Online Appendix

Horizontal Differentiation and the Policy Effect of Charter Schools

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A Assigning Horizontal Differentiation

This appendix briefly describes the sample of charter schools that were approved in the first wave of charter school applications after the lifting of the charter school cap. It then describes exactly how we classify charters into 'horizontally differentiated' and 'non-horizontally differentiated' based on their charter school application and shows how schools' philosophies and practices differ based on differentiation status.

All data on charter school applications come from the State Board of Education, which has data on shortlisted and approved charters and applications for all charter schools that applied to the State Board of Education from 2012 onwards.[41] Table A.1 reports the full list of newly-opened charter schools used in our sample along with their LEA code,[42] their location, their horizontal differentiation status and the reason they were classified as horizontally differentiated based on their charter school application (if applicable).

The so-called 'fast track' charter applications for charters planning to open in the 2012-13 school year were due in November 2011, approximately 5 months after the lifting of the 100 charter school cap. There were 27 'fast track' applications, of which 9 were approved to open by the North Carolina Public Charter Schools Advisory Council. Of those 9, we drop 3 schools from our analysis: two for being high schools and one for never opening.[43]

[41] Available at `http://www.ncpublicschools.org/charterschools/applications/`.

[42] Every charter school in North Carolina is given its own Local Education Area (LEA) code which uniquely identifies it. The first two characters of the code are numbers, which link it to the public school LEA wherein it locates. The last character of the code is a letter, which allows the charter school to be uniquely identified.

[43] The two high schools were Bear Grass Charter and Research Triangle High, while the approved The Howard and Lillian Lee charter school never opened.

This leaves us with a sample of 6 schools opening in 2012-13, of which 4 are designated as 'horizontally differentiated' and 2 are designated as 'non-horizontally differentiated.'

For the 'normal track' charter schools that planned to open for the 2013-14 school year, applications were due in April 2012. There were 63 applications, of which 30 were shortlisted in June 2012. Applications of 24 of the shortlisted charters were then approved in March 2013. Of those 24 schools, we drop 7 schools from our analysis: five for being high schools, one for being a private-charter conversion, and one for never opening.[44] This leaves us with 17 charter schools opening for the 2013-14 school year of which 9 are designated as 'horizontally differentiated' and 8 are designated as 'non-horizontally differentiated.' Our final sample of newly-opened charter schools thus consists of 23 schools, where 13 are designated as 'horizontally differentiated' and 10 are designated as 'non-horizontally differentiated.'

In addition to reading for differentiation of educational program, we coded characteristics of schools' philosophy and practices based on the content of the applications. To do this, we followed Angrist et al. (2013) to identify important characteristics of focus. Applications were read to asses whether a school's application indicates strict adherence to standards, a focus on discipline, a focus on college preparation, adherence to a strict dress code, the curricula includes extended math instruction, a focus on social and physical well-being, a focus on cultural awareness, a focus on leadership development, and whether group projects are a principal element of instruction. From these indicators, we created three summary index values of each charter school's philosophy and practices, including an index capturing alignment with "No Excuses" (based on the correlations reported in Angrist et al. (2013)). The construction of the indices is detailed in the notes of Table A.2, which summarizes the associations of the indices with horizontal differentiation.

[44]The 5 high schools were Flemington Academy, Longleaf School of the Arts, Oxford Preparatory High, Paul Brown Leadership Academy and Uwharrie Charter Academy, while the approved charter of The Howard and Lillian Lee never opened (the same school whose fast track application was approved but never opened). The conversion school was Student First Academy, which converted from a private school to a charter school and later closed at the end of the 2013-14 school year due to financial mismanagement.

Table A.1: List of Newly-Opened Charters and Reason for Designating Charter as Horizontally Differentiated

School name (LEA)	Opened	(Lat, Lon)	Diff.	Reason
Cabarrus Charter Academy (13B)	2013-14	(35.4104, -80.6691)	N	
Willow Oak Montessori (19C)	2013-14	(35.855, -79.0253)	Y	Montessori
Pinnacle Classical Academy (23A)	2013-14	(35.2611, -81.5043)	Y	Classical education
STEM Education for a Global Society Academy (24C)[1]	2013-14	(34.3127, -78.2063)	Y	"seeks to emphasize personalized learning... for students who enter school with challenges and who are frequently underperforming" (Goals, p. 7)
Water's Edge Village School (27A)	2012-13	(36.37826, -75.832041)	Y	"hands-on curriculum empower students by instilling a sense of social and environmental responsibility while nurturing both body and mind" (Mission, p. 6)
The Institute for the Development of Young Leaders (32P)	2013-14	(36.0163, -78.9139)	Y	"project based, child centered educational environment that is inspiring, intellectually stimulating, personally affirming and emotionally supportive" (Mission, p. 4)
North East Carolina Preparatory School (33A)	2012-13	(35.891794, -77.58057)	Y	"teach and inspire through a challenging curriculum that integrates technology, experiential learning and critical thinking skills" (Mission, p. 8)
North Carolina Leadership Academy (34H)	2013-14	(36.1099, -80.0515)	N	
Falls Lake Academy (39A)	2013-14	(36.1104, -78.7351)	Y	"believe students benefit from challenging experiential and traditional learning experience" (Mission, p. 6)
Cornerstone Academy (41G)	2012-13	(36.13432, -79.827041)	N	
The College Prep and Leadership Academy of High Point (41H)	2012-13	(36.070916, -79.959375)	N	
Summerfield Charter Academy (41J)	2013-14	(36.2179, -79.9124)	N	
Langtree Charter Academy (49F)	2013-14	(35.5413, -80.8652)	N	
Corvian Community School (60M)	2012-13	(35.32301, -80.756351)	Y	"use the Basic School educational philosophy to provide an optimum environment for learning in which students are intrinsically motivated as lifelong learners" (Mission, p. 5)
Aristotle Preparatory Academy (60N)	2013-14	(35.2246, -80.8819)	N	
Charlotte Choice Charter (60P)	2013-14	(35.2441, -80.7949)	N	
Invest Collegiate Transform (60Q)	2013-14	(35.2254, -80.8732)	Y	"the entire school community builds upon the collaboration across six active domains of learning: imagine, nurture, value, engage, sustain, and transform" (Educational Focus, p. 9)
Douglass Academy (65C)[2]	2013-14	(34.242, -77.9434)	N	
Island Montessori Charter (65D)	2013-14	(34.1079, -77.8985)	Y	Montessori
ZECA School of Arts and Technology (67B)	2013-14	(34.7791, -77.4152)	Y	"staff will participate in staff development covering the following topics; Social and Emotional Teaching, Technology Instruction, Project Based Learning" (Goals, p. 6)
The Expedition School (68C)[2]	2013-14	(36.07067, -79.113701)	Y	"provide excellent and innovative education to students through experiential and project based learning and STEM focused curriculum" (Mission, p. 9)
Southeastern Academy (78B)	2013-14	(34.6517, -78.8738)	N	
Triangle Math and Science Academy (92T)	2012-13	(35.77853, -78.635361)	Y	"employs an inquiry-based curriculum" (Curriculum Design, p. 50)

