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The effect of charter schools on traditional public school students in Texas: Are children who stay behind left behind?

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Abstract

Texas has been an important player in the emergence of the charter school industry. We test for a competitive effect of charters by looking for changes in student achievement in traditional public schools following charter market penetration. We use an eight-year panel of data on individual student test scores for public schools students in Texas in order to evaluate the achievement impact of charter schools. We estimate a model that includes student/campus spell fixed effects to control for campus demographic and peer group characteristics, and to control directly for student and student family background characteristics. We find a positive and significant effect of charter school penetration on traditional public school student outcomes.

1. Introduction

The debate over choice reform of US elementary and secondary public schools continues to rage. Against a backdrop of measured and perceived declines in the quality of public school outputs, institutional reforms which expand choice, such as vouchers, compete with institutional reforms that expand resources, such as reductions in class size, as potential policies to enhance performance. An important claim which distinguishes choice reform from most within-institution reforms is the possibility of increasing educational outcomes for all students without increasing the allocation of resources to the educational sector. One argument for the existence of potential gains across the student population is based upon potential inefficiency within the current public education market. In particular, existing public school suppliers may not be cost efficient due to technical and/or allocative failures. Weak incentives could result in public schools operating above their relevant cost frontiers. A significant literature has developed which suggests that a lack of competition in the education market is an important root cause of this cost inefficiency. If choice reforms increase effective competition and all suppliers in the new equilibrium move toward or onto their frontiers, then across-the-board improvements in outcomes are possible. Examples of papers which develop this theme include Hoxby (2000, 2003a, 2003b), Dee (1998), and Grosskopf et al. (2004).

A second mechanism for potential systemic improvements from expanded choice is sorting. New entrants

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competing within the expanded choice environment may alter the composition of the student body at a traditional public school along some relevant dimensions. For example, the ability distribution of students may be altered by the exit of some of the highest and/or lowest ability children. The impact of compositional effects may operate through at least two channels. First, the composition of the student body may affect the instructional technique decisions of teachers. The best technique for delivering effective instruction to a classroom of students homogeneous in ability may differ from that technique which works best with a heterogeneous class. Second, the composition of the student body may directly affect achievement via peer effects. For example, adding a disruptive student to a classroom might well reduce the ability of other students to learn. Others have suggested that individual learning is affected by the mean ability of the individual's peers.[1] The direction of impact of peer effects on student achievement depends on the specific peer effect at issue, and individual student responses to the same change in peers may be quite different. The net effect of any compositional changes accompanying expansion of school choices on student performance is, obviously, ambiguous ex ante, as the precise dimension of the compositional changes and the directional impact of those changes is not clear. However, to the extent that compositional effects have a positive impact on student performance, the equilibrium sort under the new institutional structure may lead to improved performance among students remaining behind at existing public schools.

The emergence of charter schools as a type of institutional reform provides an important opportunity to test the systemic effect of competition on public school students. In particular, we test whether competition from charters leads to improved scores of students remaining in traditional public schools. Because the large majority of public students remain in traditional public schools (and this is likely to remain true for the foreseeable future), the potential benefits arising from competitive effects of charter schools on traditional public schools may be of greater importance than the direct effects of charter school attendance, which have generally received more scrutiny.[2] Charter schools operate as new public sector entrants and compete directly with traditional public schools for students. Although they retain the major defining characteristics of a public school, including public sector funding, non-selective admission, and public sector monitoring, charters are given greater degrees of freedom in dealing with certain regulations.[3] The ability of charters to differentiate their product from that offered by traditional public schools while charging the same zero tuition as public schools makes charters potentially strong competitors for existing public schools in the market for students.

One indicator of the success of charters as a whole is their rapid growth. This is a particularly valid indicator of charter viability because students attend charters voluntarily and with the option of returning to a traditional public school if charters prove unsatisfactory. During the 1994–1995 school year there were roughly 100 charter schools enrolling 25,000 students in the United States; during the 2003–2004 school year there were approximately 3000 charter schools operating with a total enrollment of about three quarters of a million students. The Center for Education Reform (2004) reports that the number of states that passed charter legislation grew from 20 in the 1994–1995 school year to 40 (plus the District of Columbia) in the 2003–2004 school year.

Texas has been an important player in the emergence of the charter school industry. The original charter legislation in Texas was passed in 1995. The first seventeen schools opened in the 1996–1997 academic year with an enrollment of 2498. By 2003–2004, almost 61,000 students were enrolled across the 190 operating charter schools. These nearly 61,000 students represent just over 1.4% of the total public school student enrollment in Texas.

In this paper we investigate the effect of charters on traditional public schools by looking for changes in student achievement outcomes in traditional public schools following charter market penetration. We utilize an eight-year panel of data on individual test scores for public school students in Texas to evaluate the achievement impact of charter schools. Using

[1] In a well-known study, Henderson et al. (1978) find that students generally perform better when the mean achievement of their peer group is higher. More recently Hoxby (2001) reports that both peer group achievement levels and peer group racial and gender composition can impact student achievement.

[2] See Booker et al. (2007) and Gronberg and Jansen (2001). Hanushek et al. (2007) also investigate the outcomes for charter students in Texas. Sass (2006) explores the performance of charter schools in Florida, while Bifulco and Ladd (2006) addresses charter school performance in North Carolina. These last two papers also explore the competitive effects of charter schools on traditional public schools, as we discuss later.

[3] Charter schools in Texas are exempt from teacher certification and minimum salary requirements, and have greater freedom in devising their curriculum. They remain subject to many of the programmatic requirements that fall on all public schools, such as those regarding special education, bilingual education, and extracurricular activities.

a value-added gain score model with student/campus spell fixed effects, we find a positive and significant relationship between charter school penetration and traditional public school student outcomes. This finding is robust with respect to three alternative measures of charter school presence. In addition to the positive average effect, we find evidence of positive differential effects of charter school penetration on performance of African-American students, Hispanic students, and upon students in low-performing campuses. These findings support the potential for systemic achievement gains from competition enhancing school reform policies.

Two recent papers have explored the effect of charter school competition on traditional public schools using methodology similar to that we employ here. Bifulco and Ladd (2006) employed data from North Carolina and found no statistically significant impact of charter school competition on reading or math performance of students in traditional public schools. Sass (2006) found evidence in data from Florida of charter entry being associated with modest improvements in math performance, but not significantly affecting reading performance. In addition to finding more evidence of positive competitive effects from charter penetration, our analysis differs from these studies in two important respects. First, both papers assess charter competition by measuring the number of charter schools within various distances from each traditional public school campus, and the enrollment of these charter schools.[4] This emphasizes the competitive forces at the campus level. However, many important school administrative decisions are made at the district level and may be influenced by the level of competition being faced throughout a district. We therefore employ measures of competition at both the level of districts and campuses. These measures of competition are discussed in Section 3. Second, in addition to studying the effect of charter competition on the general population of traditional public school students (as was the focus of the studies referred to above), we analyze the impact of charter competition on particular subgroups of the traditional public school population, including minority groups, poorly performing students, and students at poorly performing campuses. We find evidence that charter competition has a particularly positive impact on several of these groups.

The presence of charter schools has grown against the backdrop of many other reforms aimed to impact public schools thus suggesting some caution in interpreting our findings. Texas began its accountability system and the statewide TAAS testing program in the early 1990s, well before it allowed charter schools. The major impact on public schools from responding to the broad accountability system should have occurred, arguably, well prior to the genesis of charter schools. Charter schools began operating in 1996–1997 and grew rapidly beginning in academic year 1998–1999. The jump in the number of active charters in 1998–1999 occurred coterminous with a change in the charter legislation designed to encourage the formation of charters targeting academically at-risk students. This growth in charters preceded No Child Left Behind, which was signed into law in January 2002, near the end of our sample period. It is also the case that the Texas accountability system was modified over the years, and a significant change occurred in 1998–1999 when the TAAS scores of tested special education students were included in the determination of accountability ratings for the first time. The standardized testing regime was also changed from the TAAS to the TAKS effective in the 2002–2003 academic year. The various institutional changes regarding charter law and accountability system could have led public schools to take actions which impacted performance regardless of charter competition. To the extent that these institutional changes differentially impact campuses facing charter competition, the potential for confounding effects exists. To address the NCLB onset/change in testing regime concern, we estimate our model over a sample period ending in 2001–2002, the last TAAS year, and the year in which NCLB was signed into law but not yet operational. Our findings of positive charter effects are robust to this change in sample period. To address the charter law/special education accountability changes, we estimate a model which allows for differential charter effects by year. Although there does appear to be an "early year effect," the summary finding of predominately positive charter effects remains intact.

2. Charter schools in Texas

If our study of Texas charter school penetration is to provide a meaningful test of the school choice competition hypothesis, then the institutional environment must generate a viable, competitive charter sector and thus a potential traditional public school response. As argued by Hoxby (2003a) in her study of charter competition in Arizona and Michigan, institutional features such as entry and funding rules will significantly impact the viability of the charter sector. The institutional structure in

[4] Sass assesses competition from private schools as well as charter schools.

Texas, as discussed below, is one of the most supportive for the formation of successful charters in the country.

