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How Does School Choice Improve Student Achievement? Estimating School-level Competitive Effects and Student-level Peer Effects

Yusuke Jinnai
International University of Japan

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IUJ Research Institute
International University of Japan

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Abstract

Although school choice programs have played a key role in public education reform in the United States for years, the impact of competition between schools on student achievement remains unclear. This study examines the effects of introducing charter schools on students at neighboring traditional public schools. Unlike prior work, which estimates the effects of charter schools as a whole, I present that such impact consists of school-level competitive effects and student-level peer effects. By using rich panel data and controlling for unobserved peer characteristics, this study demonstrates that three-quarters of the positive charter impact are driven by the former while one-quarter results from the latter. I also show that peer effects play a larger role in math than in reading.

JEL classification: I21, H4

Keywords: School choice; Charter school; Competitive effects; Peer effects

1 Introduction

In many developed countries, policymakers have introduced school choice programs to improve the quality of public education. Such programs introduce market mechanisms into public education and allow students to easily switch from their current school to an alternative public school, generating strong pressure on schools to avoid losing students and public funding. By encouraging school choice, policymakers hope to induce more effort from public schools.

While there are a wide variety of school choice programs around the globe such as voucher programs, open enrollment, and home schooling, charter school policies have rapidly gained in popularity in the United States since 1991, when the nation's first charter school legislation was enacted by Minnesota. In 2013, 6.3% of all public schools nationwide were charter schools, and 4.6% of all public-school students were enrolled at charter schools.[1] These figures are expected to further increase in the future as the current administration aims at expanding charter school systems.

Charter schools are publicly funded and free to all students as same as traditional public schools. But charter schools are typically exempt from a number of local regulations and have considerable freedom in personnel and curricular decision-making.[2] Unlike traditional schools, however, charter schools are not geographically restricted by school districts or attendance zones. Wherever they live, parents are able to enroll their children in any charter school rather than an assigned traditional school.[3] In this regard, charter schools provide parents and children with an alternative choice to traditional schools and thus have a potential to improve the quality of neighboring traditional schools through competition. If traditional-school students leave for charter schools, traditional schools will lose public funding proportional to their enrollment loss; this is the financial pressure that traditional schools face when a charter school opens in their

[1] See Figure 1 and 2 as well as The National Alliance for Public Charter Schools.

[2] Studies on the effectiveness of charter schools themselves have been inconclusive. Some papers find positive impact on their student achievement (Hoxby and Rockoff, 2005; Hoxby and Murarka, 2009; Angrist et al., 2010, 2012), while others find insignificant or negative impact (Buddin and Zimmer, 2005; Zimmer and Buddin, 2006; Hanushek et al., 2007; Booker et al., 2007).

[3] Charter legislations vary from state to state; some states allow students to attend a charter school only across attendance zones, while other states allow attendance even across school districts. If oversubscribed, charter schools are required to select students by lottery.

neighborhood and that policymakers hope will induce additional effort from traditional schools.

A number of educators and researchers have examined the effects of charter schools on nearby traditional schools, but to date there has been no consensus regarding the direction, let alone the existence, of such charter impact. The literature on this topic has found conflicting results: positive effects (Booker et al., 2008; Holmes et al., 2003; Hoxby, 2004; Jinnai, 2014; Sass, 2006), no effects (Bettinger, 2005; Bifulco and Ladd, 2006; Buddin and Zimmer, 2009), and negative effects (Imberman, 2011) on student achievement at neighboring traditional schools. Using data from a school choice program in Britain, Clark (2009) also finds no such effects. Beyond achievement effects, Jackson (2012) estimates the impact of charter school entry on teacher labor markets and finds a significant increase in teacher compensation. But more importantly, these studies have not yet examined the mechanism on *how* charter schools affect student achievement at neighboring traditional schools.

This paper aims at opening the black box of charter-school effects, by using rich panel data set from the state of North Carolina, U.S. First, I present that the charter impact consists of school-level competitive effects and student-level peer effects. Competitive effects are the effects that improve the productivity of traditional schools, which policymakers hope to induce by generating competitive pressure on traditional schools. Yet, peer effects are also included in the charter impact. Since some students switch from traditional schools to charter schools, the remaining students at traditional schools are affected by changes in classmates (peers). If low-achieving students leave for charter schools, for instance, then traditional-school students benefit not only from the school-level competitive effects but also from the student-level peer effects generated by relatively higher-performing classmates. Since such positive peer effects can increase student achievement even without competitive effects, it is essential to distinguish between these two different effects to understand *how* charter schools affect nearby traditional schools.

Secondly, I develop a model to take into account unobserved characteristics of peers. Although Hsieh and Urquiola (2006) discuss the challenge of disentangling the respective magnitude of the competitive effects and peer effects, this study proposes a new approach to overcome the hurdle by employing an iterative estimation method developed by Arcidiacono et al. (2012). By controlling

for unobserved peer characteristics, I find that 24% of the positive charter impact is driven by changes in peers. This is consistent with the fact that low-achieving students are more likely to switch from traditional schools to charter schools in North Carolina, leaving higher-performing students at traditional schools. The rest of the charter impact (76%) can be attributed to the competitive effects. I also present that such peer effects are larger in magnitude and weight for math than for reading. My approach demonstrated in this paper brings new insight into the controversial literature and contributes to a better understanding of the impact of charter schools.

This paper is organized as follows: The next section provides an overview of charter schools in North Carolina, and Section 3 describes the administrative data obtained from the North Carolina Education Research Data Center. Section 4 develops an empirical framework to distinguish between peer effects and competitive effects. Section 5 demonstrates the main results, and Section 6 concludes.