[1]This school closed at the end of the 2014-15 school year.
[2]This school did not open until 2014-15.

Table A.2: School Philosophy and Practices Correlated with Horizontal Differentiation

	"No Excuses" (1)	Comportment (2)	Well-Being (3)	Academic Skills (4)
Non-Horizontally Differentiated	0.419	0.376	-0.470	0.267
Horizontally Differentiated	-0.322	-0.289	0.362	-0.206
Difference	0.740	0.665	-0.832	0.474

Notes: This table reports average normalized index values by horizontal differentiation and the difference in normalized values between horizontally and non-horizontally differentiated charter schools in the sample. The 'Skills' index takes into account whether a school's application indicates a college preparatory focus and extended math instruction. The 'Comportment' index considers whether the application indicates a focus on discipline, adherence to strict standards, and a strict dress code. The 'Well-Being' index takes into account whether the application indicates a focus on social and physical well-being and on cultural awareness. The "No Excuses" index is constructed from application philosophy and practices correlates reported in Angrist et al. (2013). Specifically, the 'No Excuses' index is defined as: *discipline* + *strict standards* + *college prep* + *strict dresscode* + *extended math* − *social or physical well-being* − *cultural awareness* − *leadership* − *group projects*, where each of those variables are indicators if the charter application mentions that the school will place a focus on that.

Table A.3: Difference-in-Differences Results Using Alternative Definitions of 'Non-Horizontally Differentiated'

	'Treated' (0-2.5 miles) vs. 'Control' (2.5-5 miles)			
'Non-Horizontally Differentiated' Defined as:	Focused on "No Excuses"	Focused on Comportment	Not Focused on Well-Being	Focused on Academic Skills
	(1)	(2)	(3)	(4)
Non-Horizontally Differentiated	0.021	0.011	0.021	0.049**
$(\beta_h + \beta_{nh-h})$	(0.016)	(0.013)	(0.016)	(0.022)
Observations (student-year)	60,328	100,307	70,305	55,140
Horizontally Differentiated	0.024	0.035*	0.020	0.011
(β_h)	(0.014)	(0.018)	(0.015)	(0.012)
Observations (student-year)	104,631	64,652	94,654	109,819
% Categorized as Horizontally Differentiated by Curriculum	30.7	36.2	75.9	20.7
Test of Equality by Differentiation Status p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$	0.88	0.27	0.95	0.14
Demographic Controls	Yes	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes	Yes

Notes: This table shows difference-in-differences estimates from equation (3.2), whereby students living within 2.5 miles of a newly-opened charter school are considered 'treated' while those living 2.5-5 miles from a newly-opened charter are considered 'control' and the effect is allow to differ by whether the newly-opened charter school is horizontally differentiated or not from the local public school. This table defines the non-horizontally differentiated status of charter schools using the correlations found in Table A.2 using the content of its charter school application. (1) A "No Excuses" charter scores at least one on the 'No Excuses" index defined in Table A.2. (2) A 'Comportment' charter's application indicates one of: (i) a focus on discipline, (ii) adherence to strict standards, and (iii) a strict dress code. (3) A 'Well-Being' charter's application indicates a focus on at least one of (i) social and physical well-being or (ii) cultural awareness. (4) An 'Academic Skills' charter's application focuses on at least one of (i) college prep or (ii) extended math instruction. Note that the large difference by differentiation status in column (4) when we define 'horizontally differentiated' as charters focusing on academic skills likely supports our hypothesis as a focus on academic skills effectively captures a charter focusing on math and English which are the cornerstone of the public school curriculum. The outcome used is standardized math scores. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$ in (3.2). Each column represents a different regression and all regressions include the same controls as column (3) in Table 3. Demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered at the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.

B Assigning Treatment Status

A key variable necessary to our analysis is the distance between each student's residence in the 2011-12 school year and all newly-opened charter schools. To construct this variable, we start with the student residential location data from the North Carolina Education Data Research Center (NCERDC), giving us the census block group of residence for every student in a North Carolina public school in 2011-12, according to the 2010 Census definitions. Unfortunately, the residential data is not available for students attending charter schools, so students are not included in our sample if they attended a charter school in 2011-12.[45]

In the next step, we use the cartographic boundary shapefiles for U.S. Census block groups according to the 2010 boundary definitions[46] and get the longitude and latitude of the centroid of each block group. The centroid of the block group in which each student resides is then assigned as the residential location for that student. To give a sense of the sparsity of the residential data, North Carolina is divided into 6,183 Census block groups with an average population of 1,546 individuals (and range between 600 and 3,000 individuals) and a median size of about 2.2 square miles (with a range between 0.5 and 300 square miles).

