The Valuation of Local School Quality under School Choice

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Abstract

School choice programs break the link between residential location and school attendance, and should weaken the capitalization of school quality into house prices. For the first time, I quantify the effect of one such program - charter school expansions - across several states using a dataset covering charter entries and house prices. I embed an event study of charter entry into a boundary discontinuity design and find that, on average, school choice decreases the valuation of traditional schools by four percentage points. Suggestive evidence shows school choice can lead to neighbourhood change through resorting as school boundaries become less important.

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The United States has traditionally relied on school attendance zones to assign children to public schools. These zones create well-defined boundaries through neighbourhoods where children on opposite sides of a street may be assigned to different schools. Demand for houses in attendance zones with good schools in turn drives up the price of real estate there, restricting educational opportunity as only high-income families are able to buy access to high-quality schools.[1]

In light of this inequality in education access, school choice programs have expanded in recent years. These aim to foster opportunity by giving families the chance to send their child to a school other than their zoned neighbourhood school. Theoretically, increased school choice – either through public reforms or improved private school access (as in Nechyba (2003b)) – should reduce the capitalization of zoned school quality into house prices since residential location no longer solely determines school assignment. Schwartz, Voicu, and Horn (2014) confirm this empirically for New York City, while Fack and Grenet (2010) do so for Paris.

To date though, the effects of large-scale changes to school choice programs on housing markets has not yet been investigated. In this paper, I show that major school choice reforms across several U.S. states weaken the relationship between house prices and the quality of traditional, zoned public schools. I do so by using an event study approach in combination with a boundary discontinuity design that exploits school choice expansion in the form of charter schools arising from the "Race to the Top" initiative spearheaded by the Obama administration. This program gave grants to states who implemented education reforms and emphasized the importance of charters for "Race to the Top" funds.[2] In turn, the expansion of charter schools provides a unique opportunity to study the impact of school choice on real estate markets as they do not use traditional school zones to determine attendance. I combine data on charter school entries, house transactions, and school boundaries for Florida, Massachusetts, New York, and Tennessee. These four states all increased the availability of charter schools in relation to The Race to the Top program.

I leverage my unique dataset to estimate how the capitalization of traditional public school quality into house prices changes with charter school entry. To do so, I implement a boundary regression discontinuity design with an event study. The boundary discontinuity measures the valuation of traditional public school quality by taking the difference in house prices close to each other but on opposite sides of a school boundary (Black, 1999). In doing so, this design controls for local unobservable neighbourhood characteristics, such as amenities. Next, the event study captures how the valuation of local school quality changes with the introduction of charter schools. Note that the event study compares the house price discontinuity across boundaries after a charter school opens nearby to regions that have not yet received a charter, but do so later on. Thus, I exploit variation in the timing of charter entry rather than charter location decisions,

[1] There is a substantial literature on neighbourhood sorting and education quality. This includes Benabou (1996), Durlauf (1996b), Durlauf (1996a), Epple and Romano (2003), Fernández and Rogerson (1996), Fernández and Rogerson (1998), and Nechyba (2003a).

[2] "States that do not have public charter laws or put artificial caps on the growth of charter schools will jeopardize their applications under the Race to the Top Fund." Department of Education Press Release, June 8, 2009.

thereby alleviating concerns around selection that would arise if areas with and without charters were compared.

I find that the valuation of traditional zoned school quality near the boundary decreases by about one percentage point the year after a charter school opens within 5 miles. In fact, the decline in the valuation continues and by the third year, it has fallen by four percent. Intuitively, when a charter school enters, the importance of school boundaries weakens as new options for schooling are available. As a consequence, the capitalization of zoned school quality into house prices should fall. Furthermore, I study how the response to charter school entry varies by urbanicity.

As charter schools enter, households who would have previously lived on the "good" side of the boundary can now live on the "worse" side but access other schooling options. Therefore, resorting of sociodemographics could be associated with the decrease in the boundary discontuinity in house prices. I present suggestive evidence from the American Community Survey at the census block group level lending support to this hypothesis. Note that this data comes with a few constraints. First, the survey has smaller sample sizes than the decennial census and is subject to more measurement error. Second, measures of sociodemographics are only available in 5-year rolling averages. With these caveats in mind, I find that the difference across school boundaries in the percentage of households with at least a Bachelor's degree and the percentage of high-income households falls post-charter entry. While my results here allude to changes in sorting patterns with charter school entry, better data is needed to establish a stronger link between school choice and changes in neighbourhood composition.

Lastly, I show that the event study boundary discontinuity specification withstands numerous robustness tests including: narrowing the distance to the boundary, restricting the length of the boundary, and narrowing the distance to the charter.

This work is related to a comprehensive literature investigating the relationship between house prices and zoned school quality. Historically, residential location was the main determinant of school assignment through 'school attendance zones,' geographic areas that mark which region a school accepts students from. Disentangling the effect of local schools on house prices is difficult due to the fact that regions with better schools may have better amenities. Black (1999) was the first to convincingly identify valuations for school quality by comparing house prices on opposite sides of school attendance zone boundaries.[3] The intuition is that houses close to a school boundary but on opposite sides should have the same amenities except for the school they have access to. Differences in house prices across the boundary can then be attributed to differences in school performance. Building on this work, Kane, Riegg, and Staiger (2006) used the boundary design to show that school quality is capitalized into house prices in North Carolina. Bayer, Ferreira, and McMillan (2007) expanded on Black (1999) by building a structural model that identifies the marginal willingness to pay for school quality. Their

[3]Initial hedonic methods elicited valuation for school quality from house prices while controlling for neighbourhood observables, such as Kain and Quigley (1975), Li and Brown (1980), and Jud and Watts (1981). These hedonics were not able to address concerns over the endogeneity of school quality and unobserved neighbourhood amenities.

paper also highlights the importance of controlling for sorting along school boundaries. Most closely related are the following two works that study how the capitalization of school quality into property values responds to changes in school choice options. First, Schwartz, Voicu, and Horn (2014) show that choice schools in New York City weakened the valuation of local school quality. They use a boundary discontinuity design and show that the discontinuity falls after the entry of a choice school. Second, Fack and Grenet (2010) show that house prices across the boundary narrow with proximity to private schools in Paris. Both of these works brought to light the importance of different schooling options for weakening the link between house prices and school quality. My work differs from theirs in that I assemble a rich dataset on house prices and school choice that covers multiple U.S. states, thereby allowing me to investigate the effects of school choice on a larger scale. Furthermore, I explore heterogeneity in the response to charter schools by urbanicity, and present some evidence suggesting that charter schools can lead to neighbourhood resorting.

Several related papers have taken alternative approaches to estimating the valuation of school quality. Barrow and Rouse (2004) use instrumental variables to study how households value public school spending. Cellini, Ferreira, and Rothstein (2010) estimate the valuation of capital expenditures using a discontinuity design around votes on the issue of bonds, and Figlio and Lucas (2004) look at how parents incorporate information from schools' state-assigned grades. In addition, Bergman et al. (2020) use an experiment in which they randomly add school quality information to house listings in order to estimate a model of demand for neighbourhood amenities in a setting with imperfect information. Relatedly, Andreyeva and Patrick (2017) and Billings, Brunner, and Ross (2014) study the capitalization of access to charter schools into house prices.

My work also ties into research studying the effect of school choice programs on neighborhoods. Nechyba (2003b) highlights how school choice in the form of private school vouchers can increase the value of poorer school districts. Furthermore, Nechyba (2003a) uses a numerical model of schooling and housing to show that public schools create more income segregation than private schools. Epple and Romano (1998) study how private school vouchers affect sorting and students of different abilities. Research on other forms of choice include Epple and Romano (2003), who use a calibrated model to characterize how intradistrict choice affects student sorting and welfare, and Avery and Pathak (2015) who highlight that school choice could negatively affect poorer families through higher house prices and induce them to leave their current neighbourhood.

Stepping back, the evidence in this paper makes clear that large-scale school choice programs significantly weaken the capitalization of school quality into house prices. Consequently, there is the potential to create stark changes in neighbourhood sorting. Specifically, the availability of school choice eliminates the need for households to live in high priced neighbourhoods, allowing families with preferences for school quality to move into lower-income neighbourhoods and transform the amenities there. In the paper I present some evidence suggesting that such resorting is taking place. Given the importance of neighbourhoods for intergenerational mobility (Chetty et al. (2018, 2014)), school choice could change neighbourhood characteristics and

create more opportunity for residents.

I Background: Public Schools in the United States

The traditional method for public school assignment in the United States is through school attendance zones, also known as catchment areas. Each school has a geographical area that they accept students from.

