6-year graduation rates from IPEDS.

Given the shift in enrollment in nonurban areas, we consider whether nonurban charters' high rates of placement of their students at elite colleges explains the large degree attainment gains. We investigate this possibility with the "conditional BA" outcome in Panel B of Table 4, which shows BA receipt conditional on college enrollment. The BA effects of urban charters are fully explained by enrollment—that is, conditional on students' having entered college, there is no additional impact on graduation—whereas nonurban charters boost attainment even conditional on students' having enrolled. This implies that even at the highly competitive colleges that make up a large portion of nonurban college gains, nonurbancharters impact both where students attend and how they experience and complete college.

3.6 Robustness

In Appendix Table B.7, we show for three key outcomes (MCAS math scores, four-year college enrollment, and four-year college graduation (6 years)) that similar results emerge under alternative specifications. Excluding covariates or adding baseline scores does not meaningfully affect the magnitudes or statistical significance of the results. Using initial offers as the only instrument slightly reduces the magnitude of our estimates and decreases their statistical precision, but our conclusions hold.

4 Conclusion

We confirm previous evidence from Massachusetts that urban charters boost test scores, with nonurban schools driving scores downward, a pattern that aligns with results in the broader charter school literature. However, when we turn to college enrollment and graduation, we have several novel findings. First, we show that the bump in college enrollment found previously for Boston charter attendance translates into degree completion in a wider sample of urban schools, with urban charters boosting BA attainment rates by 4.1 percentage points and attainment of any degree by

4.6 percentage points within 6 years of projected high-school graduation. Second, we show that nonurban charter schools—the same schools that *decrease* test scores—increase four-year college enrollment and BA attainment by 10 and 11 percentage points, respectively. Even conditional on college enrollment, nonurban charters still boost college graduation.

We draw two main conclusions from these findings. First, multiple charter school models can induce college gains. While many have focused on the "No Excuses" practices as the path forward for charter school success (Chabrier et al., 2016; Epple et al., 2016; Cohodes and Parham, 2021) (though there is a recent move away from that model (Torres, 2022)), the nonurban schools in this sample operating on alternative models deliver a large boost to BA attainment. Second, although test scores and longer-term outcomes are typically positively correlated (Krueger, 2003; Chetty et al., 2011; Hanushek, 2011; Dynarski et al., 2013; Chetty et al., 2014), we show that the relationship between test scores and college outcomes does not hold in all contexts, concluding that researchers and policymakers should be wary of evaluating programs solely on standardized test results, especially when participants are relatively high achieving. In future work, we will investigate the mechanisms behind this pattern of results, including differences in school practices and contexts.

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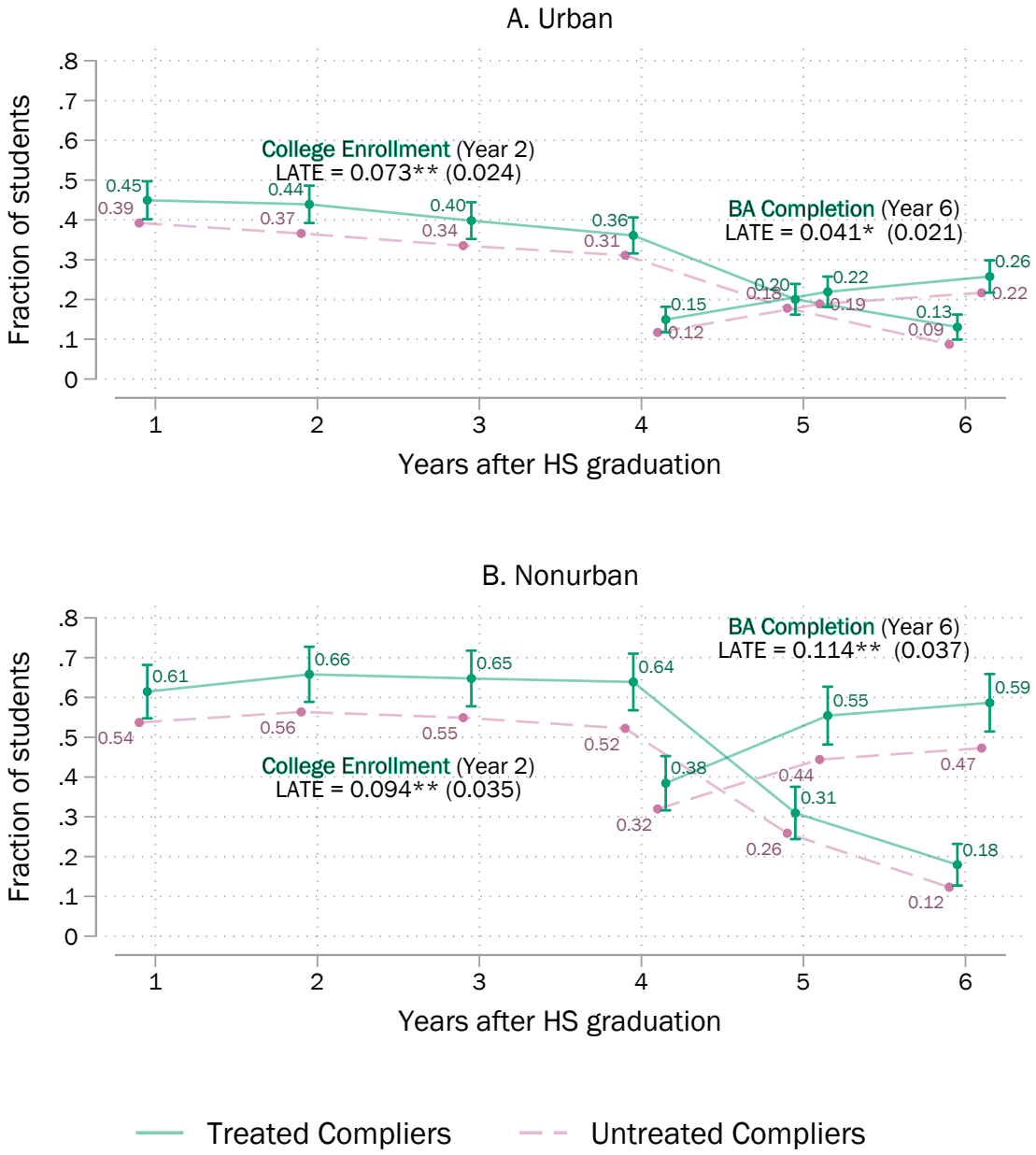
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Figure 1: Four-Year College Progression for Treated and Untreated Compliers



Notes: This figure shows the treatment and control complier means for four-year college enrollment and graduation for treated and untreated compliers. Treatment effects on college enrollment two years after projected high-school graduation and graduation rates six years after projected high-school graduation are reported under the labels. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001).

