Accountability and Flexibility in Public Schools: New Evidence from Boston's Charters and Pilots

Atila Abdulkadiroğlu, Duke
Josh Angrist, MIT
Susan Dynarski, University of Michigan
Thomas Kane, Harvard GSE
Parag A. Pathak, MIT

November 2009

Background

- An enduring question: How to improve the public education production function and close racial achievement gaps?
  - ✓ Inputs (class size, etc)
  - ✓ Incentives (for students and teachers)
  - ✓ Choice with the public system (magnet schools)
  - ✓ Autonomy and decentralization (charters, vouchers)
- Can *schools alone* close large achievement gaps ?
- We look at two autonomy / decentralization models in Boston

The Charter Model

- Charter schools are publicly funded, but operate with minimal supervision
  - ✓ Nonprofits, universities, teachers, or parents can open charters; no for-profit in this state
  - ✓ Charters are granted by the state DOE
  - ✓ Each Charter runs as its own district
  - ✓ Charters often adhere to a formula; most of ours are "No Excuses", similar to KIPP, a national franchise
- State Charters are funded through tuition paid by sending districts
  - ✓ Tuition $\approx$ senders' average per-pupil expenditure
  - ✓ Since 1999, senders' tuition is partially reimbursed by state (determined by growth in costs)

Key Charter Features

- State Charters are outside local collective bargaining agreements
  - ✓ State Charters hire, fire, and have loose work rules much like private schools
  - ✓ Charter teachers need not be certified, but must pass the state ed test in first year of work
- Charter schools are meant to be accountable
  - ✓ A charter is subject to periodic review; may be suspended, revoked, or non-renewed
  - ✓ Accountability criteria: success of academic program; organizational viability; faithfulness to a charter
  - ✓ Of 75 charters granted in Mass., 9 have been lost

The Pilot Alternative

- Pilots were introduced in the wake of charters
  - ✓ Free to: allocate staff, set budget priorities, curriculum, and scheduling
  - ✓ Boston pilots remain in BPS; typically use BPS student assignment mechanism
- Pilots are approved by the Boston Teachers Union and school staff (as start-up or conversion)
  - ✓ Free from: most collectively bargained work rules and district curriculum requirements
  - ✓ Covered by: union pay scales, seniority provisions, and employment protection
  - ✓ Some accountability

Practical Differences

1. Pilot schools use union staff
   - Charter schools hire almost as freely as private schools
2. Accountability is weaker for Pilots than for charters
   - Pilot schools do not appear to be at risk of closure
3. Pilot schools retain some union work rules
   - Pilots limit unpaid overtime
   - Charters use overtime extensively, often unpaid
4. Charters rely heavily on tutoring during and after school

Teacher characteristics compared: **Table 1**

Charter and Pilot Assignment

- Charter admissions
  - ✓ Charters cannot use admissions tests, and must take Special Ed and ESL students
  - ✓ No walk-zone priority
  - ✓ Charters use school-specific lotteries when oversubscribed
- Elementary and middle Pilots use the BPS assignment mechanism
  - ✓ The BPS assignment mechanism uses a lottery to break ties at in-demand schools
  - ✓ Two Pilot high schools use BPS assignment as well; Four have applications or auditions, no lottery
- Some Pilots and Charters are under-subscribed or filled with guaranteed applicants and/or siblings

Related work

- Lottery-based charter evaluations
  - ✓ Dobbie and Fryer (2009) Harlem Children's Zone
  - ✓ Hoxby-Muraka (2009) NYC; Hoxby-Rockoff (2004) Chicago
- Design-based studies of related questions
  - ✓ IV Estimates of charter effects on graduation/college in Florida and Chicago (Booker, Sass, Gill, and Zimmer 2008)
  - ✓ RD: Grant-maintained schools in the UK (Clark 2009)
  - ✓ Lottery evaluation of Chicago magnet schools (Cullen, Jacob, and Levitt 2005)
- Qualitative charter studies
  - ✓ Merseth (2009) describes 5 Massachusetts charters
  - ✓ Mathews (2009) describes KIPP schools

Our Agenda

- To estimate causal effects of years (grades) spent in a Pilot or Charter school on MCAS test scores
- To this end, we use two study designs:
  1. Quasi-experimental ("lottery")
  - ✓ This solves the selection problem
  - ✓ Covers only schools with effective lotteries and reasonably good records
  2. Observational ("regression")
  - ✓ Relies on statistical controls
  - ✓ Covers all public schools in Metro Boston
  - ✓ We compare observational results for the lottery subsample to lottery results; this gives us confidence in the full-sample observational findings

Data

1. Quasi-experimental samples:
   - ✓ Pilot applicants to lottery-using over-subscribed schools
     - ◇ exclude guaranteed applicants and siblings
     - ◇ with baseline data and MCAS in 2004-8
   - ✓ Charter applicants to over-subscribed Boston charters with usable lottery records
     - ◇ exclude guaranteed applicants and siblings
     - ◇ with baseline data and MCAS in 2004-8
2. Observational sample:
   - ✓ BPS residents attending BPS schools or a Boston Charter at baseline
   - ✓ In state (SIMS) data files; with baseline demographics
   - ✓ Have MCAS scores and attending BPS or Boston Charter in outcome years

Coverage Notes

- Charter lottery sample includes over-subscribed charters with usable records (middle, high only)
  - ✓ 5/11 middle schools; 2 of 6 omitted schools closed. Coverage among open is 5/9
  - ✓ 4/8 high schools; 2 of 4 omitted closed, 2 are 5-12 w/no 9th grade admits. Coverage among open 9-12 is 4/4
- 4 covered charters described in Merseth (2009): "high performing schools in high-poverty areas"
- Pilot lottery sample includes all over-subscribed pilots with lotteries
  - ✓ 5/7 elementary schools (2 under-subscribed)
  - ✓ 6/7 middle schools (1 under-subscribed)
  - ✓ 2/7 high schools (4 selective admits, 1 under-subscribed); among 9-12, coverage is 2/6

Descriptive Statistics

Table 2 shows demographics and baseline scores by school type for BPS and lottery samples

- ✓ BPS is majority nonwhite
- ✓ Charters have higher Black enrollment, lower Hispanic enrollment than BPS
- ✓ Pilots similar minority enrollment pattern but closer to BPS than charters
- ✓ Charters and Pilots have fewer SPED and ESL kids, with Charters less than Pilots
- ✓ Baseline scores show positive selection into Charters and Pilots in high school

Quasi-experimental study

Quasi-experimental Design: Charters

- We study charter applicants for spots in 6th (middle school) and 9th grade (high school)
  - ✓ Our charter applicant file includes non-sibling first-round applicants who apply to schools in our sample
  - ✓ Charters run and document their own lotteries
  - ✓ Charters are city-wide with no walk zones
- The *Charter lottery instrument* indicates students offered a seat at any Charter to which they applied
- The *Charter risk set* is defined by the set of schools to which an applicant applied (e.g., 3 schools generates 7 risk sets)

Quasi-experimental Design: Pilots

- We study non-sibling pilot applicants for spots in K2, 6th and 9th grade
  - ✓ The Pilot applicant sample includes those with a Pilot first choice on the BPS assignment form
  - ✓ Applicants are randomized within priority groups: Sibling-Walk; Sibling; Walk Zone; Others
  - ✓ Within priority groups at over-subscribed schools, offers are made by lottery number
- The *Pilot lottery instrument* indicates students with a BPS lottery number below the highest number offered at students' first-choice school
- The *Pilot risk set* is defined by: `first-choice school * app year * walk zone`

Covariate Balance

- Are lottery offers independent of observable characteristics?
- **Table 3** addresses this question for charters and pilots
  - The results show a few significant differences, but the overall picture is encouraging
  - Most differences are small (we should expect some sig. gaps given the many contrasts)
  - The differences do not all run the same way
  - With the exception of FRPL in pilot high schools, differences are borderline significant at most