2 Charter schools in North Carolina

2.1 Locations and grades

North Carolina presents an ideal case study for examining the effects of charter schools on student achievement. Although some states have not yet introduced a charter school program and others have only recently adopted such a system, North Carolina passed the Charter Schools Act in 1996. As in many states, charter schools in North Carolina are managed by an independent board under a chartering contract with a local school district, the state university, or the State Board of Education. Although local districts can comment on how the charter school would affect them, because local schools would suffer from budget decrease in response to charter school entry, the final approval for a charter school comes from the State Board of Education.

The first charter school in North Carolina opened in fall 1997, and as of the 2009-10 school year (2010 hereafter) there were ninety-six charter schools which have approximately 39,000 students enrolled.[4] Figure 3 illustrates the location of charter schools in North Carolina in 2010. Similar to

[4]U.S. Department of Education and North Carolina State Board of Education.

traditional public schools, many of large charter schools in terms of enrollment are located around highly populated cities, while smaller charter schools are open in rural areas. Table 1 shows the numbers and proportions of traditional public schools and charter schools by location. Compared to traditional schools, on average, charter schools are more likely to enter urbanized areas.[5] Of ninety-six charter schools in 2010, eight schools (8.3%) operate in Charlotte, the largest city in North Carolina, and nine schools (9.4%) in Raleigh, the second-largest city. In total, fifty charter schools (52.1%) are located in urbanized areas; the proportion is higher than that of traditional schools that operate in the same area (36.3%).

Table 2 illustrates the numbers and proportions of traditional schools and charter schools in 2010 by grade-levels. In North Carolina, there is a huge variation in grade-levels offered by both types of schools. Although the majority of elementary schools have grades that begin from pre-kindergarten (Pre-K) or kindergarten (K) and terminate at grade five, a number of schools have grades up to six or eight, combining elementary-school grades and middle-school grades. For instance, of 2,411 traditional public schools, 459 schools (19.0%) have grades Pre-K through 5, while forty schools (1.7%) have Pre-K through 6 and forty-six schools (1.9%) have Pre-K through 8. Middle schools and high schools also demonstrate a similar pattern. Although their grade ranges are traditionally 6–8 and 9–12, respectively, some schools have grade ranges such as 5–8 or 6–12.

Regarding charter schools, many offer a wider range of grades than their traditional counterparts. Among ninety-six charter schools, forty-one schools (42.7%) offer K–8 and seventeen schools (17.7%) offer K–12. In addition, another unique feature of charter schools is that they expand their grades over time. For instance, of those forty-one K–8 charter schools in 2010, only twelve schools (29.3%) had the same K–8 grades from the beginning. The majority of schools opened with a shorter range of grades such as K–2 and K–3.

[5]In the U.S. Census, an urbanized area is defined as an area with 50,000 or more people. Rural encompasses all other areas not included within an urban area.

2.2 Regulation and exemption

The charter school law in North Carolina limits the number of charter schools to a total of one hundred, with no more than five new charter schools in any school district in a single year. The growth of charter schools in North Carolina clearly illustrates that the quota has been almost reached each year since 2002 (Figure 4 and 5). As a result, the proportions of charter schools and charter school students in 2010 are 3.8% and 2.6%, compared to the U.S. averages of 5.0% and 3.3%, respectively. The reason for this cap on charter schools is the controversy over whether charter schools improve or harm the quality of neighboring traditional schools. Therefore, assessing the impact of charter schools is particularly informative for North Carolina's state government.

Charter schools are also subject to the same statewide testing requirements and accountability standards as traditional schools. But unlike traditional schools, charter schools can be closed due to poor student performance or financial mismanagement. On the other hand, charter schools are given greater flexibility in management than traditional schools. In particular, they are exempt from regulations requiring state certification of public-school teachers. Charter schools, for example, are allowed to hire non-certified teachers with proportions of up to 25% in grades K–5 and up to 50% in grades 6–12, leaving them with more freedom in recruiting decisions than traditional schools. The remainder of teachers can be appointed as long as they satisfy federal requirements.[6]

2.3 Competition between charter schools and traditional schools

North Carolina's charter schools receive the same amount of per-pupil state funding as traditional public schools receive. Thus, when students leave traditional schools for charter schools, those traditional schools also lose public funding proportional to their enrollment loss. This is the financial pressure that traditional schools face when a charter school is introduced in their neighborhood and that policymakers hope will induce additional effort from traditional schools.

For example, when there is no charter school, there is no competition among traditional public schools, as illustrated in Figure 6. Suppose there are four traditional elementary schools A, B, C,

[6]For instance, Angrist et al. (2010) show that a number of teachers at the charter school in their study are graduates of the national Teach For America internship program.

and D. Since students cannot attend a traditional public school across their school attendance area, they are required to enroll at each assigned school; students who reside in school A's attendance area have no choice but to attend school A. Even though parents can always send their children to a different school by moving to another attendance area or by paying for a private school, it is costly for many families to do so. The bottom line is that traditional schools face few pressures of losing their students and public funding, providing them with little motivation to improve their education.

In contrast, the charter school system provides an alternative to parents without the costs of moving or private schooling. For instance, when a charter elementary school opens, as in Figure 7, students have a choice to switch to the charter school without moving. Since charter schools are not restricted by school attendance areas, any student can enroll at the charter school across attendance area boundaries.[7] Some students at the charter school would otherwise enroll at traditional school A, while others would enroll at school B. Policymakers expect that these traditional schools will improve their education quality so as not to lose their students and public funding. Students can switch from traditional schools C and D to the charter school as well, or from farther attendance areas, but distance to the charter school is a critical determinant of whether those students would actually attend the charter school; this is why I will define market areas for charter schools in Section 4.