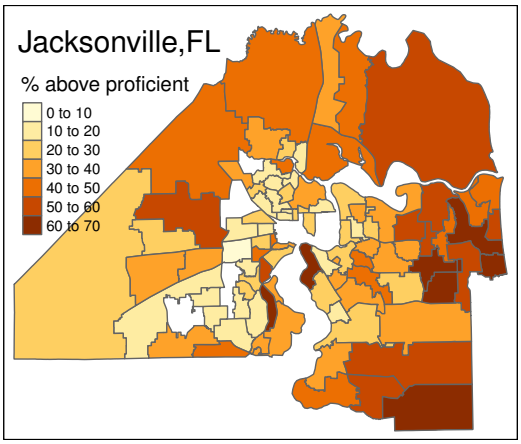

Figure 1: Elementary School Attendance Zones in Jacksonville, Florida. The school district is Duval County Public Schools. Each area represents an elementary school zone. The different colours represent the percentage of students who perform above proficient on standardized math tests (Florida Statewide Assessment Program). Test scores are averaged across grades for each school. School zone information is from the School Attendance Boundary Survey, 2015-2016. Test score information is from the Florida Department of Education website.

Crossing a school attendance boundary can imply large changes in the quality of the zoned school as seen in Figure 1, which shows elementary school zones and their test performance in Jacksonville, Florida. Each area on the map encompasses a school attendance zone and the different colors reflect their test score performance in terms of the percentage of students who score above proficient. Darker colours indicate better test results. There are several cases where a high performing school is located next to a low performing one.

The link between residential location and zoned school quality gives rise to equity concerns, prompting policymakers to implement reforms providing families with more school options. Recently, four school choice programs have risen in prominence in the United States: open enrollment, vouchers, magnet schools and charter schools.

Open enrollment gives students the option to be admitted to a school in a different school zone. Typically, students are guaranteed admission to the public school they are zoned for, but may enter a lottery system to go to a different school. Note that open enrollment is subject to available seats at the school of choice. Next, vouchers are tuition subsidies given to parents who send their child to a private school. Currently fifteen states have a voucher program. In addition, magnet schools are schools that are themed, such as schools focusing on STEM or arts programs. They do not have attendance zones. In this paper, I focus on school choice through

charter schools. Charter schools are publicly-funded schools that are independently operated, but held accountable to the local school district or government. Charter schools cannot charge tuition or select students based on ability, and importantly, do not have attendance zones.

Charter schools have seen rapid growth in the past twenty years. In the year 2000, charter schools enrolled 480,000 students whereas in 2016, they enrolled just over 3 million students. Currently, charter schools are more popular than magnet schools[4] and their 2016 enrollment was around half of the size of students enrolled in private schools. Of the students in private schools, only around 400,000 use private school vouchers. [5]

Sample Selection

My sample consists of Florida, Massachusetts, New York, and Tennessee, who all expanded access to charter schools in relation to the Race to the Top program. This program was a federal grant initiative from the Obama administration, which gave funding to states that implemented education reforms. As previously mentioned, Arne Duncan, Education Secretary for President Obama, explicitly emphasized that openness to charter schools was a key condition in securing funding. Consequently, several states introduced policies to expand access to charter schools. The implementation of Race to the Top thus acts as an exogenous shock that led to an increase in charter schools in these states. [6]

In practice, charter school legislation took on different forms across the four states. Tennessee eliminated a ceiling on the maximum number of charters allowed to operate and removed restrictions requiring charters to only enroll at-risk students. New York raised the cap on the number of charter schools allowed. Florida made it easier for high performing charters to add additional campuses, while Massachusetts facilitated the growth of charters in underperforming districts.[7] These legislative changes took place in the 2009-10 school year for Massachusetts, Florida, and New York, and the 2010-11 school year for Tennessee.[8]

[4]In 2017-2018 charter schools enrolled 3,143,269 students while magnet schools enrolled 2,665,820 students. *Source:* National Center for Education Statistics, Education Digest, Table 216.20

[5]Data on enrollment is from the U.S. Department of Education, National Center for Education Statistics: Private School Universe Survey (PSS), 1995-96 through 2015-16. and Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey," 1990-91 through 2016-17. Data on private school vouchers is from "Fast Facts on School Choice," by EdChoice (May 28, 2019). A comparison to the number of students using open enrollment is not provided because to the best of my knowledge, this data is not available.

[6]Other states that received Race to the Top Funding were: Delaware, D.C., Hawaii, Arizona, Georgia, Maryland, North Carolina, Ohio, Rhode Island, Colorado, Illinois, Kentucky, Louisiana, New Jersey and Pennsylvania. I excluded these states because to the best of my knowledge, they did not have a change in legislation to expand charter schools. There are two exceptions: Louisiana expanded charter schools in 2009 in response to Hurricane Katrina (prior to Race to the Top). Due to the endogeneity of their charter expansion, in addition to the lack of test score data, I do not include it. In addition, North Carolina did expand charter schools, but is not included due to many missing observations in the housing dataset.

[7]Cohodes, Setren, and Walters (2019) discuss the changes in Massachusetts in more detail. The "CS/CS/C-S/HB 1569 (2010) - Charter Schools bill" outlines the legislation change for Florida and SCORE (2012) studies the changes in Tennessee.

[8]Several charter schools opened in the year 2009-10 for Florida and New York, prior to the implementation of the charter school law. These schools are included in the event study, since charter school regulators may have started becoming more responsive to new charter applications leading up to the formal law change at the state level.

The process for applying to open a charter school requires an application to be submitted to a sponsor (usually either the school district or the state board of education). In Florida, the application must be submitted at least seven months prior to the proposed opening of the charter, while in New York it is eight months. For Tennessee and Massachusetts the process takes over a year.[9] While charter schools tend not to have admission requirements, they do hold lotteries when they are oversubscribed. In this case, charters may not represent a viable school choice option for families since there is no guarantee that their child will be allowed to attend. Although information on the percentage of charters with lotteries is limited, evidence indicates that it is the case for a small fraction of charters. For instance, Tuttle, Gleason, and Clark (2012) find that only 10-15 percent of middle school charters in the years 2005-2007 were oversubscribed. In addition, the authors show that oversubscribed charters tend to be in operation for a longer period of time. Given that I study how house prices respond to the opening of new charter schools, it is unlikely that many of these will be oversubscribed in their first few years.

While charter schools do not use formal zones for school admissions, they are allowed to give enrollment preference to certain groups. For example, the state of Florida permits charters to favour students residing within a certain distance to the school. In practice though, it does not seem that Florida charters implement this rule.[10] Out of 230 Florida charters in my sample, I manually checked the admissions rules for a random subset of 60. I did not find a single charter that prioritized students (within district) based on their distance to the school. Some charters do give preference to children of charter school employees, siblings of existing charter students, children residing in the same district, or children of active duty military members. I also found in the sample of 230 Florida charters, at least 49 that allowed for enrollment from more than one district. For the states of Massachusetts, Tennessee and New York, I did not find any evidence to suggest that preference can be given to students based on distance, only that preference can be given to students who reside in the same district (New York, Tennessee) or city where the charter is located (Massachusetts). In addition, in New York state, any state resident is eligible to attend a charter.[11]

Table 1 shows how the percentage of charter schools and the percentage of students in charters increased between 2010 and 2016 (National Center for Education Statistics, 2019). The 2nd and 3rd columns show that the percentage of public schools classified as charters increased in this time period, highlighting that charters expanded relatively faster than traditional public schools. Comparing the 4th and 5th columns, the percentage of students enrolled in charter schools almost doubled in Florida between 2010 and 2016, while in New York and Tennessee, it more than doubled. Massachusetts also saw an increase, going from 3 percent to 4.5 percent.

[9] See each state's Department of Education website for more information on the application process to open a charter school.

[10] See the Florida Department of Education's Charter Schools Frequently Asked Questions page.

[11] Regulations covering charter schools for New York can be found from the "New York Charter Schools Association" website. Massachusetts and Tennessee have information concerning charter school rules on their respective Department of Education website.

State	Charter Schools (% Total Public Schools)		Charter School Enrollment (% Total Enrollment)	
	2010-2011	2016-2017	2010-2011	2016-2017
(1)	(2)	(3)	(4)	(5)
Florida	11.1	15.7	5.9	10.1
Massachusetts	3.4	4.2	3.0	4.5
Tennessee	1.6	5.9	0.7	3.5
New York	3.6	5.6	2.0	5.0

Table 1: Changes in Charter School Enrollment. The first two columns show the change in the proportion of charter schools out of all public schools, by state, for the years 2010-2011, and 2016-2017. The third and fourth columns show the change in the proportion of students attending charter schools for the years 2010-2011, and 2016-2017. *Source:* Table 216.90, Digest of Education Statistics, National Center of Education Statistics

II Empirical Framework

In this section, I discuss the empirical specifications that I employ. To start, I present the data sources used. I then discuss the boundary discontinuity design that allows me to identify the capitalization of school quality into house prices.