From there, we use STATA to calculate the distance from the centroid of each student's census block group to the latitude and longitude of the nearest newly-opened charter (see Appendix A for list of all newly-opened charters and their latitude and longitude coordinates). We drop about 2,700 students (representing about 0.2 percent of the sample) with multiple locations per year, as it is unclear to which location they should be assigned. From here, the main treatment status of each student in our analysis is easily defined: a student is assigned a value of one if the student's residential census block group centroid is within 2.5 miles of the nearest newly-opened charter and a value of zero if the student's residential census block group centroid is between 2.5 and 5 miles away from the nearest newly-opened charter.

[45] This is a general data limitation we face: residential location data is not reported for students attending charter schools.

[46] Available at `https://www.census.gov/geo/maps-data/data/cbf/cbf_blkgrp.html`.

Once we have determined the distance between each student's residence and the nearest charter school, we restrict the sample to students for whom we observe at least one test score both before and after new charter schools enter in the 2012-13 academic year. After matching to test scores, we have a sample of 1,117,142 student-year observations covering 285,601 students in grades 3-5. Further restricting to students living within 5 miles of a newly-opened charter school, our sample consists 170,776 student-year observations covering 43,819 students.

The last data issue we address is the few instances of overlapping treatment and control regions. These few cases can be seen in Figure 2, which plots circles with a radius of 2.5 miles around each charter school in our sample. Students who live within these circles are treated in our main specifications and those who live between 2.5 and 5 miles of each charter school (i.e., the mid-point of each circle) are in the control group. Although we do not distinguish between treated and control students in Figure 2 for the sake of readability, one can see that some students living in the Charlotte area are treated by both a horizontally and non-horizontally differentiated charter school, while other students live in the treated region of one charter school but the control region of another.

For students residing in these overlapping regions, we assign treatment using the *closest* newly-opened charter to their residence and drop all observations where there is another charter school of a different horizontal differentiation status within the 'treatment' region (i.e., within 2.5 miles of the student's residence) and all observations when there is another charter school with the same horizontal differentiation status within the 'control' region (i.e., between 2.5 and 5 miles of the student's residence).[47] This sample restriction eliminates 5,463 student-year observations (about three percent of our sample) leaving us with a final sample of 165,313 student-year observations covering 42,440 unique students.

[47] A similar sample restriction setup is implemented for Figure 6 whereby we drop all observations where there is another charter school of a different horizontal differentiation status within the 'treatment' region (i.e., within r miles of the student's residence) and all observations when there is another charter school with the same horizontal differentiation status within the 'control' region (i.e., between r and $2r$ miles of the student's residence).

C Supplemental Evidence for Competitive Effects

In this appendix, we provide supplemental evidence that the estimated effects in our main sample are driven by traditional public schools becoming more productive in response to competitive pressure. In the main text, we restricted the sample period to run only until the 2012-13 academic year and focused only on students living near charter schools that opened in the 2013-14 academic year. Doing so eliminated the possibility of direct effects and changing peer composition at traditional public schools, thus demonstrating that our main estimates are driven by a competitive response. In the following two subsections, we provide direct evidence to this effect in the full (unrestricted) sample, explicitly showing that direct effects and changing peer quality do not drive our estimates even when new charter schools begin operations and students can attend them.

C.1 Spillover vs. Direct Effects

We first show the aggregate effect that we estimate in the full sample is not driven by the direct effects of the newly-opened charter schools. We do so in two ways.

First, we examine the value-added of the charter school entrants. To do so, we estimate school-level value-added using standard methods, regressing student test scores on a flexible function of prior-year test scores, student demographic controls, and school fixed effects in a pooled sample of traditional public school and charter school students. We then take each school-year's fixed effect as its value-added estimate.[48] Figure C.1 depicts the average charter school-level value-added in each post-policy-change year. The average non-horizontally differentiated charter school has much higher test score value-added than the average horizontally differentiated school. As a point of reference, the average value-added among traditional public schools is approximately zero. In the first post-policy-change year, both types of charter school have substantially lower value-added than traditional public schools on average. By the second year, however, non-horizontally differentiated charter

[48] We normalize the fixed effects to sum to zero.

schools have slightly higher average value-added than traditional public schools. Horizontally differentiated charter schools, on the other hand, continue to lag behind for the duration of the sample period.

While the variation in Figure C.1 suggests that direct effects may account for a share of the aggregate effect of non-horizontally differentiated charters we estimate in the full sample, few students in our sample actually switch to a charter school: among 'treated' students, just 2.37 percent attend the nearby charter school by the end of our sample period.[49] Thus, an accounting exercise strongly suggests that direct effects cannot explain the aggregate increase in student math scores, even when students are able to switch into the new charter schools.

Second, to quantitatively isolate the influence of the spillover effect on traditional public schools in the full sample, we estimate our main specification while effectively 'netting-out' the direct channel. To do so, we reproduce our difference-in-difference results from equation (3.2) except that we re-code the test score gains of students who switch from public schools to the newly-opened charter school to zero.[50] This re-coding shuts down any test score increases caused by the charter schools themselves and so can be considered a test for the presence of spillover effects. These results are presented in column (1) of Table C.1 and are virtually identical to our main estimates, indicating that our estimates are driven by spillover effects on traditional public schools. Likewise, columns (2) and (3) of Table C.1 follow the spirit of Lee bounds (Lee, 2009) and recode test score gains of switching students to the 5th and 95th percentile of test score gains. This exercise provides very tight 'bounds,' ruling out the possibility that the direct effect of charters substantially contributes to the net effect of charter school expansion.