2SLS Strategy

- The second stage controls for lottery risk sets:

$$y_{igt} = \alpha_t + \beta_g + \sum_j \delta_j d_{ij} + \gamma' X_i + \rho s_{igt} + \epsilon_{igt}, \quad (1)$$

  where d_{ij} indicates i in risk set j, with effect δ_j; s_{igt} is years in charter or pilot

- The corresponding first stage is:

$$s_{igt} = \lambda_t + \kappa_g + \sum_j \mu_j d_{ij} + \Gamma' X_i + \Pi' Z_i + \eta_{igt} \quad (2)$$

- The instruments, Z_i, indicate lottery offers in student i's risk set

Quasi-experimental Results

- Reduced form, first stage, and 2SLS results
  - ✓ Charter and pilots results (using ever-offer): **Table 4**
  - ✓ two-instrument models for charters: **Table A5**
- Large sig. charter effects in middle and high school, for ELA and esp. Math
- Pilot lotteries generate modest sig. effects on elementary school outcomes and a marg. sig. HS writing effect
- Effects with controls: **Table 5**
  - ✓ Charter results robust to controls for covs, baseline scores
  - ✓ Pilot results become negative, with baseline scores - this is due to the absence of K-8 pilots
- Understanding charter magnitudes
  - ✓ *The Brookline Figure* [**Middle and High**]

Attrition

- Are we equally likely to find winners' and losers' MCAS scores?
- The model for attrition parallels the reduced form that goes with equations (1) and (2)
- Results: **Table 6**
  - ✓ In MS and HS, we find about .80 of charter controls; .70-.75 of pilot controls
  - ✓ Rates are .04-.05 higher among charter treated in MS, .05-.07 among pilot treated in HS
  - ✓ Other attrition gaps are insignificant
- As a check, we discarded imbalanced applicant cohorts (Table A3)
  - ✓ Results are similar in the balanced sample (Table A4)

Lottery Estimates in Depth

Compliers' School Characteristics

- Charter and Pilot lottery compliers school environment may differ
- Let X_0 denote non charter/pilot characteristics; X_1 denotes charter/pilot characteristics
- Following Abadie (2003), we estimate
  - $E[X_0|D_1 > D_0] = \frac{E[X(1-D)|Z=1]-E[X(1-D)|Z=0]}{E[(1-D)|Z=1]-E[(1-D)|Z=0]}$
  - $E[X_1|D_1 > D_0] = \frac{E[XD|Z=1]-E[XD|Z=0]}{E[D|Z=1]-E[D|Z=0]}$
- Results: **Table 7**
  - ✓ X_0's are similar; both fall back to BPS
  - ✓ Charter treated have fewer LEP, SPED, higher baseline, less FRPL in MS
  - ✓ More girls, more black, similar FRPL students in HS
  - ✓ Pilot treated also have higher baseline in MS

Charter and Pilot Peer Effects

- Is the charter treatment partly be a peer effect due to charter peers higher baseline scores (Table 7)?
- We investigate this by interacting years in charter with baseline mean scores in the risk set
- **Table 9** reports the resulting main effects and interaction terms
  - ✓ A high peer mean is most often associated with *smaller* treatment effects for charter MS
  - ✓ Peer effects seem to matter more at Pilots
- The Charters ramp up inputs (tutoring, longer school day, smaller classes); the question of which matters most is hard to pin down
- A natural subject for future research!

Observational study

Observational Study Methods

- Full-sample regression estimates offer a handle on external validity
- Regression model for scores of kid i in grade g, tested in year t:

$$y_{igt} = \alpha_t + \beta_g + \gamma' X_i + \rho' S_{igt} + \epsilon_{igt} \qquad (3)$$

  - ✓ Includes year and grade effects, demographics, and sometimes a baseline score
  - ✓ S_{igt} is a *vector* of years in Pilot/Charter/Alt/Exam school from baseline to year t
  - ✓ s.e.s clustered on student when grades are stacked, and always on school-by-year (2-way)
  - ✓ Any time spent in a Pilot or Charter counts as a year ~~(grade); repeats are counted once~~

Observational Study Results

- **Table 10** reports estimates by school level and score type
  - ✓ Elementary and Middle schools
    - ◇ Charter and Pilot: ELA, Math
  - ✓ High schools
    - ◇ Charter and Pilot: ELA, Math, Writing

- Summary
  - ✓ Consistently positive Charter effects of $0.1\sigma - 0.2\sigma$ in models with baseline scores
  - ✓ Mixed Pilot effects: zero in elementary school, negative in middle school, positive in high school
  - ✓ The positive Pilot effects in high school are less than the corresponding charter effects (especially in Math)

Observational vs Lottery Estimates

- **Table 11** compares results across designs
- Charters
  - ✓ Observational results (with baseline scores) in the lottery sample are remarkably close to lottery estimates
  - ✓ This validates observational results, though obs results also suggest our lottery-sample charters are better
- Pilots
  - ✓ A match on modest effects for elementary pilots
  - ✓ Observational results for middle school pilots are, like lotteries, also negative, in and out of lottery sample
  - ✓ Observational results for pilot high schools ELA + Math are positive, while lottery results are insignificant
  - ✓ Observational pilot study agrees with lottery in that it shows weaker, mixed effects

(Tentative) Conclusions

- We can only study the experiments we've got: we plan to bring in more schools soon
  - ✓ Still, we have unusually complete follow-up and clean study designs
- The evidence on Charters so far is encouraging
  - ✓ Our results show the potential for No Excuses Charters to generate large score gains for all types of students, including minorities and SPED/LEP
  - ✓ This does not appear to be a peer effect, though we can't yet say what features of the charter model are decisive
  - ✓ Gains may come partly from a focus on MCAS scores, but policy-makers and parents value this
- Pilot results are less conclusive, but clearly less encouraging

Tables and Figures

Table 1: Teacher Characteristics by School Type

	Traditional BPS	Pilot, Charter, Exam or Alternative School				Lottery Sample	
	Schools	Charter	Pilot	Exam	Alternative	Charter	Pilot
	(1)	(2)	(3)	(4)	(5)	(7)	(8)
I. Elementary School (3rd and 4th grades)							
Teachers licensed to teach assignment	86.0%	60.0%	73.2%	-	70.6%	-	71.9%
Core academic teachers identified as highly qualified	90.6%	61.3%	78.2%	-	56.6%	-	77.8%
Student/Teacher ratio	15.7	11.4	15.9	-	6.9	-	15.8
Proportion of teachers 32 and younger	26.6%	64.5%	51.8%	-	27.3%	-	50.4%
Proportion of teachers 49 and older	39.9%	8.0%	11.9%	-	31.6%	-	11.1%
Number of teachers	28.0	87.3	25.5	-	50.8	-	27.1
Number of schools	72	3	7	-	2	-	5
II. Middle School (6th, 7th, and 8th grades)							
Teachers licensed to teach assignment	77.8%	53.9%	65.8%	90.8%	48.6%	54.4%	65.5%
Core academic teachers identified as highly qualified	84.8%	70.4%	70.2%	94.5%	45.4%	73.1%	69.8%
Student/Teacher ratio	16.1	11.9	19.5	21.1	5.2	11.9	19.6
Proportion of teachers 32 and younger	27.1%	74.5%	55.0%	30.0%	28.6%	81.1%	54.4%
Proportion of teachers 49 and older	36.0%	4.8%	13.6%	43.3%	27.8%	1.3%	13.9%
Number of teachers	39.5	35.4	26.4	89.1	36.1	18.7	26.9
Number of schools	29	11	7	3	4	5	7
III. High School (10th grade)							
Teachers licensed to teach assignment	80.9%	57.6%	64.1%	90.7%	75.8%	57.7%	73.5%
Core academic teachers identified as highly qualified	85.7%	78.6%	72.7%	94.3%	80.6%	82.1%	83.6%
Student/Teacher ratio	17.6	10.9	16.0	21.1	8.9	10.6	17.5
Proportion of teachers 32 and younger	31.9%	66.9%	44.7%	30.0%	29.7%	64.3%	41.3%
Proportion of teachers 49 and older	40.3%	6.9%	15.0%	43.9%	25.3%	8.2%	7.7%
Number of teachers	62.5	20.7	20.8	89.4	35.9	17.9	9.0
Number of schools	22	8	7	3	4	4	2