Since the passage of the original charter school legislation in 1995, charter schools in Texas have been expanding rapidly in both the number of charter schools and the number of students enrolled in charter schools. The expansion is at least partly attributable to the supportive charter law environment. At the onset of the charter school movement, the charter law structure in Texas was ranked as the seventh most charter-friendly in the United States by the Center for Education Reform (1998). At the end of our sample period, the Texas charter law environment was rated as strong, although its relative ranking among the states fell to nineteenth (Center for Education Reform, 2004).[5] The State Board of Education is the principal chartering agency in Texas. This granting structure facilitates greater competition between charters and traditional local public schools than in states in which the local public school district is also the charter-granting agent.[6]

For open enrollment charter schools in operation prior to the 2001–2002 school year, the Texas school financing rules transfer one hundred percent of the maintenance and operation formula support from the child's home district to the charter school. Note of course that per-pupil funds vary with the needs and characteristics of the student. The local district revenue implications of losing a student to a charter are thus significant. Beginning with the 1998–1999 school year an idiosyncrasy in Texas charter legislation granted charters on the condition that they serve primarily (at least 75%) academically at-risk students, and the number of charters issued to this type of school was not capped. Other open enrollment charters were subject to legislative caps. This charter law incentive structure appears to have had an effect, as well over half (45 out of 70) of the new charter schools which opened in academic year 1998–1999 were of the "75% Rule" type. The evidence suggests that this was largely a one year effect. Over the following two academic years, the number of open-enrollment charters grew by 66 while the number of 75% Rule charters increased by only 5. This distinction between charter types and chartering rules was eliminated effective in the 2001–2002 academic year.[7]

As one might expect in the early stages of charter school entry, most of the growth in students enrolled in charters was driven by the entrance of new charters, as opposed to the expansion of existing charters. As shown in Table 1, there were 17 charter schools in academic year 1996–1997, the first year of charter operation. This number of charters grew nearly tenfold to 160 by 2000–2001, and there were 190 operating in 2003–2004. Enrollment in charters also grew rapidly, from 2,498 in 1996–1997 to almost 61,000 in 2003–2004. To put this in perspective, by AY 2003–2004 charter schools were enrolling just over 1.4% of the total public school student body in Texas.

Charter schools in Texas are spatially concentrated. Although there are charter schools operating in 41 of the State's 254 counties, over 60% of charters are located in counties within the five largest metropolitan areas: Houston, Dallas-Fort Worth, El Paso, San Antonio, and Austin. These six counties (Bexar, Dallas, El Paso, Harris, Tarrant, and Travis) contain almost 48% of the population of Texas. At the same time, there are 35 additional counties in Texas containing 65 charters, and these counties account for over 24% of the population of Texas. Finally, there are 213 counties in Texas without a single charter school.

The concentration of charters in metropolitan areas might be expected, as charters must draw students away from existing traditional public schools and may find it

[5] The data from the Center for Education Reform is employed by Stoddard and Corcoran (2006) to study the political economy of support for charter schools. They find that income inequality, persistently low student outcomes, and growing population heterogeneity are associated with greater support for charter schools.

[6] Texas charter school law allows both open enrollment charter schools, which are independent school districts, and district-chartered charter schools, which are chartered by an existing public school district and function as a part of that school district. Over our sample period the number of district-charted schools was very small and limited to a 13 campuses in the Houston, Spring Branch, and Nacogdoches ISDs. There were also a smaller number of traditional public campuses that were granted district charter status while continuing operations. These seem to be operated differently than new campuses chartered by school districts. In this paper we focus on open enrollment charter schools, on the grounds that schools chartered by public school districts do not represent a competitive threat to school districts. However, it is useful to examine district-charted schools for two reasons. First, district-chartered schools certainly could compete with traditional public schools within a district. Second, even if the district-chartered schools were not a competitive threat to school districts, they could still improve traditional public school performance by enabling advantageous sorting. In any case, we estimated models with separate charter penetration measures for open enrollment charters and district-sponsored charters. Our open enrollment indicators continued to show positive and significant impacts of open enrollment charters on traditional public schools, while the district-charter indicators were not statistically significant. (We thank two anonymous referees for suggesting this robustness check.)

[7] Open enrollment charters were initially capped at 60 students for academic year 1998–1999, then 120 for 1999–2000. In 2001 the legislature eliminated the at-risk exemption and capped the number of charters at 215, while also allowing for unlimited charters sponsored by colleges or universities.

Table 1
Charter schools in Texas: number, enrollment, penetration of school districts

Year	Number of charters in operation	Total enrollment in charters	Annual charter enrollment growth	Percent of public students in charters	Number of districts with at least one charter	Total enrollment in districts with at least one charter	Percent of public enrollment in districts with at least one charter
2003–2004	190	60,748	14%	1.41	70	1,829,382	43.0
2002–2003	185	53,156	15%	1.25	70	1,815,280	43.4
2001–2002	180	46,304	22%	1.13	67	1,738,360	41.9
2000–2001	160	37,976	48%	0.94	59	1,587,469	39.1
1999–2000	146	25,687	46%	0.64	40	963,714	24.2
1998–1999	89	17,616	326%	0.31	21	940,460	23.9
1997–1998	19	4135	66%	0.10	10	632,311	16.3
1996–1997	17	2498	–	0.06	5	158,765	4.2

easier to attract a critical mass in areas of relatively high population density. This geographic concentration also suggests that the competitive effects of charters might be strongest, or at least most easily detected, in these six counties. On the other hand, school districts in major metropolitan areas may differ from school districts in other areas of the state in ways that lead to differential responses to charter school competition.

Table 1 also provides information on the extent of charter school penetration of traditional public school districts. The table provides, for each relevant academic year, the number of traditional school districts containing at least one charter school, the enrollment of the districts containing at least one charter school, and the percentage of the overall public school enrollment that is in districts containing at least one charter school. Of the 1041 school districts in Texas, the number of districts facing competition for students from at least one charter has increased from 5 in 1996–1997 to 70 in 2003–2004. These 70 districts, however, represent nearly 43% of the total public school enrollment in Texas.

3. Measuring charter school competition

A central issue in testing for the impact of charter competition is to select an appropriate measure of competition. The issue is challenging at both the conceptual and the empirical levels. There are at least three conceptual approaches to measuring the competitiveness of charters. From a pure contestability perspective, the potential for charter school entry that was created by the passage of the enabling charter school legislation is key. School districts might respond to the threat of competition without a single charter ever forming. One could perhaps empirically estimate this effect by employing an event study in which competition would be measured by date of the effective establishment of charter legislation. We do include year (by grade) indicator variables in our regression analysis, and these may control for the potential entry effect of charters on trends in student score growth. Our relative focus, however, is upon evidence of responses to various measures of realized entry rather than potential entry. A modified form of contestability would suggest that it is the presence of a competing proximal charter school that creates a meaningful competitive threat. This suggests an empirical strategy involving a type of production function study in which competition is be measured by the spatially adjusted number of charter schools.[8]

Alternatively, the effect of charter school competition may depend on the realized loss of students (reduced market share) to charters, rather than merely the potential for such loss that arises when a charter competitor enters. This suggests measuring competition as not merely the number of competing charter schools but rather the percentage of students from the district (or campus) who have exited to charters. This approach measures competition by the actual number of students—and accompanying dollars of funding—lost to charter schools. An advantage of this approach is that it counts not the number of charter schools regardless of size but instead counts the number of students that charters have successfully attracted away from traditional public schools. We adopt versions of both of these approaches in our study.

As noted earlier, we model charter penetration at the district and at the campus level. Our district penetration measure is the number of public school students who attend a charter school located within a district relative to total (traditional public plus charter) public school enrollment in that district. This measure is an approxi-

[8] Bettinger (2005), Bifulco and Ladd (2006), Eberts and Hollenbeck (2002), Greene and Forster (2002), Holmes et al. (2006), and Sass (2006) are examples of studies that use charter competition measures based on the distance between public campuses and surrounding charter schools.

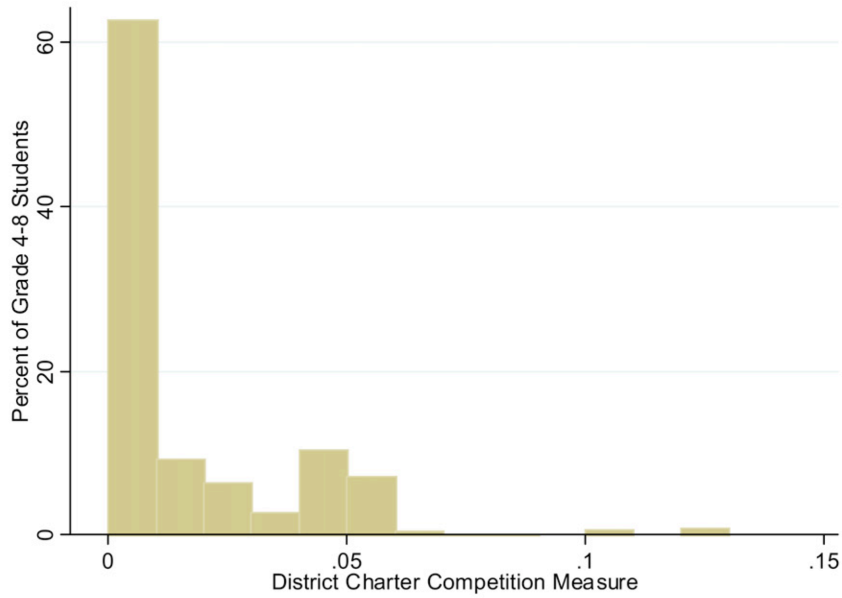

Fig. 1. Distribution of traditional public school students in grades 4–8 by the percent of students in their district that are attending charters, 2002–2003.

mation to what is arguably the ideal measure of realized competition at the district level, namely the percentage of public school students who reside in a particular district but who attend school at a charter.[9] Fig. 1 shows the distribution of students in grades 4–8 by the district charter competition that their district faces, for the 2002–2003 school year. Almost 40 percent of traditional public students are in districts with at least one charter school, almost 20 percent of students are in districts with district competition measures of 0.04 or higher.