Data Sources

The data are drawn from the 2008-09 school year to the 2017-2018 school year. Individual house transaction data are provided by the real estate company Zillow Research, through its Zillow Transaction and Assessment dataset (Zillow, 2018). This data includes information on sale price, time of sale, geographic location, and physical house characteristics such as number of bedrooms and bathrooms, square footage, and year built. I convert the year of sale to match the school calendar year, starting in the month of September. A house sold in May 2010 would count as the 2009-10 school year. I drop all house sales that are foreclosures, gifts, not at arm's length or have missing price or characteristics information. To ensure that the estimation results are not driven by extreme values of house prices, I drop sales below $10,000 and above $14.5 million.[12] I only include houses that are for residential use, are owner-occupied, and are single-family residences. Finally, I convert sale prices into real 2008 dollars using the consumer price index from the FRED database (U.S. Bureau of Labor Statistics). One concern is that the house price data I have lines up with the timing of the Great Recession, which led to drastic decreases in house prices and credit availability across the United States. The financial crisis should not affect identification of the change in the valuation for zoned school quality, which relies on the boundary discontinuity design. It is unlikely that the tightening of credit would affect house prices differently from one side of the boundary versus the other, especially once controlling for neighbourhood sociodemographics. One concern though would be if the timing of 'fire sales' coincided with charter entry. To control for this, I drop houses that are in zipcodes where the foreclosure rate is above 5 percent.[13]

[12] 14.5 million is the 99.99th percentile of house prices in my sample.
[13] Foreclosure data is available from the real estate company Zillow.

Geographical data on school attendance zone boundaries are provided by the National Center for Education Statistics' (NCES) School Attendance Boundary Survey (SABS) for the year 2015-2016 (National Center for Education Statistics, 2018). This survey collected school boundaries for more than 70,000 schools in 12,000 school districts nationwide. Data for boundaries are only available for one year[14] and a potential concern is boundary changes. For instance, charter school entry may decrease enrollment in traditional public schools causing boundaries to be redrawn. In this case, house price differences across a former boundary would decrease, not due to charter entry, but due to the boundary being no longer in place. The risk of bias from this issue is small however, for two reasons. First, the boundary data I have are from later in the sample, 2015-2016, once many charters have already entered. Second, data from the NCES shows that boundaries change infrequently - out of 4,317 elementary schools in the four states of interest, only 111 had a boundary change from 2010 to 2014 (National Center for Education Statistics, 2009-2018b).[15]

The geography of school attendance zones can be complex and I take the following steps to clean the data. I focus on schools located in districts large enough such that there was more than one school serving each grade and eliminate so-called de-facto districts.[16] Following Black (1999), I ensure that the boundaries in my dataset are from intersecting school attendance zones in the same district, in order to control for differences in financing and tax rates across districts.

The recent changes to school choice through charter school access affected elementary school children the most, since high schools and middle schools previously had popular choice options in the form of magnet schools, which are schools with specialized curricula and often do not have attendance zones. In addition, the boundary discontinuity design does not allow for overlapping school zones; each house can only be assigned to one zone. Consequently, I only use elementary schools in the analysis; they are also a natural choice, being the most numerous. However, school zones may still overlap, for example, if there is an elementary school serving grades 1 to 3 and another one serving grades 1 to 6 in the same area. While most elementary schools end in grades 4, 5, or 6, the highest grade served by elementary schools does vary by state. To minimize the chance of overlapping zones, I set restrictions on the highest grade a school can serve. Table A1 in the Appendix lists the restrictions for each state and the percent of elementary schools I keep. Finally, I drop any remaining houses that are associated with more than one school zone.

Charter school entry information from 2009-10 to 2017-18 is provided by the NCES (National Center for Education Statistics, 2009-2018b). Roughly 6% of charters closed during the sample period. While I do not include these closed charters in the main sample for the event study estimation, I do run the event study on this sample in a separate exercise.

Data on individual school test score performance on standardized tests are from each state's Department of Education website and the NCES Common Core of Data (National Center for Education Statistics, 2009-2018a).[17] I focus on test scores in math and restrict the data to

[14] There is a SABS survey from 2013-2014 but of a smaller sample.

[15] The NCES has a survey called "Public Elementary/Secondary School Universe Survey Data" which tracks annual school information including whether it has a boundary change.

[16] These are primarily located in smaller towns.

[17] The test for Florida is "Florida Statewide Assessment Program" (Florida Department of Education, 2009-

elementary schools, consistent with the previous steps. The test score measure for a school is the percentage of students who exceed proficiency on a test by grade, averaged across all grades in the school. The test score I focus on is mathematics because Hansen et al. (2018) and Cronin et al. (2005) argue that performance in mathematics is a more accurate reflection of school quality, since learning in reading can often take place at home. Hansen et al. (2018) showed that when school interventions (such as No Child Left Behind) occur to improve schools, the more noticeable gains are seen in math test scores.

Boundaries that have schools with similar test score performances on either side do not represent a discontinuity in school quality and need to be dropped. I calculate the median test gap across boundaries and drop those that are less than half the median.[18] In running the event study, I also keep boundaries only if they were present in my dataset before and after a charter school opened, in order to ensure that I am comparing the same types of boundaries pre and post charter school entry.

Lastly, the empirical strategy requires controlling for neighbourhood sociodemographics. Bayer, Ferreira, and McMillan (2007) highlight the importance of controlling for sociodemographics at the boundary because of residential sorting. Consider a boundary where there is a high-quality school on one side of the boundary and a low-quality school on the other side. People of certain types (high income, high education attainment, those with children) are more likely to live on the high-quality side of the boundary, because they are more likely to value school quality. Bayer, Ferreira, and McMillan (2007) point out that demand for being on the high-quality side of the boundary could then be driven either by school performance or by the composition of neighbours. For example, someone may not care about school quality, but may want to live on a specific side of the boundary because they want to have higher-educated neighbours. As a result, failing to control for neighbourhood sociodemographics may overstate the valuation of local school quality. To this end, I use five-year census block group estimates from the American Community Survey (ACS) for the period 2009-2013 and then 2013-2017 (Steven Manson and Ruggles, 2020). The ACS does not have year-by-year estimates; the data is only available in five-year rolling averages. In addition, due to a smaller sample size, the ACS estimates are less accurate than those from the decennial census. Nevertheless, the ACS is chosen since it is the only publicly available dataset that reflects changing demographics over a smaller time frame. The selected sociodemographic variables at the census block group level are: family structure, racial composition, median household income, and education attainment. Census block groups have an optimal size of 1,500 people while the average school attendance zone has a population of 7,300 (Bischoff and Tach, 2018).

Note though, that the boundaries of attendance zones and block groups do not always line up. In such a case it is not possible to get a precise measure of how sociodemographics change from

2017), for Massachusetts "Next Generation MCAS Achievement" (Massachusetts Department of Elementary and Secondary Education, 2019), and for Tennessee "TCAP" (Tennessee Department of Education, 2020). Data for New York State is from the ELA and Math Assessment (New York State Department of Education, 2008-2018).

[18]This filtering is similar to the one used in Bayer, Ferreira, and McMillan (2007). By dropping only test gaps below half the median, I ensure that I have a discontinuity in school quality, but also that I do not drop a substantial proportion of the observations.

one side of a school zone boundary to another. Figure 2 gives an example of the school attendance zone for Stirling Elementary School, in Broward County, Florida. The shaded area is the school attendance zone, and the areas outlined in black represent different census block groups. Several borders of the school attendance zone line up with census block group boundaries. When this is not the case, I flag in my sample house observations where its associated census block group overlaps with more than 10 percent of the area of the school zone on the other side of the boundary.[19]

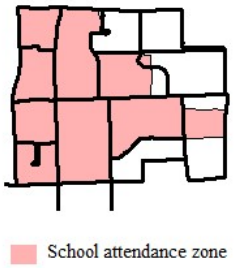

Figure 2: Stirling Elementary School, Broward County, Florida. The shaded area is a school attendance zone and the areas outlined in black are different census zones. Source: SABS 2015-2016, 2010 Census.

Boundary Discontinuity Design

The goal of the estimation strategy is to identify how the valuation of zoned school quality changes with the introduction of charter schools. The main challenge to identification is dealing with unobservable neighbourhood characteristics that also influence house prices. Black (1999)

[19]I drop these flagged observations in my main specification in order to get a more accurate estimate of sociodemographics at the boundary.

proposed comparing houses that are within a short distance to an attendance zone boundary but on opposite sides. The idea is that houses close to each other should have equal access to unobservable amenities. After controlling for physical house characteristics and sociodemographics along the boundary, the only factor that varies at the boundary should be the difference in school quality.

Figure 3 represents school zones in Broward County, Florida and gives a simple example of how the boundary approach works. The different areas are separate school zones, and the crosses and triangles represent houses. Each house is assigned to its nearest boundary and so I compare the house prices of the "crosses" on opposite sides of their boundary. Similarly, the house prices of the "triangles" are compared on both sides of their boundary.

