Can Successful Schools Replicate? Scaling Up Boston's Charter School Sector

Sarah Cohodes
Elizabeth Setren
Christopher R. Walters

October 2016

Can Successful Schools Replicate? Scaling Up Boston's
Charter School Sector
Sarah Cohodes, Elizabeth Setren, Christopher R. Walters
SEII Discussion Paper #2016.06
October 2016

ABSTRACT

In a climate of school turnarounds, charter school conversions, and new school openings, an important question is whether schools that boost student outcomes can reproduce their success at new campuses. We study a policy reform that allowed effective charter schools in Boston, Massachusetts to replicate their school models at new locations. Estimates based on randomized admission lotteries show that replicate charter schools generate large achievement gains on par with those produced by their parent campuses. The average effectiveness of Boston's charter middle school sector increased after the reform despite a doubling of charter market share.

1 Introduction

The feasibility of scaling up effective programs is a perennial problem in social policy. Successful demonstration projects may fail to reproduce their effects at scale if these impacts are driven by unique inputs or population characteristics. In the education sphere, for example, recent large-scale studies of early childhood programs, class size reductions, and the Success For All curriculum show effects that fall short of the impressive gains seen in smaller-scale evaluations of similar interventions (Heckman et al., 2010; Heckman, Pinto, and Savelyev, 2013; Puma, Bell, and Heid, 2012; Krueger, 1999; Jepsen and Rivkin, 2009; Borman et al., 2007; Quint et al., 2015). This suggests that in some cases the success of education programs may be due to special teachers, school leaders, peer environments, or other factors that cannot be easily replicated.

The potential for sustained success at scale is of particular interest for "No Excuses" charter schools, a recent educational innovation that has demonstrated promise for low-income urban students. These schools share a set of practices that includes high expectations, strict discipline, frequent teacher feedback, high-intensity tutoring, and data-driven instruction. Evidence based on randomized admission lotteries shows that No Excuses charter schools generate test score gains large enough to close racial and socioeconomic achievement gaps in a short time, as well as improvements in longer-run outcomes like teen pregnancy and four-year college attendance (Abdulkadiroğlu et al., 2011, 2015; Angrist, Pathak, and Walters, 2013; Angrist et al., 2012, 2016; Dobbie and Fryer, 2011, 2013, 2015; Tuttle et al., 2013). Other recent studies demonstrate positive effects of No Excuses policies when implemented in traditional public schools or in low-performing schools converted to charter status (Fryer, 2014; Abdulkadiroğlu et al., 2016). No school district has adopted these policies on a wide scale, however, and No Excuses charters serve small shares of students in the cities where they operate. It therefore remains an open question whether the effects documented in previous research can be replicated at a larger scale.

We address this question using a recent policy change that expanded the charter school

sector in Boston, Massachusetts, a city where most charter schools operate according to No Excuses principles. In 2010, Massachusetts passed a comprehensive education reform law that raised the state's cap on the fraction of funding dedicated to charter school tuition payments in low-performing districts. Charter operators that the state deemed "proven providers" with track records of success were permitted to expand existing campuses or open new schools in these districts. As a result, the number of charter schools in Boston increased from 16 to 32 between 2010 and 2014, with most of these new campuses linked to existing No Excuses charter schools. This expansion led to dramatic growth in charter market share in Boston, particularly in middle school: the fraction of sixth grade students attending charter schools increased from 15 to 31 percent between 2010 and 2015.

We use records from randomized charter school admission lotteries to study changes in the effectiveness of Boston's charter middle school sector during this period of rapid expansion. Comparisons of students who randomly receive lottery offers to those who do not receive offers are free of selection bias and therefore generate credible estimates of the causal effects of charter school attendance. The lottery records studied here cover 14 of the 15 charter schools admitting students in fifth or sixth grade, permitting a broadly representative analysis of charter middle schools in Boston.

Lottery-based estimates reveal that Boston's charter sector remained effective while doubling in size. Consistent with previous evidence, our results for cohorts applying before 2010 show that a year of attendance at a Boston charter middle school boosted math achievement by between 0.18 and 0.33 standard deviations (σ) and increased English achievement by about 0.1σ during this period. Results indicate that policymakers selected more effective schools for expansion: proven providers produced larger effects than other charter schools before the reform. Proven providers and other existing charters maintained their effectiveness after the charter expansion.

Estimates for expansion charters show that new campuses generate achievement gains comparable to those of their parent schools. Moreover, expansion charters produce these

large impacts while enrolling students that appear more representative of the general Boston population than students at other charters. Together, the estimates for new and existing schools imply an increase in overall charter effectiveness despite the substantial growth in charter market share after the 2010 reform.

The next section provides background on charter schools in Boston and the charter expansion reform. Section 3 describes the data and Section 4 details the empirical framework used to analyze it. Section 5 presents lottery-based estimates of charter school effects and explores variation in these effects across students and schools. Section 6 notes some caveats to our analysis and offers concluding thoughts.

2   Background

2.1   Charter schools in Boston

The first charter schools in Boston opened in 1994. Boston charters offer a different educational experience than traditional public schools operating in the Boston Public Schools (BPS) district. Table 1 compares inputs and practices of BPS schools and the 14 charter middle schools in our analysis sample (described in more detail later on). Columns (1) and (5) of Panel A show that charter students spend more days per year and hours per day in school than BPS students. Charter teachers tend to be younger and less experienced than BPS teachers; as a result, they are much less likely to be licensed or designated highly-qualified.[1] Student/teacher ratios are similar in BPS and charter schools, but charters spend somewhat less money per pupil ($18,766 vs. $17,041), a difference driven by lower salaries and retirement costs for their less-experienced teachers (Setren, 2016).

Boston charter schools commonly subscribe to No Excuses pedagogy, an approach that utilizes strict discipline, extended instructional time, selective teacher hiring, frequent testing, high expectations, teacher feedback, data-driven instruction, and tutoring (Carter, 2000;

---

[1]Teachers are designated as highly qualified if they possess a Massachusetts teaching license and a bachelor's degree, and pass a state examination or hold a degree in their subject area. See `http://www.doe.mass.edu/educators/title-iia/hq/hq_faq.html`.

Thernstrom and Thernstrom, 2003). Panel B of Table 1 reports the mean of an index of No Excuses policies, constructed as an equally-weighted average of features typically associated with the No Excuses model.[2] On average, Boston charter schools implement 90 percent of these policies. Charters also commonly offer Saturday and school break programming for homework help, tutoring, and academic enrichment. These practices differ markedly from practices at BPS schools and at non-urban charter schools in Massachusetts (Angrist, Pathak, and Walters, 2013).

Previous research has documented that Boston charters boost math and English standardized test scores (Abdulkadiroğlu et al., 2011; Cohodes et al., 2013). This finding is consistent with studies showing positive test score effects for urban No Excuses charters elsewhere (Dobbie and Fryer, 2011, 2013; Angrist et al., 2012; Abdulkadiroğlu et al., 2015; Chabrier, Cohodes, and Oreopoulos, 2016). Recent evidence shows that Boston charter high schools also increase longer-term outcomes, including SAT scores, Advanced Placement (AP) credit, and enrollment in four-year college (Angrist et al., 2016).

Funding for Massachusetts public school students follows their school enrollment. Specifically, charter schools receive tuition payments from their students' home districts equal to district per-pupil expenditure. The state partially reimburses districts for charter school payments during a transition period, but these reimbursements have not been fully funded in recent years. Prior to 2010, Massachusetts law capped the overall number of charter schools at 120 and limited total charter school tuition to 9 percent of a district's spending. Charter expenditure in Boston reached this cap in fall 2009 (Boston Municipal Research Bureau, 2008). As a result, the charter cap limited the expansion of charter schools in Boston before 2010.

---

[2]The No Excuses index is an average of indicators equal to one if the following items are mentioned in a school's annual report: high expectations for academics, high expectations for behavior, strict behavior code, college preparatory curriculum, core values in school culture, selective teacher hiring or incentive pay, emphasis on math and reading, uniforms, hires Teach for America teachers, Teaching Fellows, or AmeriCorps members, affiliated with Teach for America alumni, data driven instruction, and regular teacher feedback.

2.2 Charter expansion

In January 2010, Governor Deval Patrick signed *An Act Relative to the Achievement Gap* into law. This reform relaxed the charter cap to allow the charter sector to double for districts in the lowest decile of performance according to a measure derived from test score levels and growth. The law also included provisions for school turnarounds and the creation of "innovation" schools (Massachusetts State Legislature, 2010).