Table 1: School and Student Characteristics

	Charter Schools		Other Public Schools	
	Urban (1)	Nonurban (2)	Urban (3)	Nonurban (4)
(A) Schools: Administrative Records				
% of teachers licensed in subject	58.867	70.611	96.608	96.855
% of core classes taught by highly qualified teachers	86.227	94.089	89.876	97.378
Title 1 school	1.000	0.667	0.767	0.409
Student-teacher ratio	11.721	10.511	13.955	13.165
Per-pupil expenditure	16250	11982	15661	14411
School size	433.333	434.556	662.812	2271.461
Counselors per 1000 students	5.204	2.150	2.793	3.043
Disciplined students per 1000 students	191.923	33.963	122.090	45.412
(B) Schools: Survey Responses				
Days per school year	191.833	182.000	-	-
Hours per school day	7.935	6.974	-	-
High-quality tutoring	0.615	0.111	-	-
Frequent teacher observations	0.538	0.375	-	-
Frequent checks for student understanding	0.846	0.500	-	-
Differentiated instruction	0.692	0.750	-	-
Culture of high expectations (No Excuses)	0.733	0.111	-	-
N(Schools)	15	9	266	599
(C) Students: Baseline Characteristics				
Female	0.519	0.516	0.482	0.491
Asian	0.029	0.030	0.076	0.039
Black	0.521	0.023	0.199	0.046
Latinx	0.284	0.022	0.316	0.062
Other race	0.042	0.024	0.028	0.017
White	0.124	0.901	0.381	0.837
Special education	0.195	0.156	0.188	0.177
English learner	0.114	0.006	0.179	0.028
Free/reduced price lunch	0.737	0.109	0.644	0.198
Baseline MCAS ELA	-0.414	0.444	-0.432	0.155
Baseline MCAS Math	-0.363	0.363	-0.426	0.153
N(Students)	14,409	3,425	276,726	643,962

Notes: This table shows characteristics for urban and nonurban charter schools in the lottery analysis sample and lottery applicants in Columns 1 and 2. Information on traditional public schools that serve 6th and/or 9th grades in urban and nonurban areas and their students appears in Columns 3 and 4 for comparative purposes. Data sources for Panel A are Massachusetts Department of Elementary and Secondary Education School District Profiles for the 2013–2014 school year. Title I eligibility is reported for the 2013–2014 school year and comes from the U.S. Department of Education Common Core of Data (CCD). The data for Panel B come from a survey of charter school leaders fielded in 2011 and 2012. Panel C uses the student-level data for charter school applicants enrolled in schools in the state of Massachusetts at the time of application in the projected high-school classes of 2006–2018 in Columns 1 and 2 and for students who attended schools in the state of Massachusetts in 9th grade in the projected high-school classes of 2006–2018 in Columns 3 and 4.

Table 2: First Stage and Attrition

	Urban			Nonurban		
	Nonoffered Mean (1)	Initial Offer (2)	Waitlist Offer (3)	Nonoffered Mean (4)	Initial Offer (5)	Waitlist Offer (6)
(A) First Stage						
Ever Attended	0.114	0.483***	0.342***	0.234	0.597***	0.407***
		(0.010)	(0.009)		(0.019)	(0.024)
Years Attended	0.790	1.737***	1.331***	0.943	2.730***	2.003***
		(0.051)	(0.049)		(0.097)	(0.120)
(B) Attrition						
Has ELA score	0.815	0.014+	0.018*	0.852	0.040***	0.001
		(0.008)	(0.008)		(0.012)	(0.014)
Has math score	0.802	0.015+	0.014+	0.864	0.040***	-0.001
		(0.008)	(0.008)		(0.012)	(0.013)
Present in 9th grade in MA	0.862	0.009	-0.001	0.852	0.047***	0.003
		(0.007)	(0.007)		(0.012)	(0.014)
Present in 12th grade in MA	0.755	-0.003	-0.000	0.801	0.026+	0.002
		(0.009)	(0.009)		(0.015)	(0.017)
Sent to NSC	0.945	0.006	0.006	0.939	0.007	0.012
		(0.004)	(0.004)		(0.008)	(0.009)

Notes: This table shows follow-up rates for MCAS scores two years after charter application, presence in the Massachusetts data in 9th or 12th grade, and an indicator for being sent to the NSC to be matched to college outcome and data for Boston charter school applicants in Panel A, and the impact of a charter school offer on charter school attendance (first stage) for the urban and nonurban samples in Panel B. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Columns 1 and 4 show the mean for nonoffered students with a given outcome or enrollment at a charter. Columns 2, 3, 5, and 6 report coefficients from regressions of indicators for follow-up data or charter attendance on initial and waitlist offer dummies, including controls for risk sets and, for the first stage only, controls for demographic characteristics (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001). N (urban) = 14165, N (nonurban) = 3425.

Table 3: The Impact of Charter School Attendance on Tests and High School Graduation