Notes: This table reports student weighted average characteristics of teachers and school using data posted 2004-2007 posted on the Mass DOE website at http://profiles.doe.mass.edu/state_report/teacherdata.aspx. Teachers licensed in teaching assignment is the percent of teachers who are licensed with Provisional, Initial, or Professional licensure to teach in the area(s) in which they are teaching. Core classes taught by highly qualified teachers is the percent of core academic classes (defined as English, reading or language arts, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography) taught by highly qualified teachers (defined as teachers not only holding a Massachusetts teaching license, but also demonstrating subject matter competency in the areas they teach). For more information on the definition and requirements of highly qualified teachers, see http://www.doe.mass.edu/nclb/hq/hq_memo.html.

Table 2: Descriptive Statistics

	Traditional BPS Schools	Enrolled in Pilot or Charter		Applicants in Lottery Sample		Applicants in Lottery Sample with Baseline Scores	
		Charter	Pilot	Charter	Pilot	Charter	Pilot
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
I. Elementary School (3rd and 4th grades)							
Female	48.3%	52.4%	48.5%	-	50.6%	-	-
Black	43.4%	71.9%	43.3%	-	54.3%	-	-
Hispanic	34.5%	15.8%	31.9%	-	22.0%	-	-
Special education	10.4%	6.4%	10.8%	-	9.9%	-	-
Free or reduced price lunch	83.1%	68.0%	69.0%	-	66.5%	-	-
Limited English proficiency	28.8%	3.8%	19.3%	-	7.0%	-	-
Years in charter	0.016	4.542	0.011	-	0.222	-	-
Years in pilot	0.031	0.023	3.787	-	1.803	-	-
Number of students	10568	659	827	-	573	-	-
Number of schools	75	3	7	-	5	-	-
II. Middle School (6th, 7th, and 8th grades)							
Female	47.0%	48.9%	49.9%	48.3%	52.6%	48.2%	54.9%
Black	46.9%	69.4%	50.5%	59.2%	49.8%	59.1%	50.6%
Hispanic	37.3%	19.0%	28.3%	19.4%	31.2%	19.6%	35.0%
Special education	24.5%	18.5%	21.4%	19.3%	17.5%	19.1%	18.2%
Free or reduced price lunch	89.3%	73.1%	85.6%	69.1%	79.3%	69.1%	87.8%
Limited English proficiency	21.8%	7.1%	21.0%	7.7%	15.0%	7.8%	18.0%
4th Grade Math Score	-0.119	-0.069	-0.196	0.167	-0.077	0.167	-0.077
4th Grade ELA Score	-0.113	0.080	-0.127	0.235	-0.018	0.235	-0.018
Years in charter	0.018	2.458	0.012	0.120	0.954	0.119	1.054
Years in pilot	0.023	0.033	2.149	1.480	0.220	1.469	0.221
Number of students	12257	2382	2696	1355	1917	1331	1298
Number of schools	33	11	7	5	7	5	6
III. High School (10th grade)							
Female	50.1%	59.9%	52.2%	59.1%	44.7%	59.0%	44.8%
Black	50.9%	65.8%	53.8%	67.6%	58.1%	67.6%	57.9%
Hispanic	36.1%	15.6%	26.7%	23.0%	24.9%	22.9%	25.0%
Special education	22.8%	14.8%	17.5%	15.5%	12.7%	15.3%	12.6%
Free or reduced price lunch	84.7%	66.7%	77.1%	75.7%	78.5%	76.1%	79.0%
Limited English proficiency	18.9%	3.9%	7.2%	4.2%	5.5%	4.1%	5.6%
8th Grade Math Score	-0.288	0.131	0.059	0.092	0.163	0.092	0.163
8th Grade ELA Score	-0.187	0.231	0.148	0.193	0.209	0.193	0.209
Years in charter	0.006	0.009	1.951	0.483	0.971	0.484	0.970
Years in pilot	0.013	2.012	0.023	0.719	0.269	0.718	0.271
Number of students	9135	1149	1949	1957	1010	1934	1003
Number of schools	23	8	7	4	2	4	2

Notes: The table reports sample means in baseline years by school type in each column with the footnotes describing the sample. Demographic characteristics are taken from grade K for elementary school students, grade 4 for middle school students, and grade 8 for high school students. All students reside in Boston and must be enrolled in BPS or a charter school in the baseline year. Students must have at least one MCAS score to be included in the table.

1. BPS students excluding exam, alternative, charter and pilot students from 2004-2008.
2. Students enrolled in charter schools from 2004-2008.
3. Students enrolled in pilot schools from 2004-2008.
4. Charter applicant cohorts in randomized lotteries: middle school students in 2002-2007, and high school students in 2002-2006.
5. Pilot applicant cohorts: elementary school students in 2002-2004, middle school students in 2002-2007, and high school students in 2003-2006.

Table 3: Covariate Balance with Lottery Winners minus Lottery Loser at Charter and Pilot Schools

	Charter Schools						Pilot Schools			
	Middle School		High School		Elementary School		Middle School		High School	
	All Lotteries	Lotteries with Baseline Scores	All Lotteries	Lotteries with Baseline Scores	All Lotteries	Lotteries with Baseline Scores	All Lotteries	Lotteries with Baseline Scores	All Lotteries	Lotteries with Baseline Scores
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Hispanic	-0.004	-0.005	-0.029	-0.028	-0.032	-	-0.016	-0.034	0.021	0.016
	(0.024)	(0.024)	(0.023)	(0.023)	(0.038)		(0.025)	(0.038)	(0.028)	(0.028)
Black	-0.014	-0.013	0.026	0.027	0.016	-	0.007	0.008	-0.002	0.006
	(0.029)	(0.030)	(0.026)	(0.026)	(0.042)		(0.027)	(0.040)	(0.031)	(0.031)
White	0.018	0.018	-0.010	-0.011	0.028	-	0.001	0.026	-0.017	-0.020
	(0.023)	(0.024)	(0.012)	(0.012)	(0.036)		(0.019)	(0.022)	(0.017)	(0.017)
Asian	0.003	0.003	0.021**	0.019*	-0.031*	-	0.001	-0.001	0.000	0.001
	(0.008)	(0.008)	(0.011)	(0.011)	(0.018)		(0.014)	(0.021)	(0.015)	(0.016)
Female	0.025	0.030	-0.004	-0.004	0.013	-	0.017	0.030	0.015	0.009
	(0.031)	(0.032)	(0.026)	(0.026)	(0.049)		(0.030)	(0.043)	(0.031)	(0.031)
Free or Reduced Price	-0.010	-0.008	0.007	0.008	-0.080*	-	-0.013	-0.019	0.059**	0.065**
Lunch	(0.029)	(0.029)	(0.023)	(0.023)	(0.043)		(0.023)	(0.029)	(0.026)	(0.026)
Special Education	-0.017	-0.017	-0.011	-0.013	-0.026	-	0.000	0.022	-0.025	-0.021
	(0.025)	(0.025)	(0.020)	(0.020)	(0.026)		(0.020)	(0.034)	(0.023)	(0.023)
Limited English	0.021	0.019	0.021*	0.022*	-0.018	-	-0.033**	-0.051*	0.015	0.007
Proficiency	(0.015)	(0.015)	(0.011)	(0.011)	(0.026)		(0.016)	(0.030)	(0.015)	(0.015)
Baseline ELA Test Score	-	0.029	-	0.022	-	-	-	0.031	-	0.013
		(0.053)		(0.043)				(0.077)		(0.054)
Baseline Math Test Score	-	0.095*	-	0.076	-	-	-	0.076	-	-0.092
		(0.055)		(0.048)				(0.078)		(0.057)
Baseline Writing	-	-	-	0.006	-	-	-	-	-	0.046
Composition Test Score				(0.044)						(0.053)
Baseline Writing Topic	-	-	-	-0.079	-	-	-	-	-	0.028
Test Score				(0.048)						(0.055)
p-value, from F-test	0.829	0.713	0.113	0.061*	0.046**	-	0.714	0.775	0.470	0.611