For Boston and other affected districts, the 2010 reform increased the limit on charter spending from 9 percent to 18 percent of district funds between 2010 and 2017. "Proven providers" – existing schools or school models the Massachusetts Board of Elementary and Secondary Education deemed effective – could apply to open new schools or expand enrollment. The law also allowed school districts to create up to 14 "in-district" charter schools without prior approval from the local teachers' union or proven provider status. Concurrent with the increased supply of charter seats, the law required charters to increase recruitment and retention efforts for high need students and allowed charters to send advertising mailers to all students in the district.[3]

The state received 71 initial applications (some of which were solicited by the state) for new charter schools or expansions from August 2010 to August 2012, and invited 60 percent of applicants to submit final round proposals. To determine whether a school model qualified for proven provider status, the Massachusetts Board of Elementary and Secondary Education compared existing schools using the model to other charters and traditional public schools. Criteria for this evaluation included enrollment of high-need students, attrition, grade retention, dropout, graduation, attendance, suspensions, and performance on state achievement tests (Massachusetts Department of Elementary and Secondary Education, 2015). The state granted proven provider status to four of seven Boston charter middle schools, as well as the KIPP organization, which operated a charter school in Lynn, Massachusetts, but had not

---

[3]The state's definition of high need students includes those with special educations status, limited English proficiency, eligibility for subsidized lunch, or low scores on state achievement tests, as well as students deemed to be at risk of dropping out of school.

yet entered Boston. Together, the provisions of the 2010 reform led to the establishment of 27 new charter campuses between 2011 and 2013, as well as expansions of 17 existing charter schools, typically to new grade levels (Massachusetts Department of Elementary and Secondary Education, 2016).

Charter enrollment in Boston expanded rapidly after 2010. This can be seen in Figure 1, which plots shares of fourth, sixth, and ninth grade students attending charter schools. These statistics are calculated using the administrative enrollment data described below. Sixth grade charter enrollment doubled after the reform, expanding from 15 to 31 percent between 2010 and 2015. Charter enrollment also grew substantially in elementary and high school, though not as dramatically as in middle school. The share of Boston students in charter schools increased from 7 percent to 11 percent in fourth grade and 9 to 15 percent in ninth grade over the same time period.

Boston's new expansion charter schools have broadly similar characteristics and practices as their proven provider parent schools. This is evident in columns (2) through (4) of Table 1, which describe proven providers, other charters operating before 2010, and new expansions. Like proven providers, expansion schools have longer school days and years than BPS schools, and rate highly on the index of No Excuses practices. Per-pupil expenditure is similar at proven provider and expansion schools, and lower at other charters. New campuses located an average of 3.1 miles from their parent campuses, often expanded into different Boston neighborhoods (see Figure 2).

Expansion charter schools are primarily staffed by young teachers with little teaching experience. As shown in Table 2, 78 percent of teachers at proven providers in the year before expansion were less than 32 years old, while 87 percent of expansion charter teachers were below this threshold in the year after expansion. These and other teacher characteristics come from an administrative database of Massachusetts public school employees (see the Data Appendix). Columns (4) and (7) show that proven providers transferred some teachers from parent campuses to help staff their expansions: 12 percent of former parent teachers

7

moved to expansion campuses, accounting for 25 percent of the teaching workforce at these new schools. Transferred teachers were less experienced than teachers who remained at parent campuses (2.2 years vs. 3.3 years). Most of the remaining expansion teachers had not taught in a Massachusetts school in the previous year (66 percent), though a few transferred from other schools (9 percent). As a result, the average teacher at an expansion charter had only 1.4 years of teaching experience, compared to 2.9 years for teachers at parent campuses and 11.5 years for BPS teachers.

3   Data

3.1   Data sources and sample construction

We study the effectiveness of Boston charter middle schools using records from randomized admission lotteries conducted between 2004 and 2013. Our sample includes 14 of the 15 Boston charter schools that accept students in 5th or 6th grade, accounting for 94 percent of enrollment for schools in this category during the 2013-2014 school year.[4] Lottery records typically list applicant names along with application grades, dates of birth, towns of residence and sibling statuses. Our analysis excludes sibling applicants, out-of-area applicants, and students who applied to non-entry grades (siblings are guaranteed admission, while out-of-area applicants are typically ineligible). The lottery records also indicate which students received admission offers. We distinguish between immediate offers received on the day of the lottery and later offers received from the waitlist; in some lotteries all students eventually receive waitlist offers, while in others the records are insufficient to distinguish between immediate and waitlist offers. Further information on school coverage and lottery records appears in Appendix Tables A1 and A2.

We match the lottery records to state administrative data based on name, date of birth,

---

[4]Two charter middle schools that closed before 2010 are excluded from this calculation. The one missing school declined to provide lottery records.

town of residence and application cohort. The administrative data cover all students enrolled in Massachusetts public schools between 2002 and 2014. As shown in Appendix Table A3, we find matches for 95 percent of lottery applicants in this database. Key administrative records include school enrollment, gender, race, special education status, English Language Learner status, subsidized lunch status, and test scores on Massachusetts Comprehensive Assessment System (MCAS) achievement tests. We standardize MCAS scores to mean zero and standard deviation one relative for BPS students by subject, grade and year. In addition to information on charter lottery applicants, we use administrative data on other Boston students to describe changes in charter application and enrollment patterns after the 2010 reform. The Data Appendix provides more details regarding data processing and sample construction.

3.2   Descriptive statistics

Charter application and enrollment patterns in our sample mirror the large increases in charter market share evident in Figure 1. As shown in Table 3, 15 percent of eligible Boston students applied to charter schools with fifth or sixth grade entry before the 2010 reform, 12 percent received offers from these schools, and 10 percent enrolled. This implies roughly 1.5 applicants for each available charter seat. The application rate increased to 35 percent in 2013, and attendance reached 17 percent. The increase in applications therefore outpaced enrollment growth, boosting the number of applicants per seat to 2. This increase in demand was particularly pronounced at other charter schools (neither proven providers or expansions), which saw their applications per seat rise from 1.9 to 4.[5] By 2013, half of charter middle school students attended new expansion campuses.

Table 4 describes the characteristics of BPS students, students enrolled in charter middle schools, and applicants in our randomized lottery sample. Charter applicants and enrolled

---

[5]The number of applicants per seat is larger for each individual charter type than for the sector as a whole because some students apply to more than one school.

students are consistently more likely to be black than BPS students. Both before and after 2010, students attending proven providers were less disadvantaged than other Boston students as measured by special education status, limited English proficiency, and fourth grade test scores. Past achievement and other characteristics of students enrolled at proven providers and randomized applicants were similar before the reform, but diverged somewhat afterward. This is due to the fact that some proven providers expanded to serve earlier grades after 2010, resulting in a larger share of middle school students grandfathered in from elementary school.

As shown in columns (11) and (12) of Table 4, the characteristics of students enrolled at expansion charters differ markedly from those of other charter students. Special education and limited English proficiency rates are similar at expansion charters and in the BPS population. Expansion charter students also score below the BPS average on 4th grade math and English tests, and are more likely than BPS students to be eligible for subsidized lunches. These facts indicate that expansion charters attract a more disadvantaged, lower-achieving population than their proven provider parent schools. This pattern may reflect the changes in recruitment practices required by the 2010 Achievement Gap Act, which mandated that charter schools take steps to enroll higher-need students.

4   Empirical Framework

We use charter lottery offers as instruments for charter school attendance in a causal model with multiple endogenous variables, each representing enrollment in a type of charter school. The structural equation links charter attendance with outcomes as follows:

$$Y_{ig} = \alpha_g + \sum_{k=1}^{K} \beta_k C_{ig}^k + \sum_{j=1}^{J} \delta_j R_{ij} + X_i'\gamma + \epsilon_{ig}, \tag{1}$$

where Y_{ig} is a test score for student i in grade g and C_{ig}^k measures years of enrollment in charter school type k through grade g. Charter types include parent campuses, replicates,

and other charters; we also distinguish between enrollment before and after the charter expansion law. The parameters of interest, β_k, represent causal effects of an additional year of attendance at each charter type relative to traditional public schools.[6] The key control variables in equation (1) are a set of indicators, R_{ij}, for all combinations of charter lottery applications present in the data. Lottery offers are randomly assigned within these "risk sets." A vector of baseline demographic characteristics, X_i, is also included to increase precision.[7]

The first stage equations predicting charter attendance are given by

$$C_{ig}^k = \mu_g^k + \sum_{\ell=1}^{K}\left(\pi_{\ell 1}^k Z_{i1}^\ell + \pi_{\ell 2}^k Z_{i2}^\ell\right) + \sum_{j=1}^{J}\lambda_j^k R_{ij} + X_i'\theta^k + \eta_{ig}^k; \ k = 1...K. \tag{2}$$

Here Z_{i1}^k denotes a dummy variable equal to one if applicant i received an offer to attend charter type k on the day of the lottery, and Z_{i2}^k equals one if the applicant later received an offer from the waitlist. Immediate offers are coded to zero in risk sets where we cannot distinguish between immediate and waitlist offers. Like equation (1), the first stage also controls for lottery risk set indicators and baseline student characteristics. Two-stage least squares (2SLS) estimates are obtained by ordinary least squares (OLS) estimation of equation (1) after substituting predicted values from (2) for the charter attendance variables. Standard errors are clustered by student to account for correlation in outcomes across grades.