	MCAS		AP		SAT		HS Graduation		
	Math	ELA	Took Any	Score 3+	Took SAT	Score (1600)	4 Year	5 Year	6 Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(A) Urban									
2SLS	0.475***	0.322***	0.157***	0.042***	0.041*	39.223***	-0.067***	-0.019	-0.011
	(0.040)	(0.038)	(0.023)	(0.014)	(0.024)	(9.473)	(0.023)	(0.022)	(0.021)
CCM	-0.299	-0.333	0.334	0.112	0.624	893.198	0.655	0.734	0.786
N	10,891	11,011	10,741	13,499	10,741	7,083	12,185	12,185	12,185
Reduced Form	0.226***	0.152***	0.074***	0.021***	0.013	17.906***	-0.029***	-0.009	-0.005
	(0.020)	(0.019)	(0.011)	(0.006)	(0.011)	(4.505)	(0.011)	(0.010)	(0.009)
Lower Bound	0.191***	0.115***	0.074***	0.021***	0.013	16.505***	-0.030***	-0.010	-0.006
	(0.020)	(0.019)	(0.011)	(0.006)	(0.011)	(4.480)	(0.011)	(0.010)	(0.009)
Upper Bound	0.272***	0.216***	0.074***	0.021***	0.013	18.417***	-0.027**	-0.008	-0.004
	(0.019)	(0.018)	(0.011)	(0.006)	(0.011)	(4.504)	(0.011)	(0.010)	(0.009)
(B) Nonurban									
2SLS	-0.122**	-0.139***	-0.291***	-0.187***	0.009	10.933	-0.016	-0.007	-0.012
	(0.059)	(0.051)	(0.035)	(0.029)	(0.032)	(15.326)	(0.026)	(0.024)	(0.023)
CCM	0.371	0.476	0.512	0.330	0.785	1122.451	0.814	0.899	0.911
N	3,054	3,018	2,937	3,425	2,937	2,282	3,026	3,026	3,026
Reduced Form	-0.073**	-0.081***	-0.159***	-0.102***	0.012	6.683	-0.013	-0.008	-0.010
	(0.034)	(0.029)	(0.020)	(0.017)	(0.018)	(8.934)	(0.015)	(0.014)	(0.013)
Lower Bound	-0.119***	-0.116***	-0.164***	-0.102***	0.005	-5.397	-0.019	-0.013	-0.016
	(0.034)	(0.029)	(0.020)	(0.017)	(0.018)	(8.767)	(0.015)	(0.014)	(0.013)
Upper Bound	0.007	0.000	-0.152***	-0.102***	0.015	18.610**	-0.009	-0.004	-0.008
	(0.034)	(0.027)	(0.021)	(0.017)	(0.018)	(8.823)	(0.015)	(0.014)	(0.013)

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter on the outcome listed in the column heading as described in Equation 1. The control complier mean is listed in the rows labeled CCM. The estimate of the effect of winning an urban or nonurban charter lottery is reported in the rows labeled Reduced Form. For concision, the reduced form estimates use a single offer variable, ever offer, in each locality. Estimates of the reduced form using Lee Bounds are labeled Lower Bound and Upper Bound. The sample includes charter lottery applicants in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001).

Table 4: The Impact of Charter School Attendance on College

	Urban			Nonurban		
	2SLS	CCM	N	2SLS	CCM	N
	(1)	(2)	(3)	(4)	(5)	(6)
(A) College Enrollment (in Y2)						
All	0.079***	0.494	13,489	0.060+	0.685	3,263
	(0.023)			(0.032)		
2 Year	-0.002	0.128	13,489	-0.037	0.129	3,263
	(0.016)			(0.023)		
4 Year	0.082***	0.364	13,489	0.097**	0.556	3,263
	(0.022)			(0.034)		
4 Year: Highly Competitive	0.037*	0.119	13,489	0.069*	0.314	3,263
	(0.016)			(0.034)		
4 Year: Competitive	0.044*	0.184	13,489	0.028	0.205	3,263
	(0.019)			(0.031)		
4 Year: Noncompetitive	0.000	0.062	13,489	-0.002	0.036	3,263
	(0.011)			(0.015)		
4 Year: College Quality ($2014)	2795*	54261	6,053	-1501	60047	2,193
	(1120)			(1941)		
4 Year: Graduation rate (IPEDS)	0.018	0.568	5,951	0.015	0.661	2,176
	(0.012)			(0.016)		
(B) College Degrees (by Y6)						
All	0.046*	0.241	11,731	0.111**	0.516	3,086
	(0.022)			(0.037)		
AA	0.009	0.041	11,731	-0.027	0.090	3,086
	(0.011)			(0.020)		
BA	0.041*	0.217	11,731	0.114**	0.473	3,086
	(0.021)			(0.037)		
BA: Highly Competitive	0.025+	0.082	11,731	0.073*	0.261	3,086
	(0.014)			(0.034)		
BA: Competitive	0.021	0.097	11,731	0.052+	0.158	3,086
	(0.015)			(0.029)		
BA: Noncompetitive	-0.005	0.038	11,731	-0.013	0.049	3,086
	(0.010)			(0.015)		
Conditional BA Receipt	0.003	0.471	5,259	0.123**	0.693	2,076
	(0.035)			(0.042)		

Notes: Each coefficient in columns labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter on the outcome listed in the column heading as described in Equation 1. The control complier mean is listed in the column labeled CCM. The sample includes charter lottery applicants in the projected high-school classes of 2006–2018. Highly Competitive includes Barron's categories *highly competitive*, *most competitive*, and *very competitive*; Competitive includes the categories *competitive* and *special*; and Noncompetitive includes *noncompetitive*, *unranked*, and *less competitive*. College quality is the estimated 2014 earnings of college attendees from the 1980-1982 birth cohorts from Chetty, et al. (2020). Students are assigned the earnings outcomes of the college they first attend. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001).

Appendix

Different Paths to College Success: The Impact of Massachusetts' Charter Schools on College Trajectories