3 Data and descriptive statistics

3.1 Data sources

An advantage of studying the effects of charter schools on traditional public schools in North Carolina is that the state allows researchers to access a broad variety of data on both school characteristics and student characteristics, including individual test scores. Like other traditional public schools, charter schools in North Carolina are required to administer the statewide End-of-

[7]Further, charter schools in North Carolina are not restricted by school districts, which are larger jurisdictions that consist of multiple school attendance areas. Thus, students can enroll at any charter school even across school district boundaries.

Grade (EOG) tests every year in reading and math for grades three through eight, and in science for grades five and eight.[8] In addition to the EOG tests at the end of their academic year, third-graders take pretests in reading and math at the beginning of the year. These test scores are used in several studies as if they are the second-grade EOG scores for the same students.[9]

The structure of the EOG data enables researchers to collect all student test scores (including in all subject areas and for tests taken in previous years) and match them to the schools students attended at the time the exams were administered. Consequently, I can follow not only the progress of an individual student over time, but also how such progress corresponds to the school that a student attended, even if a student stayed at the same school or switched to another school. Using these detailed panel datasets, this study assesses the impact of charter school entry on student achievement at neighboring traditional public schools.

This paper uses two kinds of datasets in North Carolina through the North Carolina Education Research Data Center (NCERDC).[10] The first dataset is the EOG which includes student test scores as well as other student characteristics such as parent education level and eligibility for free or reduced-priced lunch. The second dataset is the Common Core of Data Public School Universe survey (CCDPSU) which includes school characteristics such as student-teacher ratio and racial composition. In my analysis, I use the data from the EOG and the CCDPSU for 1997 through 2002. As described in Section 2, 1997 was one year prior to the entry of the first charter schools in North Carolina, and most charter schools were established by 2002.

3.2 Descriptive statistics

In 1998, when the first charter schools opened, students at charter schools were predominantly black. The parents of charter school students, on average, had higher education levels than the parents of traditional school students. However, test scores of charter school students were lower than those of their counterparts in both reading and math. The average size of charter schools, measured by school and grade enrollment, was much smaller than that of traditional schools.

[8] Students take the statewide End-of-Course (EOC) tests in a variety of subjects at grades nine to twelve.

[9] For example, see Rothstein (2010).

[10] The data center stores and manages data on North Carolina's public schools, students, and teachers. The datasets are available to university researchers, non-profit research institutions, and government agencies.

For my estimation, I combine EOG with CCDPSU and obtain a sample from 1,307 schools and 381,322 students, leading to a total of 1,081,761 observations. Table 3 shows summary statistics of the data of traditional school students, as this study aims at estimating the impact of charter schools on traditional-school students. Standardized scores for both math and reading are above zero, which implies that traditional-school students, on average, perform better than charter-school students, as discussed above.

4 Identification strategy

4.1 Defining market area and measuring competition

To assess the impact of charter schools on neighboring traditional public schools, it is necessary to first identify which charter schools are geographically competing with traditional schools. Following previous studies including Bifulco and Ladd (2006) and Sass (2006), I also use 2.5 miles from traditional schools as a distance measure. In addition to defining schools' market areas, another issue regarding school competition is how to measure the competitive pressure that traditional schools face from charter schools; this measure is referred to as charter penetration in the literature. As same as other papers (Bifulco and Ladd, 2006; Jackson, 2012), I also use the number of charter schools as my primary definition of charter penetration.

4.2 Econometric model

4.2.1 Two sources of endogeneity

I begin with the following test-score production function:[11]

$$Y_{ijgt} = X_{ijgt}\beta + \alpha Charter_{jgt} + \delta_{gt} + u_{ijgt} \tag{1}$$

In Equation (1), Y_{ijgt} denotes student i's test score, in math and reading respectively, at grade

[11] See Todd and Wolpin (2003) for a detailed discussion of the theoretical and econometric assumptions underlying model specifications.

g of traditional school j in year t. Test scores are standardized with mean zero and standard deviation one for each subject, grade, and year.

X_{ijgt} controls for student and school characteristics such as school-level minority share as well as whether the student switched to a different school from the previous year. $Charter_{jgt}$ is the grade-level indicator for charter penetration defined as the number of charter schools, within 2.5 miles from traditional school j, which has grade g in year t. Grade-by-year fixed effects δ_{gt} capture any systematic differences across exams. The parameter of interest is α, which measures the charter-school effects on traditional-school students.

There are two potential endogeneity problems in Equation (1). The first problem is that charter schools' location decisions are not random. If charter schools target specific areas for their entry, such as school districts where traditional schools are performing poorly, then charter school competition becomes endogenous.

The second problem is that students' schooling decisions are not random, either. If some unobservables are driving students into traditional schools that face charter school competition, then student selection also becomes endogenous. One example of this endogeneity is that only certain types of students leave traditional schools for charters. In particular, charter-school students perform worse in both reading and math tests than traditional school students, as Table 3 shows that average academic performance of traditional-school students exceeds that of charter-school students. As a result, the departure of these low-performing students from traditional schools to nearby charter schools could bias the estimates.