Notes: This table reports coefficients on regressions of the variable indicated in each row on an indicator variable equal to one if the student won the lottery. Regressions also include (school choice)*(year of application) fixed effects. Samples in columns (1), (3), (5), (7), and (9) are restricted to students from cohorts where we should observe at least one test score. Samples in columns (2), (4), (6), (8), and (10) are restricted to students who also have baseline test scores. F tests are for the null hypothesis that the coefficients on winning the lottery in all regressions are all equal to zero. These tests statistics are calculated for the subsample that has non-missing values for all variables tested.

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

Table 4: Lottery Results (ALL Lotteries)

			Charter			Pilots		
			First Stage	Reduced Form	2SLS	First Stage	Reduced Form	2SLS
Level	Subject		(1)	(2)	(3)	(4)	(5)	(6)
Elementary School								
	ELA		-	-	-	2.852***	0.196**	0.069**
						(0.193)	(0.078)	(0.027)
		N					876	
	Math		-	-	-	2.858***	0.177**	0.062**
						(0.194)	(0.078)	(0.027)
		N					874	
Middle School								
	ELA		0.965***	0.181***	0.187***	1.378***	0.021	0.016
			(0.114)	(0.061)	(0.062)	(0.189)	(0.065)	(0.047)
		N		2416			3390	
	Math		0.918***	0.397***	0.432***	1.291***	-0.078	-0.060
			(0.108)	(0.067)	(0.075)	(0.181)	(0.069)	(0.053)
		N		2582			3851	
High School								
	ELA		0.742***	0.147***	0.199***	0.653***	0.004	0.006
			(0.139)	(0.053)	(0.062)	(0.108)	(0.049)	(0.074)
		N		1947			1007	
	Math		0.738***	0.235***	0.318***	0.642***	0.007	0.011
			(0.137)	(0.059)	(0.077)	(0.107)	(0.064)	(0.098)
		N		1929			996	
	Writing Topic		0.741***	0.206***	0.278***	0.645***	0.119**	0.184**
			(0.138)	(0.069)	(0.083)	(0.108)	(0.058)	(0.090)
		N		1931			997	
	Writing Composition		0.741***	0.127**	0.171***	0.645***	0.084	0.130
			(0.138)	(0.052)	(0.064)	(0.108)	(0.054)	(0.084)
		N		1931			997	

Notes: This table reports the coefficients on regressions using years spent in charter or pilot schools. Sample restricted to students with baseline demographic characteristics. Regressions include year of test and year of birth dummies. Middle school and elementary school regressions pool grade outcomes and include dummies for grade level. Charter regressions include dummies for (combination of schools applied to)*(year of application) and exclude students with sibling priority. Pilot regressions include dummies for (first choice)*(year of application)*(walk zone status) and exclude students with sibling priority or guaranteed admission. Regressions use robust standard errors and are clustered on year by 10th grade school for high school and student identifier as well as school by year for pooled regressions.

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

Table A.5: Charter Lottery Results, Alternative Identification Schemes

			No Controls			Demographics + Baseline Scores		
Level	Subject		Initial and Eventual offer (1)	Initial offer (2)	Eventual offer (3)	Initial and Eventual offer (4)	Initial offer (5)	Eventual offer (6)
Middle School								
	ELA		0.175***	0.114	0.187***	0.137***	0.104	0.144***
			(0.061)	(0.086)	(0.062)	(0.044)	(0.067)	(0.044)
		N		2,428			2,377	
	Math		0.395***	0.256***	0.432***	0.346***	0.206***	0.386***
			(0.070)	(0.094)	(0.075)	(0.050)	(0.065)	(0.054)
		N		2,594			2,540	
High School								
	ELA		0.162***	0.058	0.199***	0.171***	0.115	0.186***
			(0.059)	(0.083)	(0.062)	(0.049)	(0.072)	(0.049)
		N		1,947			1,629	
	Math		0.276***	0.165*	0.318***	0.194***	0.106	0.226***
			(0.071)	(0.092)	(0.077)	(0.059)	(0.075)	(0.060)
		N		1,929			1,892	
	Writing Topic		0.252***	0.176**	0.278***	0.269***	0.220**	0.281***
			(0.074)	(0.082)	(0.083)	(0.079)	(0.103)	(0.083)
		N		1,931			1,616	
	Writing Composition		0.143**	0.064	0.171***	0.115**	0.046	0.132**
			(0.058)	(0.074)	(0.064)	(0.056)	(0.080)	(0.059)
		N		1,931			1,616	

Notes: The notes for this table are the same as Table 4. Columns (1) and (4) report estimates from 2SLS where the instrumental variables are initial offer and ever offer, so the model is overidentified. Columns (2) and (5) report estimates from 2SLS where the instrumental variable is equal to 1 if the student received an offer from the initial lottery ("initial offer"). Columns (3) and (6) report estimates from 2SLS where the instrumental variable is equal to 1 if the student was present at the initial lottery and eventually receives an offer after the waitlist process ("eventual offer").

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

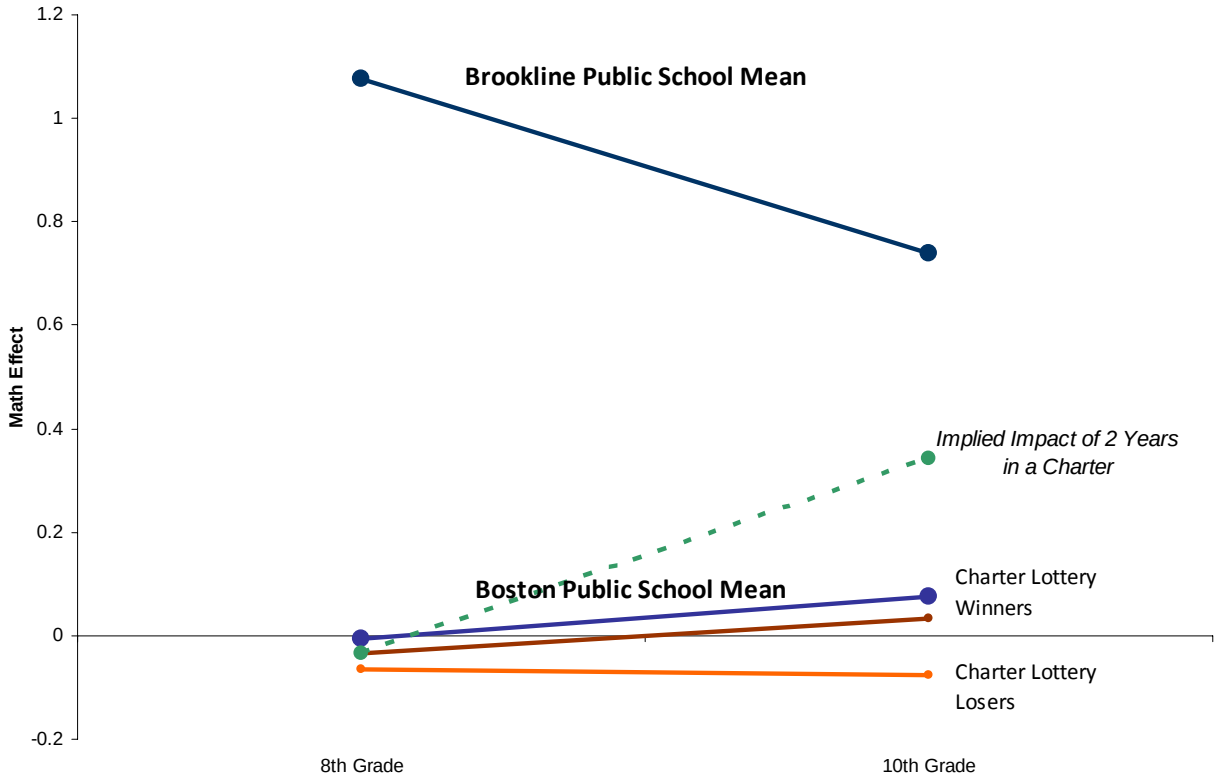
Table 5: Lottery Results, Robustness Check