Sarah R. Cohodes and Astrid Pineda

Appendix A: Lottery Details

Table A.1: Massachusetts Charter Schools Eligible for Lottery Study

School (1)	Town (2)	Urban (3)	Grades Served (4)	Lottery Entry Grade(s) (5)	Available Lottery Years (6)
(A) Participating Schools					
Academy of the Pacific Rim Charter School	Boston	Yes	5-12	5,6	2005-2010
Boston Collegiate Charter School	Boston	Yes	5-12	5	2002-2010
Boston Green Academy	Boston	Yes	6-12	9	2011-2014
Boston Preparatory Charter Public School	Boston	Yes	6-12	6	2005-2011, 2014
Cape Cod Lighthouse Charter School	Orleans	No	6-8	6	2007-2010
City on a Hill Charter Public School (Circuit Street)	Boston	Yes	9-12	9	2002, 2004-2014
City on a Hill Charter Public School (Dudley Square)	Boston	Yes	9-12	9	2013-2014
Codman Academy Charter Public School	Boston	Yes	K-12	9	2004, 2008-2014
Edward Brooke Charter School	Boston	Yes	K-12	5	2006-2009
Excel Academy Charter School	Boston	Yes	5-8	5	2008-2010
Four Rivers Charter Public School	Greenfield	No	7-12	7	2003-2012
Francis W Parker Charter Essential School	Devins	No	7-12	7	2006-2011
Global Learning Charter Public School	New Bedford	Yes	5-12	5	2006-2007, 2009
Innovation Academy Charter School	Tyngsboro	No	5-12	5	2007-2010
KIPP Academy Lynn	Lynn	Yes	K-12	5	2005-2009
Marblehead Community Charter Public School	Marblehead	No	4-8	4	2005-2007, 2009
MATCH Charter Public School	Boston	Yes	K-12	6,9	2002-2011
Pioneer Valley Performing Arts Charter Public School	South Hadley	No	7-12	7	2006-2010
Rising Tide Charter Public School	Plymouth	No	5-8	5	2009-2010
Roxbury Preparatory Charter School	Boston	Yes	6-12	6	2002-2011
Salem Academy Charter School	Salem	No	6-12	6	2010-2011
Sturgis Charter Public School	Hyannis	No	9-12	9	2004, 2006, 2008-2011
UP Academy Boston	Boston	Yes	K-8	6	2011
(B) Eligible but Nonparticipating Schools					
Advanced Math and Science Academy Charter School	Marlborough	No	6-12		
Berkshire Arts and Technology Charter Public School	Adams	No	6-12		
Christa McAuliffe Regional Charter Public School	Framingham	Yes	6-8		
Community Charter School of Cambridge	Cambridge	Yes	7-12		
Hampden Charter School of Science	Chicopee	Yes	6-12		
Health Careers Academy Charter School	Boston	Yes	9-12		
New Leadership Charter School	Springfield	Yes	6-12		
Phoenix Charter Academy	Chelsea	Yes	9-12		
Pioneer Charter School of Science	Everett	Yes	7-12		
Sizer School, A North Central Charter Essential School	Fitchburg	Yes	7-12		

Notes: This table includes charter schools that meet the following criteria: 1) admitted students for middle or high-school grades (4-7, 9); 2) has students in the projected high-school classes of 2006-2018; 3) does not serve special populations (such as students a risk of dropping out), and 4) are not closed charter schools. Schools that indicate grade ranges that do not begin at the lottery entry grade expanded grades served after lottery data was collected. Schools in Panel B that are eligible for the lottery study either had fewer applicants than seats available or did not retain usable lottery records. There were 12 closed schools at appropriate grade levels. Urban towns include those which participate in the Massachusetts Urban Superintendents Network: 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 (Salem joined the network at a later date and thus is categorized as nonurban in this study). MATCH is included in the study as both a middle and a high school.

Table A.2: Covariate Balance

	Urban			Nonurban		
	Fraction of Non-Offered With Outcome (1)	Initial Offer Differential (2)	Waitlist Offer Differential (3)	Fraction of Non-Offered With Outcome (4)	Initial Offer Differential (5)	Waitlist Offer Differential (6)
Female	0.516	-0.003	0.008	0.520	-0.002	0.023
		(0.010)	(0.011)		(0.019)	(0.022)
Asian	0.028	0.003	-0.001	0.025	-0.006	0.014+
		(0.003)	(0.003)		(0.007)	(0.008)
Black	0.506	0.002	-0.000	0.025	0.002	0.001
		(0.010)	(0.010)		(0.006)	(0.006)
Latinx	0.280	-0.006	0.010	0.023	0.012*	-0.013*
		(0.009)	(0.009)		(0.006)	(0.006)
Other race	0.044	0.002	-0.007+	0.032	-0.001	-0.008
		(0.004)	(0.004)		(0.006)	(0.006)
White	0.142	-0.001	-0.001	0.896	-0.008	0.006
		(0.006)	(0.006)		(0.011)	(0.013)
Special education	0.196	-0.001	-0.011	0.163	0.001	-0.010
		(0.008)	(0.008)		(0.014)	(0.015)
English learner	0.107	-0.001	0.008	0.007	0.001	-0.004
		(0.006)	(0.007)		(0.003)	(0.003)
Subsidized lunch	0.716	0.008	0.001	0.098	0.001	0.017
		(0.009)	(0.009)		(0.012)	(0.014)
Baseline MCAS ELA	-0.398	-0.012	0.022	0.466	0.005	-0.046
		(0.021)	(0.022)		(0.033)	(0.038)
Baseline MCAS Math	-0.368	-0.010	0.011	0.361	0.008	-0.025
		(0.020)	(0.021)		(0.037)	(0.041)
p-value		0.966	0.778		0.701	0.525

Notes: This table shows student characteristics and test scores, and differentials between offered and nonoffered charter applicants. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Columns 1 and 4 show the proportion of non-offered students with a given characteristic. Columns 2, 3, 5, and 6 report coefficients from regressions of the student characteristic on initial and waitlist offer dummies, including controls for risk sets (+ $p<0.10$ * $p<0.05$). N (urban) = 14165, N (nonurban) = 3425.