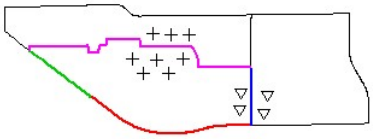

Figure 3: School Zones in Broward County, Florida. This example shows how the boundary discontinuity design works. The crosses and triangles represent individual houses. The lines represent boundaries. Each house is allocated to the closest boundary and compared to houses on the other side of that boundary. The crosses (triangles) are compared to the crosses (triangles) on the other side of the boundary that they are closest to. Source: School Attendance Boundary Survey 2015-16.

The main empirical contribution of this paper is to show that the capitalization of school quality into house prices falls significantly after a charter school opens in the neighbourhood. For each house, I use its geographic coordinates to match it to the census block group it belongs to and record the sociodemographic information for that neighbourhood. Next, I determine what attendance zone the house is in and link it to school-level test score performance. I calculate which boundary the house is closest to and restrict my sample to houses that are within 0.25 miles of the boundary. Finally, I look at whether a charter school opened within 5 miles of the house, and if so, what year it opened relative to the year the house sold.[20] Distance to the charter is measured "as the crow flies". I use 5 miles as my measure of treated households because Gilraine, Petronijevic, and Singleton (2019) show that in North Carolina seventy five

[20]If multiple charter schools opened in different years, I count the minimum year as the "event year".

percent of students who switched from a public school to a charter school did so to one within 5 miles of their residence. In addition, Blagg et al. (2018) study modes of travel to school in cities with ample choice, and also use a 5 mile radius to define possible school options for an individual. Nevertheless, I also conduct robustness tests where I restrict the distance to the charter to 4 miles and 3 miles. Houses within 5 miles but in a different district are still considered as being exposed to charter entry. While charters can give preference to students residing within district, a substantial proportion of charters in my sample are allowed to accept students from outside district given available space.[21] Since I look at the entry of new charters, it is unlikely that they will be oversubscribed as shown by Tuttle, Gleason, and Clark (2012). Houses that never experienced a charter opening either before or after being sold are dropped from the sample. Consequently, note that whether or not charters select into certain neighbourhoods does not affect the event study estimation.

Formally, the specification is:

$$\underbrace{\log p_{iab}}_{\text{house prices}} = \alpha X_{iab} + \beta Test_a + \underbrace{\theta_b}_{\text{boundary FE}} + \underbrace{\sum_{j=-4}^{5} \delta_j Test_a \mathbb{1}_{Event==j}}_{\text{coeff. of interest}} + \varepsilon_{iab} \tag{1}$$

where i is the house, a is the attendance zone the house is in, and b is the boundary that the house is closest to. X_{iab} is a vector of house and sociodemographic characteristics, $Test_a$ is the test score of the school, θ_b is a vector of boundary fixed effects, and $\sum_{j=-4}^{5} \delta_j Test_a \mathbb{1}_{Event==j}$ shows how the valuation of zoned school quality changes with charter school entry.

I now describe all the variables in detail. Standard errors for my estimated coefficients are clustered at the census block group level, as in Bayer, Ferreira, and McMillan (2007).

X_{iab} is a vector of house and sociodemographic characteristics such as number of bathrooms, square footage in logs, year built fixed effects, year sold fixed effects, racial composition, percentage of families with children, median household income, and education attainment.[22]

$Test_a$ is the test score of the school that the house is zoned for. As previously mentioned, I use the percentage of students in a grade who score above proficient in mathematics, averaged across the grades in a school. This choice is in line with recent evidence from MacLeod and Urquiola (2019) and Bergman et al. (2020), who show that parents value schools based on absolute levels of test achievement rather than on achievement gains (such as value-added). Furthermore, I use test score data only from the year 2009-2010. Using test score data across years creates some endogeneity concerns that test scores change as charter schools enter and resorting takes places, as supported by Urquiola (2005).[23] As a robustness check, I run a version of the event study estimation where test scores do vary over time and find quantitatively similar results (see Table A5).

[21] For example, recall that in New York State, any state resident is eligible to attend a charter school and that several Florida charters allow students from different districts to attend.

[22] I do not include number of bedrooms due to a large number of missing observations.

[23] Ideally I would use 2008-2009 test scores, before any charter entry. However, I found that a substantial proportion of test scores from this year are missing.

θ_b is a vector of boundary fixed effects. Each boundary is allocated a fixed effect and is given a value of one if the house is within 0.25 miles of that boundary and zero otherwise. Any unobserved amenity value that houses on both sides of a boundary have access to will be absorbed by the boundary fixed effect.

The next terms represent the event study component of the analysis. $\mathbb{1}_{Event==j}$ is an indicator function representing which year the house sold relative to a charter school opening within 5 miles of the house. If $j < 0$, the house sold before a charter school opened; for $j >= 0$, after. The coefficients of interest are the δ_j - they represent how the premium on zoned school quality (captured by $Test_a$) changes relative to the opening of the charter school. Fixed effects for each event year are also included. The year $t = 0$, the year the charter opens, is the omitted year. This specification is similar to the difference-in-discontinuity techniques from Gilraine (2019) and Grembi, Nannicini, and Troiano (2016).

Table 2 presents summary statistics for several cuts of the data. Column (1) displays the mean (with the standard deviation in parentheses) of house and neighbourhood characteristics for the entire sample of all houses sold between 2009-2018 in the states of Florida, Tennessee, Massachusetts, and New York that are within 7 miles of a charter opening (7 miles is the maximum distance to a charter I consider in the robustness analysis). The average sale price of all houses sold is around \$248,590, and 33% of the average school's student body is proficient. In columns (2)-(3) I show the statistics for the sample of houses within 0.25 miles of a school attendance zone boundary by whether the house is on the high test score side (column (2)) or on the low test score side (columns (3)). By design, test scores on the high side of the boundary are significantly higher: 49% versus 34% on the low side.[24] Note first that the average prices of houses on the high test score side is around \$240,000 compared to an average of roughly \$215,000 on the low test score side. However, the physical housing characteristics on either of side the boundary are very similar, in terms of square footage, number of bathrooms, and year built. The neighbourhood characteristics are suggestive of sorting along the boundary, with the high test score side of the boundary having an average median household income approximately \$4,000 higher, and having more people with a bachelor's degree or higher. As pointed out by Bayer et al. (2007), the evidence for sorting at the boundary highlights the importance of including neighbourhood sociodemographics in the estimation of equation (1).[25] Finally, columns (4)-(5) show the housing and sociodemographic characteristics for the subsample I use for the main event study: within 0.25 miles of the boundary and within 5 miles of a charter school opening. Comparing columns (2)-(3) to columns (4)-(5) suggest that there are not significant differences in characteristics between households within 0.25 miles to a boundary without a nearby charter and those that have a charter school open within 5 miles. In this sample I have 73 school districts, with 24 in Florida, 4 in Tennessee, 15 in Massachusetts, and 30 in New York.

Finally, Black (1999) noted that in some cases, school boundaries may represent physical or natural boundaries such as highways or forests. In this case, we cannot think of houses on

[24] Recall that boundaries between two school zones with similar test score performance were dropped from the dataset.

[25] This sample includes census block groups that overlap across school zones. Such census block groups are dropped from the main estimation.

opposite sides of a boundary as having access to the same amenities. Note however, that the key estimates of interest - the event study estimates of how the valuation of zoned schools changes with charter school entry - are not affected by time-invariant physical or natural boundaries. [26]

[26]Black (1999) carefully dealt with this issue by using maps to check whether a boundary was a physical or natural boundary. Given that my data covers four states, such a task would not be feasible.

Table 2: Summary Statistics

Sample	All Observations	Within 0.25 Miles of a Boundary		Within 0.25 Miles of a Boundary and 5 miles of a Charter	
		High Test Score Side	Low Test Score Side	High Test Score Side	Low Test Score Side
	(1)	(2)	(3)	(4)	(5)
Number of Observations	1,320,929	292,109	290,715	237,763	234,608
		House Characteristics			
Sale Price (nominal dollars)	248,596	240,847	215,387	232,732	207,538
	(388,772)	(370,805)	(321,059)	(365,654)	(315,215)
Square Footage (logs)	9.16	9.05	9.09	8.99	9.02
	(0.99)	(1.02)	(0.92)	(1.0)	(0.9)
Number of Bathrooms	1.69	1.63	1.61	1.60	1.58
	(1.01)	(0.98)	(0.96)	(0.98)	(0.95)
Year Built	1981	1978	1978	1977	1977
	(24)	(25)	(24.7)	(25)	(24)
		Neighbourhood Characteristics			
% students above standard	33	49.6	34.2	49.4	33.9
	(16)	(18)	(16)	(18)	(16)
Median Household Income	62,327	59,995	56,484	57,936	54,762
	(32,840)	(32,143)	(30,294)	(30,776)	(28,560)
% white	80	78	76	77	75
	(20)	(21)	(23)	(22)	(24)
% with Bachelor's or Higher	34	33	31	32	30
	(19)	(19)	(18)	(19)	(18)

Notes: Summary statistics for several cuts of the data. Column (1) is the mean (standard deviation in parentheses), for all observations. Columns (2)-(3) is for the sample of houses within 0.25 miles of the boundary. Columns (4)-(5) is houses within 0.25 miles of the boundary and within 5 miles of a charter. Source: Zillow ZTRAX Dataset, American Community Survey 2009-2013, 2013-2017.