We employ two campus-level charter competition measures. The first is based on the number of charter schools competing with a traditional public campus, and second is based on the enrollment in these competing charter schools. For each measure we differentiate between "nearby" competition, based on charter schools operating within 5 miles of the traditional public school campus, and "less near" competition, based on charter schools operating between 6 and 10 miles from the traditional public school campus. Figs. 2(a) and 2(b) show the distributions of the campus competition measures for 2002–2003. Sixty percent of traditional public students are at campuses with at least one charter school within 5 miles, and over 10 percent of those students are at campuses with 10 or more charter schools within five miles. The distributions for charters within 6–10 miles are similar, with almost 65 percent of traditional public students having at least one charter within 6–10 miles of their campus.

Our campus penetration measures are generated using data on the latitude and longitude of each charter campus and each traditional public school campus. This data was obtained through the 2002–2003 academic year, and therefore this is the terminal year of the sample used for our specifications involving campus-level charter penetration.

The district penetration measure has the possible advantage of focusing on the impact of charters at the district level, which is also the level where overall district fiscal decisions are made. Districts receive education dollars largely on a per student basis, and have a centralized decision process allocating resources among campuses. These district decision makers face the direct fiscal impact of students exiting to charters, and many important decisions regarding instructional practices are taken at the district level. For this reason it is possible that a campus that does not have nearby charter competitors but resides in a district in which charter competition is significant may exhibit some competitive response.

The campus penetration variable provides a measure of charter competition at an administrative level closer to the students we are observing. This measure more closely captures the realized impact of charter schools on campus enrollment, and allows us to distinguish the

[9] The difference is due to inter-district charter moves. If such moves are minimal in number, or if they are reasonably symmetric among districts, then the difference between the two measures will be small.

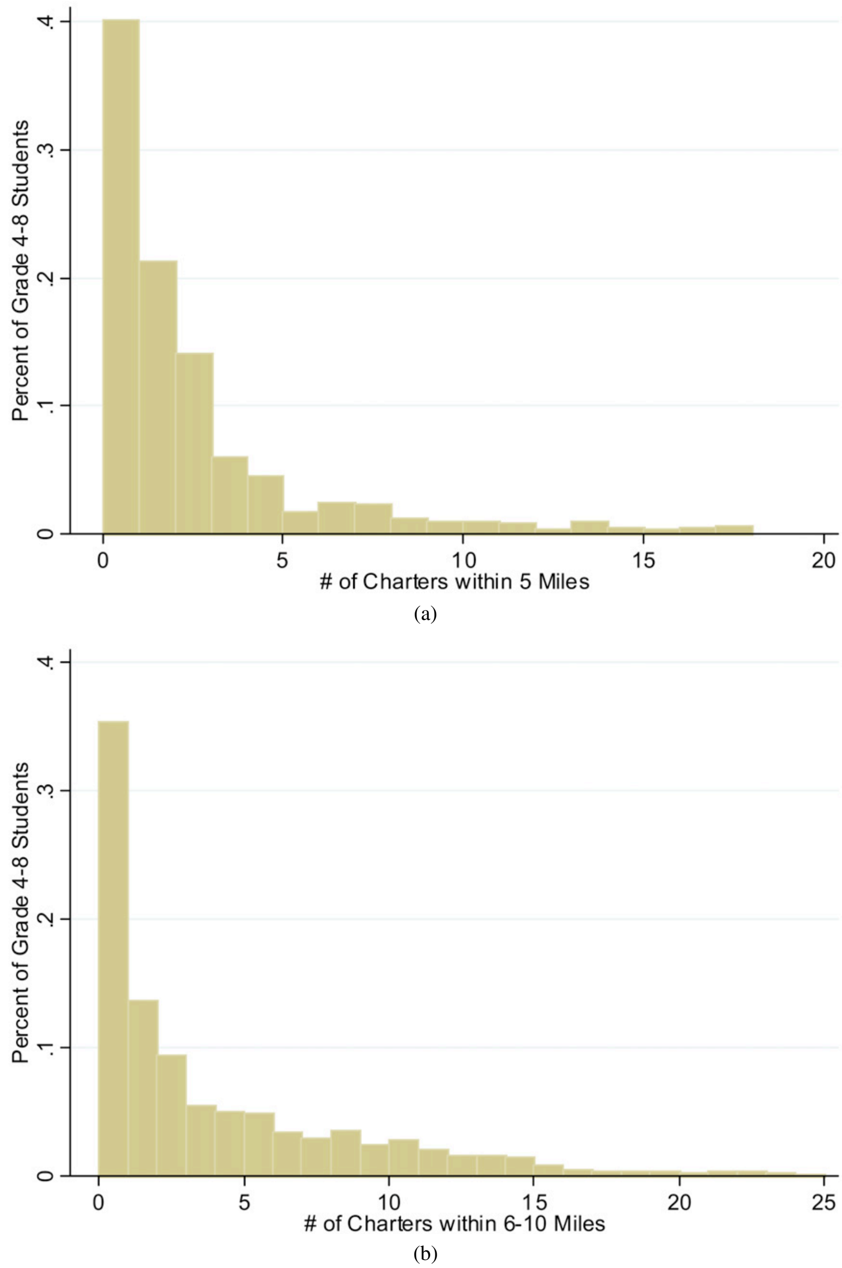

Fig. 2. Distribution of traditional public school students in grades 4–8 by number of charter schools 2002–2003. (a) Within 5 miles of their campus, (b) within 6–10 miles of their campus.

impact of charters on nearby public campuses, arguably the campuses feeling the pressure (if any) from charter competition. Fiscal decisions are made at the district level, but these decisions may allocate resources across district campuses in response to the presence of charters. In our view competitive effects may arise both through district and campus level decision-making, and may be dependent on both the presence of nearby charters drawing students from a campus as well as on the competition perceived by district decision-makers. We estimate the effect of district and campus competition separately and find that they yield qualitatively similar results indicating positive responses to charter competition. We also estimate a model that jointly includes both measures. This allows us to address whether both are present and capture distinct competitive effects, or whether the competitive response arises primarily at the district or at the campus. To preview these results, we find that the campus measures are significant and the district measures insignificant when both are included in our model.

We note that, to the extent there is a positive system-wide announcement effect concomitant with the passage of charter legislation, and given our inclusion of year (by grade) indicators as noted above, our realized competition estimates should be viewed as the effect of charter schools above and beyond that introduced by the threat of charter entry. The potential existence of a positive inframarginal announcement effect both makes the identification of marginal effects of realized competition more difficult and suggests that our realized measure effects could significantly underestimate the total effect of the charter school initiative on traditional public school students.

We also note that traditional public schools face other competition in the market for students. There is the traditional Tiebout competition[10] with other public schools, as well as competition from private schools.[11] These competitive factors are present before and after the charter legislation in Texas and the subsequent entry of charter schools. Tiebout competition may involve high transactions costs—parents have to move across campus or perhaps even district boundary lines in order to move schools—and private schools charge substantial tuition. Charter competition is unique in that parents may take advantage of the availability of a charter school at zero direct tuition cost and without moving. Thus the advent of charter schools and their growth over time allows a unique look at school competition. In estimating the charter competition effect we assume campus fixed effects control for any differential availability of Tiebout competition and private school competition across campuses and districts. To the extent that charter schools draw students away from private schools rather than from traditional public schools, the emergence of charters leads to substitution among competitors rather than to an increase in aggregate competition facing traditional public schools. This substitution effect, if relevant, will dampen our estimated effect of charter school penetration.[12]

[10] Empirical support for positive student achievement effects from Tiebout competition is found in Hoxby (2000).

[11] A recent paper on private school competition is Geller et al. (2002) This paper finds no significant effect of private school competition on public school performance.

[12] We do not have data to assess this potential substitution effect. In a recent paper, Toma et al. (2006) estimate that approximately 17% of students who enroll in charter schools in Michigan were previously enrolled in private schools.

4. The data: descriptive statistics and sampling

The data for this project were obtained from the Texas Education Agency and consist of district, campus and student level observations. The student level data consist of observations on all tested students in grades 3 through 8 for the 1993–1994 through the 2003–2004 academic years. Each student was given a unique identification number, which allows us to track individuals as long as they remain in the public school system. The data contain student, family, and program characteristics including gender, ethnicity, eligibility for a free or reduced price lunch (used here to indicate economically disadvantaged status), limited English proficiency, and participation in special education.[13]

Texas administered the Texas Assessment of Academic Skills or TAAS test in math and reading in the spring to all eligible students in grades 3 through 8 and 10 through academic year 2001–2002. Approximately 15% of students in the relevant grades did not take the test either because they were exempt or they were absent on testing days.[14] The TAAS math and reading tests each contain 40 questions.

Beginning in 2002–2003 Texas administered the Texas Assessment of Knowledge and Skills or TAKS test. The TAKS tests in math and reading are administered in the spring and the number of questions vary by subject, grade, and year. For example, there were 40 grade-3 math questions and 48 grade-8 math questions in 2002–2003. There were 36 grade-3 reading questions. Raw scores are converted to scaled scores (generally the scale is in the range 1000–3200) and performance standards (met standard, commendable) are fixed values in the scaled distribution.