			All Charter Lotteries	Charter Lotteries w/Baseline Scores			All Pilot Lotteries	Pilot Lotteries w/Baseline Scores		
Level	Subject		(No Controls) (1)	(No Controls) (2)	(Demographics) (3)	(Dems & Scores) (4)	(No Controls) (5)	(No Controls) (6)	(Demographics) (7)	(Dems & Scores) (8)
Elementary School										
	ELA		-	-	-	-	0.069**	-	-	-
							(0.027)			
		N					876			
	Math		-	-	-	-	0.062**	-	-	-
							(0.027)			
		N					874			
Middle School										
	ELA		0.187***	0.188***	0.146***	0.144***	0.016	-0.051	-0.062	-0.035
			(0.062)	(0.062)	(0.052)	(0.044)	(0.047)	(0.129)	(0.119)	(0.112)
		N	2416		2365		3390		2414	
	Math		0.432***	0.441***	0.409***	0.386***	-0.060	-0.273*	-0.250*	-0.251**
			(0.075)	(0.076)	(0.066)	(0.054)	(0.053)	(0.147)	(0.134)	(0.106)
		N	2582		2528		3851		2733	
High School										
	ELA		0.199***	0.205***	0.197***	0.186***	0.006	-0.004	-0.007	-0.053
			(0.062)	(0.062)	(0.056)	(0.049)	(0.074)	(0.075)	(0.072)	(0.058)
		N	1947		1629		1007		949	
	Math		0.318***	0.320***	0.277***	0.226***	0.011	0.002	-0.025	0.009
			(0.077)	(0.075)	(0.070)	(0.060)	(0.098)	(0.100)	(0.102)	(0.067)
		N	1929		1892		996		983	
	Writing Topic		0.278***	0.261***	0.251***	0.281***	0.184**	0.168*	0.172*	0.161*
			(0.083)	(0.085)	(0.082)	(0.083)	(0.090)	(0.091)	(0.091)	(0.087)
		N	1931		1616		997		934	
	Writing Composition		0.171***	0.137**	0.138**	0.132**	0.130	0.137	0.138	0.117
			(0.064)	(0.062)	(0.062)	(0.059)	(0.084)	(0.085)	(0.088)	(0.081)
		N	1931		1616		997		934	

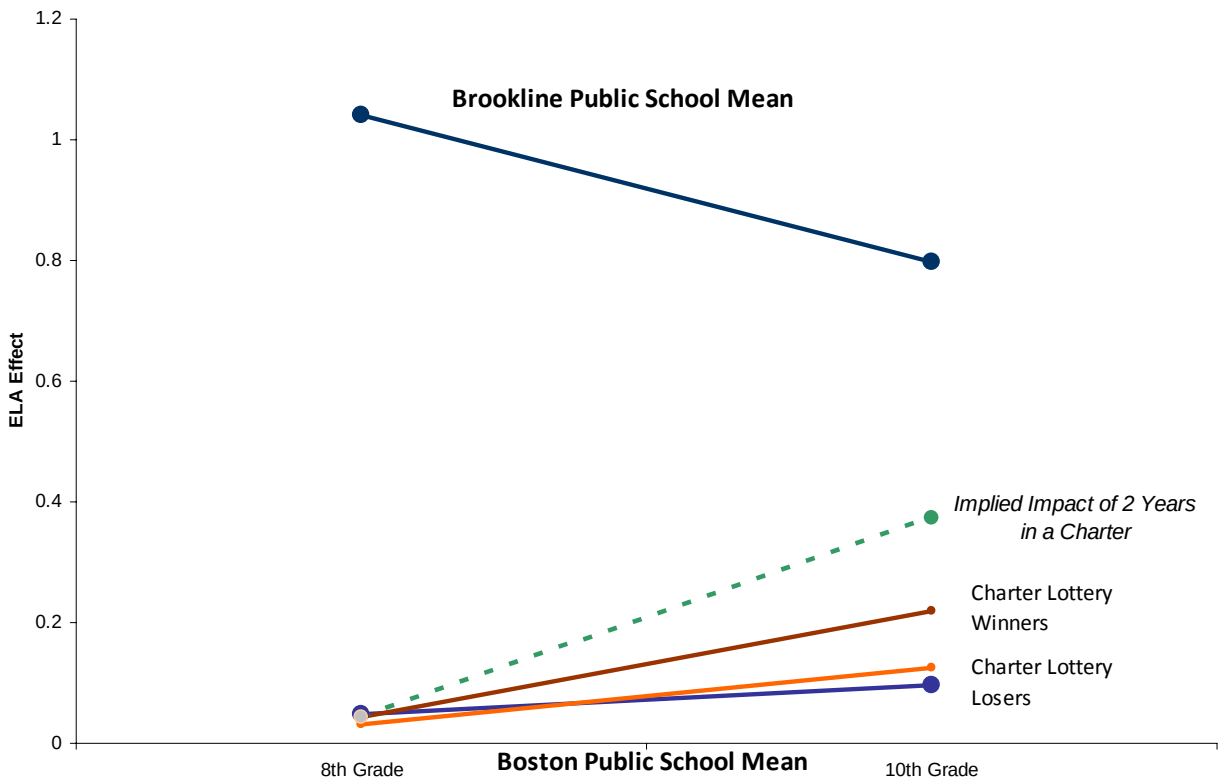
Notes: This table reports the coefficients on regressions using years spent in charter or pilot schools. Sample restricted to students with baseline demographic characteristics. Demographics include female, black, hispanic, asian, other race, special education, limited english proficiency, free/reduced price lunch, and a female*minority dummy. All regressions also include year of test and year of birth dummies. Middle school and elementary school regressions pool grade outcomes and include dummies for grade level. Charter regressions include dummies for (combination of schools applied to)*(year of application) and exclude students with sibling priority. Pilot regressions include dummeis for (first choice)*(year of application)*(walk zone) and exclude students with sibling priority or guaranteed admission. Regressions use robust standard errors and are clustered on year by 10th grade school for high school and student identifier as well as school by year for pooled regressions.