Our empirical strategy is motivated by the fact that charter lottery offers are randomly assigned within risk sets and therefore independent of family background and all other student attributes. Appendix Table A4 presents a check on this by comparing baseline characteristics for offered and non-offered applicants, controlling for risk sets. These comparisons show that students with and without lottery offers are similar for all charter school types and time periods, indicating that random assignment was successful.[8]

---

[6] If charter effects are not linear in years of enrollment, β_k will capture a weighted average of unit causal effects for students shifted across each attendance increment by lottery offers (Angrist and Imbens, 1995).

[7] These characteristics, which are measured in the year prior to a student's lottery application, include gender, race, a female-minority interaction, subsidized lunch status, English language learner status, and special education status.

[8] Even with random assignment, selective attrition may lead to bias in comparisons of those with and without lottery offers. Appendix Tables A3 and A5 show that the attrition rate from our sample is low: we

5   Effects of Charter School Expansion

5.1   Lottery estimates

Students randomly offered charter seats spend more time in charter schools than students not offered seats. Table 5 reports estimated effects of immediate and waitlist offers on years of charter enrollment for proven providers, expansion charters, and other charters before and after the reform. These estimates correspond to the parameters π_{k1}^k and π_{k2}^k in equation (2). Columns (1) and (3) show that immediate offers boost charter attendance by an average of one year for students applying to proven providers and other charters before 2010. The effects of waitlist offers (reported in columns (2) and (4)) are smaller, likely because some students make arrangements to attend school elsewhere before gaining admission from the waitlist. The first stage coefficients are generally smaller but still positive and significant in the post-expansion period for all charter types. This reflects the fact that less time has elapsed in our data for cohorts applying after 2010, resulting in fewer years of potential charter enrollment between lottery and test dates.

Proven provider charter schools generated larger achievement gains than other charter schools in Boston prior to the 2010 expansion. This can be seen in Table 6, which reports second-stage estimates of equation (1). Columns (2) and (3) demonstrate that a year of charter attendance at a proven provider increased math and English scores by 0.33σ and 0.14σ prior to the reform, estimates that are highly statistically significant. Corresponding math and English effects for other Boston charters were 0.18σ and 0.09σ. The difference in effects for proven providers and other charters is statistically significant in math ($p = 0.00$), though not in English. This finding indicates that policymakers selected more effective charter schools for expansion. The large positive impacts for both charter groups are consistent

---

match 95 percent of applicants to the administrative data, and find roughly 85 percent of post-lottery test scores that should be observed in our sample window for matched students. The match rate is 4 percent higher for students offered charter seats, and we are 3 percent more likely to find scores for students with lottery offers at non-proven-provider charters before 2010. This modest differential attrition seems unlikely to meaningfully affect the results reported below.

with the results reported by Abdulkadiroğlu et al. (2011) in a subsample of the schools and cohorts studied here.

Columns (5) and (7) of Table 6 reveal that the impacts of proven providers and other charters did not change after the charter expansion reform. For cohorts applying after 2010, proven providers boosted math and English scores by 0.36σ and 0.19σ per year of attendance, while other charters increased scores by 0.21σ and 0.13σ. These estimates are slightly larger than estimates for earlier cohorts, though the differences between pre- and post-reform effects are not statistically significant for either group. If anything, this pattern suggests that existing Boston charter schools slightly improved their effectiveness after the 2010 reform.

Proven providers also successfully replicated their impacts at expansion campuses. As shown in column (6) of Table 6, a year of attendance at an expansion charter school increases math and English test scores by 0.32σ and 0.23σ. These estimates are comparable to estimates for parent campuses and larger than estimates for other charters during the same time period. Combined with the consistent effects for proven providers and other charters over time, these results imply an increase in overall effectiveness for Boston's charter middle school sector despite the substantial increase in charter market share over this period. The impacts of expansion charters are particularly striking in view of the selection patterns documented in Table 3: new charter campuses generate above-average effects despite serving more typical Boston students.[9] This implies that positive charter effects are not an artifact of a positively-selected peer environment.

5.2 Effects for subgroups

The 2010 charter expansion law encourages charter schools to recruit and retain students with higher needs, as measured by criteria including English proficiency, special education status and past achievement. Table 7 summarizes effect heterogeneity as a function of these

---

[9]This is consistent with findings reported by Walters (2014), who argues that charter school effects are likely to be larger for the average Boston student than for the selected set of charter lottery applicants.

characteristics.

The estimates show consistent positive impacts across most subgroups, charter school types, time periods and subjects. Effects are similar for students designated English language learners and students without this designation, though estimates for the former group are often imprecise due to small sample sizes. All estimates are positive for students with and without special education status; effects for special education students appear to be somewhat smaller at proven providers and larger at expansion charters, but these differences may be a chance finding due to the many splits examined. As in previous studies (e.g., Walters, 2014), we find that effects tend to be larger for students with lower previous test scores. The large estimated effects for high-need subgroups at expansion charters are noteworthy: evidently, expansion schools continue to generate substantial gains for these groups despite serving larger shares of such students than other Boston charters.

5.3 Variation across charter schools

The results in Table 6 indicate that on average, expansion charter schools are as effective as their proven provider parent schools. It is also of interest to ask whether impacts differ across individual charter schools. We explore variation in effects across campuses by estimating a version of equation (1) that includes separate endogenous variables for enrollment in each charter school and time period, instrumenting with school- and period-specific lottery offers.

The results of this analysis reveal substantial heterogeneity in impacts across schools. Figure 3 plots school-specific estimates of math effects against corresponding English effects. Schools with larger math effects also generate larger gains in English, and the spread in estimated effects is large for each subject. Some of this variation is due to the considerable sampling error in school-specific estimates, but statistical tests establish that impacts vary across schools. We can reject the hypothesis that effects for all expansion schools equal those of their parent campuses at marginal significance levels in math ($p = 0.07$) but not in English ($p = 0.18$). The hypothesis that effects are equal for all expansion charters is rejected in both

subjects ($p = 0.06$ and $p = 0.02$). These results indicate that although effects for parent and replicate campuses are similar on average, some replication efforts are more successful than others. The factors that drive variation in impacts across charter schools are an important subject to be explored in future work.

6   Conclusion

The replication and expansion of successful schools is one strategy to address persistent achievement gaps in the United States. The efficacy of this strategy requires schools selected for expansion to maintain their success at new locations and with new student populations. Previous research has shown that urban No Excuses charter schools boost test scores markedly for small groups of applicants, suggesting the potential for transformational effects on urban achievement if these gains can be maintained at larger scales. We examine a recent policy change in Massachusetts that doubled Boston's charter sector over a short time period, allowing us to evaluate changes in the effects of No Excuses charters as these schools expanded to serve a larger share of the population.

Our results show that Boston's No Excuses charters reproduced their effectiveness at new campuses. Lottery-based estimates show that schools selected for expansion produce larger gains than other charters, indicating that Massachusetts' accountability regime successfully identified more successful schools. New expansion campuses generate test score gains similar to those of their parent campuses, despite a doubling of charter market share. After expansion, the effects of parent campuses, expansion schools, and other charters are positive for all subgroups.

It is worth noting some caveats to these results. Despite the rapid growth of Boston's charter sector, less than one third of the city's middle school students attend charter schools. Expansion to serve a large majority of students could lead to changes in public school behavior and other general equilibrium effects that are outside the scope of the analysis here. In

15

addition, Boston is a relatively small city that likely faces elastic supply of charter teachers and other inputs. Attempts to implement No Excuses practices more widely could lead to scarcity of quality teachers or other key ingredients necessary for continued success. Nonetheless, our results demonstrate that Boston's charter sector maintained its effectiveness during the substantial expansion considered here.