In order to compare performance across years and in particular across testing environments, we standardize our test score measures using rank-based Z scores.[15] This transformation fits the statewide distribution of test

[13] Due to confidentiality concerns at TEA, the data on student characteristics such as ethnicity are masked if there are fewer than five students in a cell in a single grade at a campus. Thus if there is only one Hispanic student in fifth grade at a school in particular year, that student's ethnicity is listed as missing. In addition, while we have an indicator for participation in special education, we do not have information on the student's specific disability. Thus the special education indicator encompasses a very wide range of students, from those with speech difficulties or learning disabilities to the deaf or blind.

[14] Certain special education students and limited English proficiency students are exempted from the TAAS if a school committee determines that the test is not educationally appropriate for the student.

[15] For a discussion and application of rank-based Z scores, see Gill et al. (2005).

Table 2
Student demographics: charters and traditional public schools, 2003–2004

Student characteristic	Charter students	Traditional public students	Traditional public students in districts with charter schools
Percent White	18.4	39.0	26.4
Percent African-American	39.0	13.9	17.7
Percent Hispanic	40.9	43.8	52.9
Percent Asian	1.4	3.0	2.7
Percent native American	.3	.3	.3
Percent FRL eligible	63.1	52.7	61.5
Percent limited English proficient	9.1	15.4	20.1
Percent in special education	11.3	11.6	11.2
Percent in career and technology	15.8	20.2	19.6
Percent gifted and talented	1.0	7.9	8.5
Percent classified as at-risk*	51.7	37.7	41.1

* At-risk percentages taken from campus level TAAS data, and reflect % at-risk in grades 3–8 and 10.

scores onto a standard normal distribution by grade, year, and test (math or reading). A student is ranked in the statewide test distribution for a subject, grade, and year. The ranking for the set of all test students by subject, grade, and year is then normalized to the unit interval and each student's rank-based Z score is the inverse cumulative distribution function applied to the ranks on the unit interval. From these rank-based Z scores we can calculate an individual student's gain in test performance over time as the change in the rank-based Z score, effectively the change in the student's ranking in the distribution from one year to the next.

Rank-based Z scores are similar to Normal Curve Equivalent (NCE) scores, in that they fit the scores onto a normal distribution by grade, subject, and year. The difference is that NCE scores are typically reported on a scale of 1 to 99 with a mean of 50, whereas rank-based Z scores have a mean of zero and a standard deviation of one for each grade and subject. This standardization forces the state-wide average student test score "growth" to be equal to zero from one year to the next. Different tests often have different test score distributions, especially when the testing regime changes, which can lead to problems comparing test score growth across students. By converting each test to a normal distribution prior to computing student test score growth, we ensure that student test score growth is treated comparably across grades, years, and subjects.[16]

It is useful to identify the characteristics of students who attend charter schools in Texas, if only as background to our analysis of the competitive impact of those students remaining in traditional public schools. Charter schools as a whole are particularly heterogeneous in terms of student characteristics, as there are charters which enroll primarily gifted and talented students, as well as charters which service students who are performing poorly academically. Table 2 provides a comparison of students enrolled in charters schools with students enrolled in traditional public schools. Charter schools serve a substantially smaller share of Anglo students, and a substantially larger share of African-American students, than do traditional public schools. Charters have a larger percentage of economically disadvantaged students (defined as those eligible for a free or reduced price school lunch) than traditional public schools.[17] Finally, charters, on average, have lower percentages of their students labeled as special education students, a lower percentage of students labeled limited English proficiency, a lower proportion of gifted and talented students, and a lower proportion of students in career and technology programs.

Our full sample of students in Texas contains 14,461,466 individual student-year observations and is too large to allow us to use the full sample for estimation. Because of this, we randomly sampled from our complete data set. We are interested in seeing the impact on public school students in public schools facing charter competition, in that we want to measure the impact of charter penetration on student achievement in public schools. Thus we adopt the following sampling rules. First, we keep every student in a district with fewer than

[16] We use rank-based Z scores because our sample includes both TAAS and TAKS testing regimes.

[17] Note that this comparison treats as missing data the 31 charter schools that reported zero disadvantaged students. These are most likely schools that have chosen not to participate in the federal school lunch program, rather than schools that in fact have zero economically disadvantaged students.

Table 3
Summary statistics for estimation sample

Variable	Overall sample mean	Mean for students in districts with charters	Mean for students in districts w/o charters
Number of student-year observations	1,316,667	1,029,565	287,102
Number of unique students	428,959	336,921	92,038
District geographic percent charter	.007	.009	NA
	(.016)	(.018)	
Number of charters within a 5-mile radius of public campus	.943	1.13	.262
	(2.23)	(2.45)	(.899)
Number of charters within a 6–10 mile radius	1.67	1.84	1.04
	(3.36)	(3.51)	(2.64)
At least one charter within a 5-mile radius of public campus	.313	.362	.136
At least one charter within a 6–10 mile radius of public campus	.143	.138	.159
Number of charter students within a 5-mile radius of public campus (divided by 1000)	.219	.264	.058
	(.663)	(.731)	(.247)
Number of charter students within a 6–10 mile radius of public campus (divided by 1000)	.382	.416	.263
	(.954)	(.999)	(.758)
African-American	.163	.184	.090
Hispanic	.401	.431	.290
Free/Reduced price lunch eligible	.480	.513	.366
Limited English proficient	.064	.072	.034
Special education	.056	.056	.054
Standardized Math score	−.013	−.056	.143
	(.978)	(.984)	(.939)
Standardized Reading score	−.004	−.042	.134
	(.969)	(.976)	(.932)
Change in Math score	−.005	−.007	.004
	(.674)	(.677)	(.664)
Change in Reading score	.003	.003	.005
	(.704)	(.705)	(.699)
Campus percent African-American	.162	.180	.100
Campus percent Hispanic	.414	.442	.315
Campus percent FRL eligible	.530	.559	.425
Campus percent limited English proficient	.132	.144	.088
Campus percent special education	.124	.123	.128

Notes. Standard deviations for non-binary variables shown in parenthesis. A district with a charter refers to a district with at least one charter school located within that district's boundary.

5000 students if that district ever had a charter within its boundaries during our sample period. We keep 20% of the students (randomly chosen) in districts with more than 5000 students that ever housed a charter during our sample period. For districts that never faced immediate charter competition (i.e. never had a charter operating within the district), we keep 10% of students in districts with less than 5000 students, and 5% of students in districts with more than 5000 students. The sampling was done at the student level, so that if a student is kept in the sample all observations on that student are kept in the sample. Students moving districts were assigned for sampling purposes to the district in which they were observed most frequently. All regression results reported below are weighted to account for the differential sampling probabilities, where the weight is the inverse of the probability that a student would be chosen for our sample.[18] Finally, students who are ever observed in a charter school are dropped from our sample.

[18] The district competition measures are estimated to have somewhat larger impacts in the reduced sample, while the campus competition measures have similar magnitudes to the full sample.

Table 3 contains descriptive information on variables in our data sample. The second column reports on our entire sample, while the third column reports on students in districts that have charters schools operating within any year of our sample, and the fourth column reports on students in districts without charters in any year in our sample. Thus we have 1,316,667 observations (student-years) consisting of 1,029,565 observations in districts with charters and 287,102 observations in districts without charters. We have almost 337,000 students from districts with charters, and over 92,000 students from districts without charter competition. The mean measure of charter competition in districts facing charter competition is just under 1%, and the average number of charters within a 5-mile radius of a public campus in districts facing charter competition is 1.13, versus 0.26 for districts not facing charter competition. Note that, because our district measure is the percent of students within a district boundary attending charter schools, while our campus measure is the number of charters within a certain radius of a campus, districts might face no competition by our district measure and yet have charters within a certain geographic radius of one or more of its campuses. This would be especially likely for campuses near district boundaries. It should also be noted that in Table 3 the means have not been weighted to reflect differential sampling probabilities. Thus there are differences in the descriptive statistics describing the overall student population (Table 2 column 3) and our estimation sample (Table 3 column 2).

Table 3 shows that districts facing charter competition serve a larger proportion of African American students and Hispanic students than districts not facing charter competition. Districts facing charter competition have larger proportions of students eligible for free or reduced price lunches and serve a higher proportion of limited English proficient students. Districts facing charter competition had students scoring lower on math and reading tests, and the change in test scores was lower.

5. Empirical model

We use a value-added measure of student performance, so that student—and school—performance is measured as the increase in a student's academic achievement. A value-added specification addresses a number of potential problems associated with omitted or mismeasured inputs, especially missing measures of school and family inputs from past years. Todd and Wolpin (2003) are less sanguine in their view of the value-added specification, and discuss the restrictions on education production technology implied by different specifications. The restricted value-added specification we employ (in which the coefficient on the lagged test score is fixed to unity) expresses the current year test score gain solely as a function of contemporaneous inputs and implies that the effect on test performance of an individual's ability endowment and of educational inputs is independent of age.

Our base model is of the form

$$\Delta A_{it} = \beta_1 S_{it} + \phi_c + \mu_i + \varepsilon_{it} \tag{1}$$

where ϕ_c is the campus fixed effect, A_{it} is the achievement of student i in year t, S_{it} is a vector of school inputs, μ_i is the student fixed effect, and ε_{it} is the error term.[19]

The inclusion of student fixed effects effectively controls for student ability and other time-invariant student or student family characteristics. Our ability to link students to campuses also allows us to include campus fixed effects, in order to control for time-invariant campus characteristics including average campus scores and the peer composition of campuses to the extent that these are relatively invariant over time. Ideally we would include a complete set of student and campus fixed effects in our regressions as specified in Eq. (1), but as this is computationally intractable with our large student sample we instead adopt a reduced set of campus-student fixed effects called spell fixed effects, which combine each unique campus-student combination into a single 'spell' that is estimated as a fixed effect. In employing spell fixed effects we follow Bifulco and Ladd (2006) and Sass (2006). As they note, the spell effect captures unobserved individual and school heterogeneity.[20] This yields the following equation:

$$\Delta A_{it} = \beta_1 S_{it} + \theta_{ci} + \varepsilon_{it} \tag{2}$$

where θ_{ci} is the campus-student spell effect for campus c and student i.