[49]The analogous number for 'control' students is 1.76 percent.

[50]Specifically, we code every public-charter switcher to have the same test score (in standard deviation units) as they had in 2011-12, the year before they could switch into the newly-opened charter school.

C.2 Student Sorting and Peer Effects

Having established that our estimates in the unrestricted sample are driven by spillover effects on traditional public schools, we now demonstrate that, even when students can leave their local public schools to attend a nearby charter, these spillover effects continue to represent a competitive response by traditional public schools and are not driven by changing peer compositions.

Table C.2 shows that students who switch from public schools to both non-horizontally and horizontally differentiated charter schools are positively selected relative to students who stay, as they score 0.24 to 0.37 standard deviations higher in math and 0.07 to 0.38 standard deviations higher in reading.[51] Because switchers are relatively high performers, their departure from traditional public schools likely implies a worsening in peer quality and perhaps correspondingly negative peer effects on achievement. Any negative effects that operate through the peers channel are likely to be quite small in our setting, however, as a very small fraction of students switch to charter schools.

As discussed in the main text, a comparison of the estimated effects in Tables 3 and 4 already illustrates the relative unimportance of peer effects even in the full sample.[52] Given that students who switch into horizontally differentiated charter schools are positively selected relative to students who do not, however, on still may worry that these charter schools do eventually cause traditional public schools to become more productive, but the competitive effect is swamped by negative effects stemming from worsening peer quality. Tables C.3 and C.4 show some evidence consistent with this possibility. Table C.3 indicates that both the switching rate to charter schools and the differential in the switching rates among treated and control students are highest in third grade and smallest in fifth grade. Table C.4 shows that grade-specific treatment effects of horizontally differentiated charter

[51] Switchers are also more likely to be white, less likely to be a racial minority, and less likely to be disadvantaged.

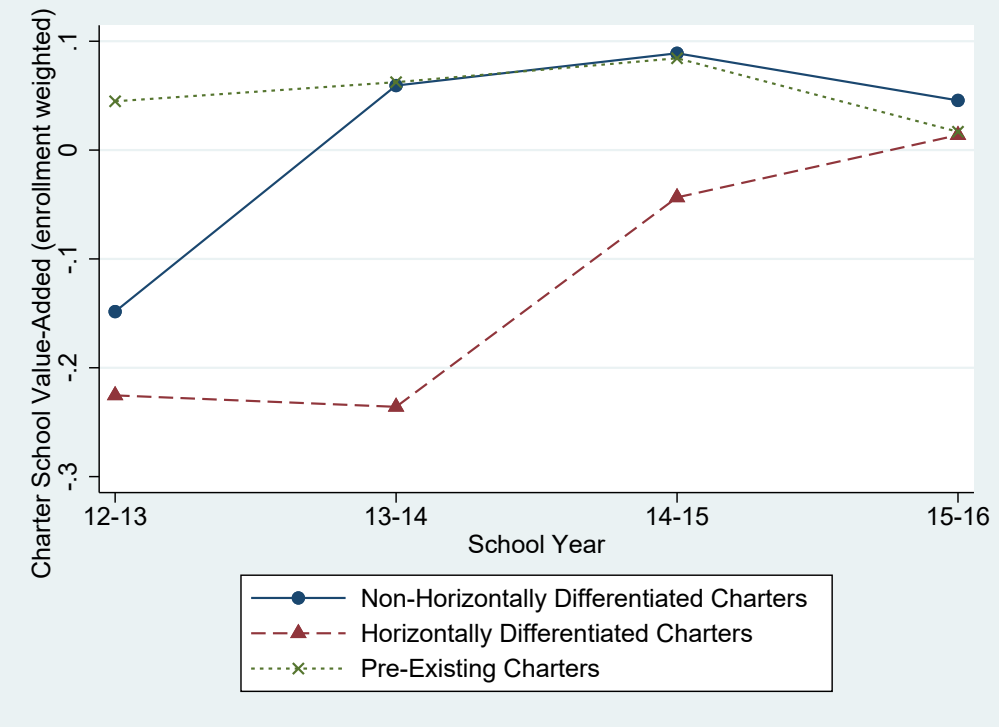
[52] For both horizontally and non-horizontally differentiated charter schools, the estimates across the two tables are virtually identical but those in Table 3 allow for changes in peer quality while those in Table 4 do not (by restricting the sample to end in the year before new charter schools opened).

schools are negative in third grade, where the largest change in peer composition occurred, and positive in fifth grade, where the smallest change occurred (although these effects are never statistically significant).

While these results are suggestive of negative peer effects confounding positive competitive effects of horizontally differentiated charter schools in the full sample, we believe this is unlikely for two reasons. First, the highest switching rate into non-horizontally differentiated schools also occurs in third grade and switchers into these schools are even more positively selected than switchers into horizontally differentiated schools. If negative peer effects are important, public schools facing non-horizontally differentiated competition in third grade should therefore be at a greater disadvantage than those facing horizontally differentiated competition. Yet the point estimate for non-horizontally differentiated charters in third grade in Table C.4 is the largest among all grades. Instead, we believe that the higher response in earlier grades is likely due to higher competitive pressure in those grades as they have higher switching rates than later grades (see Table C.3). Second, even if peer effects are much more important in public schools exposed to competition from horizontally differentiated charters, the total number of switching students is very small in our setting, implying that magnitude of peer effects would have to be implausibly large for the peers channel to totally confound the competitive channel.[53]

[53]With 2.5 percent of students switching and these students scoring 0.3σ higher than stayers, public school peer quality should decline by about 0.007σ. Even using the high-end of peer effects found in the literature, this change in peer quality will not have a substantive effect: e.g., peer effects estimated in Graham (2008) indicate the change in peer quality will decrease test scores of students staying in public schools by 0.006σ.