Figure 1: Charter School Enrollment in Boston
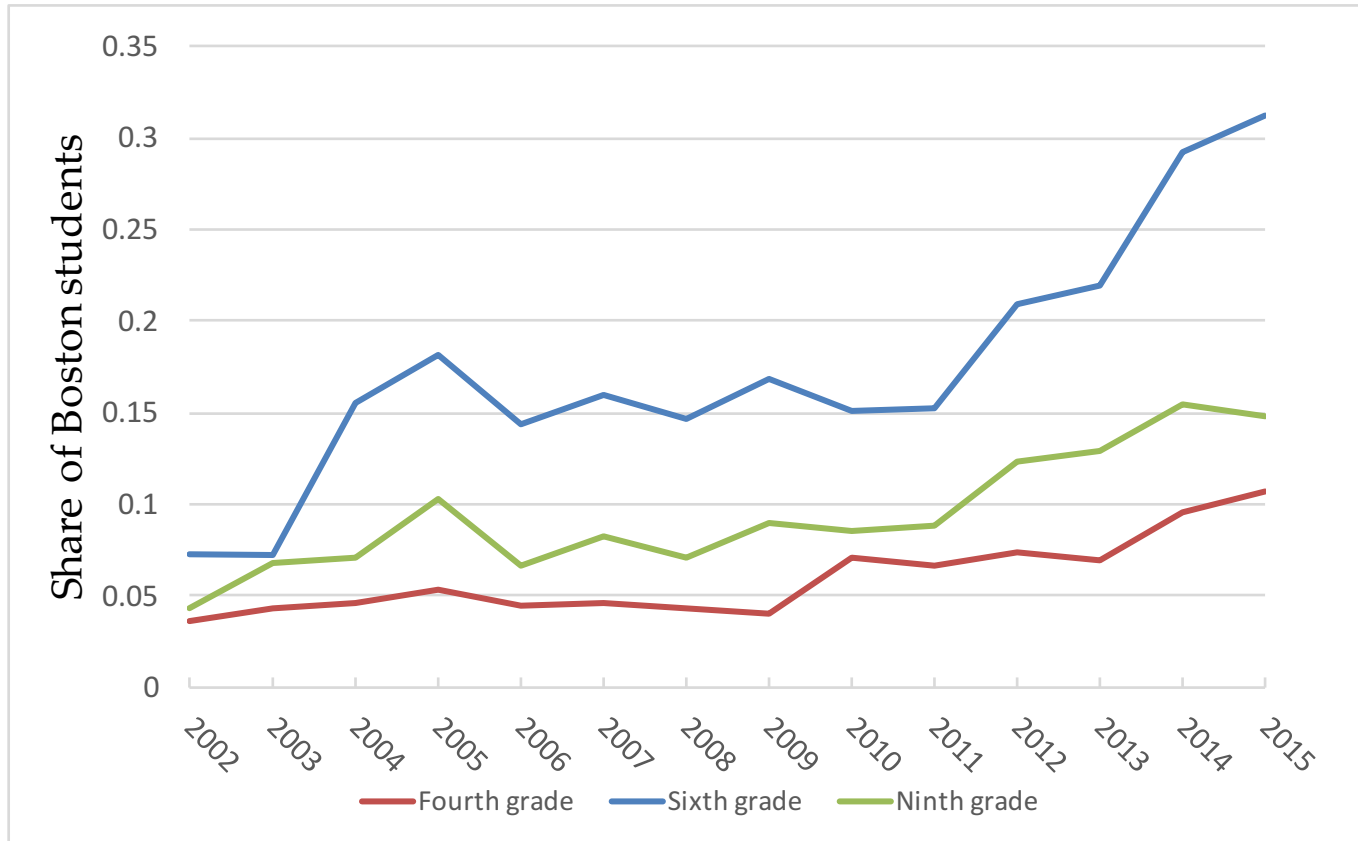
Notes: This figure plots the share of Boston fourth, sixth, and ninth grade students enrolled in charter schools between 2002 and 2015.