To address the two sources of endogeneity mentioned above, I introduce both school- and student-fixed effects as follows;

$$Y_{ijgt} = X_{ijgt}\beta + \alpha Charter_{jgt} + \theta_i + \gamma_j + \delta_{gt} + \mu_{ijgt}, \tag{2}$$

where γ_j accounts for charter location decisions and θ_i accounts for students' schooling decisions. The parameter of interest α is consistently estimated under the strict exogeneity assumption; that is E $[\mu_{ijgt}|Charter, X, \theta_i, \gamma_j, \delta_{gt}] = 0$ for any time period t.

The parameter α is identified by traditional-school students whose test scores are observed

both before and after the entry of charter schools. Students who enroll in grades which overlap with charter schools' grades contribute to identifying α.

4.2.2 Controlling for unobserved peer characteristics

This paper further examines the impact of charter schools on neighboring traditional schools, because the charter effects are the combination of competitive effects and peer effects. As Hsieh and Urquiola (2006) discuss in detail, the impact of charter schools or any other school-choice programs captures both school-level competitive effects, which result from strong pressure on traditional schools, and student-level peer effects, which result from the change in student composition.

From policymaker's viewpoint, it is essential to distinguish between competitive effects and peer effects, because school choice programs intend to induce more effort and additional educational inputs at traditional schools through market pressure generated by competition, but not through sorting students into two different types of schools.

While Hsieh and Urquiola (2006) clearly point out this issue, they also discuss that it is hard to disentangle peer effects from competitive effects, as it is always a hurdle to identify peer effects. By contrast, this paper aims at providing a new empirical approach for separately identifying peer effects and competitive effects under a school choice program. In particular, I analyze to what extent the charter effects can be explained by peer effects and competitive effects, respectively. To define peers for each student, I use the data only for elementary-school students because student data can be matched with classroom teacher data. As a result, this study defines peers as classmates taught by the same teacher.

One big challenge in estimation is how to deal with unobservables, since student achievement might be affected by unobserved peer characteristics such as classmates' motivation to learn (Hsieh and Urquiola, 2006). To examine this possibility, I further control for peer unobservables in the following model:

$$Y_{ijgt} = X_{ijgt}\beta + \pi Charter_{jgt} + \theta_i + \gamma_j + \delta_{gt} + \frac{\phi}{K_{it}} \sum_{k \in I_{it}} (X_{kjgt}\beta + \theta_k) + \epsilon_{ijgt}. \tag{3}$$

Denote as I_{it} the set of students who are in the same class of student i in year t. Also, denote

as K_{it} the total number of classmates (peers) of student i in year t. Note that the model includes fixed effects (θ_k) for all of student i's classmate k in each year t. By including all θ_k's, the model controls for peer unobservables that might affect student i's achievement.

Since Equation (3) controls for both observed and unobserved peer characteristics, the coefficient on Charter variable becomes the competitive effects, while the corresponding coefficient in Equation (2) measures the charter effects as a whole, which capture both school-level competitive effects and student-level peer effects.

Another parameter of interest in the above model is ϕ, which measures the weight on peers compared to students themselves. A large ϕ implies that peers play an important role in determining student achievement, while small ϕ suggests that peer characteristics do not considerably affect student performance.

Since the above model cannot be estimated by a simple regression, I employ an iterative method developed by Arcidiacono et al. (2012) to consistently estimate the parameters in Equation (3).[12] Consider the following problem:

$$\min \sum_i \sum_j \sum_g \sum_t \Big\{ Y_{ijgt} - X_{ijgt}\beta - \pi Charter_{jgt} - \theta_i - \gamma_j - \delta_{gt} - \frac{\phi}{K_{it}} \sum_{k \in I_{it}} (X_{kjgt}\beta + \theta_k) \Big\}^2 \quad (4)$$

This problem is estimated by the following two-step procedure with any initial values for the parameters:

Step 1: Conditional on θ^{q-1}, γ^{q-1}, and δ^{q-1}, estimate β^q, π^q, and ϕ^q by OLS.

Step 2: Conditional on β^q, π^q, and ϕ^q, estimate θ^q, γ^q, and δ^q by the first order conditions of the above equation.

The main idea of this method is, given initial values, to estimate one part of the parameters in the first step and to use those estimates to estimate the other part of the parameters in the second step. At each step in the process, the sum of squared errors is decreased, and the iteration

[12] This method is also used by Harris and Sass (2011) and Kinsler (2012) to assess teacher quality.

process continues until the parameters converge, leading to the least squares solution. The primary advantage of this method is that it is capable of handling interactions among individuals with an extremely large set of fixed effects. Therefore, this approach is particularly beneficial in this study, where the model analyzes peer effects of as many as 381,322 students (Table 3).

5 Estimation results

Table 4 presents the main results for math scores. Column (1) shows the baseline estimates of Equation (2) that includes student fixed effects and school fixed effects to correct students' and schools' endogenous decisions. The coefficient on Charter variable is 0.0392 with significance at the 1% level. This result implies that the average math score of students at traditional schools increases by 0.0392 standard deviations (s.d) as one charter school opens in a neighborhood. This is considered a sizeable, economically significant magnitude, which is comparable to the results from previous studies.[13]

Although some related studies also find positive effects of charter schools on nearby traditional schools, they do not examine the mechanism on how student achievement increases in response to charter school entry. By contrast, this study demonstrates that 24% of such positive charter impact is driven by peers, while the rest of 76% results from competition.