This specification controls for time-invariant campus and student characteristics, and for large samples is a close approximation of the model with separate campus and student fixed effects. The spell effects model

[19] We investigated the robustness of our results to altering our restricted value-added model to allow the coefficient on lagged test scores to be less than unity. We estimated the model imposing that this 'persistence' coefficient is 0.8, 0.6, 0.4, and 0.2. As the persistence coefficient gets smaller, the size of the estimated charter penetration coefficient declines, but it remains positive and statistically significant.

[20] Spell fixed effects are introduced in Abowd et al. (1999), and Andrews et al. (2006) have an extensive discussion of spell fixed effects.

also has the advantage that the effects resulting from the model are relatively easy to interpret, as they represent the difference between test score gains for students at the campus while it was in treatment, relative to the test score gains of those same students while they were at that same campus when it was out of treatment, or faced lower levels of treatment.

One might be concerned that charter competition is endogenous, and likely to arise when traditional public schools are performing poorly. Bifulco and Ladd (2006) and Sass (2006) both argue that the inclusion of student and campus fixed-effects effectively controls for this endogeneity bias, by eliminating any time-invariant characteristics of a district or campus that might lead to greater charter penetration.[21]

Identification in our model is based upon students for whom we have multiple observations at the same school. If turnover rates are high in campus neighborhoods where charters locate, then a potential selection problem can arise. Students who are observed multiple times at the same school may be more likely to make large gains (say do to the increased stability of their home environment) than are more transient students. If charters locate in relatively high turnover campus neighborhoods, and if the students who contribute to identification from those campuses are relatively concentrated among the stayers, then a positive relationship between charter penetration and achievement gains could be induced independent of any public school response to charters. Given this concern, we looked into the possibility that schools facing charter competition had a relatively small proportion of stable students. For districts that ever had charters, 89.3% of students who could potentially be in our estimation sample, i.e. those how have two or more years of test scores, are contributing to identification by having at least two tested years at the same campus. For districts that have no charters, the comparable figure is 88.2%. These features of the data alleviate much of the concern over this potential selection issue.[22]

Our measure of academic achievement is the rank-based Z score on the annual Texas statewide exam, either TAAS or TAKS, and our value added measure is the change in this rank-based Z score. Our access to individual student data allows us to measure student performance as individual student change in test score, and to measure school performance as the school average of individual student change in test score. In contrast, many researchers without access to student level data have looked at changes over time in school average test scores.

6. Results

6.1. *Effects in baseline specifications*

Table 4 presents our first set of results. These are the estimated effect of district-level charter competition, defined as the percent of students in grades 3–8 that attend a charter school within the geographic boundaries of the public school district. We include campus-student spell fixed effects, as well as measures of movers (across

Table 4
Effect of charter penetration on math and reading performance: district level charter competition measure

Variable	District-level competition	
	Math	Reading
Percent of students in geographic district attending charter schools	3.81	3.03
	(1.06)	(.844)
District mover	−.050	−.030
	(.015)	(.016)
Structural mover	−.108	−.071
	(.012)	(.011)
Campus mover	−.108	−.066
	(.014)	(.012)
Student in special education	.017	.018
	(.023)	(.024)
Sample size	1,316,667	1,309,109

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects.

[21] There is the possibility that charters are more likely to locate near schools that had been experiencing a bad spell of particularly low achievement, an Ashenfelter dip. We examine this by including indicators for a student being in a district facing charter competition, and a separate indicator for a student being in a district that will face charter competition in the immediate future year. There is no evidence of an Ashenfelter dip, of campuses having lower performance in the year prior to charter entry. If anything the coefficient estimates indicate that traditional public campuses may have been responding to the imminent opening of charter schools by improving performance in the year prior to charter opening. Since charter opening is announced in advance, this is consistent with a competition story.

[22] As an additional selection diagnostic, we also estimated our baseline model using data from the pre-charter period 1994–1996 and employing the charter competition measures from the last two years in our sample. For this “faux competition” regression, only one of the six estimated charter competition variables (two district measures and four campus measures) was positive and significant. This evidence further allays selection concerns. We thank an anonymous referee for drawing our attention to this selection issue and for suggesting the “faux competition” test.

Table 5
Effect of charter penetration on math and reading performance: campus-level competition measures

Variable	Campus-level competition (# of charters within an N-mile radius)		Campus-level competition (# of charter students—in thousands—within an N-mile radius)	
	Math	Reading	Math	Reading
# of charters within 0–5 miles of public campus	.021	.021	NA	NA
	(.006)	(.005)		
# of charters within 6–10 miles of public campus	.010	.008	NA	NA
	(.004)	(.003)		
# of charter students within five miles of public campus (divided by 1000)	NA	NA	.061	.065
			(.023)	(.020)
# of charter students within 6–10 miles of public campus (divided by 1000)	NA	NA	.047	.030
			(.014)	(.012)
District mover	−.051	−.024	−.051	−.024
	(.017)	(.017)	(.017)	(.017)
Structural mover	−.107	−.071	−.106	−.071
	(.013)	(.012)	(.013)	(.012)
Campus mover	−.104	−.060	−.103	−.060
	(.014)	(.013)	(.014)	(.013)
Student in special education	.020	.018	.019	.018
	(.024)	(.026)	(.024)	(.026)
Sample size	1,199,938	1,193,323	1,199,938	1,193,323

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects.

district boundaries, non-structural moves within district boundaries, and structural moves[23]) and an indicator for the student being in special education (which can change over time). The second column reports the results for the math test, the third column for the reading test. For the math test, the coefficient estimate of 3.81 on the district measure of charter competition is statistically significant. An increase in charter competition of 1 percentage point—a large change, given that the average measure of charter competition in a district facing charter competition is about 1 percent—is estimated to increase the student math gain (change in rank-based Z score) of .038. These rank-based Z scores have a standard normal distribution with standard deviation of unity, so a .038 increase is important but fairly modest in size. However, when one looks at the implications of our estimated effect of charter competition for students in districts where charters are a significant presence in the market the impact appears very substantial. Consider that in 2004 charter enrollment in the two largest districts in Texas, Houston and Dallas, had reached 4.7% and 5.9% respectively. Our estimate of the effect of district charter penetration implies that if charter enrollment constitutes 5% of students in a district this level of competition would yield a .19 average increase in student math test gains.

The coefficient of district charter competition is 3.03 in reading, also statistically significant. This suggests that an increase in district charter competition of one percentage point (basically doubling the average level of district charter competition among districts facing charter competition in our sample) would results in an increase in student reading test gains of .030. Again at a high level of charter penetration of 5% yields the implication is a .15 average increase in student reading test gains, which is quite substantial.

Table 5 presents our results using two alternative campus-level measures of charter competition. Columns two and three report coefficient estimates for math and reading, respectively, when we measure charter penetration based on two variables, the number of charter campuses within 0–5 miles of a public school campus and the number of charter campuses within 6–10 miles of the public school campus. For the math test, the coefficient on the number of charter campuses within 0–5 miles is .021 (and statistically significant), and the coefficient on the number of charter campuses within 6–10 miles is .010 (and statistically significant). To interpret these coefficients, recall from Table 3 that the mean number of charter campuses with 0–5 miles of

[23] A structural move is defined as one in which a student moves with 30% or more of his cohort (e.g. progressing from elementary to middle school). See Hanushek et al. (2004) and Booker et al. (2007) for more discussion of mover effects and differences between types of moves.

a public school campus is nearly one. So if this number would increase by one, more than doubling, the effect is to raise math test scores by .021. Again this is a change in a standard normal distribution, and is the same order of magnitude, but smaller, as the estimated impact of roughly doubling the measure of district competition. The coefficient on the number of charters within 6–10 miles of a public school campus should be interpreted in light of the mean number of charter campuses within this distance of a public school campus, nearly 1.7. Raising this number by one is estimated to increase math test score gains by .010. Thus the impact on math test score gains is stronger for charters located closer to public school campuses, an intuitively plausible result.

As we did with the district penetration measure, we can ask what the implied magnitude of the effect of campus penetration is for schools facing a high degree competition. In 2003 the median number of charter campuses with 5 miles of a traditional public school in Houston and Dallas was 7 and 6 respectively (average numbers are slightly larger). The numbers between 5 and 10 miles were 22 and 20. Again at a high level of charter penetration, 6 charter schools within 5 miles and 20 between 5 and 10 miles, implies a substantial effect on average student performance. In this case the implication is a .326 average increase in student math test gains.

For reading the results follow a similar pattern. The coefficient on the number of charters within 0–5 miles is nearly identical to the analogous coefficient for the math test, .021, and statistically significant. The coefficient on the number of charters within 6–10 miles is .008 and statistically significant but somewhat smaller in magnitude than the analogous coefficient for the math test. As with math, the implication for campuses facing a high level of charter competition is substantial. Given 6 charter schools within 5 miles and 20 between 5 and 10 miles the implication is a .286 average increase in student reading test gains.