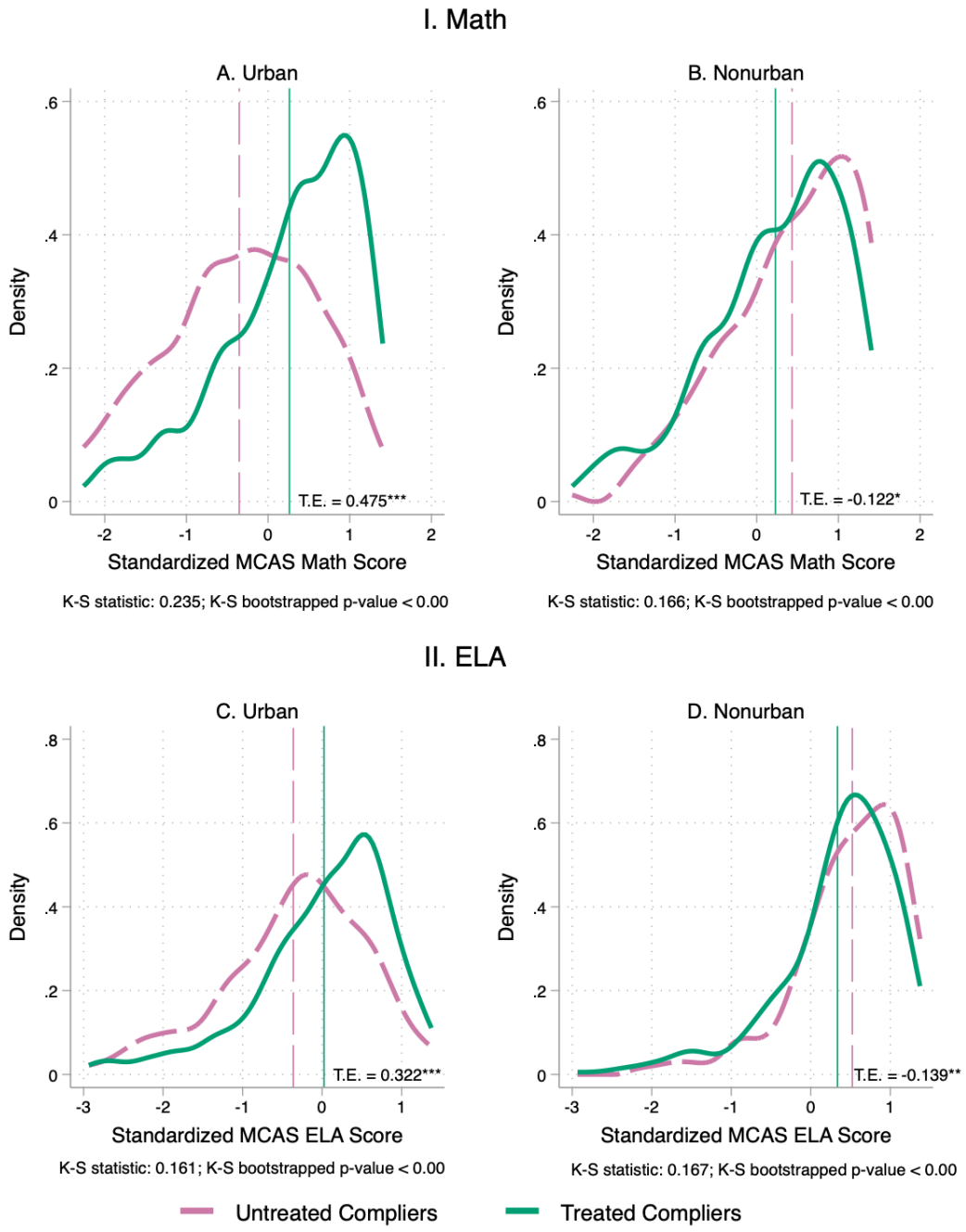
Table A.3: Match Rate to SIMS

Projected HS Class	Non-offered Mean (1)	Initial Offer Differential (2)	Waitlist Offer Differential (3)	Number of Applications (4)
2006	0.986	-0.008	0.008	515
		(0.012)	(0.009)	
2007	0.997	-0.011	-0.033	422
		(0.017)	(0.038)	
2008	0.996	-0.014	0.007	939
		(0.011)	(0.009)	
2009	0.992	0.003	-0.007	1,010
		(0.009)	(0.009)	
2010	0.994	0.000	-0.003	1,332
		(0.009)	(0.010)	
2011	0.996	-0.000	-0.002	1,595
		(0.006)	(0.008)	
2012	0.989	-0.005	0.002	2,159
		(0.006)	(0.004)	
2013	0.992	-0.004	0.000	2,472
		(0.006)	(0.005)	
2014	0.993	-0.000	0.000	2,972
		(0.004)	(0.004)	
2015	0.994	-0.001	-0.000	3,791
		(0.004)	(0.003)	
2016	0.993	-0.000	0.000	3,724
		(0.004)	(0.004)	
2017	0.993	-0.001	0.000	5,273
		(0.003)	(0.003)	
2018	0.995	-0.003	0.001	5,611
		(0.003)	(0.003)	
All cohorts	0.994	-0.003*	0.000	31,815
		(0.001)	(0.001)	

Notes: This table shows the match between lottery records and the SIMS data by projected high school class. The sample excludes disqualified, late, out-of-area, and sibling applications. Individuals can be in the sample multiple times if they apply to multiple schools. Columns 2 and 3 report coefficients from regressions of the student characteristic on initial and waitlist offer dummies, including controls for risk sets (+ $p<0.10$ * $p<0.05$ ** $p<0.01$ ***$p<0.001$).