Figure C.1: Vertical Differentiation by Charter Type



Notes: This figure shows value-added of charters by whether the charter was horizontally or non-horizontally differentiated. It is also shown for 'pre-existing' charters that were present in North Carolina before 2012-13. Value-added is defined as the school-year fixed effect in a regression of (grade-year) standardized math test scores on cubic controls for prior year math and English test scores interacted with grade indicators as well as demographic controls and grade and year fixed effects. The regression includes all North Carolina grade 4-8 students with prior test scores. Demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade.

Table C.1: Bounding Competitive Effects

Mathematics Test Scores	Public-Charter Switchers Test Gains Set to Zero (1)	Public-Charter Switchers Test Gains Set to 5^{th} Percentile (2)	Public-Charter Switchers Test Gains Set to 95^{th} Percentile (3)
A. Pooled			
All Newly-Opened Charters	0.025**	0.021*	0.030***
	(0.011)	(0.012)	(0.011)
B. Heterogeneous			
Non-Horizontally Differentiated	0.048***	0.043**	0.054***
$(\beta_h + \beta_{nh-h})$	(0.015)	(0.016)	(0.016)
Horizontally Differentiated	-0.001	-0.004	0.002
(β_h)	(0.016)	(0.017)	(0.016)
Test of Equality by Differentiation Status	0.03	0.04	0.02
p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$			
Demographic Controls	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes
Observations (student-year)	164,964	164,964	164,964

Notes: This table attempts to bound the competitive effects of charters by making different assumptions on the test score gains of public-charter switchers when estimating equation (3.2). Column (1) sets the test score gains of public-charter switchers to zero, while columns (2) and (3) set the test score gains of public-charter switchers to the 5^{th} and 95^{th} percentile, respectively. Setting test score gains of public-charter switchers to the 5^{th} and 95^{th} percentile mimics the intuition behind Lee (2009) bounds. Students living within 2.5 miles of a newly-opened charter school are considered 'treated' while those living 2.5-5 miles from a newly-opened charter are considered 'control' and the effect is allow to differ by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. About 55 percent of total observations come from non-horizontally differentiated charters with the remaining 45 percent of observations coming from horizontally differentiated charters. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$ in (3.2). Regressions include the controls in column (3) of Table 3, which consist of grade and year fixed effects and demographic controls which incorporate ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered at the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table C.2: Characteristics of Public School Stayers and Public-Charter Switchers (2012-13 Third Grade Cohort)

Newly-Opened Charter is:	Non-Horizontally Differentiated		Horizontally Differentiated	
	Public Stayers	Public-Charter Switchers	Public Stayers	Public-Charter Switchers
	(1)	(2)	(3)	(4)
2012-13 Math Score (standardized)	0.032	0.371	-0.035	0.240
2012-13 ELA Score (standardized)	-0.009	0.384	-0.046	0.073
Percent White	41.2	75.8	33.2	48.6
Percent Black	32.3	13.3	40.2	40.4
Percent Hispanic	17.6	5.5	19.1	5.5
Percent Asian	4.8	4.2	3.1	0.9
Percent Disadvantaged	58.7	20.0	59.6	55.0
Percent with Disability	12.5	12.1	10.9	8.3
Percent Gifted	10.0	17.0	9.8	2.8
Observations (student-year)	6,467	165	5,966	109

Notes: This table shows the characteristics of students in the 2012-13 third grade cohort within five miles of a newly-opened charter school by whether they remained in the local public school or switched to the newly-opened charter school. The third grade cohort is chosen as this cohort switched at far higher rates that the fourth or fifth grade cohorts. Student characteristics are set at their values in the 2012-13 school year. Column (1) shows summary statistics for students that remained in the local public (non-charter) school while column (2) displays the characteristics of student that switched from the public school to the newly opened non-horizontally differentiated charter. Columns (3) and (4) do the same for when the newly-opened charter is horizontally differentiated.

Table C.3: Public-Charter Switch Rates by 2012-13 Grade

% Switching from Public to Newly-Opened Charter	2012-13 Grade: Third Grade (1)	Fourth Grade (2)	Fifth Grade (3)
Panel A. Non-Horizontally Differentiated			
Among 'Treated' ('Treated' Reside <2.5 miles from Charter)	3.29	2.70	0.54
Among 'Control' ('Control' Reside 2.5-5 miles from Charter)	2.14	2.18	0.38
Difference	1.15	0.52	0.16
Panel B. Horizontally Differentiated			
Among 'Treated' ('Treated' Reside <2.5 miles from Charter)	2.63	1.24	0.72
Among 'Control' ('Control' Reside 2.5-5 miles from Charter)	1.48	1.23	0.41
Difference	1.15	0.01	0.31

Notes: This table shows the percent of student that switched from a public school to a newly-opened charter by treatment status, where students residing 0-2.5 miles from the newly-opened charter are considered 'treated' while those 2.5-5 miles away are considered 'control.' Panels A and B split the sample by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. The table shows the switching rates by grade of the student in the 2012-13 school year, which is the first year more than one hundred charters could operate in North Carolina.