Table 4 Column (2) shows that, once unobserved peer fixed effects are included as in Equation (3), the coefficient on Charter variable decreases by 24% from 0.0392 to 0.0298. This finding illustrates that peer effects play a significant role in achieving higher test scores. Since lower performing students are more likely to switch to charter schools, as discussed in the previous chapter, remaining students at traditional schools are surrounded by relatively higher achieving students after the departure of lower achieving students for nearby charter schools. Once such changes in student composition are taken into account, the impact of charter school significantly decreases. As a result, the findings suggest that the average math score of students at traditional schools improves by 0.0298 s.d. through competition as one charter school opens in a neighborhood.

Regarding other variables, Table 4 underscores that when students switch a school, their aca-

[13]For instance, Booker et al. (2008) finds the impact is 0.021 s.d. in Texas.

demic performance decreases; this negative effect is widely found in the literature. Also, once peers are controlled for, other variables turned out to have no significant impact on student achievement.

Table 5 presents the main results for reading scores. The estimates show a similar pattern to the results from math; student test scores increase as a charter school opens in a neighborhood. In line with other previous papers, the impact on reading scores is significantly smaller than that on math scores; a number of education policies often improve students' math skills in the short run compared to their reading ability. More interestingly, this study also finds that peer effects are larger for math than for reading. The peer effects in reading account for 9% of the total charter impact, since the results highlight that the coefficient on Charter variable decreases by 9% from 0.0198 to 0.0180; the magnitude is significantly smaller than the magnitude of 24% in math.

Another important finding, for the first time in this literature, is the estimate of the weight on peers in test-score production function. In Equation (3), ϕ captures the weight on peers compared to students' own characteristics including their own abilities. Table 6 demonstrates that the weight is estimated as 0.3073 in math and 0.1092 in reading. These results make a point again that peer effects play a significant role in determining student academic achievement and that they play a larger role in math than in reading.

6 Conclusion

Developed countries around the globe have introduced a wide variety of school choice programs to improve education quality. In the U.S., charter schools have become the most popular alternatives to traditional public schools over the past two decades. Although a number of educators and researchers have examined the impact of school choice programs, and charter schools in particular, on student achievement, there has been no consensus so far regarding the existence or the direction of such effects.

Furthermore, previous studies have found no answer on how charter schools improve student achievement at nearby traditional schools even if positive charter effects are identified. This paper contributes to this controversial literature by proposing a new empirical approach to separately estimate school-level competitive effects and student-level peer effects under a charter school pro-

gram.

In this study, I present that charter impact consists of both competitive effects and peer effects and, by controlling for unobserved peer characteristics, demonstrate that 24% of the positive charter impact is driven by peers while 76% of the impact results from competition. The findings presented in this paper provide policymakers with a better understanding of the effects of introducing charter schools and, more in general, school choice programs.

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Figure 1: Charter schools in the U.S.