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

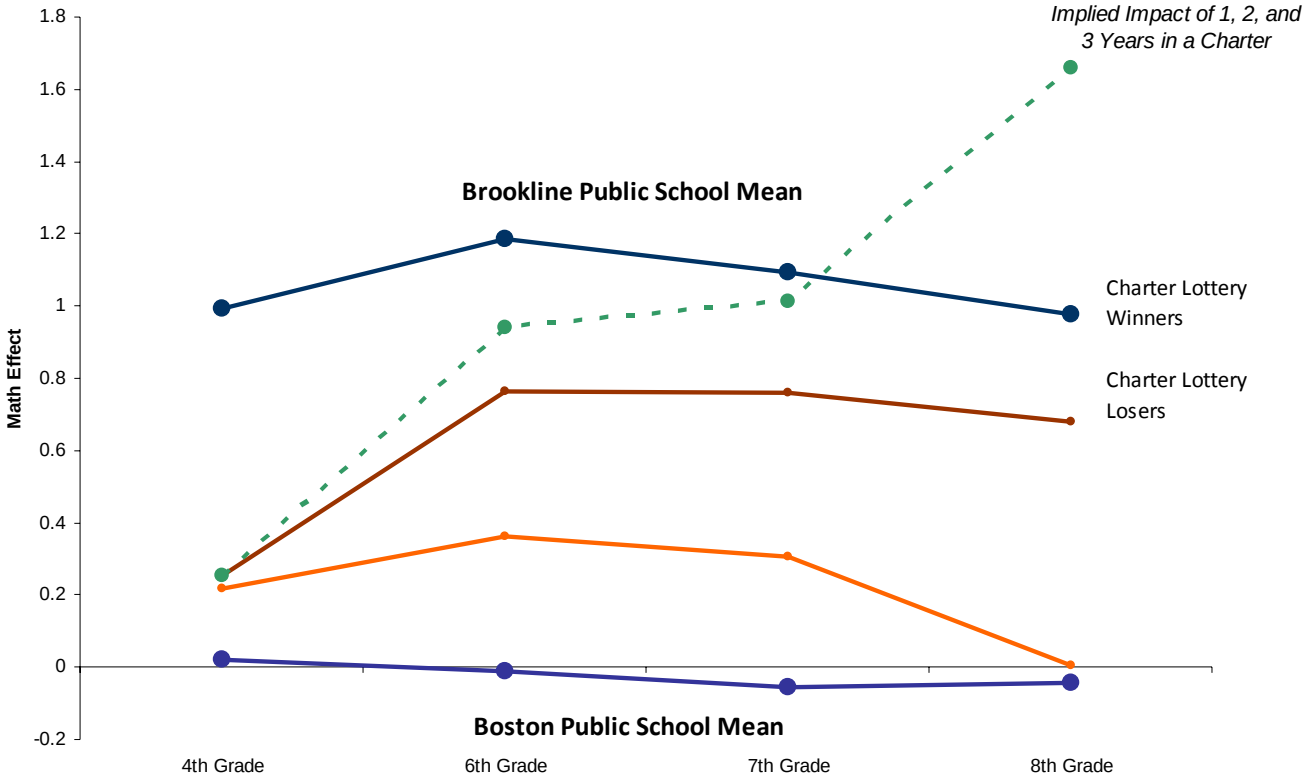
High School Math



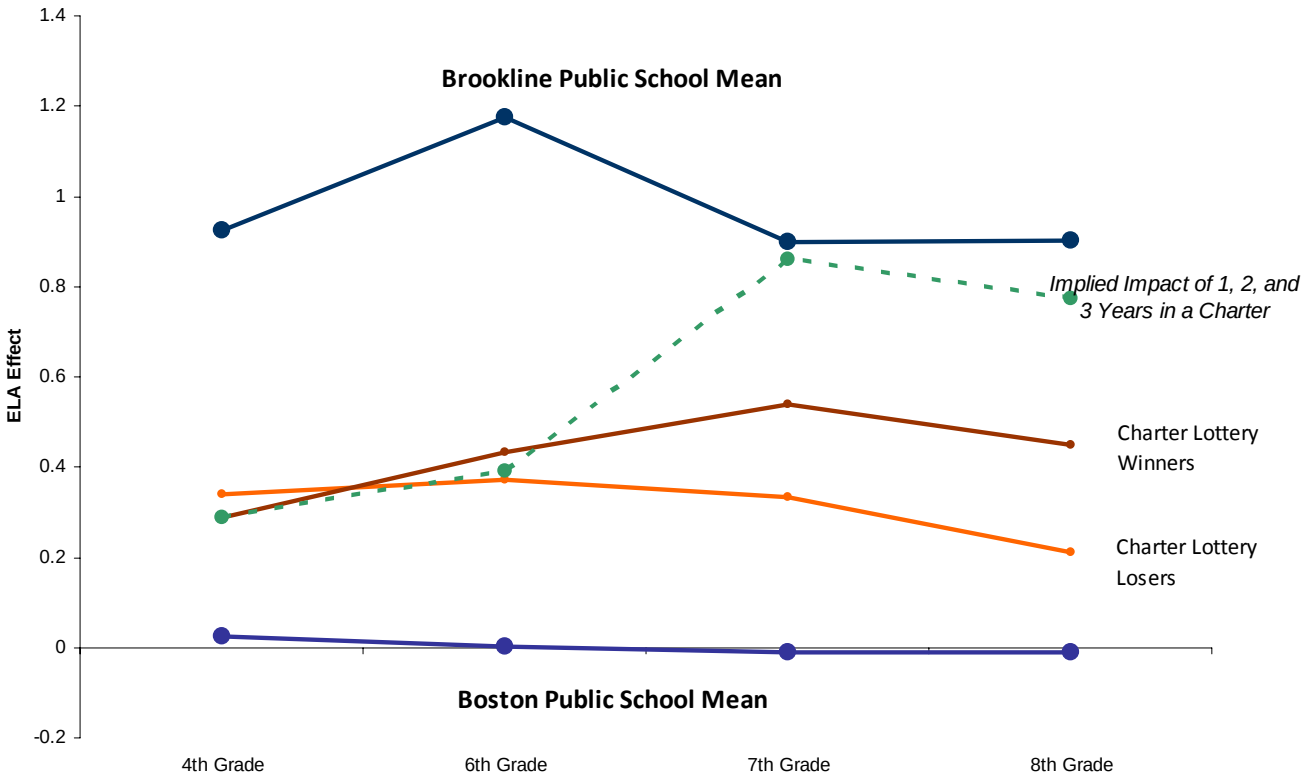
High School English/Language Arts

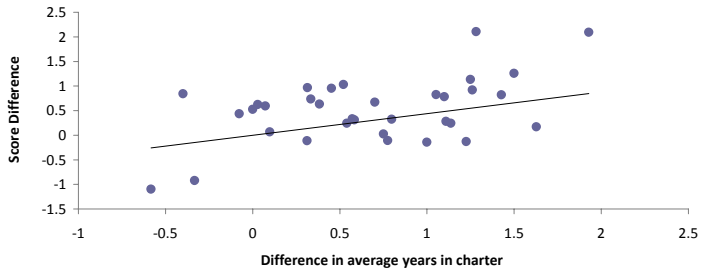


Middle School Math



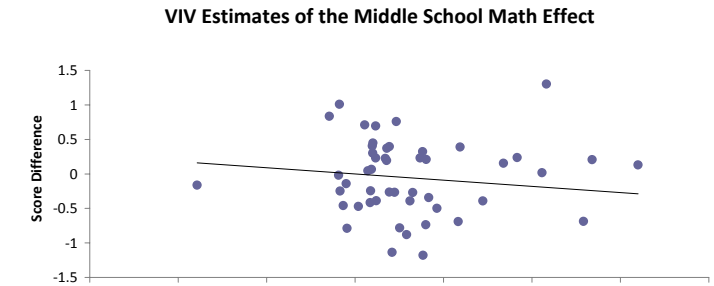
Middle School English/Language Arts





This figure plots treatment-control differences in test score means against treatment-control differences in years in charter. The unit of observation is a charter application risk set (N=34). The slope (weighted by risk set size) is 0.44. The corresponding 2SLS estimate is 0.44.

A. Charter Schools



This figure plots treatment-control differences in test score means against treatment-control differences in years in pilot. The unit of observation is a pilot application risk set (N=52). The slope (weighted by risk set size) is -0.045. The corresponding 2SLS estimate is -0.007.