Figure 2: Locations of Boston Charter Schools

Legend

🚩 Proven Providers

● Expansion Charters
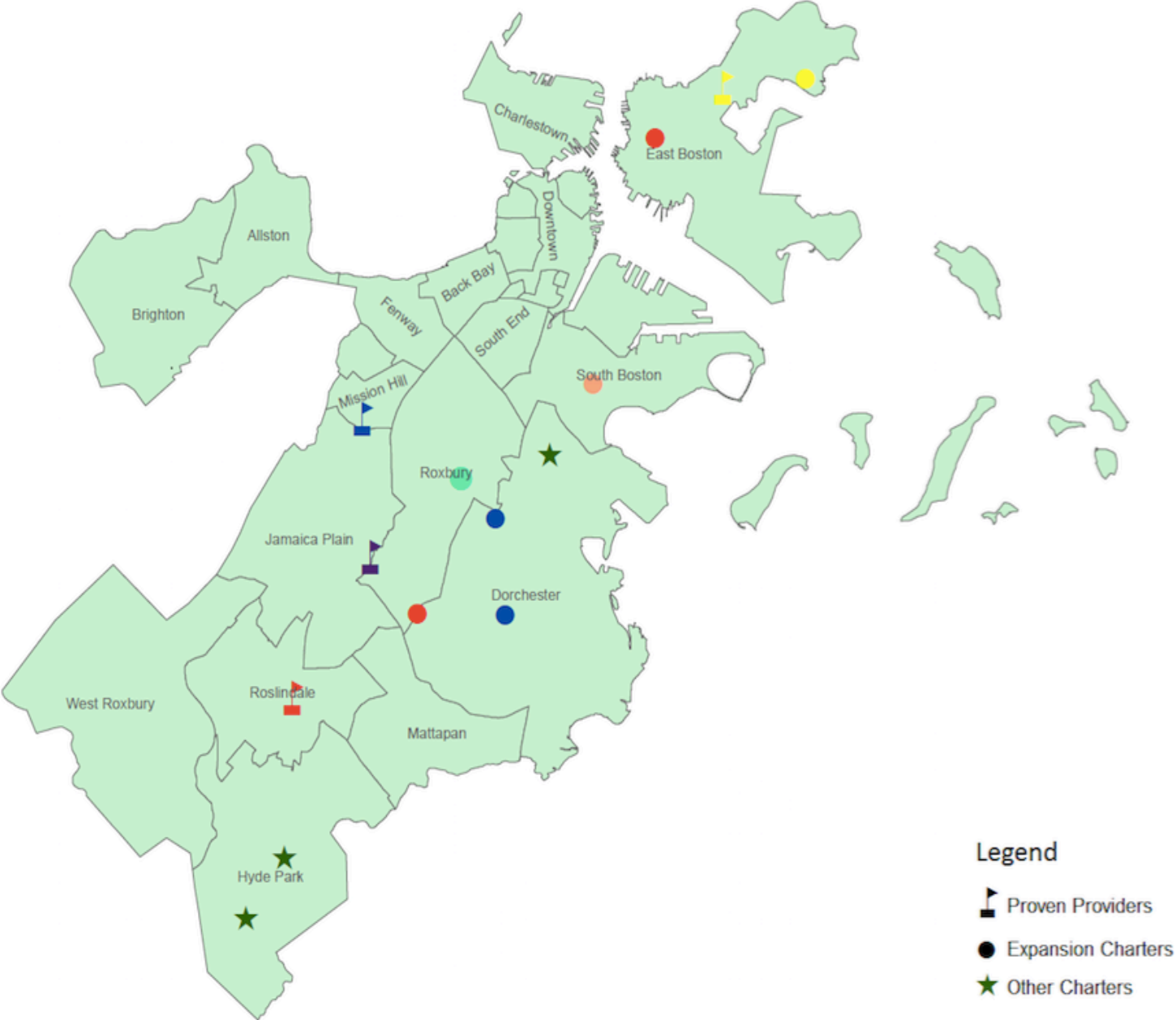
★ Other Charters

Figure 3: School-specific Estimates
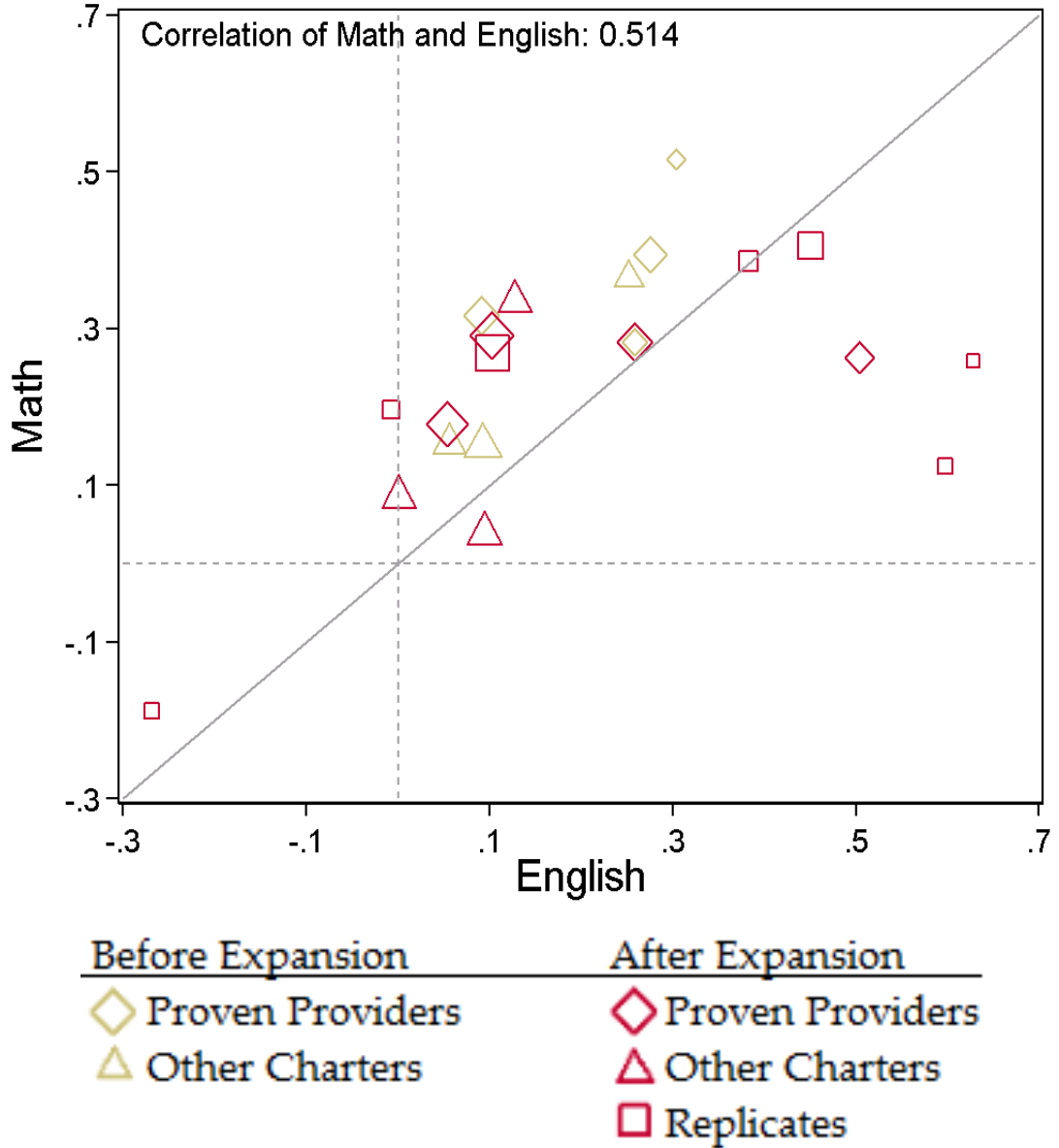
Notes: This figure plots estimates of test score effects for individual charter schools. These estimates come from 2SLS models using school-specific lottery offers as instruments for charter enrollment, treating enrollment in each school and time period as a separate endogenous variable. Models also control for lottery risk sets and baseline covariates. Marker sizes are inversely proportional to the average standard error of estimates for math and English. The 45 degree line is marked in grey.

Table 1: School Characteristics

	All Charters	Proven Providers	Expansion Charters	Other Charters	Boston Public Schools
	(1)	(2)	(3)	(4)	(5)
Panel A: Comparison with traditional public schools					
Days per year	185.9	183.8	186.6	187.3	180.0
Hours per day	8.1	8.1	8.0	8.0	7.3
% of teachers licensed in teaching assignment	47.2	45.7	42.8	59.6	95.1
% of core academic classes taught by highly qualified teachers	78.7	88.9	68.7	88.4	93.2
Average years of teaching experience in MA for teachers	2.6	2.9	1.6	3.3	12.3
Student/teacher ratio	11.2	12.5	10.2	11.7	11.7
Average per-pupil expenditure	$17,041	$17,900	$17,831	$14,052	$18,766
Title 1 eligible	1.0	1.0	1.0	1.0	1.0
Panel B: Charter school characteristics					
Years open through 2012-2013	7.4	11.0	2.4	14.3	
Tutoring	1.0	1.0	1.0	1.0	
Homework help program	0.4	0.3	0.3	1.0	
Saturday programming	0.6	0.5	0.6	0.7	
School break programming	0.5	0.5	0.3	1.0	
No Excuses index	0.9	0.9	0.9	0.8	
Contact parents at least monthly	0.5	0.5	0.4	0.7	
Distance from parent campus (miles)	-	-	3.1	-	
N (schools)	14	4	7	3	5

Notes: This table displays characteristics for charter schools in the analysis sample along with Boston Public Schools (BPS) district schools serving middle school grades. Data sources include charter school annual reports, school websites, Massachusetts Department of Elementary and Secondary Education (MA DESE) School District Profiles, and MA DESE Education Personnel Information Management System (EPIMS) data. Characteristics are measured in the 2012-2013 school year. Per-pupil expenditure is CPI-adjusted to 2015 dollars. The No Excuses index is an equally-weighted average of indicators equal to one if the following items are discussed in a school's annual report: high expectations for academics, high expectations for behavior, strict behavior code, college preparatory curriculum, core values in school culture, selective teacher hiring or incentive pay, emphasis on math and reading, uniforms, hires Teach for America teachers, Teaching Fellows, or AmeriCorps members, affiliated with Teach for America alumni, data driven instruction, and regular teacher feedback.

Table 2: Staffing at Parent and Replicate Charter Schools

| | | Teachers at Proven Providers in 2010-11 | | | | Teachers at Expansion Charters in First Year | | | |
| | BPS overall | All | Stay at Parent | Move to Expansion | Leave Network | All | Came from Parent Campus | Came from Other School | New Teacher |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Fraction in category	-	1.00	0.62	0.12	0.26	1.00	0.25	0.09	0.66
<32 years old	0.30	0.78	0.73	0.95	0.85	0.87	0.86	0.80	0.89
>49 years old	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unlicensed	0.04	0.28	0.24	0.29	0.38	0.53	0.07	0.20	0.76
Years Working in MA Public Schools	11.47	2.89	3.26	2.20	2.25	1.44	3.41	3.10	0.45
N (Full Time Equivalent Teachers)	4261	88	54	11	22	55	14	5	36

Notes: This table describes characteristics of teachers at Boston charter schools before and after expansion. Column (1) summarizes Boston Public Schools (BPS) teacher characteristics in 2011-12. Columns (2) - (5) display statistics for teachers working at proven provider charters in the 2010-2011 school year. Columns (6) - (9) show statistics for teachers working at expansion charters during the 2011-2012 school year.

Table 3: Charter Applications and Enrollment

	Before Charter Expansion			After Charter Expansion			
	Any Charter	Proven Providers	Other Charters	Any Charter	Proven Providers	Expansion Charters	Other Charters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
% of Boston Students Applying	15%	9%	8%	35%	19%	19%	18%
% of Boston Students with Lottery Offers	4%	2%	3%	10%	4%	7%	3%
% of Boston Students with Lottery or Waitlist Offers	12%	7%	6%	23%	10%	15%	6%
% of Boston Students Enrolling in Charters	10%	5%	4%	17%	5%	9%	4%
Applicants per Seat	1.5	1.8	1.9	2.0	3.4	2.2	4.0

Notes: This table summarizes applications and enrollment for Boston charter middle schools in the analysis sample before and after the 2010-11 charter sector expansion. The sample consists of students enrolled in Boston schools in both 4th and 6th grades. Pre-expansion refers to students who applied in spring 2008 or 2009. Post-expansion includes students who applied in spring 2011 through 2013.

Table 4: Characteristics of Boston Middle School Students

	Before Charter Expansion					After Charter Expansion						
	BPS	All Charters		Proven Providers		BPS	All Charters		Proven Providers		Expansion Charters	
			Randomized		Randomized			Randomized		Randomized		Randomized
	Enrolled	Enrolled	Applicants	Enrolled	Applicants	Enrolled	Enrolled	Applicants	Enrolled	Applicants	Enrolled	Applicants
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Female	0.478	0.495	0.486	0.509	0.482	0.476	0.495	0.491	0.483	0.482	0.503	0.485
Black	0.418	0.585	0.561	0.572	0.639	0.313	0.490	0.442	0.459	0.449	0.491	0.453
Latino/a	0.353	0.263	0.238	0.362	0.295	0.435	0.384	0.406	0.456	0.455	0.403	0.431
Asian	0.093	0.008	0.017	0.005	0.012	0.096	0.021	0.033	0.017	0.025	0.025	0.034
White	0.122	0.133	0.170	0.051	0.039	0.130	0.080	0.093	0.048	0.047	0.054	0.054
Subsidized lunch	0.839	0.726	0.684	0.775	0.738	0.792	0.791	0.801	0.832	0.832	0.828	0.830
English Language Learners	0.223	0.114	0.116	0.165	0.159	0.410	0.328	0.363	0.323	0.412	0.388	0.396
Special education	0.248	0.178	0.192	0.174	0.184	0.236	0.188	0.204	0.150	0.200	0.197	0.212
Attended charter in 4th grade	0.002	0.107	0.120	0.081	0.093	0.001	0.120	0.040	0.282	0.028	0.024	0.016
4th grade math score	-	0.108	0.220	0.073	0.046	-	0.066	0.050	0.388	0.051	-0.133	-0.032
4th grade English score	-	0.174	0.309	0.155	0.161	-	0.121	0.075	0.407	0.044	-0.084	-0.038
N	18934	2240	2745	995	1273	8330	2473	4513	666	2264	1233	2437

Notes: This table shows descriptive statistics for Boston middle school students before and after the 2010-11 charter school sector expansion. The sample includes all students who attended Boston schools in 4th grade and 5th or 6th grade between 2004 and 2013. Columns (1) and (6) show statistics for students who did not enroll in a charter school in 5th or 6th grade. Columns (2), (4), (7), (9) and (11) show statistics for students who enrolled in a charter school in 5th or 6th grade. Columns (3), (5), (8), (10) and (12) report statistics for randomized charter school applicants. Randomized applicants exclude siblings, disqualified students, and out of area applicants. Test scores are standardized to have mean zero and standard deviation one in BPS schools by subject, grade and year.