III Empirical Results

Event Study Results: Hedonic Regressions

I start by running a hedonic event study of charter entry. The hedonic model is identical to equation (1) without the boundary fixed effects. Table A2 in the Appendix presents results from this specification. There is a positive and significant coefficient on $Test$ - indicating that households value the quality of their zoned public school. The coefficient is 0.056, indicating that a one standard deviation increase in zoned school quality is associated with a 5.6 percent increase in house prices. As expected, the coefficients on number of bathrooms, and log square feet of a house are positive and significant. Households also value having neighbours with higher incomes - the coefficient on "Median HH Income" is positive and significant. The main coefficients of interest are $Test : Event_j$: they show how the valuation of traditional public school quality changes with charter entry. $j > 0$ denotes post-charter entry. These coefficients can be better visualized in Figure 4. Time 0 is the year that the charter school opened, and the coefficient at $t = 0$ is normalized to zero. There is a drop in the valuation for school quality at $t = 1$. Looking at the magnitude of the decrease, we see that at $t = 3$, the decrease is around 3.4 percentage points.

The hedonic regression shows that households value zoned school quality and that this valuation falls a year after a charter school enters. While suggestive, one may be concerned about charters timing entry based on differential neighborhood characteristics. As previously discussed, such concerns can be alleviated through the inclusion of the boundary discontinuity design. By comparing houses very close to each other, the boundary discontinuity design controls for local neighbourhood characteristics as it is unlikely that houses on either side of the boundary would be subject to different ones. In fact, I find that the results from the hedonic event study and the boundary discontinuity design event study are quite similar, suggesting that the issue of neighbourhood characteristics is unlikely to be of first-order concern.

Event Study Results: Boundary Discontinuity

I now present the findings from the boundary discontinuity and event study design. To start, one concern for validity is that charter schools enter where house prices are already trending downward. I present evidence showing that this is not the case. To do so, I run an event study of house prices around charter entry without the school quality interaction term. I estimate the following regression equation:

$$\underbrace{\log p_{iab}}_{\text{house prices}} = \alpha X_{iab} + \underbrace{\theta_b}_{\text{boundary FE}} + \underbrace{\sum_{j=-4}^{5} \gamma_j \mathbb{1}_{Event==j}}_{\text{coeff. of interest}} + \varepsilon_{iab} \tag{2}$$

House characteristics and sociodemographics (X_{iab}), year fixed effects, and boundary fixed effects (θ_b) are included. In Figure 5 I plot the γ_j coefficients - they represent the average log house

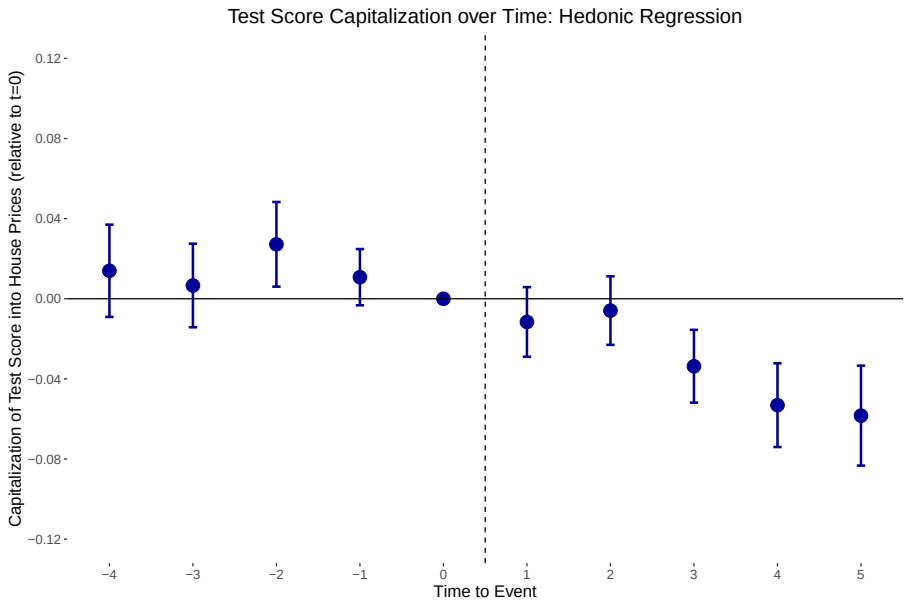

Figure 4: Hedonic Event Study. This figure plots the capitalization of test scores into house prices. On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. These coefficients are the estimates of $Test : Event_j$ from Table A2. Error bars represent 95% Confidence Intervals.

price relative to charter entry. The coefficient at $t = 0$ is normalized to zero. Figure 5 shows that there is no significant downward pre-trend prior to charter school entry lending support to the exogeneity of charter school entry. While the average log house price does trend slightly downward from $t = -4$ to $t = -2$, it rises again afterwards. Furthermore, none of the pre-event coefficients are significantly different from zero. As an additional check, in the event studies I run on the valuation of local school quality, I also show that there is no pre-trend leading up to charter entry. Note that the fact that average house prices rise post-charter entry is consistent with the findings from Andreyeva and Patrick (2017).

To investigate the causal effect of test performance and charter school entry on house prices, I run the specification in equation (1). There is a premium paid for houses in high-performing school zones but it drops after a charter school opens nearby. To get a more precise estimate of sociodemographics along the boundary, I drop any houses that were flagged as being in a census block group that overlapped with multiple school zones. Column (1) of Table A3 in the Appendix presents the results of the main specification. The variables $Test$, % white, % Bachelor's (percentage with a bachelor's degree or higher), % with Children (percentage of households married with children), and Median Household Income are in standard deviations. Other controls included are: Year Fixed effects, Year Built of the house, and dummies for the year the house sold relative to the year a charter entered. I present the δ_js - how the $Test$ coefficient changes relative to charter school openings in Figure 6.

Column (1) of Table A3 shows the main coefficients from the specification in equation (1). The coefficient on $Test$ is 0.055 and statistically significant: a one standard deviation better school (a 16 percentage point increase in test score performance) is associated with a 5.5 percent higher

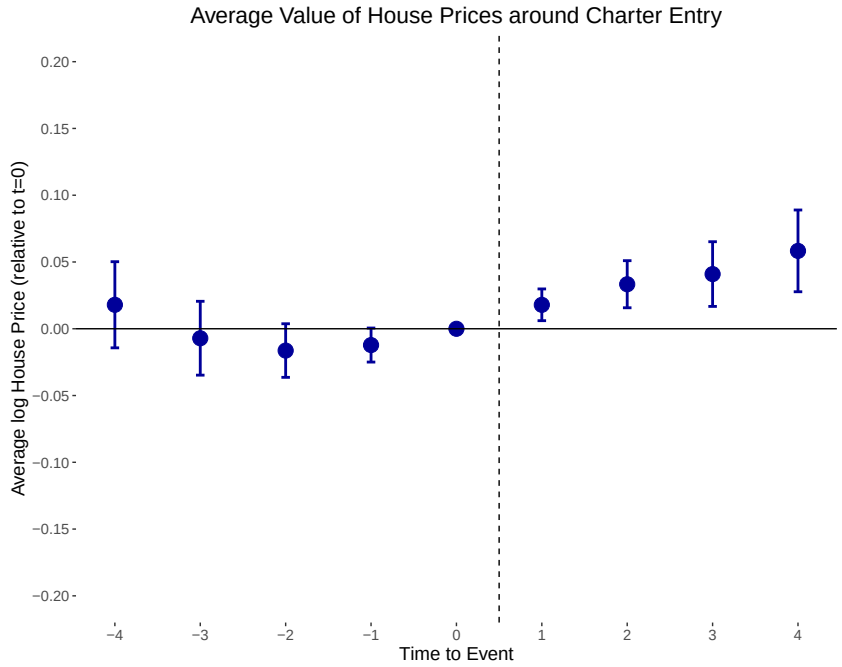

Figure 5: This figure plots average house prices in logs as charter schools enter. On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. Error bars represent 95% Confidence Intervals.

house price.[27]

As in the hedonic model, households value the physical characteristics of their house and sociodemographic characteristics of their neighbours. The rest of the estimates are labeled as $Test : Event_j$ where $-4 \leq j \leq 5$. These are the estimates for how the premium on zoned school quality changes relative to the opening of a charter school within 5 miles. These coefficients are represented graphically in Figure 6 for the specification run in column (1). The coefficient at time $t = 0$, the year the charter opens, is normalized to 0.