The fourth and fifth columns of Table 5 provide estimates for math and reading, respectively, when the campus-level measure of charter competition is the number of students enrolled in charter campuses within 0–5 miles, and 6–10 miles, of a public school campus. For the math test gains, the coefficient on number of charter school students within 0–5 miles is .061, and the coefficient on the number of charter school students within 6–10 miles is .047. From Table 3 the average number of charter students within 0–5 miles is .219 (in thousands), and the average number of charter students within 6–10 miles of a public campus is .382 (thousand). Thus the coefficient .061 suggests that a doubling of the number of charter school students within 0–5 miles would increase math test score gains by .013, and a doubling of the number of charter school students within 6–10 miles would increase math test score gains by .018. These are statistically significant coefficients and the magnitudes of the effects are in rough agreement with the other estimated impacts of charter competition for math test score gains.

Table 6
Effect of charter penetration on math and reading performance: district and campus-level competition measures jointly estimated

Variable	District and Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading
Percent of students in geographic district attending charter schools	2.11	1.47
	(1.32)	(1.06)
# of charter students within five miles of public campus (divided by 1000)	.016	.018
	(.006)	(.005)
# of charter students within 6–10 miles of public campus (divided by 1000)	.0086	.007
	(.004)	(.003)
District mover	−.051	−.024
	(.017)	(.017)
Structural mover	−.107	−.071
	(.013)	(.012)
Campus mover	−.102	−.060
	(.014)	(.013)
Student in special education	.019	.018
	(.024)	(.026)
Sample size	1,199,938	1,193,323

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects.

For reading test gains the estimated coefficient on the number of charter school students within 0–5 miles of a public school campus is .065, and the estimated coefficient on the number of charter school students within 6–10 miles is .030. These coefficients are both statistically significant. The effects on reading test gains are similar in magnitude to the estimated impact on math test gains.

It is certainly possible that our measures of charter competition at the district level and at the campus level capture different competitive forces and responses to these forces. Table 6 provides estimates of competitive effects from a specification including both the district and the student-enrollment based campus competition measures. For both reading and math the estimated effect of district-level competition is approximately half what we found when district competition was employed exclusively, and is no longer statistically significant. The estimated effects of campus-level competition fall in the joint specification relative to that in which only campus-level effects are included, but the decline is fairly small in both math and reading and all estimates remain significantly positive. These results suggest that competitive effects are felt and, importantly, responded to, more at the campus level than at the district level.[24]

The major changes in institutional environment that we identified in the introduction motivate two robustness checks to our baseline model estimates. First, we estimate our model limiting our sample to the TAAS years, i.e. ending in the 2001/2002 school year. We find positive and statistically significant impacts of charter school penetration on traditional public schools in this TAAS-only sample, consistent with our results over the entire period. Second, we interact our charter penetration variable with time to estimate a model that allows for the charter effect to vary by year. The evidence from the early start-up years is mixed for our district competition measure, with negative and significant coefficients for two of the three startup years (1996–1997, 1997–1998, 1998–1999), although with positive and significant coefficients for all other years. The evidence from our campus competition measure (our preferred measure, based on Table 6) is more uniformly positive for campus charter competition of 0–5 miles, with all coefficients positive (and all statistically significant except for an early year) over the entire 1996–1997 through 2002–2003 period. The coefficients on charter competition of 6–10 miles are less uniformly positive in the early years, but all statistically significant coefficients are positive and the (insignificant) negative coefficients occur in the three early years for the reading test results and one early year for the math test results. Estimation results are reported in the appendix, Tables A.1 and A.2.

The early years are marked by a small number of charters and little charter penetration, and the standard errors on coefficients in the first three years (and especially the first two years) are noticeably larger than the standard errors on coefficients in later years. Given the small number of identifying observations in these early years, as well as the uncertainties as to the viability of charters as a choice competitor, the mixed infant year results are not completely surprising. It is also the case that the estimated charter effects for 1998–1999, a year of dramatic growth in charters, are systematically different from the estimates over the last five years of the sample. At the district level, the estimated charter coefficients are negative and significant, and at the campus level, the estimated charter coefficients are positive but much smaller in magnitude. One possible explanation for this pattern is that charters, particularly at-risk charters, might have located near schools that were scrambling to meet the new accountability standards for their special education students. The reallocation of resources toward special education kids may have lowered performance for their average student. The estimated charter coefficients for this year may be dominated by a negative accountability system change effect.[25] During the more mature phase of the charter institution, the evidence for the charter competition effect is consistently positive and statistically significant.

6.2. Subgroup effects

We next turn to an examination of the potential differential impact of charter competition by student ethnic characteristics and by student or campus achievement levels. Table 7 reports separate estimates of the impact of charter penetration for African American, Hispanic, and all other students (White, Asian American, and others). We report two sets of estimates. Columns two and three report estimates for district charter penetration measures interacted with our ethnic categories, for math and reading tests respectively. For math test gains the coefficient estimates on district charter penetration are 4.77 for African American students, 4.17 for Hispanic students, and 1.44 for all other students. The first two coefficients are statistically significant, and indicate that charter penetration has a larger and more statistically significant impact on academic achievement of traditional public school African American and Hispanic students. In fact, an increase of one percent in the number of students attending charters within a district's boundaries is estimated to increase math test gains for African American students by almost .05, and to increase math test gains for Hispanic students by over .04.

The reading test gain coefficients exhibit a similar pattern, with a coefficient on district charter penetration of 4.46 for African American students, 3.26 for Hispanic students, both statistically significant, and a statistically insignificant .008 coefficient on all other students. Again, an increase in district charter penetration of one percent is estimated to increase reading test score gains by over .04 for African American students and by over .03 for Hispanic students, while leaving

[24] The correlations between the district and campus competition measures are .61 for the district measure and the 0–5 mile campus measures, and .48 for the district measure and the 6–10 mile campus measures.

[25] We thank the anonymous referees for drawing our attention to these two robustness checks. The estimates of yearly charter school effects are reported in the appendix. The estimates of the model for the TAAS sample period are available upon request.

Table 7
Charter penetration effect on African-American, Hispanic, and other students

Variable	District-level competition		Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading	Math	Reading
District geographic charter percent, student is African-American	4.77 (1.65)	4.46 (1.27)	–	–
District geographic charter percent, student is Hispanic	4.17 (1.22)	3.26 (1.06)	–	–
District geographic charter percent, other students	1.44 (1.03)	.008 (.994)	–	–
# of charters within five miles of public campus, student is African-American	–	–	.023 (.009)	.030 (.008)
# of charters within five miles of public campus, student is Hispanic	–	–	.017 (.007)	.017 (.007)
# of charters within five miles of public campus, other students	–	–	.012 (.010)	.004 (.009)
# of charters within 6–10 miles of public campus, student is African-American	–	–	.022 (.006)	.013 (.006)
# of charters within 6–10 miles of public campus, student is Hispanic	–	–	.013 (.005)	.012 (.004)
# of charters within 6–10 miles of public campus, other students	–	–	−.001 (.005)	.000 (.005)
Sample size	1,316,667	1,309,109	1,199,938	1,193,323

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects, student mover variables, and an indicator for the student being in special education.

reading test score gains for other students basically unchanged.

We also report estimates for one measure of campus level charter penetration, the measure based on number of charters within a 5-mile radius, and number of charters within a 6–10 mile radius. For math test score gains, the impact on African American students is estimated as .023 for the number of charters within a 5-mile radius, and .022 for the number of charters within 6–10 miles. Both coefficients are statistically significant, and indicate that an increase by one in the number of charter schools within 5 miles (slightly more than doubling the average number for public schools facing charter penetration) would increase African American students math test gains by .023, and increasing the number of charters within 6–10 miles by one (increasing the average by about two thirds) would increase African American test gains by .022. For Hispanic students, the estimated effects are smaller in magnitude but still statistically significant, .017 for charter campuses within 0–5 miles and .013 for charter campuses within 6–10 miles. The coefficient estimates for other students is smaller than the estimates discussed above but still statistically significant for charters within 0–5 miles, .012. The coefficient estimate for other students for charters within 6–10 miles is small in magnitude and statistically insignificant.

For reading test score gains the results are similar. For African American students the estimated coefficients are both statistically significant, and the impact of charter campuses within 0–5 miles is .030, even larger than the analogous coefficient estimate for math test gains. For Hispanic students the estimated coefficients are both statistically significant and very close in magnitude to the estimated coefficients for math test gains. For other students, both coefficients on charters within 0–5 miles and charters within 6–10 miles are statistically insignificant and small in magnitude.

Overall, our results suggest that charter penetration, whether measured at the campus or district level, has a larger impact on public school African American and Hispanic test score gains than on test score gains of other public school students. The exact source of this difference is open for interpretation, but the fact that charter schools enroll disproportionately more African American and Hispanic students than public school campuses in districts facing charter competition suggests that competition for these students is a possible explanation. A sorting impact of charters is another possibility, as charters may lead to traditional public schools with more homogeneous student bodies in terms of motivation and ability. Charters may provide an outlet to students unsuccessful in traditional public schools,

Table 8
Charter penetration effect by student initial achievement quartile

Variable	Lowest quartile	Second quartile	Third quartile	Highest quartile
Math, District-level geographic charter competition	4.67	5.21	4.99	4.98
	(1.53)	(1.34)	(1.17)	(1.22)
Reading, District-level geographic charter competition	4.50	3.58	4.45	3.54
	(1.33)	(1.15)	(1.18)	(1.10)
Math, # of charters within five miles of public campus	.021	.026	.029	.037
	(.009)	(.008)	(.009)	(.010)
Math, # of charters within 6–10 miles of public campus	.019	.014	.009	.002
	(.006)	(.006)	(.006)	(.006)
Reading, # of charters within five miles of public campus	.026	.023	.037	.023
	(.008)	(.008)	(.008)	(.009)
Reading, # of charters within 6–10 miles of public campus	.013	.008	.006	.007
	(.005)	(.006)	(.006)	(.006)

Notes. The table has the results from sixteen different regressions: math and reading, district-level and campus-level competition, four different student quartiles. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects, student mover variables, and an indicator for the student being in special education.

and such unsuccessful students may provide poor peer interactions and behavioral issues if left in the classroom. Sorting may explain our results, to the extent that African American and Hispanic students tend to be enrolled in traditional public schools that have unmotivated students and students with behavioral problems, and to the extent that charters help remove these students from the traditional public school classroom.