Table 5: First Stage Estimates

	Before Charter Expansion				After Charter Expansion					
	Proven Providers		Other Charters		Proven Providers		Expansion Charters		Other Charters	
	Immediate Offer	Waitlist Offer	Immediate Offer	Waitlist Offer	Immediate Offer	Waitlist Offer	Immediate Offer	Waitlist Offer	Immediate Offer	Waitlist Offer
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Math	1.304***	1.027***	1.554***	0.984***	0.795***	0.400***	0.659***	0.348***	0.930***	0.853***
	(0.067)	(0.050)	(0.047)	(0.061)	(0.054)	(0.048)	(0.046)	(0.041)	(0.052)	(0.071)
N (Applicants)	1279		1909		2303		2416		2405	
English	1.302***	1.027***	1.556***	0.985***	0.792***	0.398***	0.660***	0.345***	0.930***	0.853***
	(0.067)	(0.052)	(0.047)	(0.061)	(0.054)	(0.048)	(0.046)	(0.040)	(0.052)	(0.071)
N (Applicants)	1277		1911		2307		2420		2412	

Notes: This table displays first stage effects of charter lottery offers on years of enrollment in charter schools. Immediate offer equals one for applicants offered seats on the day of the lottery. Waitlist offer equals one for applicants offered seats from the waitlist.

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

Table 6: Charter Effects on Test Scores Before and After Charter Expansion

	Before Charter Expansion			After Charter Expansion			
		2SLS				2SLS	
	Non-Charter Mean	Proven Providers	Other Charters	Non-Charter Mean	Proven Providers	Expansion Charters	Other Charters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Math	0.208	0.332***	0.180***	0.035	0.362***	0.322***	0.209***
		(0.036)	(0.026)		(0.069)	(0.073)	(0.057)
P-value: Equals proven provider			0.000			0.623	0.058
P-value: Equals other charters						0.135	
N (Applicants)	3515	3836	6095	5106	4296	4759	4352
N (Total scores)				17395			
English	0.271	0.140***	0.088***	0.071	0.185**	0.226***	0.134**
		(0.035)	(0.025)		(0.072)	(0.075)	(0.056)
P-value: Equals proven provider			0.164			0.625	0.540
P-value: Equals other charters						0.218	
N (Applicants)	3485	3754	6084	5108	4298	4769	4363
N (Total scores)				17316			

Notes: This table reports 2SLS estimates of the effects of charter school attendance on test scores. The sample stacks post-lottery test scores in grades five through eight. The endogenous variables are counts of years spent in the different charter types (pre-expansion proven providers, pre-expansion other charters, post-expansion proven providers, expansion schools, and post-expansion other charters). The instruments are immediate and any lottery offer dummies for each school type. Controls include lottery risk sets, as well as gender, ethnicity, a female-minority interaction, special education, English language learner, subsidized lunch status, and grade and year indicators. Standard errors are clustered by student.

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

Table 7: Charter School Effects for Subgroups

	Math scores					English scores				
	Before expansion		After expansion			Before expansion		After expansion		
	Proven Providers	Other Charters	Proven Providers	Expansion Charters	Other Charters	Proven Providers	Other Charters	Proven Providers	Expansion Charters	Other Charters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
English Language Learner	0.289***	-0.197	0.499***	0.283*	0.328***	0.164	-0.251*	0.331***	0.219	0.233**
	(0.088)	(0.157)	(0.099)	(0.146)	(0.116)	(0.100)	(0.136)	(0.106)	(0.144)	(0.118)
N (applicants)	468	455	1729	1804	1275	468	454	1733	1807	1279
Not English Language Learner	0.332***	0.193***	0.248***	0.330***	0.144**	0.126***	0.096***	0.090	0.239***	0.090
	(0.040)	(0.027)	(0.092)	(0.081)	(0.066)	(0.037)	(0.025)	(0.096)	(0.083)	(0.063)
N (applicants)	3368	5640	2567	2955	3077	3286	5630	2565	2962	3084
Special Education	0.219**	0.157**	0.239	0.622***	0.183	0.041	0.119*	0.129	0.299	0.163
	(0.104)	(0.064)	(0.187)	(0.175)	(0.209)	(0.116)	(0.062)	(0.201)	(0.200)	(0.224)
N (applicants)	693	1178	823	930	758	683	1171	818	936	763
Not Special Education	0.347***	0.185***	0.402***	0.268***	0.189***	0.157***	0.091***	0.230***	0.220***	0.109*
	(0.039)	(0.029)	(0.072)	(0.081)	(0.059)	(0.036)	(0.026)	(0.074)	(0.079)	(0.057)
	3143	4917	3473	3829	3594	3071	4913	3480	3833	3600
Below-mean baseline score	0.359***	0.237***	0.465***	0.486***	0.183**	0.124*	0.108**	0.313***	0.289***	0.185**
	(0.058)	(0.043)	(0.099)	(0.112)	(0.075)	(0.070)	(0.048)	(0.108)	(0.099)	(0.086)
N (applicants)	1460	2050	2078	2224	1874	1282	1817	1858	2150	1684
Above-mean baseline score	0.345***	0.155***	0.230***	0.287***	0.240***	0.177***	0.076***	0.031	0.184**	0.132**
	(0.035)	(0.026)	(0.075)	(0.068)	(0.055)	(0.031)	(0.023)	(0.080)	(0.074)	(0.059)
N (applicants)	2376	4045	2218	2535	2478	2472	4267	2440	2619	2679

Notes: This table reports 2SLS estimates of the effects of charter school attendance on test scores for subgroups of students. The sample stacks post-lottery test scores in grades five through eight. The endogenous variables are counts of years spent in the different charter types. The instruments are immediate and any lottery offer dummies for each school type. Controls include lottery risk sets, as well as gender, ethnicity, a female-minority interaction, special education, English language learner, subsidized lunch status, and grade and year indicators.

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

References

Abdulkadiroğlu, Atila, Joshua Angrist, Susan Dynarski, Thomas J. Kane, and Parag Pathak. 2011. "Accountability and flexibility in public schools: Evidence from Boston's charters and pilots." *The Quarterly Journal of Economics* 126 (2):699–748.

Abdulkadiroğlu, Atila, Joshua D. Angrist, Peter D. Hull, and Parag A. Pathak. 2016. "Charters Without Lotteries: Testing Takeovers in New Orleans and Boston." *American Economic Review* 106 (7):1878–1920.

Abdulkadiroğlu, Atila, Joshua D. Angrist, Yusuke Narita, and Parag A. Pathak. 2015. "Research Design Meets Market Design: Using Centralized Assignment for Impact Evaluation." NBER Working Paper No. 21705.

Angrist, Joshua, Parag Pathak, and Christopher Walters. 2013. "Explaining Charter School Effectiveness." *American Economic Journal: Applied Economics* 5 (4):1–27.

Angrist, Joshua D., Sarah R. Cohodes, Susan M. Dynarski, Parag A. Pathak, and Christopher R. Walters. 2016. "Stand and Deliver: Effects of Boston's Charter High Schools on College Preparation, Entry, and Choice." *Journal of Labor Economics* 34 (2):275–318.

Angrist, Joshua D., Susan M. Dynarski, Thomas J. Kane, Parag A. Pathak, and Christopher R. Walters. 2012. "Who Benefits from KIPP?" *Journal of Policy Analysis and Management* 31 (4):837–860.

Angrist, Joshua D. and Guido W. Imbens. 1995. "Two-stage Least Squares Estimation of Average Causal Effects in Models with Variable Treatment Intensity." *Journal of the American Statistical Association* 90 (430):431–442.