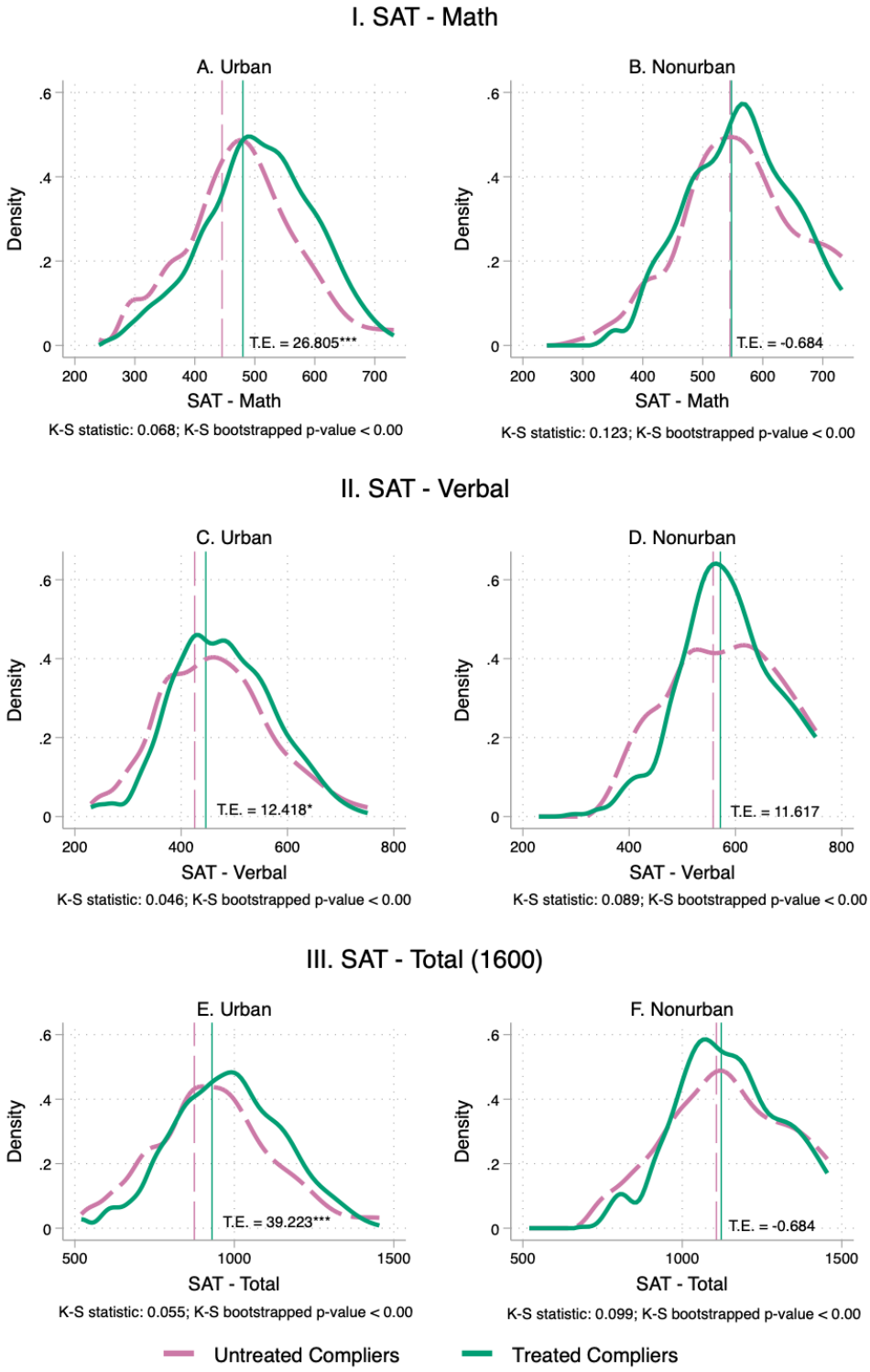
Appendix B: Additional Results

Figure B.1: Test Score Distributions for Treated and Untreated Compliers



Notes: This figure shows the distribution of test scores for treated and untreated compliers, for MCAS Math and ELA two years after the lottery.

Figure B.2: SAT Score Distributions for Treated and Untreated Compliers



Notes: This figure shows the distribution of SAT scores among takers in math and verbal (each out of 800) and the total score (out of 1600). Vertical dashed lines indicate control complier means and solid lines indicate treated complier means. Kolmogorov-Smirnov statistics are maximum differences in complier CDFs and p-values are bootstrapped.

Table B.1: Sample Characteristics and Outcomes

	Urban				Nonurban			
	Noncharter Public Schools (1)	Lottery Applicants (2)	Offered Charter (3)	Not Offered Charter (4)	Noncharter Public Schools (5)	Lottery Applicants (6)	Offered Charter (7)	Not Offered Charter (8)
(A) Baseline characteristics								
Female	0.482	0.519	0.519	0.518	0.491	0.516	0.513	0.520
Asian	0.076	0.029	0.029	0.030	0.039	0.030	0.033	0.025
Black	0.199	0.521	0.532	0.500	0.046	0.023	0.022	0.025
Latinx	0.316	0.284	0.288	0.277	0.062	0.022	0.022	0.023
Other race	0.028	0.042	0.038	0.048	0.017	0.024	0.020	0.032
White	0.381	0.124	0.113	0.145	0.837	0.901	0.904	0.896
Special education	0.188	0.195	0.195	0.194	0.177	0.156	0.152	0.163
English learner	0.179	0.114	0.116	0.110	0.028	0.006	0.006	0.007
Free/reduced price lunch	0.644	0.737	0.748	0.715	0.198	0.109	0.114	0.098
Baseline MCAS ELA	-0.432	-0.414	-0.428	-0.388	0.155	0.444	0.433	0.466
Baseline MCAS Math	-0.426	-0.363	-0.366	-0.356	0.153	0.363	0.364	0.361
(B) Charter school enrollment								
Attend any charter in grades 5-12	0.058	0.428	0.516	0.260	0.052	0.568	0.706	0.291
(C) Academic outcomes								
MCAS Math	-0.360	-0.199	-0.137	-0.313	0.174	0.314	0.303	0.337
MCAS ELA	-0.392	-0.285	-0.245	-0.355	0.189	0.382	0.362	0.426
Took any AP	0.288	0.371	0.381	0.353	0.356	0.302	0.255	0.400
Score 3+ on any AP	0.132	0.106	0.105	0.108	0.253	0.211	0.183	0.267
Took SAT	0.548	0.640	0.639	0.644	0.678	0.777	0.775	0.781
SAT score (1600) (for takers)	94.865	900.001	898.068	903.506	107.148	1129.566	1133.172	1122.008
Graduate high school (4 years)	0.609	0.626	0.610	0.656	0.827	0.820	0.825	0.808
Graduate high school (5 years)	0.656	0.714	0.704	0.733	0.850	0.881	0.878	0.888
Enroll in any college	0.501	0.603	0.606	0.596	0.700	0.801	0.804	0.796
Enroll in 4-year college	0.315	0.448	0.454	0.436	0.564	0.672	0.678	0.659
Enroll in 2-year college	0.220	0.200	0.199	0.201	0.177	0.182	0.177	0.193
Complete any degree	0.257	0.251	0.250	0.251	0.492	0.562	0.568	0.549
Complete BA	0.214	0.216	0.214	0.220	0.449	0.515	0.525	0.496
Complete AA	0.059	0.050	0.052	0.047	0.066	0.071	0.064	0.085
N	275,568	14,409	9,447	4,962	642,847	3,425	2,293	1,132

Notes: This table shows demographic characteristics and outcome means, for various samples. Charter attendance includes attendance at non-lottery charters and thus will not match first stage estimates. The sample in Column 1 is restricted to students who attended schools in the state of Massachusetts in 9th grade in the projected high-school classes of 2006–2018. The sample in Column 2 is restricted to charter school applicants enrolled in schools in the state of Massachusetts at the time of application in the projected high-school classes of 2006–2018. The samples in Columns 3 and 4 are further restricted to those offered and not offered a seat at a charter in the lottery, respectively.