Table C.4: Difference-in-Differences Results by 2011-12 Grade

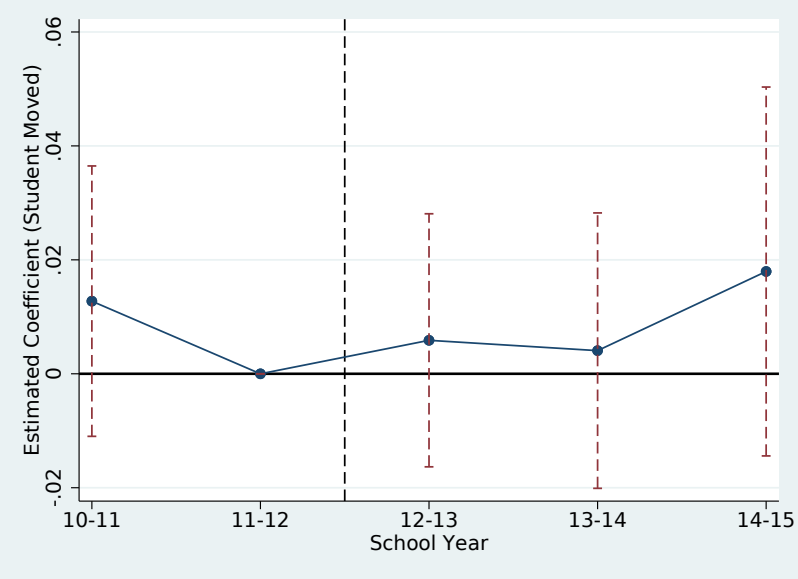
	'Treated' (0-2.5 miles) vs. 'Control' (2.5-5 miles)		
	Third Grade	Fourth Grade	Fifth Grade
Mathematics Test Scores	(1)	(2)	(3)
Panel A. Pooled			
All Newly-Opened Charters	0.018	0.020	0.038**
	(0.018)	(0.015)	(0.018)
Panel B. Heterogeneous			
Non-Horizontally Differentiated	0.054**	0.048**	0.047***
$(\beta_h + \beta_{nh-h})$	(0.024)	(0.022)	(0.025)
Horizontally Differentiated	-0.022	-0.009	0.027
(β_h)	(0.028)	(0.021)	(0.024)
Test of Equality by Differentiation Status	0.04	0.06	0.56
p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$			
Demographic Controls	Yes	Yes	Yes
Student Fixed Effects	Yes	Yes	Yes
Observations (student-year)	55,828	55,250	53,112

Notes: This table shows difference-in-differences estimates from equation (3.2) by grade. Grade is defined as the grade the student was in during the 2011-12 school year, which is the first year prior to the lifting of the one hundred charter cap in North Carolina. Students living within 2.5 miles of a newly-opened charter school are considered 'treated' while those living 2.5-5 miles from a newly-opened charter are considered 'control' and the effect is allow to differ by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h} = 0$ vs. H_1: $\beta_{nh-h} \neq 0$ in (3.2). Each column represents a different regression and regressions include the controls in column (3) of Table 3, which represents the (enrollment-weighted) average effect over all grades. Regressions include grade and year fixed effects and demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered at the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.