Borman, Geoffrey D., Robert E. Slavin, Alan C. K. Cheung, Anne M. Chamberlain, Nancy A. Madden, and Bette Chambers. 2007. "Final Reading Outcomes of the National Randomized Field Trial of Success for All." *American Educational Research Journal* 44 (3):701–731.

Boston Municipal Research Bureau. 2008. "The Status of Charter Schools in Boston." Available at http://bmrb.org/wp-content/uploads/2014/10/Charter608.pdf.

Carter, Samuel Casey. 2000. *No Excuses: Lessons from 21 High-Performing, High-Poverty Schools.* Washington, DC: Heritage Foundation.

Chabrier, Julia, Sarah Cohodes, and Philip Oreopoulos. 2016. "What Can We Learn from Charter School Lotteries." NBER Working Paper No. 22390.

Cohodes, Sarah R., Elizabeth M. Setren, Christopher R. Walters, Joshua D. Angrist, and Parag A. Pathak. 2013. "Charter School Demand and Effectiveness: a Boston Update." Boston, MA: The Boston Foundation.

Dobbie, Will and Roland Fryer. 2011. "Are High Quality Schools Enough to Increase Achievement Among the Poor?" *American Economic Journal: Applied Economics* 3 (3):158–187.

———. 2013. "Getting Beneath the Veil of Effective Schools: Evidence from New York City." *American Economic Journal: Applied Economics* 5 (4):28–60.

———. 2015. "The Medium-Term Impacts of High-Achieving Charter Schools." *Journal of Political Economy* 123 (5):985–1037.

Fryer, Roland. 2014. "Injecting Charter School Best Practices Into Traditional Public Schools: Evidence from Field Experiments." *Quarterly Journal of Economics* 129 (3):1355–1407.

Heckman, James, Seong Hyeok Moon, Rodrigo Pinto, Peter A. Savelyev, and Adam Yavitz. 2010. "Analyzing Social Experiments as Implemented: A Reexamination of the Evidence from the High/ Scope Perry Preschool Program." *Quantitative Economics* 1 (1):1–46.

Heckman, James, Rodrigo Pinto, and Peter Savelyev. 2013. "Understanding the Mechanisms Through Which an Influential Early Childhood Program Boosted Adult Outcomes." *American Economic Review* 103 (6):2052–2086.

Jepsen, Christopher and Steven Rivkin. 2009. "Class Size Reduction and Student Achievement: The Potential Tradeoff between Teacher Quality and Class Size." *The Journal of Human Resources* 44 (1):223–250.

Krueger, Alan. 1999. "Experimental Estimates of Education Production Functions." *Quarterly Journal of Economics* 114 (2):497–532.

Massachusetts Department of Elementary and Secondary Education. 2015. "Education Laws and Regulations 603 CMR 1.00: Charter Schools." Available at http://www.doe.mass.edu/lawsregs/603cmr1.html.

———. 2016. "Massachusetts Charter Schools Fact Sheet." Available at http://www.doe.mass.edu/charter/factsheet.pdf.

Massachusetts State Legislature. 2010. "An Act Relative to the Achievement Gap." Chapter 12.

Puma, Michael, Stephen Bell, and Camilla Heid. 2012. "Third Grade Follow-up to the Head Start Impact Study." U.S. Department of Health and Human Services. Washington, DC.

Quint, Janet, Pei Zhu, Rekha Balu, Shelley Rappaport, and Micah DeLaurentis. 2015. "Scaling Up the Sucess for All Model of School Reform." MDRC Report.

Setren, Elizabeth M. 2016. "Special Education and English Language Learner Students in Boston Charter Schools: Impact and Classification." Working Paper.

Thernstrom, Abigail and Stephen Thernstrom. 2003. *No Excuses: Closing the Racial Gap in Learning.* New York: Simon and Schuster.

Tuttle, Christina Clark, Brian Gill, Philip Gleason, Virginia Knechtel, Ira Nichols-Barrer, and Alexandra Resch. 2013. "KIPP Middle Schools: Impact on Achievement and Other Outcomes." Mathematica Policy Research Report.

Walters, Christopher R. 2014. "The Demand for Effective Charter Schools." NBER Working Paper no. 20640.

Data Appendix

We use lottery records, student demographic and enrollment data, state standardized test scores, and school personnel files in this article. Lottery records collected from individual schools contain the list of applicants, offer status, and factors that affect an applicant's lottery odds, including sibling status, disqualifications, late applications, and applying from outside of Boston. The Student Information Management Systems (SIMS) dataset contains enrollment and demographic data for all public school students in Massachusetts. Student standardized test scores come from the state database for the Massachusetts Comprehensive Assessment System (MCAS). The Massachusetts Education Personnel Information Management Systems (EPIMS) database provides school staff information. Next we describe these datasets, the matching process, and sample construction.

Lottery records

Massachusetts legally requires charters to admit students via lottery when more students apply to a charter school than the number of available seats for a given grade. Our paper uses records from charter lotteries conducted between spring 2004 to spring 2013 for 14 charter schools accepting students in 5th or 6th grade. Each of the 14 schools contributes oversubscribed lottery data.[10] Schools vary in the grades they serve and in years of operation. Table A1 lists this information and the years each school contributes to the analysis. We exclude one school that did not provide lottery records (Smith Leadership Academy) and two schools that closed before the charter expansion (Uphams Corner Charter School in 2009 and Fredrick Douglas Charter School in 2005).

Lottery data typically includes applicants' names, dates of birth, and lottery and waitlist offer status. Offers to attend charter schools either occur on the day of the lottery (referred to as *immediate offer*) or after the day of the lottery when students receive offers from the

---

[10]We do not have Spring 2004 lottery records for Brooke Roslindale, Boston Prep, and Academy of the Pacific Rim or Spring 2005 records for Brooke Roslindale. Brooke Roslindale does not have lotteries in after charter expansion because their elementary school students filled the middle school seat. All other schools and years have oversubscribed lottery data.

randomly sequenced waitlist as seats become available. In three out of the 65 lotteries in the study, the schools gave all applicants offers or did not give waitlist offers to non-siblings. Four lotteries did not distinguish the timing of the offers so we code the immediate offer variable to equal zero for these cohorts.

The Uncommon Schools/Roxbury Preparatory charter network held a single lottery for its three campuses in the Spring 2012 and Spring 2013 lotteries. When the school called a students lottery number, the student could pick from the campuses that still had open seats. Our lottery records show which campus they picked at the time of the lottery. We find the last lottery number for each campus and code all students with better lottery numbers as having offers from that campus.

Uncommon Schools offered seats from the waitlist as they became available for individual campuses. Parents chose to accept or decline waitlist offers for single schools. If they declined, they were taken off the waitlist and would not be considered for seats at the other campuses.

Enrollment and demographics

The SIMS data contains individual level data for students enrolled in public schools in Massachusetts from 2003-2004 through 2013-2014. The data contains snapshots from October and the end of the school year. Each student has only one observation in each time period, except when students switch grades or schools within year. Fields include a unique student identifier, grade level, year, name, date of birth, gender, ethnicity, special education status, limited English proficiency status, free or reduced price lunch status, school attended, suspensions, attendance rates, and days truant.

We code students as charter attendees in a school year if they attended a charter at any point during a year. Students who attend more than one charter school in a year are assigned to the charter they attended the longest. Students who attend more than one traditional public school and no charter schools in a year are assigned to the school they attended the longest. We randomly choose between schools if students have attendance ties between the most attended schools.

Test scores

This paper uses individual student math and English Language Arts (ELA) Massachusetts Comprehensive Assessment System (MCAS) test scores from 2003-2004 through 2013-2014. Massachusetts public school students take the exam each year in grades grades 5 through 8. Data includes the unique student identifier. We standardize the raw scores to to have a mean of zero within subject-grade-year in Massachusetts.

Staff records

The Education Personnel Information Management Systems (EPIMS) contains yearly staff level data for all employees in Massachusetts public schools. We use data collected in October of the 2007-08 through the 2013-14 school years. Data includes job position, school, full time equivalency, date of birth, date of hire for first public school job in Massachusetts, license status, and highly qualified status. We use the full time equivalency of all staff and teachers. If one school has two half time teachers, they are counted as one full time equivalent teacher. A teacher who teaches at multiple schools counts towards the staff statistics at each school.

Matching data

We use applicants' names, date of birth, grade, and year to match their lottery records to the state enrollment data. The applicants who uniquely and exactly match the grade, year, name, and date of birth (if available) in the state records are assigned to the matched unique student id. After this initial match, we strip names in the lottery and enrollment data of spaces, surnames, hyphens, and apostrophes. Unique matches after this cleaning are assigned to the matched unique student id. Then, we use reclink, a fuzzy matching STATA program, to suggest potential matches for the remaining students. This matches students with slight spelling differences and those who appear in one grade older or younger than the charter application grade. We hand check these suggested matches for accuracy. We search for the remaining unmatched students by hand in the data. Typically this last group

contains name truncations, name misspellings, or first and last names in the wrong field.