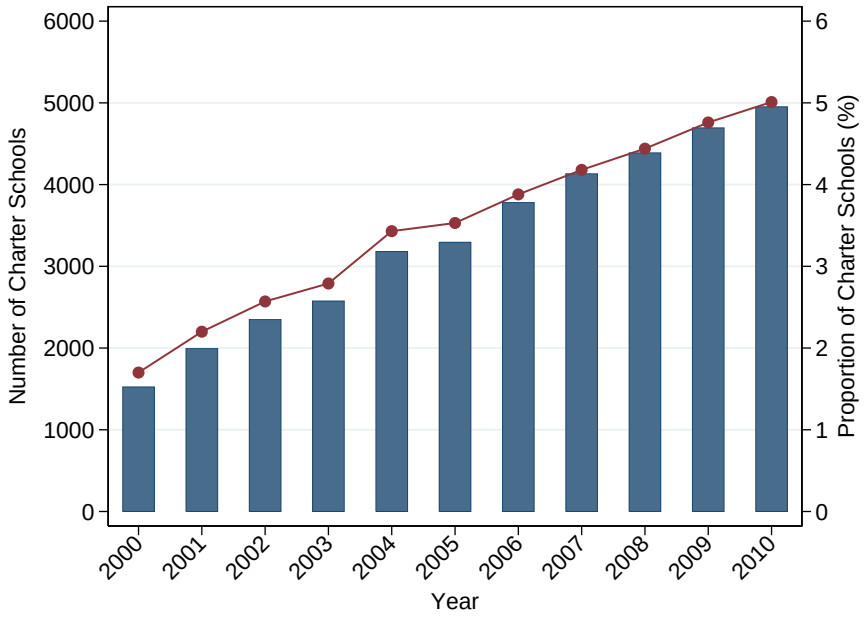
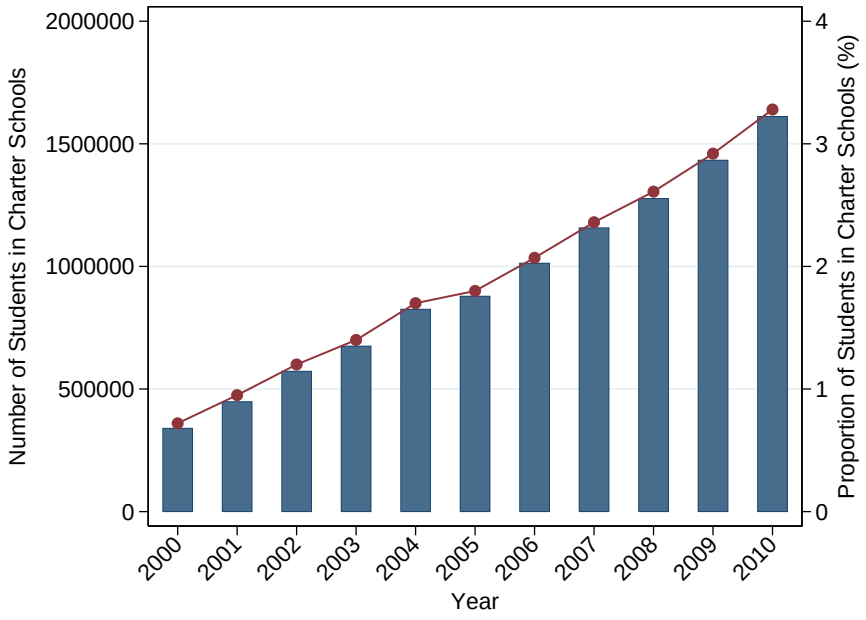
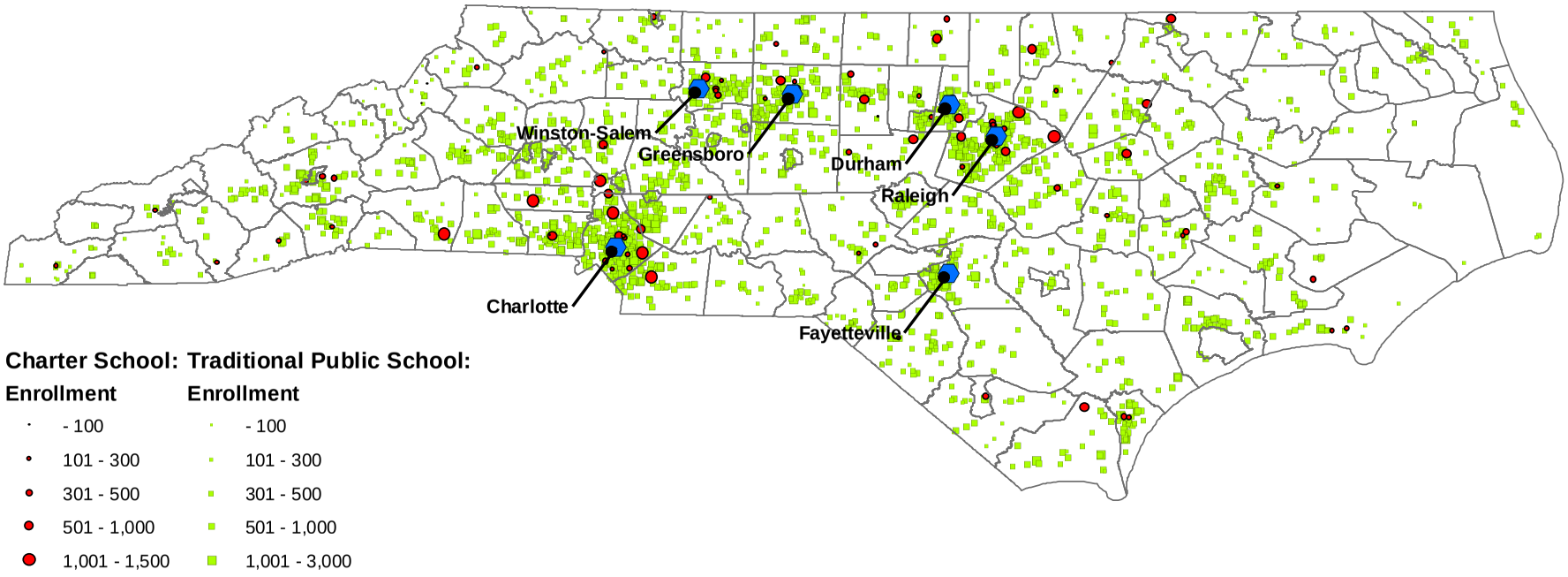


Figure 2: Students in charter schools in the U.S.



Note: U.S. Department of Education, The Common Core of Data (CCD).

Figure 3: The location of charter schools and traditional public schools in North Carolina in 2010



Note: The figure shows the location of 96 charter schools and 2,411 traditional public schools. Only regular schools are included, and alternative schools or vocational schools are excluded. The data on school addresses are drawn from North Carolina CCDPUG. Six largest cities in population are also shown: Charlotte, Raleigh, Greensboro, Winston-Salem, Durham, and Fayetteville in this order.