We also look at the impact of charter competition for students and schools at various levels in the performance distribution on the Texas statewide tests. Charter schools in Texas seem to attract students who perform poorly on the statewide Texas tests. Because of this, one might expect that schools facing charter competition would divert resources toward improving the performance of their lowest-performing students, students who appear to be most attracted to charter schools. Table 8 looks at the impact of charter competition on students by the achievement quartile of the student in the first year they are observed in our sample, where the achievement quartile is in terms of student test score (and not test score gains). Table 8 summarizes results of sixteen different regressions: math and reading, four different initial achievement quartiles, for our district level charter penetration measure and for one campus-level charter penetration measure.

Table 8 provides mixed evidence favoring the hypothesis that the impact of charter penetration at public schools is differentiated by student test score levels. For district level charter penetration, math test score gains are positive and statistically significant for all initial student achievement quartiles, and if anything the magnitude of the impact rises as initial student achievement rises. For reading test score gains, the impact is positive and statistically significant, and the magnitude of the impact is not monotonic in the initial student achievement level. When we measure charter penetration at the campus level (using number of charters within a geographic area), the results for math gains are statistically significant and impacts increasing with initial student achievement for charter campuses within 0–5 miles of a public campus, while the impacts decrease with initial student achievement for charters within 6–10 miles of a public campus and are insignificant for the highest two quartiles of initial student achievement. For reading the results are also statistically significant but not monotonic in initial student achievement for charter campuses within 0–5 miles, and statistically significant only for the lowest level of initial student achievement for charter campuses within 6–10 miles. Thus we find no clear-cut relationship between the impact of charter penetration and initial student achievement.

Another hypothesis is that the effect of charter penetration varies by the initial average achievement level at the public school campus. Thus if districts reallocate resources across campuses based on charter penetration, this reallocation may take the effect of providing more resources to campuses that are performing poorly and perceived as most in danger of losing students to charters. Table 9 reports estimates that bear on this issue, investigating whether student performance gains from charter penetration occur mostly in high-performing campuses or mostly in low-performing campuses. We develop a ranking of campuses in the 1993–1994 academic year using campus average math and reading test scores, in order to assign campuses to quartiles. We create indicators to assign each campus to each quartile and interact these indicators with our measures of charter competition, either district-level or campus-level. Our models already include student and campus

Table 9
Charter penetration effect by campus initial performance quartile

Variable	District-level competition		Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading	Math	Reading
District geographic charter percent, campus in lowest quartile	6.06	5.51	–	–
	(1.55)	(1.16)		
District geographic charter percent, campus in second quartile	3.89	3.14	–	–
	(1.80)	(1.47)		
District geographic charter percent, campus in third quartile	−.320	−.871	–	–
	(2.14)	(1.32)		
District geographic charter percent, campus in highest quartile	−1.08	−0.992	–	–
	(2.57)	(1.89)		
# of charters within five miles of public campus, campus in lowest quartile	–	–	.016	.021
			(.008)	(.007)
# of charters within five miles of public campus, campus in second quartile	–	–	.029	.027
			(.014)	(.013)
# of charters within five miles of public campus, campus in third quartile	–	–	.012	.006
			(.016)	(.015)
# of charters within five miles of public campus, campus in highest quartile	–	–	.010	.004
			(.011)	(.012)
# of charters within 6–10 miles of public campus, campus in lowest quartile	–	–	.023	.020
			(.006)	(.006)
# of charters within 6–10 miles of public campus, campus in second quartile	–	–	.008	.006
			(.010)	(.007)
# of charters within 6–10 miles of public campus, campus in third quartile	–	–	.011	−.000
			(.009)	(.009)
# of charters within 6–10 miles of public campus, campus in highest quartile	–	–	−.002	.001
			(.006)	(.006)
Sample size	1,174,861	1,168,144	1,081,216	1,075,314

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects, student mover variables, and an indicator for the student being in special education.

spell fixed effects, so we control for time-invariant campus characteristics, but the magnitudes of the estimated coefficients on these interaction terms allow us to draw conclusions about the differential impact of charter penetration on students at a campus by campus performance levels in 1993–1994.

The results in Table 9 report a dramatic difference between the impact of charter competition on students attending campuses in the bottom and top halves of the initial campus performance levels. For the district competition measure, the impact on students attending public school campuses in the bottom quartile is estimated to be 6.06, while it falls to 3.89 for the second quartile, −.32 for the third quartile (and statistically insignificant), and −1.08 for the highest quartile (and again statistically insignificant). Results for reading test score gains follow a similar pattern. Thus students at public schools in the bottom half of the initial campus achievement distribution are strongly positively impacted by charter penetration, while students at campuses in the top half of the initial campus achievement level are not.

We also look at campus level penetration measures based on number of charters within 0–5 miles and within 6–10 miles and find the same basic pattern of results—students in schools in the bottom half of the initial campus achievement level are positively and statistically significantly impacted by charter penetration, while the estimated impact on students in school in the top half of the initial campus achievement level is not statistically significant. This pattern holds for the number of charters within 0–5 miles, and for the number of charters within 6–10 miles the impact is only statistically significant for public campuses in the bottom quartile of the distribution of initial campus achievement levels.

The results in Table 9, together with results in Tables 5 and 6, suggest that charter penetration is effective at raising student performance levels of students remaining behind in traditional public schools, especially when students are at schools that were performing below average in 1993–1994. Thus charter penetration increases performance of students at traditional public schools, and differentially increases the performance of students at traditional public schools that were underperforming relative to other public schools.[26]

In order to gain more perspective on our results regarding student ethnicity, campus initial performance quartile, and charter penetration, we estimated models interacting student ethnicity with campus initial performance quartile. These results are reported in Table 10 for our district measure of charter penetration, and in Table 11 for our campus measures of charter penetration. In Table 10, it is clear that there the impact of district charter penetration differs with both ethnicity and campus initial performance quartile. In the lowest campus initial performance quartile, the estimated charter penetration effect is fairly similar across ethnic categories. For math it ranges from 5 to 6, while for reading it varies from 4 to 7. However, in the second quartile of campus initial performance, the estimated impact of charter penetration is large and statistically significant for African American students. It is smaller but positive and statistically significant for reading, and it is small and statistically insignificant for other students. In the third and fourth quartiles of campus initial performance, the coefficient estimates vary but are not statistically significant. Thus it appears that the district charter impact varies with both ethnicity and campus initial performance, with African American students in the lowest two quartiles of campus initial performance having the largest impact from charter penetration. Hispanic students in both the first and second quartiles also have positive and generally significant impacts of charter penetration, but the impact for Hispanic students in the second quartile are only about half the size of the impact of Hispanics in campuses in the lowest quartile of initial performance. Finally, other students receive a positive and significant impact of charter penetration only when in campuses in the lowest quartile of initial performance.

How do we interpret these results? It appears that African American and Hispanic students in traditional public schools benefit from charter penetration in part because they tend to be in schools that are low performing, but this does not explain all our results. In particular, there seems to be a positive impact on African American students, and a lesser positive impact on Hispanic students, for schools in the second performance quartile, even though other students in these schools have only a small and statistically insignificant impact of district charter penetration.

In Table 11 we present a set of results interacting our campus charter penetration measure with ethnicity and with campus initial performance quartile. Here we estimate a much larger number of coefficients and get a more complex set of results, but overall the results largely accord with our district penetration results. In particular, African American and Hispanic students tend to receive a positive and statistically significant impact of charter competition in the lowest or second quartile of initial campus performance when we look at charter penetration within five miles, and these same students tend to receive a positive and statistically significant impact of charter competition in the lowest quartile of initial campus performance when we look at charter pene-

Table 10
District charter penetration effect by campus initial performance quartile and ethnicity

Variable	District-level competition	
	Math	Reading
District geographic charter percent, campus in lowest quartile, Black	6.37 (1.35)	6.62 (1.05)
District geographic charter percent, campus in lowest quartile, Hispanic	5.89 (1.15)	4.38 (.95)
District geographic charter percent, campus in lowest quartile, other	4.92 (1.35)	4.97 (1.56)
District geographic charter percent, campus in second quartile, Black	6.06 (1.44)	4.96 (1.83)
District geographic charter percent, campus in second quartile, Hispanic	2.93 (1.67)	2.76 (1.17)
District geographic charter percent, campus in second quartile, other	1.07 (1.12)	.87 (1.16)
District geographic charter percent, campus in third quartile, Black	−3.22 (2.13)	−0.89 (1.17)
District geographic charter percent, campus in third quartile, Hispanic	−0.02 (1.64)	.17 (1.88)
District geographic charter percent, campus in third quartile, other	1.05 (1.60)	−1.71 (1.17)
District geographic charter percent, campus in highest quartile, Black	−.20 (2.36)	1.43 (1.55)
District geographic charter percent, campus in highest quartile, Hispanic	−0.85 (2.71)	−0.08 (2.23)
District geographic charter percent, campus in highest quartile, other	−2.42 (1.92)	−2.27 (1.42)
Sample size	1,174,778	1,168,062

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects, student mover variables, and an indicator for the student being in special education.