The matching process assigns 95 percent of applicants to the state administrative records (see Table A3). Students who do not match either enroll in private, parochial, or out-of-state schools, have names and birthdates too common to match, or have spelling errors too extreme to match with confidence. Receiving a charter offer makes students 3.8 more likely to match to the data, as shown in Table A3. As a result, our findings show causal estimates for the set of students who enroll in Massachusetts Public Schools.

We match the enrollment and demographic data to the student test scores using the unique student identifier. Students who attend out of state, private, or parochial schools do not have test score outcomes for their years outside of Massachusetts public schools.

Sample restrictions

We exclude applicants who receive higher or lower preference in the lottery. Late applicants, those who apply to the wrong grade, out-of-area applicants, and siblings fall into these categories and typically have no variation in offer status. When students have duplicate applications within an individual school's lottery, we keep only one application. If students apply to charter schools in different years, we use only the first application year. We restrict the sample to students with baseline demographics data, excluding students applying from outside of Massachusetts public schools. With these restrictions imposed, the original raw sample of applications narrows from 20,981 to 8,473.

Table A1: Charter Middle Schools in Boston

	Year Opened	Grades	Outcome Years In Analysis
	(1)	(2)	(3)
Parent campuses			
Roxbury Preparatory: Mission Hill Campus	1999 - 2000	5 - 8 (12)	2004-05 - 2013-14
Brooke Roslindale	2002 - 03	5 - 8	2006-07 - 2009-10
Excel East Boston	2003 - 04	5 - 9 (12)	2008-09 - 2013-14
MATCH Middle School	2008 - 09	6 - 8	2008-09 - 2013-14
Expansion Charters			
Roxbury Preparatory: Lucy Stone Campus	2011 - 12	5 - 8	2011-12 - 2013-14
Roxbury Preparatory: Dorchester Campus	2012 - 13	5 - 7 (8)	2012-13 - 2013-14
Brooke Mattapan	2011 - 12	5 - 8	2011-12 - 2013-14
Brooke East Boston	2012 - 13	5 - 7 (8)	2012-13 - 2013-14
Excel Orient Heights	2012 - 13	5 - 7 (8)	2012-13 - 2013-14
KIPP	2012 - 13	5 - 7 (8)	2012-13 - 2013-14
UP Academy Boston	2011 - 12	6 - 8	2011-12 - 2013-14
Other Charters			
Academy of the Pacific Rim	1997 - 98	5 - 12	2005-06 - 2013-14
Boston Collegiate	1998 - 99	5 - 12	2004-05 - 2013-14
Boston Prep	2004 - 05	6 - 12	2005-06 - 2013-14
Not Included in Study			
Helen Davis Leadership Academy	2003 - 04	6 - 8	declined to participate
Frederick Douglas Charter	2000 - 01	6 - 10	closed in 2004-05
Uphams Corner Charter	2002 - 03	5 - 8	closed in 2008-09

A2: Lottery Records

Year of application	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	All
Total number of records	341	739	913	1143	1422	1595	1467	4283	4312	4766	20981
Excluding disqualifed applications	341	738	911	1135	1404	1594	1444	4273	4305	4760	20905
Excluding late applications	340	738	909	1135	1363	1566	1397	4163	4196	4583	20390
Excluding out of area applications	340	733	900	1123	1353	1548	1379	4094	4071	4513	20054
Excluding siblings	300	677	836	1021	1223	1408	1249	3758	3760	4320	18552
Excluding records not matched to SIMS	266	634	801	1000	1181	1378	1179	3627	3573	4016	17655
Keep only first year of charter application	266	617	770	962	1093	1282	1038	3308	2962	3469	15767
Excluding repeat applications	266	617	770	962	1093	1282	1038	3308	2962	3458	15756
Reshaping to one record per student	265	523	586	760	868	963	812	2055	1715	1900	10447
Has baseline demographics and in Boston at baseline	176	382	437	571	679	722	623	1790	1499	1594	8473

Notes: This table describes the processing of charter lottery records.

Table A3: Match from Lottery Data to Administrative Data

| | | | Reg of Match on Offer | |
Lottery Year	Number of Applications (1)	Proportion Matched (2)	Immediate Offer (3)	Any Offer (4)
2004	268	0.989	-0.006	-0.007
			(0.026)	(0.013)
2005	616	0.987	-	0.002
			-	(0.013)
2006	742	0.991	-	0.004
			-	(0.016)
2007	924	0.984	0.019**	0.034***
			(0.008)	(0.013)
2008	1018	0.957	0.042***	0.061***
			(0.013)	(0.019)
2009	1106	0.977	0.004	0.011
			(0.011)	(0.010)
2010	1041	0.924	0.065***	0.071***
			(0.016)	(0.017)
2011	2614	0.954	0.018***	0.025***
			(0.007)	(0.007)
2012	2503	0.939	0.001	0.033***
			(0.011)	(0.011)
2013	2712	0.902	0.045***	0.078***
			(0.012)	(0.015)
All Cohorts	15482	0.949	0.023***	0.038***
			(0.003)	(0.004)

Notes: This table summarizes the match from the lottery records to administrative student data. The sample excludes late applicants, siblings, disqualified applicants, duplicate names, and out-of-area applicants. Columns (3) and (4) report coefficients from regressions on a dummy for a successful match on immediate and any charter offer dummies. All regressions control for school-by-year dummies.

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

	Before Charter Expansion		After Charter Expansion		
	Proven Providers	Other Charters	Proven Providers	Expansion Schools	Other Charters
	(1)	(2)	(3)	(4)	(5)
Female	0.000	-0.004	-0.005	0.011	0.020
	(0.034)	(0.028)	(0.027)	(0.027)	(0.028)
Black	-0.026	0.007	-0.027	-0.025	-0.015
	(0.032)	(0.027)	(0.027)	(0.026)	(0.028)
Latino/a	0.027	0.000	-0.001	0.005	-0.010
	(0.031)	(0.022)	(0.027)	(0.026)	(0.027)
Asian	-0.014	0.007	0.008	0.010	0.000
	(0.009)	(0.008)	(0.010)	(0.011)	(0.009)
White	0.016	-0.003	0.007	0.001	0.018
	(0.011)	(0.024)	(0.010)	(0.012)	(0.017)
Subsidized Lunch	0.015	0.010	-0.011	-0.016	-0.016
	(0.029)	(0.027)	(0.020)	(0.019)	(0.023)
English Language Learners	-0.005	-0.001	-0.004	-0.039	-0.027
	(0.023)	(0.014)	(0.027)	(0.026)	(0.025)
Special Education	-0.005	0.005	0.002	0.013	0.018
	(0.027)	(0.022)	(0.021)	(0.022)	(0.022)
Attended charter before applying	0.010	-0.008	-0.015	-0.015*	-0.003
	(0.019)	(0.020)	(0.010)	(0.008)	(0.014)
Baseline math score	-0.024	-0.022	0.058	-0.032	-0.003
	(0.071)	(0.052)	(0.050)	(0.051)	(0.055)
Baseline English score	-0.036	0.000	0.048	0.038	0.012
	(0.070)	(0.052)	(0.052)	(0.051)	(0.055)
N (offered)	1009	1309	1466	1825	1142
P-value	0.594	0.891	0.526	0.134	0.978

Notes: This table reports coefficients from regressions of baseline characteristics on charter offers, controlling for lottery risk set indicators. P-values are from tests of the hypothesis that all coefficients are zero.

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

	Before Charter Expansion			After Charter Expansion			
		Offer Differential				Offer Differential	
	Non-offered Followup Rate (1)	Proven Providers (2)	Other Charters (3)	Non-offered Followup Rate (4)	Proven Providers (5)	Expansion Charters (6)	Other Charters (7)
Math	0.834	0.018	0.032**	0.869	0.000	0.013	-0.023
		(0.018)	(0.015)		(0.015)	(0.016)	(0.018)
N				20102			
English	0.825	0.018	0.034**	0.869	0.001	0.011	-0.025
		(0.017)	(0.015)		(0.015)	(0.016)	(0.018)
N				20102			

Notes: This table investigates attrition for randomized charter school lottery applicants. Columns (1) and (4) report fractions of follow-up test scores in grades five through eight that are observed for students not offered seats. Columns (2)-(3) and (5)-(7) report coefficients from regressions of a follow-up indicator on a lottery offer indicator (immediate or waitlist) and students not offered seats. Regressions control for lottery risk sets, as well as gender, ethnicity, a female-minority interaction, special education, English language learner, subsidized lunch status, and grade and year indicators. Standard errors are clustered by student.

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