The event study shows that there is a drop in the valuation of zoned school quality after the charter school opens. Living on one side of the boundary versus another is not as valuable because there are other options for schooling now. In fact, three years after the charter opens, at $t = 3$, $\delta_3 = -0.043$. In other words the premium that households place on the zoned public school quality drops by four percentage points. In addition, the event study graphs for the hedonic regression and the boundary discontinuity are similar, suggesting that the issue of charters entering into neighbourhoods with changing school quality valuations is not of big concern.

One mechanism that could be linked to the drop in zoned school valuation is that with school choice families who would have previously chosen to buy into the "better" side of the boundary, can now live on the "worse" side but still access good schools in the form of charters. Later on, I present some evidence on sociodemographics from the American Community Survey suggesting that such sorting is taking place.

[27]Recall that in this estimate, the presence of physical/natural boundaries are not controlled for. These boundaries may affect the initial premium on school quality. The focus in this paper though is to look at the change in premium after charter school entry, which is unaffected by the presence of time-invariant boundaries.

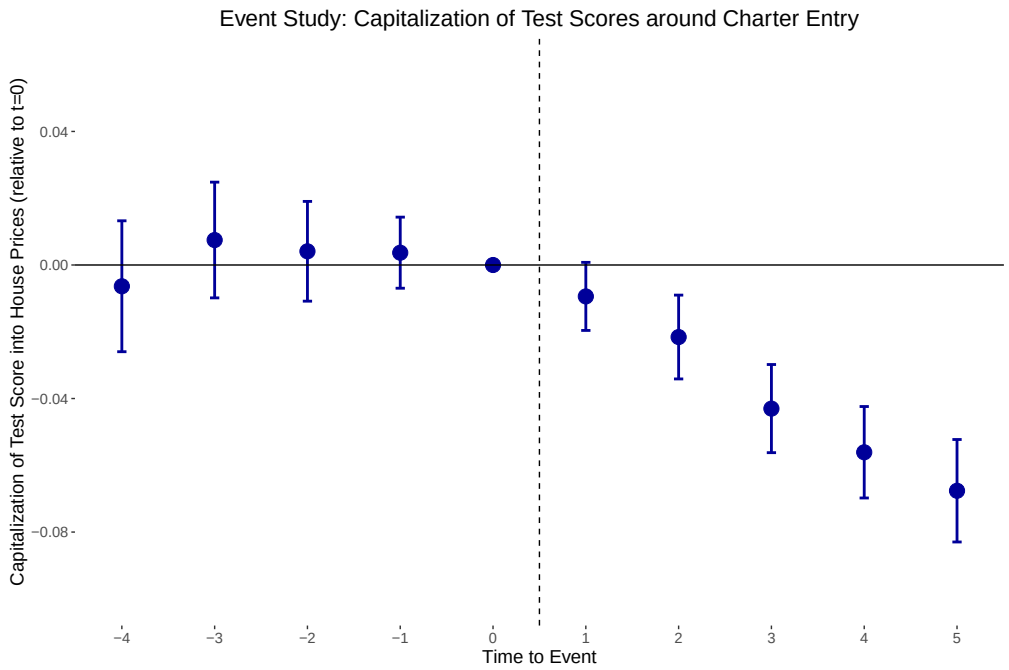

Figure 6: Main Event study. This figure plots how the capitalization of local school quality into house prices changes with charter entry. On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. Error bars represent 95% Confidence Intervals.

The last row of Table A3 checks for the existence of pre-trends in the event study. To do so, I perform an F-test of the null hypothesis $\delta_{-1} = \delta_{-2} = \delta_{-3} = \delta_{-4} = 0$ and report the p-value.[28] In the main specification, the p-value is 0.50, and therefore the null hypothesis cannot be rejected.

The main specification controls for sociodemographics along the boundary. As previously mentioned, this is important since school attendance zone boundaries lead to sorting, and households value the type of neighbours they have. In addition, factoring in sociodemographics is needed for the event study estimates as households may resort in response to charter entry. The downside of including sociodemographic controls though, is that it limits the sample size by about 35 percent since it is necessary to drop census block groups that overlap with multiple school attendance zones. In Column (2) of Table A3, I present the event study results from the full sample, without controlling for sociodemographics. The event study is also presented graphically in the graph "No Sociodemographics" of Figure 7. The point estimates of the event study are quite similar to the one with sociodemographics. Note though that the initial valuation on zoned school quality is higher, at 9 percent compared to 5.5 percent when controlling for sociodemographics. This finding reflects the work of Bayer, Ferreira, and McMillan (2007): leaving out sociodemographics will bias the valuation of school quality upwards. Having established though the similarity between the event study results with or without sociodemographics, I run the rest of the specifications without sociodemographics, in the interest of keeping the full sample of data.

Next, I show how my results vary with distance to the charter. First, I restrict the distance to a charter to 4 miles and to 3 miles. Again, we see a drop in the coefficient on the premium

[28] Note that $\delta_0 = 0$ by assumption.

for school quality at $t = 1$ in the graph "Charter School (4 miles)" and "Charter School (3 miles)" in Figure 7. Other estimates from this estimation are in Column (3) and (4) of Table A3. Narrowing the distance to the charter results in similar findings to the baseline specification.

Additionally, I run the event study for houses that are between 4 to 6 miles from a charter, and between 4 to 7 miles. This test supports the validity of the main hypothesis - that charter openings drive the changes in house prices across school zone boundaries. When charters are farther away, they should have less effect on the property values in a school zone. The graphs "Charter (4-6 miles)" and "Charter (4-7 miles)" in Figure 7 confirm this intuition. The event study results here do not show a substantial drop in the premium on school quality. While the valuation of zoned public school quality for the 4-7 mile subsample does drop slightly at $t = 3$, the magnitude of the drop is much smaller. Columns (5) to (6) in Table A3 show the results for other coefficients for these specifications.

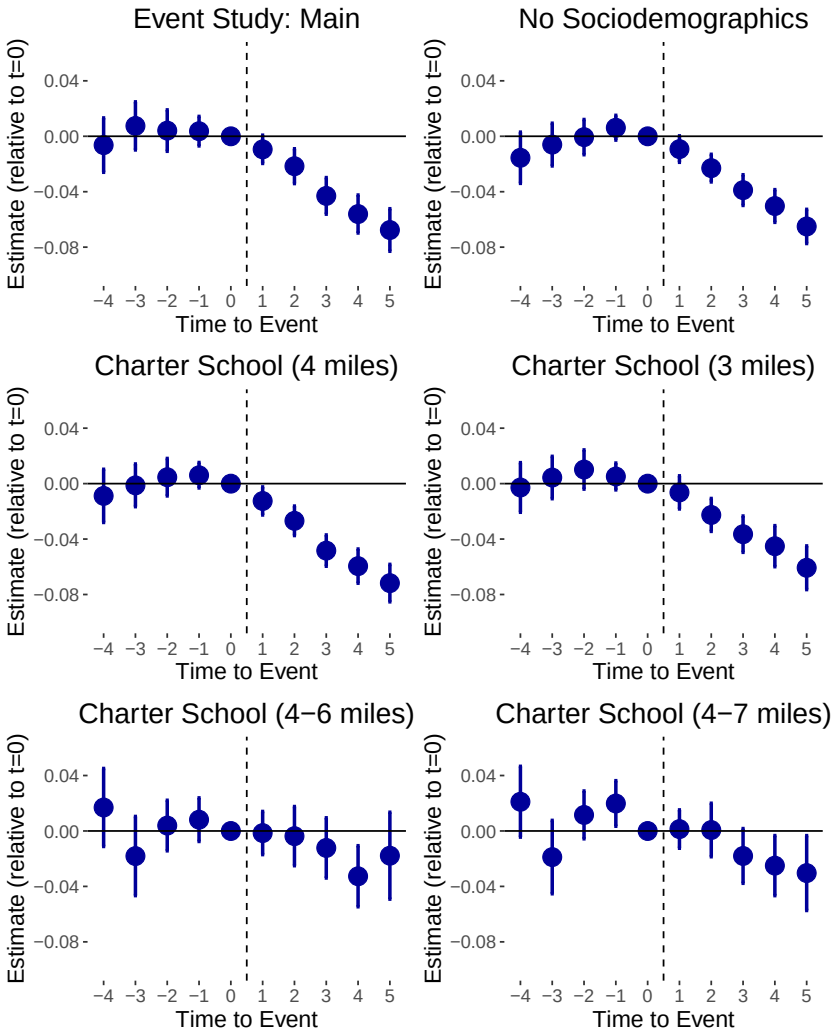

Figure 7: This figure plots how the capitalization of local school quality into house prices changes with charter entry for several specifications. On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. Error bars represent 95% Confidence Intervals. "Event Study: Main" is the main specification from Equation 1, with sociodemographic controls included. "No Sociodemographics" is without sociodemographic controls. "Charter School (4 Miles)" is only with the sample of houses within 4 miles of a charter school opening. "Charter School (3 Miles)" is only with the sample of houses within 3 miles of a charter school opening. "Charter School (4-6 miles)" and "Charter School (4-7 miles)" are with the sample of houses within 4-6 miles and 4-7 miles, respectively, of a charter school opening.