Table B.2: The Impact of Charter School Attendance on Advanced Placement

	Urban			Nonurban		
	2SLS (1)	CCM (2)	N (3)	2SLS (4)	CCM (5)	N (6)
(A) Advanced Placement						
Offered AP	0.037	0.582	6,564	-0.411***	0.672	1,427
	(0.025)			(0.066)		
Number of APs offered	-0.517+	3.419	6,564	-2.753***	3.964	1,427
	(0.294)			(0.599)		
(B) AP by subject						
Offered AP Calculus	0.133***	0.386	6,564	-0.309***	0.481	1,427
	(0.028)			(0.068)		
Offered AP English	-0.105***	0.441	6,564	-0.346***	0.536	1,427
	(0.028)			(0.067)		
Offered AP History	0.031	0.316	6,564	-0.277***	0.427	1,427
	(0.027)			(0.065)		
Offered AP Science	-0.005	0.314	6,564	-0.277***	0.325	1,427
	(0.028)			(0.063)		
(C) AP scores						
Score 2+ on any AP	0.091***	0.179	13,499	-0.238***	0.408	3,425
	(0.018)			(0.031)		
Score 3+ on any AP	0.042**	0.112	13,499	-0.187***	0.330	3,425
	(0.014)			(0.029)		
Score 4+ on any AP	0.007	0.066	13,499	-0.133***	0.236	3,425
	(0.011)			(0.027)		
Score 5 on any AP	-0.000	0.027	13,499	-0.099***	0.155	3,425
	(0.007)			(0.021)		
(D) Conditional AP scores						
Score 2+ on any AP	0.042	0.621	3,980	-0.068	0.944	887
	(0.034)			(0.045)		
Score 3+ on any AP	0.004	0.385	3,980	0.013	0.736	887
	(0.034)			(0.064)		
Score 4+ on any AP	-0.038	0.224	3,980	0.010	0.535	887
	(0.028)			(0.078)		
Score 5 on any AP	-0.020	0.087	3,980	-0.071	0.367	887
	(0.018)			(0.075)		

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter at any period of time before the outcome listed in the column heading occurred as described in Equation 1. Indicator variables for a lottery offer on the day of the lottery (initial offer) and lottery offer from the waitlist (waitlist offer), separately for urban and nonurban charters, are the instruments for charter attendance. The control complier mean is labeled CCM. All regressions control for lottery risk sets and a vector of demographic characteristics including indicators for race, gender, birth year, calendar year, and baseline special education, English learner, and free or reduced price lunch status. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001). AP outcomes are available for the class of 2007 and later. In the second panel, AP offers are defined based on whether students' 9th grade school offered an AP class. In the third panel, AP scores are conditional on having taken at least one AP.

Table B.3: The Impact of Charter School Attendance on High School Progression

	Urban			Nonurban		
	2SLS (1)	CCM (2)	N (3)	2SLS (4)	CCM (5)	N (6)
(A) On-time grade progression						
10th grade	-0.020	0.914	11,407	-0.003	0.996	2,950
	(0.014)			(0.008)		
11th grade	-0.043**	0.919	10,604	0.005	0.992	2,866
	(0.015)			(0.009)		
12th grade	-0.034*	0.911	10,615	-0.015	0.990	2,825
	(0.015)			(0.011)		
Repeat 9th or 10th	0.039*	0.161	12,203	-0.005	0.029	3,026
	(0.019)			(0.013)		
(B) High school graduation						
Graduate high school (4 years)	-0.067**	0.655	12,185	-0.016	0.814	3,026
	(0.023)			(0.026)		
Graduate high school (5 years)	-0.019	0.734	12,185	-0.007	0.899	3,026
	(0.022)			(0.024)		
Graduate high school (6 years)	-0.011	0.786	12,185	-0.012	0.911	3,026
	(0.021)			(0.023)		
(C) Days attended						
9th grade	0.854	162.561	12,169	1.139	169.725	3,026
	(1.793)			(1.810)		
10th grade	1.112	162.082	11,397	2.809+	167.257	2,950
	(1.601)			(1.639)		
11th grade	1.951	156.874	10,594	0.982	167.436	2,866
	(1.776)			(1.701)		
12th grade	3.672*	153.221	10,606	-2.063	160.646	2,825
	(1.660)			(1.624)		

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter at any period of time before the outcome listed in the column heading occurred as described in Equation 1. Indicator variables for a lottery offer on the day of the lottery (initial offer) and lottery offer from the waitlist (waitlist offer), separately for urban and nonurban charters, are the instruments for charter attendance. The control complier mean is labeled CCM. All regressions control for lottery risk sets and a vector of demographic characteristics including indicators for race, gender, birth year, calendar year, and baseline special education, English learner, and free or reduced price lunch status. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ $p<0.10$ * $p<0.05$ ** $p<0.01$ ***$p<0.001$).

Table B.4: The Impact of Charter School Attendance on School Suspensions

	Urban			Nonurban		
	2SLS (1)	CCM (2)	N (3)	2SLS (4)	CCM (5)	N (6)
(A) Total suspensions						
Suspension days	1.201***	2.623	11,649	0.076	0.597	3,209
	(0.328)			(0.247)		
Number of in-school suspensions	0.314***	0.275	11,649	0.070	0.116	3,209
	(0.065)			(0.060)		
Number of out-of-school suspensions	1.229***	1.357	11,649	-0.035	0.287	3,209
	(0.165)			(0.101)		
(B) Ever suspended						
Any suspension	0.152***	0.385	11,649	-0.026	0.173	3,209
	(0.021)			(0.026)		
In-school suspension	0.075***	0.113	11,649	-0.003	0.086	3,209
	(0.015)			(0.020)		
Out-of-school suspension	0.137***	0.352	11,649	-0.018	0.133	3,209
	(0.021)			(0.024)		

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter at any period of time before the outcome listed in the column heading occurred as described in Equation 1. Indicator variables for a lottery offer on the day of the lottery (initial offer) and lottery offer from the waitlist (waitlist offer), separately for urban and nonurban charters, are the instruments for charter attendance. The control complier mean is labeled CCM. All regressions control for lottery risk sets and a vector of demographic characteristics including indicators for race, gender, birth year, calendar year, and baseline special education, English learner, and free or reduced price lunch status. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ $p<0.10$ * $p<0.05$ ** $p<0.01$ ***$p<0.001$). Students are marked as having no suspensions if they are missing from the data.