B. Pilot Schools

Table 6: Attrition

		Charter				Pilot			
			Differential between Offered and Not Offered				Differential between Offered and Not Offered		
Level	Subject	Prop of non-offered with MCAS	All Lotteries, no Controls	Lotteries with Baseline Scores, No Controls	Lotteries with Baseline Scores, Demographics + Baseline Scores	Prop of non-offered with MCAS	All Lotteries, no Controls	Lotteries with Baseline Scores, No Controls	Lotteries with Baseline Scores, Demographics + Baseline Scores
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Elementary School									
	ELA	-	-	-	-	0.796	0.034	-	-
							(0.036)		
	N					686	1085	-	-
	Math	-	-	-	-	0.796	0.033	-	-
							(0.036)		
	N					686	1085		
Middle School									
	ELA	0.805	0.045**	0.042*	0.040*	0.699	0.026	0.007	0.008
			(0.021)	(0.022)	(0.022)		(0.024)	(0.026)	(0.026)
	N	923	2869	2801	2801	2625	4596	2778	2778
	Math	0.811	0.049**	0.049**	0.046**	0.702	0.028	0.009	0.009
			(0.021)	(0.021)	(0.021)		(0.023)	(0.026)	(0.026)
	N	968	3034	2958	2958	2874	5130	3124	3124
High School									
	ELA	0.776	0.030	0.023	0.020	0.749	0.055**	0.076***	0.074***
			(0.022)	(0.024)	(0.024)		(0.026)	(0.026)	(0.026)
	N	825	2433	2026	2026	786	1300	1210	1210
	Math	0.767	0.032	0.032	0.028	0.740	0.051**	0.064**	0.064**
			(0.022)	(0.022)	(0.023)		(0.026)	(0.026)	(0.026)
	N	825	2433	2375	2375	786	1300	1271	1271
	Writing Topic and Writing Composition	0.768	0.030	0.030	0.026	0.743	0.051**	0.074***	0.073***
			(0.022)	(0.024)	(0.024)		(0.026)	(0.026)	(0.026)
	N	825	2433	2019	2019	786	1300	1200	1200

Notes: This table reports coefficients on regressions of an indicator variable equal to one if the outcome test score is non-missing on an indicator variable equal to one if the student won the lottery. Regressions in column (2) and (3) include (school choice)*(year of application) fixed effects, year of birth dummies and year of baseline dummies. Regressions in column (6) and (7) include (walk zone)*(school choice)*(year of application) fixed effects, year of birth dummies and year of baseline dummies. Regressions in columns (4) and (8) add baseline covariates and test scores. Regressions in columns (4) and (8) add baseline covariates and baseline test scores. Middle school and elementary school regressions pool grades and include grade dummies. Standard errors are clustered at student level. Sample is restricted to students who participated in an effective lottery from cohorts where we should observe follow-up scores. High school students who take Writing Topic must also take Writing Composition.

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

Table 7: Characteristics of Treated and Non-treated Schools for Compliers

	Middle Schools				High Schools			
	Charter		Pilot		Charter		Pilot	
School Characteristic	Non-Treated (1)	Treated (2)	Non-Treated (3)	Treated (4)	Non-Treated (5)	Treated (6)	Non-Treated (7)	Treated (8)
Fraction female	0.464	0.545	0.465	0.477	0.494	0.652	0.473	0.406
Fraction black	0.469	0.361	0.455	0.361	0.547	0.652	0.544	0.507
Fraction hispanic	0.273	0.192	0.371	0.220	0.322	0.242	0.256	0.254
Fraction with limited English proficiency	0.123	-0.002	0.109	0.103	0.147	0.001	0.110	0.021
Fraction special ed	0.227	0.103	0.267	0.186	0.188	0.089	0.194	0.143
Fraction free or reduced price lunch	0.767	0.501	0.786	0.762	0.668	0.683	0.631	0.502
Fraction with first language not English	0.310	0.143	0.390	0.382	0.368	0.229	0.346	0.315
Mean baseline ELA MCAS score	0.110	0.353	-0.043	0.262	-0.211	0.202	-0.168	0.039
Mean baseline Math MCAS score	0.098	0.380	-0.019	0.293	-0.385	0.050	-0.276	-0.078
Fraction of teachers licensed to teach assignment	0.904	0.496	0.889	0.857	0.842	0.776	0.864	0.898
Student/teacher ratio	12.680	10.605	12.639	13.084	14.644	13.372	14.221	14.786

Notes: This table reports the results of IV regressions designed to estimate mean treated and non-treated characteristics for compliers in the charter and pilot lotteries. The non-treated means are produced by estimating models of the form: X(1-D)=a + b(1-D) + R'g+e, where X is the school characteristic of interest observed at the school actually attended by each student in the year immediately after the lottery, D is a dummy for whether the student attended charter/pilot in this year, R is a vector of risk set dummies, and (1-D) is instrumented using the lottery win/loss dummy. The IV estimate of "b" gives an estimate of the mean of X for the compliers in the non-treated state. The treated means are produced by estimating models of the form X*D=a+b*D+R'g + e, where D is instrumented by the lottery win/loss dummy. Here, the IV estimate of "b" gives an estimate of the mean of X for the compliers in the treated state.

October 6th version of subgroup table (with baseline score controls)

			By SPED/LEP				By Race				By School Lunch Status			
			Charter		Pilot		Charter		Pilot		Charter		Pilot	
Level	Subject		SPED/LEP (1)	Not SPED/LEP (2)	SPED/LEP (3)	Not SPED/LEP (4)	Black (5)	Not Black (6)	Black (7)	Not Black (8)	Sub Lunch (9)	Not Sub (10)	Sub Lunch (11)	Not Sub (12)
Elementary														
	ELA		-	-	0.019	0.073**	-	-	0.077*	0.059	-	-	0.062*	0.038
					(0.108)	(0.028)			(0.040)	(0.036)			(0.036)	(0.033)
		N			132	744			478	398			579	297
	Math		-	-	0.067	0.058**	-	-	0.063	0.077*	-	-	0.058	0.053
					(0.095)	(0.028)			(0.044)	(0.040)			(0.039)	(0.036)
		N			130	744			480	394			578	296
Middle School														
	ELA		0.307**	0.126***	-0.201	0.128	0.182***	0.131**	0.207	-0.245**	0.188***	0.132	-0.057	-0.033
			(0.120)	(0.045)	(0.157)	(0.164)	(0.068)	(0.057)	(0.196)	(0.115)	(0.050)	(0.091)	(0.130)	(0.162)
		N	562	1803	750	1664	1409	956	1237	1177	1629	736	2114	300
	Math		0.392***	0.381***	-0.385**	-0.163	0.496***	0.279***	-0.338*	-0.255**	0.399***	0.410***	-0.328**	-0.065
			(0.131)	(0.057)	(0.156)	(0.140)	(0.081)	(0.064)	(0.187)	(0.114)	(0.060)	(0.111)	(0.128)	(0.179)
		N	593	1935	880	1853	1499	1029	1389	1344	1742	786	2397	336
High School														
	ELA		0.329*	0.170***	-0.021	-0.065	0.237***	0.133	-0.095	0.006	0.133**	0.396***	-0.068	0.162
			(0.179)	(0.050)	(0.190)	(0.069)	(0.060)	(0.090)	(0.082)	(0.086)	(0.055)	(0.118)	(0.063)	(0.117)
		N	282	1347	151	798	1082	547	555	394	1251	378	754	195
	Math		0.394***	0.217***	-0.138	0.082	0.261***	0.226***	-0.089	0.212**	0.199***	0.499***	-0.009	0.189*
			(0.149)	(0.053)	(0.112)	(0.074)	(0.071)	(0.077)	(0.084)	(0.098)	(0.065)	(0.122)	(0.081)	(0.097)
		N	343	1549	168	815	1284	608	569	414	1444	448	782	201
	Writing Topic		0.291	0.299***	0.214	0.163*	0.417***	0.067	0.067	0.307**	0.209**	0.629***	0.124	0.298
			(0.246)	(0.083)	(0.248)	(0.096)	(0.102)	(0.135)	(0.120)	(0.136)	(0.093)	(0.191)	(0.090)	(0.187)
		N	279	1337	145	789	1068	548	545	389	1241	375	741	193
	Writing Composition		0.178	0.143**	0.325	0.085	0.223***	-0.059	-0.067	0.432***	0.051	0.476***	0.087	0.195
			(0.238)	(0.057)	(0.255)	(0.087)	(0.071)	(0.113)	(0.108)	(0.147)	(0.071)	(0.150)	(0.085)	(0.162)
		N	279	1337	145	789	1068	548	545	389	1241	375	741	193