Figure 4: Charter schools in North Carolina

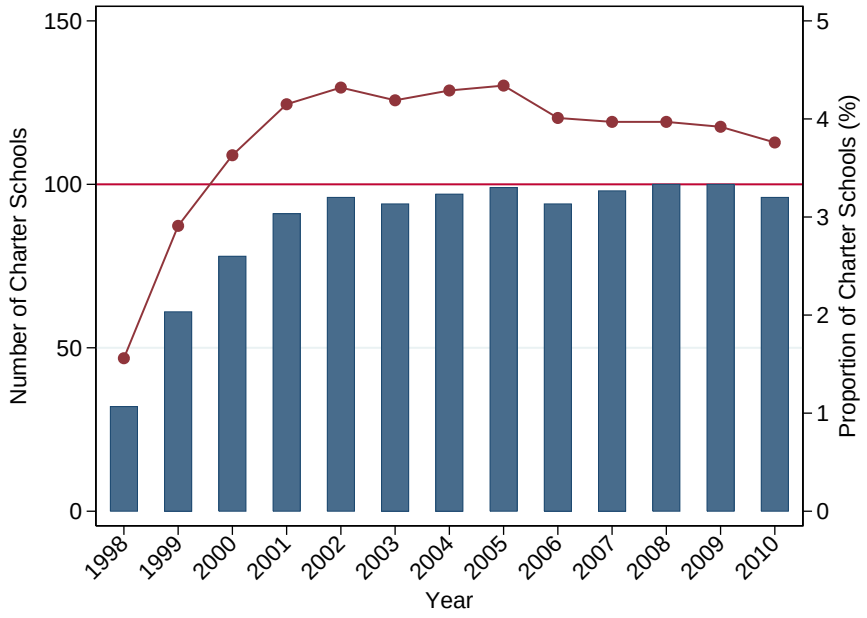
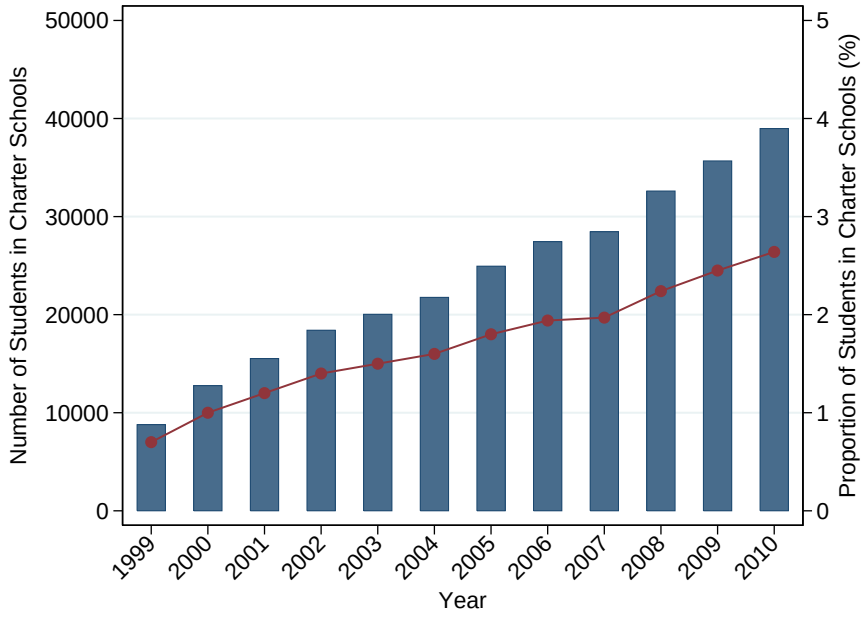
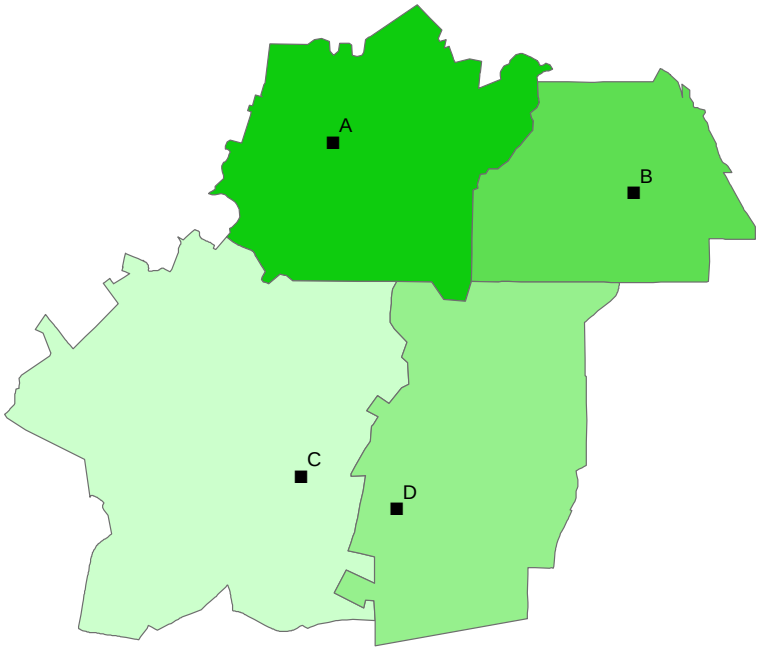


Figure 5: Students in charter schools in North Carolina



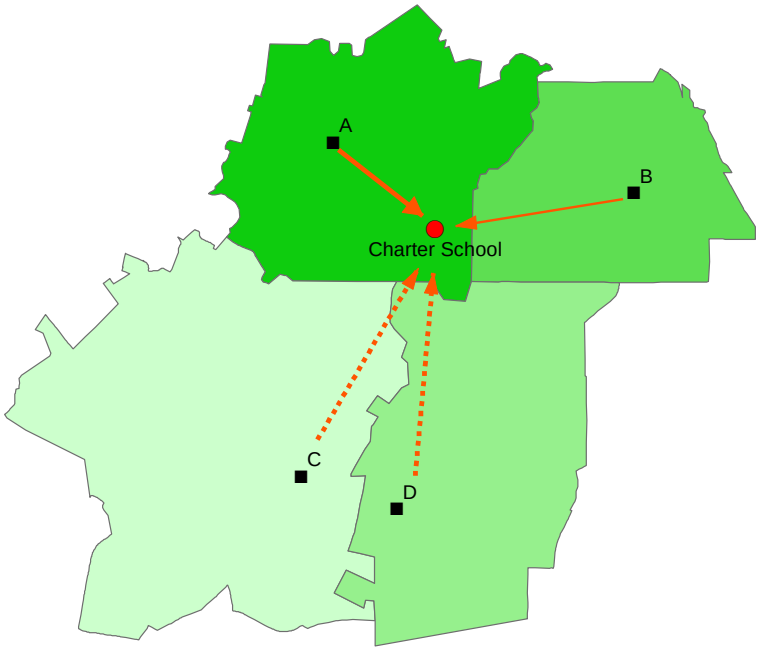
Note: U.S. Department of Education, National Center for Education Statistics, The Common Core of Data (CCD) and North Carolina State Board of Education, Department of Public Instruction.