Table B.5: The Impact of Charter School Attendance on College Enrollment

	Any College		4 Year College		2 Year College		
Year after Projected High School Graduation	2SLS (1)	CCM (2)	2SLS (3)	CCM (4)	2SLS (5)	CCM (6)	N (7)
(A) 1st year							
Urban	0.024	0.519	0.063**	0.391	-0.038*	0.126	13,489
	(0.023)		(0.023)		(0.015)		
Nonurban	0.014	0.667	0.086**	0.533	-0.072**	0.134	3,263
	(0.031)		(0.033)		(0.022)		
(B) 2nd year							
Urban	0.079***	0.494	0.082***	0.364	-0.002	0.128	13,489
	(0.023)		(0.022)		(0.016)		
Nonurban	0.060+	0.685	0.097**	0.556	-0.037	0.129	3,263
	(0.032)		(0.034)		(0.023)		
(C) 3rd year							
Urban	0.076***	0.436	0.066**	0.334	0.012	0.101	13,489
	(0.023)		(0.022)		(0.015)		
Nonurban	0.094**	0.628	0.100**	0.540	-0.007	0.088	3,263
	(0.034)		(0.035)		(0.020)		
(D) 4th year							
Urban	0.067**	0.397	0.052*	0.311	0.016	0.085	13,489
	(0.023)		(0.021)		(0.014)		
Nonurban	0.121***	0.571	0.125***	0.510	-0.004	0.061	3,263
	(0.035)		(0.035)		(0.017)		
(E) 5th year							
Urban	0.015	0.244	0.022	0.179	-0.009	0.065	13,489
	(0.020)		(0.018)		(0.012)		
Nonurban	0.032	0.299	0.044	0.258	-0.012	0.043	3,263
	(0.034)		(0.033)		(0.013)		
(F) 6th year							
Urban	0.050**	0.131	0.043**	0.087	0.006	0.043	11,731
	(0.019)		(0.016)		(0.011)		
Nonurban	0.048+	0.146	0.056*	0.123	-0.010	0.024	3,086
	(0.028)		(0.027)		(0.011)		

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter at any period of time before the outcome listed in the column heading occurred as described in Equation 1. Indicator variables for a lottery offer on the day of the lottery (initial offer) and lottery offer from the waitlist (waitlist offer), separately for urban and nonurban charters, are the instruments for charter attendance. The control complier mean is labeled CCM. All regressions control for lottery risk sets and a vector of demographic characteristics including indicators for race, gender, birth year, calendar year, and baseline special education, English learner, and free or reduced price lunch status. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001).

Table B.6: The Impact of Charter School Attendance on College Degrees

	Any Degree		B.A.		A.A.		
Year after Projected High School Graduation	2SLS (1)	CCM (2)	2SLS (3)	CCM (4)	2SLS (5)	CCM (6)	N (7)
(A) 4th year							
Urban	0.037*	0.133	0.032*	0.116	0.008	0.022	13,489
	(0.016)		(0.015)		(0.008)		
Nonurban	0.057	0.365	0.069*	0.309	-0.025	0.074	3,263
	(0.035)		(0.034)		(0.017)		
(B) 5th year							
Urban	0.037+	0.212	0.032+	0.190	0.003	0.037	13,489
	(0.019)		(0.018)		(0.009)		
Nonurban	0.101**	0.486	0.111**	0.435	-0.029	0.084	3,263
	(0.036)		(0.036)		(0.018)		
(C) 6th year							
Urban	0.046*	0.241	0.041*	0.217	0.009	0.041	11,731
	(0.022)		(0.021)		(0.011)		
Nonurban	0.111**	0.516	0.114**	0.473	-0.027	0.090	3,086
	(0.037)		(0.037)		(0.020)		

Notes: Each coefficient labeled 2SLS is the instrumental variables estimate of the effect of attending an urban or nonurban charter at any period of time before the outcome listed in the column heading occurred as described in Equation 1. Indicator variables for a lottery offer on the day of the lottery (initial offer) and lottery offer from the waitlist (waitlist offer), separately for urban and nonurban charters, are the instruments for charter attendance. The control complier mean is labeled CCM. All regressions control for lottery risk sets and a vector of demographic characteristics including indicators for race, gender, birth year, calendar year, and baseline special education, English learner, and free or reduced price lunch status. The sample is restricted to students enrolled in Massachusetts schools at the time of application in the projected high-school classes of 2006–2018. Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001). Students can obtain both a BA and an AA, so the coefficient for any degree will not be the sum of the BA and AA coefficients.

Table B.7: The Impact of Charter School Attendance on Test Scores, College Enrollment and Graduation

	Urban			Nonurban		
	Math MCAS (1)	4-Year College Enrollment (2)	4-Year College Graduation (3)	Math MCAS (4)	4-year College Enrollment (5)	4-year College Graduation (6)
Main Specification	0.467***	0.073**	0.041*	-0.138*	0.094**	0.114**
	(0.043)	(0.024)	(0.021)	(0.060)	(0.035)	(0.037)
N	9,787	11,731	11,731	2,884	3,086	3,086
Initial offer only	0.391***	0.052	0.035	-0.080	0.099*	0.103*
	(0.057)	(0.033)	(0.029)	(0.076)	(0.045)	(0.046)
N	9,787	11,731	11,731	2,884	3,086	3,086
Baseline test scores	0.478***	0.073**	0.039+	-0.110+	0.106**	0.126**
	(0.044)	(0.025)	(0.022)	(0.064)	(0.037)	(0.039)
N	9,069	10,574	10,574	2,446	2,590	2,590
No covariates	0.494***	0.078**	0.043*	-0.129+	0.095**	0.117**
	(0.047)	(0.025)	(0.021)	(0.066)	(0.036)	(0.038)
N	9,787	11,731	11,731	2,884	3,086	3,086

Notes: The first row of the table repeats the main specification reported in the other tables, see Tables 3, **??**, and **??** for details. Four-year college enrollment is enrollment within 2 years of projected high school graduation. Each subsequent panel shows an alternative specification. The panel labeled Initial offer only uses only admissions offers on the day of the charter school lottery as an instrument for charter attendance (excluding the waitlist offer). The panel labeled Baseline test scores uses only students for which baseline math MCAS scores are available. The panel labeled No covariates excludes all demographic variables from the regression.Robust standard errors in parentheses (+ p<0.10 * p<0.05 ** p<0.01 ***p<0.001).