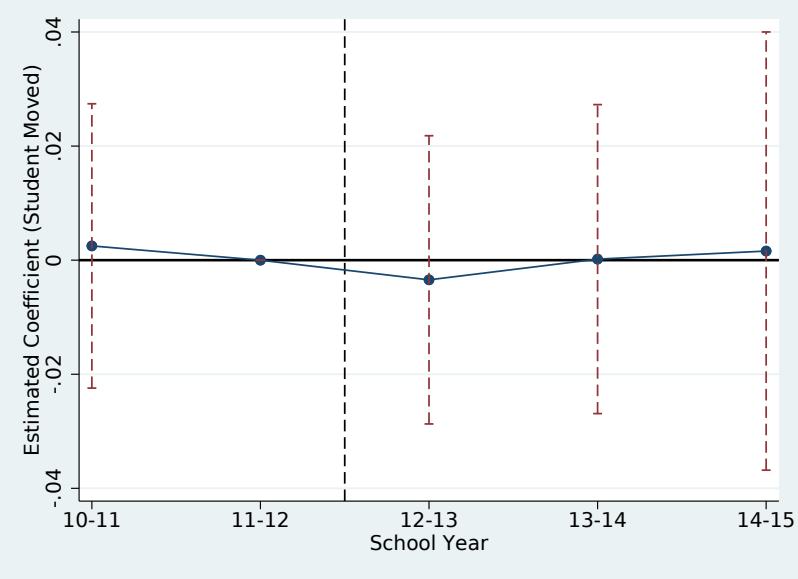
D Additional Figures and Tables

Figure D.1: Robustness: Difference-in-Differences Results for Moving

(a) Non-Horizontally Differentiated

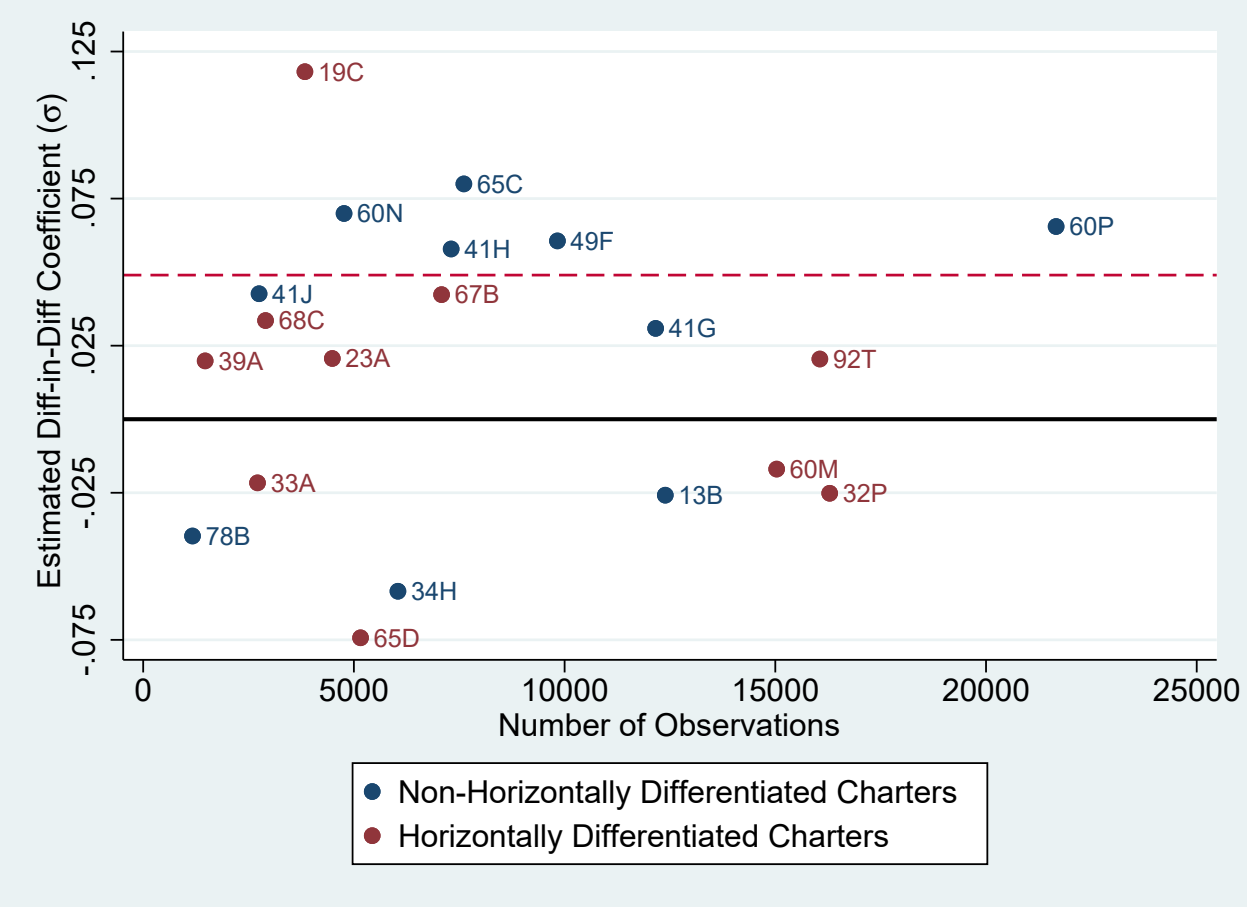


(b) Horizontally Differentiated



Notes: This figure shows a difference-in-differences estimate where the test score outcome from equation (3.2) has been replaced with a moving indicator as described in equation (4.1). A student is coded as having moved if their residential location has changed and is over one mile away from their residential location in the prior year. Treated areas are defined as neighborhoods within 2.5 miles of a charter school that opened in 2012-13 or 2013-14. Control areas are defined as neighborhoods between 2.5 and 5 miles of a charter schools that opened in 2012-13 or 2013-14. Results are subdivided by whether the nearby charter was horizontally differentiated or not from the local public school as described in Section 2.2. School year 2009-10 is omitted due to the change from the 2000 to 2010 census subdivisions created artificially high moving rates that year. Note that 2012-13 is considered the first 'treated' year because although the charters themselves opened in either the 2012-13 or 2013-14 school year, public schools would have known by the start of 2012-13 whether or not a charter was opening nearby or would open nearby in 2013-14. The dashed vertical line therefore separates the 'pre-years' from the 'post-years'. The horizontal line represents a point estimate of zero. The dashed 'whiskers' represent 95 percent confidence intervals with standard errors clustered at the census block group level.

Figure D.2: Difference-in-Differences Estimates by Charter



Notes: This figure shows results from the difference-in-differences regression defined by equation (3.2) whereby students living within 2.5 miles of a newly-opened charter school are considered 'treated' while those living 2.5-5 miles from a newly-opened charter are considered 'control' for *each* charter school in our sample. These regressions include demographic controls and student fixed-effects (i.e., the set of controls from column (3) of Table 3). Three newly-opened charters are omitted due to a lack of observations creating extremely noisy point estimates (all three omitted charters have less than 100 student-year observations within a five mile radius). The labels represent the LEA codes of the newly-opened charter school, which can be matched to charter school names and locations in Table A.1.

Table D.1: Summary Statistics of Students by School Type: 2012-13 to 2015-16

	All Non-Charter Students	All Students in Pre-Expansion Charters	Students in Expansion Charters: Non-Horizontally Differentiated	Students in Expansion Charters: Horizontally Differentiated
	(1)	(2)	(3)	(4)
Math Score (standardized)	-0.006	0.134	0.208	-0.095
ELA Score (standardized)	-0.011	0.233	0.304	0.113
Percent White	50.4	59.1	66.3	54.2
Percent Black	25.3	26.4	19.3	26.1
Percent Hispanic	16.2	7.4	5.4	4.9
Percent Asian	3.0	2.6	5.9	10.7
Percent Disadvantaged	55.4	32.3	19.0	24.8
Percent with Disability	15.9	14.4	12.8	12.9
Percent Gifted	13.9	2.8	0.3	1.1
Observations (student-year)	1,312,788	56,299	4,115	3,538

Notes: Sample is restricted to grade 3-6 students during the school years 2012-13 through 2014-15 (inclusive). Column (1) shows summary statistics for students in public (non-charter) while column (2) displays summary statistics for students attending a 'pre-existing' charter that opened before the 2012-13 school year. Columns (3) and (4) then show summary statistics for students attending the 23 'newly-opened' charters that opened in the 2012-13 or 2013-14 school years, with the statistics subdivided into charters we label as 'non-horizontally differentiated' in column (3) and 'horizontally differentiated' in column (4).