Table 9: Interaction Models for Charter and Pilot Lottery Results: Risk Set Baseline Score Averages

			Charters		Pilots	
			main effect	interaction	main effect	interaction
Level	Subject		(1)	(2)	(3)	(4)
Middle School						
	ELA		0.185***	-0.716**	-0.041	-0.105
			(0.050)	(0.346)	(0.155)	(0.565)
		N	2,365		2,414	
	Math		0.441***	-1.015***	-0.406**	0.855**
			(0.059)	(0.279)	(0.171)	(0.362)
		N	2,528		2,733	
High School						
	ELA		0.185***	0.052	-0.040	0.792
			(0.050)	(0.419)	(0.059)	(0.672)
		N	1,629		949	
	Math		0.218***	0.609**	0.023	0.606
			(0.055)	(0.297)	(0.070)	(0.565)
		N	1,892		983	
	Writing Topic		0.272***	0.385	0.164*	0.143
			(0.086)	(0.942)	(0.090)	(0.629)
		N	1,616		934	
	Writing Composition		0.140**	-0.238	0.129	0.428
			(0.068)	(0.614)	(0.087)	(0.557)
		N	1,616		934	

Notes: This table shows results results analogous to those reported in the 2SLS lottery results in Table 4, but specifications now include interaction terms. The models estimated are of the form: Y=X'B + A1*C+A2*(C*T), where Y is the outcome of interest, C is years spent in charter (or Pilot), and T is mean baseline test score in the risk set. The main effects are at the mean.

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

Table 10: Observational Analysis for Charter and Pilot

		Demographics		Demographics & Baseline Scores	
		Charter	Pilot	Charter	Pilot
Level	Subject	(1)	(2)	(3)	(4)
Elementary School					
	ELA[1]	0.055***	0.015	-	-
		(0.017)	(0.020)		
	N	20058			
	R^2	0.134			
	Math[2]	0.038	0.024	-	-
		(0.023)	(0.023)		
	N	17356			
	R^2	0.131			
Middle School					
	ELA[3]	0.116***	-0.072***	0.103***	-0.046***
		(0.014)	(0.014)	(0.012)	(0.013)
	N	34301		33021	
	R^2	0.339		0.537	
	Math[4]	0.176***	-0.096***	0.180***	-0.065***
		(0.020)	(0.017)	(0.018)	(0.014)
	N	38583		37362	
	R^2	0.350		0.573	
High School					
	ELA[5]	0.228***	0.155***	0.166***	0.094***
		(0.020)	(0.018)	(0.018)	(0.016)
	N	16609		12347	
	R^2	0.487		0.623	
	Math[6]	0.247***	0.126***	0.151***	0.052**
		(0.040)	(0.026)	(0.031)	(0.023)
	N	16350		15868	
	R^2	0.509		0.700	
	Writing Topic[7]	0.228***	0.154***	0.206***	0.141***
		(0.028)	(0.023)	(0.031)	(0.024)
	N	16289		12181	
	R^2	0.308		0.354	
	Writing Composition[8]	0.204***	0.148***	0.178***	0.129***
		(0.021)	(0.019)	(0.022)	(0.018)
	N	16289		12181	
	R^2	0.348		0.394	

Notes: This table reports the coefficients on regressions using years spent in types of schools. The excluded group are students in traditional BPS schools. Coefficients are estimated for years spent in pilot schools, charter schools, exam schools, and alternative schools. Sample restricted to students with baseline demographic characteristics. Demographics include female, black, hispanic, asian, other race, special education, limited english proficiency, free/reduced price lunch, and a female*minority dummy. Regressions also include year of test and year of birth dummies. Middle school and elementary school regressions pool grade outcomes and include dummies for grade level. Regressions use robust standard errors and are clustered on year by 10th grade school for high school and student identifier and school by year for the pooled middle school and elementary school regressions.

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

1. Elementary school ELA is for Grade 3 (2005-08) and Grade 4 (2005-08).
2. Elementary school Math is for Grade 3 (2005-08) and Grade 4 (2005-08).
3. Middle school ELA is for Grade 6 (2005-08), Grade 7 (2005-08), and Grade 8 (2005-08).
4. Middle school Math is for Grade 6 (2004-08), Grade 7 (2005-08), and Grade 8 (2006-08).
5. High school ELA is for Grade 10 (2004-08).
6. High school Math is for Grade 10 (2004-08).
7. High school Writing Topic is for Grade 10 (2004-08).
8. High school Writing Composition is for Grade 10 (2004-08).

Table 11: Estimates in and Out of the Lottery Sample

			Charters				Pilots			
			Lottery		Observational		Lottery		Observational	
Level	Subject		All (1)	with Baseline Scores (2)	In Lottery Sample (3)	Not in Lottery Sample (4)	All (5)	with Baseline Scores (6)	In Lottery Sample (7)	Not in Lottery Sample (8)
Elementary School										
	ELA		-	-	-	0.055***	0.069**	-	0.051*	-0.033
						(0.018)	(0.027)		(0.026)	(0.025)
		N				20058	876			20058
	Math		-	-	-	0.037	0.062**	-	0.079***	-0.059*
						(0.023)	(0.027)		(0.028)	(0.032)
		N				17356	874			17356
Middle School										
	ELA		0.187***	0.144***	0.157***	0.082***	0.016	-0.035	-0.038**	-0.057***
			(0.062)	(0.044)	(0.016)	(0.014)	(0.047)	(0.112)	(0.017)	(0.017)
		N	2416	2365		33021	3390	2414		33021
	Math		0.432***	0.386***	0.307***	0.131***	-0.060	-0.251**	-0.068***	-0.059***
			(0.075)	(0.054)	(0.028)	(0.020)	(0.053)	(0.106)	(0.018)	(0.021)
		N	2582	2528		37362	3851	2733		37362
High School										
	ELA		0.199***	0.186***	0.188***	0.134***	0.006	-0.053	0.141***	0.077***
			(0.062)	(0.049)	(0.023)	(0.022)	(0.074)	(0.058)	(0.018)	(0.017)
		N	1947	1629		12347	1007	949		12347
	Math		0.318***	0.226***	0.158***	0.140***	0.011	0.009	0.139***	0.024
			(0.077)	(0.060)	(0.045)	(0.032)	(0.098)	(0.067)	(0.036)	(0.023)
		N	1929	1892		15868	996	983		15868
	Writing Topic		0.278***	0.281***	0.253***	0.136***	0.184**	0.161*	0.242***	0.103***
			(0.083)	(0.083)	(0.041)	(0.032)	(0.090)	(0.087)	(0.019)	(0.025)
		N	1931	1616		12181	997	934		12181
	Writing Composition		0.171***	0.132**	0.207***	0.134***	0.130	0.117	0.195***	0.104***
			(0.064)	(0.059)	(0.029)	(0.024)	(0.084)	(0.081)	(0.021)	(0.018)
		N	1931	1616		12181	997	934		12181

Notes: Columns (1) and (5) report 2SLS coefficients from Table 4. Columns (2) and (6) report 2SLS coefficients from Table 5. These models include demographic and baseline test score controls. Observational models include separate variables for years in lottery sample pilot schools, lottery sample charter schools, non-lottery sample pilot schools, and non-lottery sample charter schools. For a given school level and test, columns (3), (4), (7), and (8) therefore report coefficient estimates from the same regression. As in Table 10, observational models restrict the sample to students who were in Boston in the year of the relevant test.

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