Heterogeneity in the Impact of Charter Schools

Thus far I have established that charter school entry decreases the valuation of zoned public school quality. Now I study how the response to the opening of charter schools differs by urbanicity.

The NCES classifies zoned schools by their urban status. I separately investigate the change in valuation for local school quality for houses located in school zones classified as "city" versus "suburbs". More precisely, the "city" classification includes large, mid-size, and small cities. The "suburbs" classification includes large, mid-size, and small suburbs in addition to towns and rural districts.[29]

The motivation for looking at urbanicity is that previous work (e.g.Angrist, Pathak, and Walters (2013), Cohodes (2018)) have documented that charter schools in urban areas tend to be of higher quality due to their "no-excuses" philosophy of having rigourous and high standards for student behaviour. Intuitively, the response to charter school entry could be stronger in these areas because of their tendency to attract better charter schools. Columns (1) and (2) in Table A4 present the results for the event study specification from these two subsamples. Figure 8 shows the event study results for the city subsample on the left, and the suburb sample on the right. Table A4 shows that the point estimates for the valuation of local schools pre-charter entry in cities is higher at 10.5 percent, compared to 7.6 percent in suburbs. Looking at the event study graphs in Figure 8, we see that the drop in the valuation of local school quality in cities takes place faster than in suburbs. For instance the point estimate in the drop at $t = 3$ is -0.052 for the city subsample but only -0.031 for the suburb sample. Note however that while the point estimates do differ between the two subsamples, the response to charter school entry between cities and suburbs is not significantly different at the 5 percent level. I formally test for this using an F-test in the following specification:

$$\log p_{iab} = \alpha X_{iab} + \beta Test_a + \underbrace{\theta_b}_{\text{boundary FE}} + \underbrace{\sum_{j=0}^{5} \sum_{k \in \{city, suburb\}} \delta_{j_k} Test_a \mathbb{1}_{Event==j} \mathbb{1}_{urban==k}}_{\text{coeff. of interest}} + \varepsilon_{iab} \tag{3}$$

where, as before, X_{iab} represent house characteristics, $Test_a$ is the school quality, θ_b is a vector of boundary fixed effects. This model is the same as Equation (1) but with no pre-entry dummies, and it allows for the coefficients on the capitalization of school quality in post-charter entry to vary by urban status (as denoted by $\sum_{k \in \{city, suburb\}}$). The null hypothesis I test is:

$$delta_{j_{city}} = delta_{j_{suburb}}$$

for $j \in \{1, 2, 3, 4, 5\}$. The resulting p-value is 0.10. Therefore I cannot reject the equality in response between cities and suburbs. On the other hand, given the institutional differences in urban charters versus non-urban charters, this question of heterogeneity certainly merits more investigation in the future.

[29] I am unable to examine towns/rural districts separately because of insufficient power.

In addition, it has been shown that charter schools in rural areas tend to be of much lower quality.[30] I am unable to say much on this front though: when restricting my sample size to rural zones I only have 15,000 observations and standard errors on my estimates are quite large.[31]

[30]For example, Gulosino and Liebert (2020) show this for California.

[31]The reason for the small rural sample is that there are less houses sold in rural areas in my sample in addition to less charters entering. In addition, the boundary discontinuity requires dropping defacto districts - when one school serves an entire grade in the district - and these are mostly found in smaller towns.

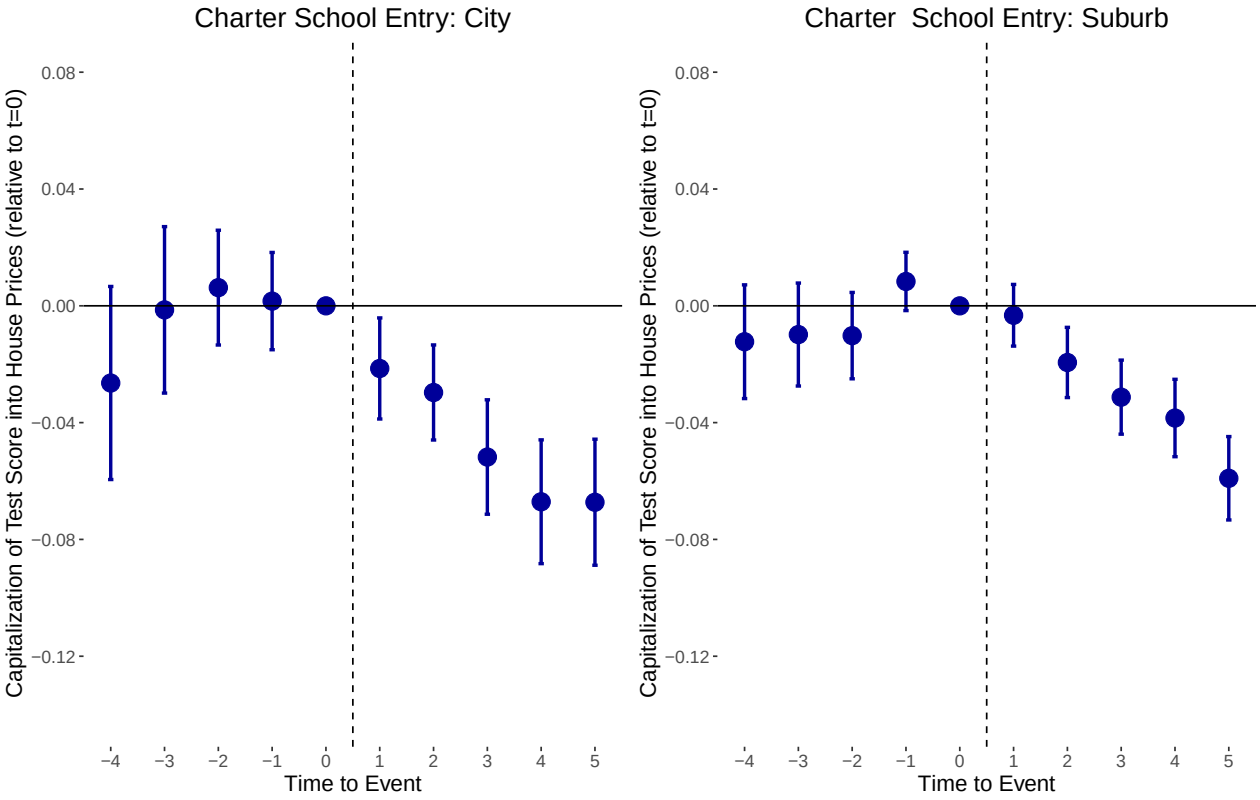

Figure 8: Heterogeneity in Charter Entry by Urbanicity. This figure plots how the capitalization of local school quality into house prices changes with charter entry for the subsample of cities (left image) and suburbs (right image). On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. Error bars represent 95% Confidence Intervals.

Evidence of Sorting

As previously discussed, as the capitalization of local school quality into house prices changes, there is the potential for neighbourhood change. The decrease in the difference in house prices across school boundaries could be related to changes in sociodemographic patterns as well.

In this subsection I explore how certain sociodemographics have changed after the entry of charter schools. The only publicly-available data of time-varying sociodemographics at the neighbourhood level is the American Community Survey (ACS). Recall that the downside of the ACS is that it uses a smaller sample size relative to the census, and the data is reported in five-year rolling averages so that it is difficult to get a precise estimate of how sociodemographics change from one year to another.

With those caveats in mind, I present some suggestive evidence of resorting. The unit of observation is a pair of adjacent census block groups where one is on the high test score side of a school boundary and the other is on the low test score side. Similar to the event study I only look at block groups within 0.25 miles of a boundary where a charter school entered within five miles. For each census block group pair and associated event year I merge in sociodemographic characteristics for the ACS from the pre-event and post-event period. For event year x, I use the ACS ending in x as the pre-period which covers years $x-4$ to x. I use the ACS starting in $x+1$ as the post-period, covering years $x+1$ to $x+5$. For example, if a charter entered in 2013, I compare how sociodemographics in block groups during 2014-2018 changed relative to 2009-2013. Note that I can only cover event years up until 2014, since the last set of years available for the ACS is 2015-2019.

For each adjacent census block group pair straddling a school zone boundary, I calculate the difference across the boundary in the sociodemographic variable of interest pre-charter entry and compare how this difference has changed with charter entry. To do so, I estimate the following simple regression model:

$$\Delta \text{sociodemog}_i = \beta \mathbb{1}_{post-charter} + \epsilon_i \tag{4}$$

where i denotes a census block group pair. $\mathbb{1}_{post-charter}$ is an indicator for after charter entry and the dependent variable is the difference in sociodemographics across a boundary. The coefficient β denotes how the average value of the difference in sociodemographics from one side of the boundary to another changes post-charter entry. Year group fixed effects and state fixed effects are also included.