Figure 6: No competition among traditional public schools



Note: Four traditional public schools A, B, C, and D have their own school attendance areas. No students can enroll at a school across their attendance area boundaries.

Figure 7: Competition between traditional public schools and a charter school



Note: Students have options to switch to a charter school across their attendance area boundaries. A charter school is required to select students by lottery if it is oversubscribed.

Table 1: The number of schools by location in North Carolina in 2010

		Traditional Public School		Charter School	
	Population	Number	Percentage	Number	Percentage
Charlotte	731,424	149	6.2	8	8.3
Raleigh	403,892	76	3.2	9	9.4
Greensboro	269,666	71	2.9	3	3.1
Winston-Salem	229,617	61	2.5	5	5.2
Durham	228,330	51	2.1	7	7.3
Fayetteville	200,564	67	2.8	1	1.0
Total Urban	-	876	36.3	50	52.1
Total Rural	-	1,535	63.7	46	47.9
Total	9,535,483	2,411	100	96	100

Note: The numbers of schools for traditional schools and charter schools include only regular schools. Alternative schools or vocational schools are excluded. Six largest cities in population are indicated. Population data are drawn from the U.S. Census 2010. Urban is defined as the area with a population of 50,000 or more. Rural encompasses all other areas not included within an urban area. The U.S. Census Bureau has not yet released the data on population by urban/rural areas.

Table 2: The number of schools by grade in North Carolina in 2010

	Lowest	Highest	Traditional Public School		Charter School	
	grade	grade	Number	Percentage	Number	Percentage
Elementary	Pre-K	5	459	19.0	0	0.0
	K	5	616	25.5	9	9.4
Middle	6	8	405	16.8	4	4.2
High	9	12	437	18.1	7	7.3
Combined	Pre-K	6	40	1.7	1	1.0
	Pre-K	8	46	1.9	1	1.0
	K	6	23	1.0	2	2.1
	K	8	28	1.2	41	42.7
	K	12	13	0.5	17	17.7
	5	8	21	0.9	1	1.0
	6	12	45	1.9	2	2.1
	7	12	13	0.5	0	0.0
	other	other	265	11.0	11	11.5
Total	-	-	2,411	100	96	100

Note: Grade Pre-K indicates pre-kindergarten, while K indicates kindergarten. The numbers of schools for traditional schools and charter schools include only regular schools. Alternative schools or vocational schools are excluded.

Table 3: Descriptive statistics

	mean	s.d.
Math score	0.067	0.975
Reading score	0.066	0.969
School enrollment	592.7	203.0
Class size	23.4	8.7
Switch	0.106	0.308
Free lunch eligible	0.418	0.211
Minority share	0.375	0.256
Charter	0.082	0.329
Number of schools	1,307	
Number of students	381,322	
Number of observations	1,081,761	

Note: Test scores are standardized at mean zero and standard deviation one. *Switch* equals one if a student switched to a different school from the previous year and zero otherwise.

Table 4: Estimates of competitive effects and peer effects (Math)

	(1)	(2)
Charter	0.0392***	0.0298***
	(0.0026)	(0.0026)
Switch	-0.0068**	-0.0061**
	(0.0030)	(0.0028)
Class size	-0.0003***	-0.0001
	(0.0001)	(0.0001)
School enrollment	-0.0001	-0.0001
	(0.0001)	(0.0002)
Minority share	-0.0484	-0.0000
	(0.0793)	(0.1529)
Free lunch eligible	-0.0455**	-0.0358
	(0.0203)	(0.0615)
Grade-year FE	√	√
Student FE	√	√
School FE	√	√
Peer FE		√
N	955,488	955,488

Note: The dependent variable is test score in math. All regressions include class size, an indicator whether a student switched a school from the previous year, and school-level enrollment, minority share, and proportion of students who are eligible for free or reduced-priced lunch. Bootstrapped standard errors are in parentheses. ** and *** denote significance at the 5% and 1% levels, respectively.

Table 5: Estimates of competitive effects and peer effects (Reading)

	(1)	(2)
Charter	0.0198***	0.0180**
	(0.0035)	(0.0072)
Switch	0.0004	0.0012
	(0.0019)	(0.0041)
Class size	-0.0001	-0.0001
	(0.0001)	(0.0001)
School enrollment	-0.0000	-0.0000
	(0.0000)	(0.0001)
Minority share	-0.0482	-0.0013
	(0.0787)	(0.1576)
Free lunch eligible	-0.0086	-0.0081
	(0.0075)	(0.0798)
Grade-year FE	√	√
Student FE	√	√
School FE	√	√
Peer FE		√
N	951,311	951,311

Note: The dependent variable is test score in reading. All regressions include class size, an indicator whether a student switched a school from the previous year, and school-level enrollment, minority share, and proportion of students who are eligible for free or reduced-priced lunch. Bootstrapped standard errors are in parentheses. ** and *** denote significance at the 5% and 1% levels, respectively.

Table 6: Estimates of the weight on peers

	(1) Math	(2) Reading
ϕ	0.3073***	0.1092***
	(0.0107)	(0.0161)
N	955,488	951,311

Note: The dependent variable is test score in math and reading, respectively. All regressions include class size, an indicator whether a student switched a school from the previous year, and school-level enrollment, minority share, and proportion of students who are eligible for free or reduced-priced lunch. Bootstrapped standard errors are in parentheses. *** denotes significance at the 1% level.