[26] These results raise an interesting question: Does charter competition lead districts to reallocate resources to poorly performing campuses and away from highly performing campuses? This may be especially interesting because charters seem to provide competition for public schools more at the lower end of the student performance levels, whereas other sources of competition such as private schools may provide competition for students at the upper end of student performance levels.

Table 11
Campus charter penetration effect by campus initial performance quartile and ethnicity

Variable	Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading
# of charters within five miles of public campus, campus in lowest quartile, Black	.019* (.007)	.024* (.006)
# of charters within five miles of public campus, campus in lowest quartile, Hispanic	.011 (.006)	.015* (.006)
# of charters within five miles of public campus, campus in lowest quartile, other	.029* (.012)	.012 (.017)
# of charters within five miles of public campus, campus in second quartile, Black	.043* (.013)	.051* (.011)
# of charters within five miles of public campus, campus in second quartile, Hispanic	.015 (.011)	.019* (.010)
# of charters within five miles of public campus, campus in second quartile, other	.022 (.014)	.003 (.014)
# of charters within five miles of public campus, campus in third quartile, Black	−.004 (.016)	.019 (.018)
# of charters within five miles of public campus, campus in third quartile, Hispanic	.027 (.014)	.021 (.012)
# of charters within five miles of public campus, campus in third quartile, other	.008 (.013)	.002 (.010)
# of charters within five miles of public campus, campus in highest quartile, Black	−.003 (.014)	−.015 (.020)
# of charters within five miles of public campus, campus in highest quartile, Hispanic	.013 (.011)	.001 (.013)
# of charters within five miles of public campus, campus in highest quartile, other	.007 (.010)	−.002 (.009)
# of charters within 6–10 miles of public campus, campus in lowest quartile, Black	.031* (.005)	.027* (.005)
# of charters within 6–10 miles of public campus, campus in lowest quartile, Hispanic	.019* (.005)	.016* (.004)
# of charters within 6–10 miles of public campus, campus in lowest quartile, other	.008 (.013)	.025 (.013)
# of charters within 6–10 miles of public campus, campus in second quartile, Black	.011 (.008)	−.006 (.011)
# of charters within 6–10 miles of public campus, campus in second quartile, Hispanic	.012 (.007)	.008 (.007)
# of charters within 6–10 miles of public campus, campus in second quartile, other	−.000 (.010)	−.008 (.007)
# of charters within 6–10 miles of public campus, campus in third quartile, Black	.000 (.012)	.004 (.008)
# of charters within 6–10 miles of public campus, campus in third quartile, Hispanic	.010 (.007)	−.004 (.009)
# of charters within 6–10 miles of public campus, campus in third quartile, other	.015* (.007)	−.001 (.006)
# of charters within 6–10 miles of public campus, campus in highest quartile, Black	.026* (.010)	.008 (.012)
# of charters within 6–10 miles of public campus, campus in highest quartile, Hispanic	.002 (.008)	.014* (.006)
# of charters within 6–10 miles of public campus, campus in highest quartile, other	−.007 (.004)	.001 (.005)
Sample size	1,081,138	1,075,246

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects, student mover variables, and an indicator for the student being in special education.

* Statistical significance at the 5% level.

tration in the five-to-ten mile range. Other students are somewhat harder to distinguish from Hispanic students in Table 11, and seem to have a stronger impact than Hispanic students in some of the estimates for math (at least if we confine our comparisons to statistically significant coefficient estimates), while Hispanic students seem to have a stronger impact from charter penetration for reading. Also, unlike the district penetration results in Table 10, we report in Table 11 positive and significant impacts for some of the upper quartiles of initial campus performance. To be specific, we find a positive and significant impact of charter penetration on other students in math in the third quartile, for African American students in math in the fourth quartile, and for Hispanic students in reading in the fourth quartile.

The results in Table 11 are more complex and more difficult to interpret, involving 24 coefficients and measures of charter penetration over various distances. However, the results are broadly consistent with the idea that the impact of charter school penetration on student performance in traditional public schools will vary with both ethnicity and initial campus performance quartile. Further, there is evidence that African American students are benefited more than other ethnicities, holding constant the initial campus performance quartile.

We find robust evidence of a positive effect of charter penetration on student performance in traditional public schools, although we are not able to identify the particular mechanisms which are driving this observed relationship. In the introduction we listed possible explanations that include increased efficiency, a positive compositional/peer effect, and competition for students. It is also possible that the increased performance occurs because districts allocate more resources to schools that face more charter penetration. Discovering the exact nature of the mechanisms driving the observed relationship is a topic for future research.

7. Conclusions

We find that the emergence of charter schools has had a positive impact on student performance—at least in terms of test scores—for students remaining in traditional public schools in Texas. This positive effect is consistent across both math and reading tests, both district and campus level penetration measures, and across a variety of specifications. Although the estimated effect is not large in the neighborhood of mean levels of charter penetration in our sample, it is substantial when evaluated at the levels of penetration that exist by the end of the sample period in major urban areas of the state. Persistent increases in value-added achievement by schools at the levels indicated by our estimates could lead to substantially higher student achievement levels.

The evidence in this paper supports claims that expanding school choice may generate systemic gains. Whether such gains would be realized under broader choice institutions, such as vouchers, is uncertain. Future research on the charter experiment which focused upon identifying the sources of gains from competition would help inform the general relevance of our findings. The relevance of school choice policies within the current policy environment rests upon the accumulation of evidence, such as ours, that children who stay behind are not necessarily left behind.

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Appendix A

Table A.1
Effect of charter penetration on math and reading performance: district level charter competition measure interacted with year dummies

Variable	District-level competition	
	Math	Reading
Percent of students in geographic district attending charter schools ∗ I(96–97)	−11.90* (4.14)	−3.76 (3.96)
Percent of students in geographic district attending charter schools ∗ I(97–98)	.35 (1.96)	−4.23* (1.90)
Percent of students in geographic district attending charter schools ∗ I(98–99)	−3.58* (1.16)	−2.11* (.99)
Percent of students in geographic district attending charter schools ∗ I(99–00)	4.02* (1.07)	3.59* (.85)
Percent of students in geographic district attending charter schools ∗ I(00–01)	2.78* (.78)	2.70* (.60)
Percent of students in geographic district attending charter schools ∗ I(01–02)	4.38* (.74)	3.75* (.60)

(*continued on next page*)

Table A.1 (*continued*)

Variable	District-level competition	
	Math	Reading
Percent of students in geographic district attending charter schools ∗ I(02–03)	3.10* (.79)	2.32* (.60)
Percent of students in geographic district attending charter schools ∗ I(03–04)	6.01* (.88)	3.78* (.60)
District mover	−.051* (.010)	−.030* (.010)
Structural mover	−.108* (.008)	−.071* (.007)
Campus mover	−.105* (.009)	−.065* (.008)
Student in special education	.016 (.015)	.017 (.016)
Sample size	1,316,667	1,309,109

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects and spell fixed effects.

* Statistical significance at the 5% level.

Table A.2
Effect of charter penetration on math and reading performance: campus-level competition measures interacted with year dummies

Variable	Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading
# of charters within 0–5 miles of public campus ∗ I(96–97)	.012 (.012)	.026* (.012)
# of charters within 0–5 miles of public campus ∗ I(97–98)	.046* (.012)	.022 (.012)
# of charters within 0–5 miles of public campus ∗ I(98–99)	.013* (.005)	.011* (.005)
# of charters within 0–5 miles of public campus ∗ I(99–00)	.018* (.004)	.019* (.003)
# of charters within 0–5 miles of public campus ∗ I(00–01)	.017* (.004)	.018* (.004)
# of charters within 0–5 miles of public campus ∗ I(01–02)	.028* (.004)	.024* (.004)
# of charters within 0–5 miles of public campus ∗ I(02–03)	.022* (.005)	.018* (.005)
# of charters within 6–10 miles of public campus ∗ I(96–97)	−.007 (.008)	−.002 (.008)
# of charters within 6–10 miles of public campus ∗ I(97–98)	.005 (.008)	−.008 (.007)
# of charters within 6–10 miles of public campus ∗ I(98–99)	.001 (.004)	−.002 (.004)
# of charters within 6–10 miles of public campus ∗ I(99–00)	.008* (.003)	.006* (.002)
# of charters within 6–10 miles of public campus ∗ I(00–01)	.010* (.003)	.007* (.003)
# of charters within 6–10 miles of public campus ∗ I(01–02)	.011* (.003)	.008* (.003)

Table A.2 (*continued*)

Variable	Campus-level competition (# of charters within an N-mile radius)	
	Math	Reading
# of charters within 6–10 miles of public campus ∗ I(02–03)	.015* (.003)	.007* (.003)
District mover	−.051* (.010)	−.024* (.011)
Structural mover	−.107* (.008)	−.071* (.008)
Campus mover	−.102* (.009)	−.061* (.008)
Student in special education	.019 (.015)	.018 (.016)
Sample size	1,199,938	1,193,323

Notes. Robust standard errors, adjusted for within-school clustering, in parenthesis. Regressions also include grade-by-year effects and spell fixed effects.

* Statistical significance at the 5% level.

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