Table 3 below shows the sociodemographic variables of interest. I find that the average difference across the boundary in the percentage of people with a Bachelor's degree or higher falls by 2.2 percentage points after charter entry. Column (2) shows that the average difference in median household income across the boundary falls by roughly $2,000 with charter entry, though the point estimate is not significant. More prominently though, the difference across the boundary in the percentage of households with income above $60,000 and above $100,000

(columns (3) and (4)) both fall by roughly 2 percentage points after charter entry.

These results support the story that with charter entry, families with higher education and income- who, absent the charter would pay to live on the good side- enter the lower quality school zones thus reducing the disparity in certain sociodemographics across school zone boundaries. I want to caution though that these findings are only suggestive due to the limitations of the data. There is certainly more work to be done in understanding how sociodemographics along school zone boundaries shift after charter school entry.

Table 3: Evidence of Sorting

	Dependent variable:			
	Δ % Bachelor's Degree	Δ Median HH Income	Δ % HH Income > $60,000	Δ % HH Income > $100,000
	(1)	(2)	(3)	(4)
post-charter	−0.0216	−1,987.121	−0.0207	−0.0205
	(0.008)	(1,468.399)	(0.010)	(0.008)
Observations	8,633	8,547	8,633	8,633
Adjusted R^2	0.010	0.007	0.010	0.008

Notes: This table shows how the average difference in sociodemographics across a school boundary changes with charter entry. The difference in census block group sociodemographics from the ACS are regressed on year and state fixed effects and *Post-Charter*, an indicator for whether the sociodemographic measure is recorded after charter entry.

IV Robustness

Now, I conduct several further robustness checks to show that the event study results stand up to different specifications.

One potential concern is that the time period of the data lines up with the Great Recession. In all the specifications run so far, any zip code where the foreclosure rate was above 5 percent was dropped. As an additional check, I use a subset of the data when house prices began to rise again. Figure A1 shows the percent change in house prices from the previous year for 2006 to 2019 in Florida, a state heavily affected by the recession. House price data is constructed from the FRED (U.S. Federal Housing Finance Agency). In 2013, the percent change became positive once more. Therefore, I look at a subset of houses that were all sold in the year 2013 or later, to ensure that the drops in the capitalization of school quality are not associated with drops in aggregate house prices overall. Column (1) in Table A5 shows the event study from this sample. The graph "Post-2012" in Figure 9 shows that the event study results are qualitatively unchanged.

Second, the main specification does not include charter schools that closed during the sample period. There are 26 such charters, in comparison to 399 that opened and stayed open. Column (2) of Table A5 and graph "Closed Charters" in Figure 9 show the results for the sample of houses that sold within five miles of a charter that opened and then closed. The estimates are noisier given the smaller sample size and there seems to be no significant change in the valuation of school quality until around $t = 5$. One reason that there still may be a drop in the valuation is that several of the charter schools that closed were in proximity to charters that opened

(and remained opened). Nevertheless, these findings do suggest that for charters who are not in operation for very long, their effect on the valuation of zoned school quality is muted.

Column (3) drops boundaries that are more than 2.5 miles in length. I do this because in the case of very long boundaries, a house at one end of the boundary versus one at the other end may not have access to the same amenities. The event study is shown in the graph "Boundary Length: 2.5 Miles" in Figure 9. The qualitative results of the event study are similar to the main specification.

In column (4) of Table A5 I refine the distance to the boundary to ensure that I am comparing houses that have access to the same neighbourhood amenities. I now compare houses that are within 0.20 miles to the boundary. The graph"Boundary: 0.20 miles" in Figure 9 show that these refinements do not greatly affect the event study results, namely, that the premium for local school quality falls with the opening of a charter school.

Next, as discussed in the empirical specification, I used test scores only from the 2009-10 school year, in case student sorting in response to charter school entry induces changes in school quality. Here, I do a robustness check to show that allowing test scores to vary year-to-year does not affect my results. Column (5) of Table A5 shows the results. The graph "Varying Test" in Figure 9 highlights that even with this measurement of test scores, there is a still a decrease in local school quality valuation with charter school entry.

Lastly Column (6) drops any high-enrollment charters. Recall that when charter schools become oversubscribed, they are required to run a lottery and places are not guaranteed. For these types of charter schools, they may not represent a viable alternative for families from their local school. Since my event study considers the response to *new* charter schools, it is unlikely that they will be oversubscribed (Tuttle, Gleason, and Clark, 2012). There is no data publicly available on which charter schools have to hold lotteries; however, I can look at how many students a charter school has enrolled each year (National Center for Education Statistics, 2009-2018b). In my data, I drop charters that had more than 1 year with less than 2 percent enrollment growth. I think of these dropped schools as "high-enrollment charters". The graph "No High-Enrollment Charters" in Figure 9 indicates that the event study results still go through for this subsample, although the pre-trend test only passes marginally. Other coefficients are in Column (6) of Table A5.

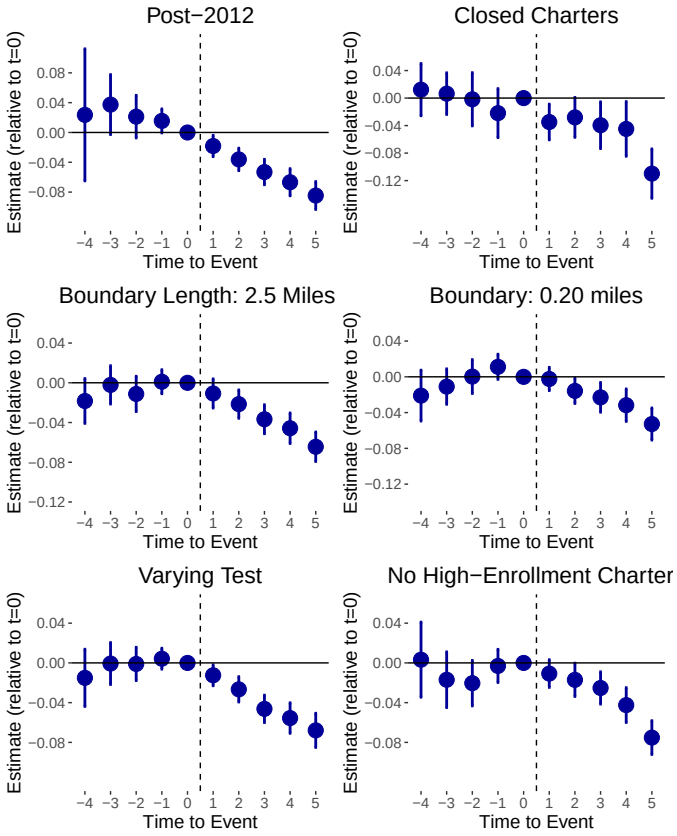

Figure 9: Additional Robustness Checks. This figure plots how the capitalization of local school quality into house prices changes with charter entry. On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = 0$ is normalized to zero. Error bars represent 95% Confidence Intervals. "Post-2012" is for the sample of houses sold after 2012. "Closed Charters" is only for houses that were within 5 miles of a charter that opened and then closed. "Boundary Length 2.5 miles" restricts the school boundary length to 2.5 miles. "Boundary 0.20 miles" restricts the distance to the boundary to 0.20 miles. "Varying Test" allows for test scores to vary year-to-year. "No High-Enrollment Charter" drops charter schools with high-enrollment.

V Conclusion

School choice is seen as a way to foster opportunity for low-income households, spurring policy-makers to expand these programs. This paper studies how school choice programs affect housing markets and the capitalization of school quality into house prices, which have not been widely assessed so far.

First, using standard hedonic methods, I provide evidence that the valuation of the average household for local school quality drops after a charter school opens. I then expand on this design to account for unobservable neighbourhood characteristics by combining an event study of charter school entry with a boundary discontinuity design, which allows me to identify how the premium for local school quality changes. Upon charter school entry, the capitalization of school quality into house prices falls by four percentage points, per standard deviation of school quality. Intuitively, the charter school provides an additional option for schooling since it does not have an attendance zone. As a result, it is less valuable to live on a certain side of a school boundary. This finding withstands a myriad of robustness tests.

As school choice transforms neighbourhoods, one implication is that low-income neighbourhoods become more desirable to live in since parents can use school choice to avoid the local school. I show suggestive evidence of such resorting: the difference across the boundary in the percent of households with a bachelor's degree and the percent of high-income households falls post-charter entry. One possible negative outcome is rising rents if low-income neighbourhoods become gentrified. The techniques developed in Bayer et al. (2016) could allow researchers to estimate how households valuation of amenities changes in response to school choice.

Given that boundary discontinuities diminish under school choice, the widely-used spatial regression discontinuity design to estimate valuation of school quality may no longer be valid in settings with high levels of school choice. This suggests that we will need to turn to alternative methods, such as structural methods proposed in Bayer, Ferreira, and McMillan (2007) or Bergman et al. (2020), to estimate willingness to pay for neighbourhood amenities and household sorting. I intend to pursue this line of research in future work.

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