Table D.2: Difference-in-Differences Results (English)

	'Treated' (0-2.5 miles) vs. 'Control' (2.5-5 miles)			
English Test Scores	(1)	(2)	(3)	(4)
A. Pooled				
All Newly-Opened Charters	0.004	0.000	0.002	0.001
	(0.010)	(0.009)	(0.009)	(0.010)
B. Heterogeneous				
Non-Horizontally Differentiated	0.008	-0.005	0.001	-0.002
$(\beta_h + \beta_{nh-h})$	(0.015)	(0.013)	(0.012)	(0.013)
Horizontally Differentiated	0.000	0.006	0.004	0.004
(β_h)	(0.015)	(0.013)	(0.013)	(0.014)
Test of Equality by Differentiation Status	0.72	0.55	0.79	0.90
p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$				
Demographic Controls	No	Yes	Yes	Yes
Student Fixed Effects	No	No	Yes	Yes
Census Block Group Time Trends (linear)	No	No	No	Yes
Observations (student-year)	164,084	164,084	164,084	164,084

Notes: This table shows difference-in-differences estimates from equation (3.2), whereby students living within 2.5 miles of a newly-opened charter school are considered 'treated' while those living 2.5-5 miles from a newly-opened charter are considered 'control' and the effect is allow to differ by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. About 55 percent of total observations come from non-horizontally differentiated charters with the remaining 45 percent of observations coming from horizontally differentiated charters. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$ in (3.2). Each column represents a different regression and all regressions include grade and year fixed effects. Demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered at the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table D.3: Difference-in-Differences Results: Continuous Treatment

	Continuous Treatment (restricted to $\leq$ 5 miles)			
Mathematics Test Scores	(1)	(2)	(3)	(4)
A. Pooled				
All Newly-Opened Charters	-0.007	-0.008*	-0.009**	-0.005
	(0.005)	(0.005)	(0.005)	(0.005)
B. Heterogeneous				
Non-Horizontally Differentiated	-0.011	-0.013*	-0.019***	-0.008
$(\beta_h + \beta_{nh-h})$	(0.008)	(0.007)	(0.006)	(0.006)
Horizontally Differentiated	-0.000	-0.002	0.001	-0.002
(β_h)	(0.007)	(0.007)	(0.007)	(0.005)
Test of Equality by Differentiation Status	0.28	0.23	0.03	0.84
p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$				
Demographic Controls	No	Yes	Yes	Yes
Student Fixed Effects	No	No	Yes	Yes
Census Block Group Time Trends (linear)	No	No	No	Yes
Observations (student-year)	164,959	164,959	164,959	164,959

Notes: This table shows difference-in-differences estimates using distance to newly-opened charter as a continuous differencing variable. The data is restricted to less than 5 miles for comparability to Table 3. The results are further subdivided by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. About 55 percent of total observations come from non-horizontally differentiated charters with the remaining 45 percent of observations coming from horizontally differentiated charters. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$ in (3.2). Each column represents a different regression and all regressions include grade and year fixed effects. Demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered at the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table D.4: Difference-in-Differences Results: Defining Treatment by School Attended in 2011-12

	Attend 'Treated' School (0-2.5 miles) vs. 'Control' School (2.5-5 miles)			
Mathematics Test Scores	(1)	(2)	(3)	(4)
A. Pooled				
All Newly-Opened Charters	0.018	0.015	0.024**	0.022*
	(0.012)	(0.012)	(0.011)	(0.013)
B. Heterogeneous				
Non-Horizontally Differentiated	0.042**	0.034**	0.049***	0.038*
$(\beta_h + \beta_{nh-h})$	(0.018)	(0.017)	(0.016)	(0.020)
Horizontally Differentiated	-0.008	-0.006	-0.003	0.006
(β_h)	(0.017)	(0.016)	(0.016)	(0.015)
Test of Equality by Differentiation Status	0.05	0.08	0.02	0.21
p-value of H_0: $\beta_{nh-h}=0$ vs. H_1: $\beta_{nh-h}\neq 0$				
Demographic Controls	No	Yes	Yes	Yes
Student Fixed Effects	No	No	Yes	Yes
Census Block Group Time Trends (linear)	No	No	No	Yes
Observations (student-year)	164,403	164,403	164,403	164,403

Notes: This table shows difference-in-differences estimates from equation (3.2), but where students are always assigned to the school they attended in 2011-12. Students attending a public school in 2011-12 within 2.5 miles of a newly-opened charter school are considered 'treated' while those attending a public school 2.5-5 miles from a newly-opened charter in 2011-12 are considered 'control' and the effect is allow to differ by whether the newly-opened charter school is horizontally differentiated or not from the local public school as described by Section 2.2. About 55 percent of total observations come from non-horizontally differentiated charters with the remaining 45 percent of observations coming from horizontally differentiated charters. 'Test of Equality by Differentiation Status' reports the p-value of the hypothesis test that the point estimate for non-horizontally differentiated charters is the same as the one for horizontally differentiated charters; this is equivalent to testing the hypothesis of H_0: $\beta_{nh-h} = 0$ vs. H_1: $\beta_{nh-h} \neq 0$ in (3.2). Each column represents a different regression and all regressions include grade and year fixed effects. Demographic controls include ethnicity, gender, limited English proficiency status, socioeconomically disadvantaged status, gifted status, disability designation and an indicator if the student is repeating or skipping a grade. Standard errors are clustered by the 2011-12 census block group level. ***,** and * denote significance at the 1%, 5% and 10% levels, respectively.