Residential Sorting, School Choice, and Inequality

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Abstract

This paper studies how the expansion of school choice affects housing markets. First, I use an event study that exploits time variation in the entry of school choice to show that, on average, school choice decreases the willingness to pay for a standard deviation increase in school quality by 6 percentage points, or around $15,000. Second, I develop a structural model featuring heterogeneous agents and residential choice to assess the effects of school choice on opportunity. While school choice is seen as a way to increase opportunity for low-income families, the model shows that school choice leads to gentrification of poorer neighbourhoods, implying that school choice does not necessarily improve outcomes for all low-income households. Intuitively, breaking the link between residence and school causes higher-income families to use school choice and move into neighbourhoods with poor performing schools, driving up house prices. Benefits from school choice programs are thus counterbalanced by a higher cost of living. There is a tradeoff between expanding school choice and benefiting high-ability children, versus making parents of low-ability children, who do not utilize school choice, worse off. Furthermore, I find that the majority of low-income families prefer that a choice school does not open in their neighbourhood, so that their costs-of-living do not change.

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1 Introduction

Recent years have seen an expansion of school choice programs, which aim to foster opportunity by giving families the chance to send their child to a school other than their zoned neighbourhood school. While the effect of school choice on student achievement has been widely studied,[1] little research has investigated the effects of school choice on housing markets. Indeed, opponents to school choice along with popular media reports[2] have highlighted that school choice programs allow wealthier families to move into poorer neighbourhoods while avoiding the local school, driving up the house prices. The housing channel thus has the potential to counteract some of the benefits provided by school choice to poorer families.

In this paper I show, for the first time, that large-scale public school choice reforms weaken the relationship between house prices and local school quality.[3] I do so by using an event study that leverages school choice expansion arising from the "Race to the Top" initiative spearheaded by the Obama administration. I then incorporate the reduced-form results into a structural model with neighbourhood choice and heterogeneous agents to investigate how school choice affects opportunity. The model highlights that school choice leads to rising costs-of-living in low-income neighborhoods, subsequently reducing wealth for individuals in these areas. The result that low-income neighbourhoods see rising house prices in school choice was also documented in Nechyba (2003b) and Avery and Pathak (2015).

This work is related to a long line of literature investigating the willingness to pay for school quality. Historically, residential location was the main determinant of school assignment through 'school attendance zones,' geographic areas that mark which regions 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 also often have better amenities. Black (1999) was the first to convincingly identify preferences for school quality by comparing house prices on opposite sides of school attendance zone boundaries. 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. 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 paper also highlights the importance of controlling for sorting along school boundaries.[4]

To start, this paper follows Black (1999) by implementing a boundary regression discontinuity design to estimate the willingness to pay for school quality. I then extend the literature by running an event study showing how price discontinuities across boundaries change with charter

[1] See Epple, Romano and Zimmer (2016) for an up-to-date review.

[2] e.g., Harris (2015), Barnum (2018), Asmar (2018). For example, from Barnum (2018) published in The Connecticut Mirror: "School choice lets wealthy families gentrify neighborhoods, avoid local schools."

[3] Schwartz, Voicu and Horn (2014) study how choice schools affect housing markets in New York City using a difference-in-difference design. My work differs from theirs in that I investigate changes in school choice across several states using an event study technique leveraging time variation in when charter schools enter. I also use a structural model to assess the implications of the changes in schools and housing markets on opportunity.

[4] Other papers using boundary discontinuity design include: Kane, Riegg, and Staiger (2006), Fack and Grenet (2010), Schwartz et al. (2014).

school entry. The event study uses variation in charter school entry arising from the introduction in 2009 of the Obama administration's "Race to the Top" program, which gave grants to states who implemented education reforms.[5] The expansion of charter schools, which are independently operated public schools without tuition, provides an ideal case study in school choice as they do not have attendance zones. The event study thus compares the house price discontinuity across school attendance zone boundaries after a charter school opens nearby to regions that had not yet received a charter, but do in the future.

I find that there is a 6 percentage point drop in the willingness to pay per standard deviation of local school quality after a charter school opens nearby. In dollar terms, this translates into a $15,000 drop for the average house. This result withstands numerous robustness checks, including: dropping physical boundaries, narrowing the distance to the boundary, restricting the length of the boundary, and allowing for time-varying school quality.

While the reduced-form results indicate that school choice programs significantly decrease the capitalization of school quality into house prices, they do not show how school choice affects opportunity. To address this, I build a structural model of overlapping generations with heterogeneous agents who differ by income and ability. Parents choose between neighbourhoods which are characterized by housing costs and school quality, and they must send their child to the school in their neighbourhood. In addition, adults can invest privately in the human capital of their child.

I calibrate my model to match moments at the school district level, such as, the Gini coefficient for income, the intergenerational mobility of income, the share of education spending, and the bequest to net wealth ratio. In addition, the model targets the relationship between house prices and school quality, prior to school choice expansion, as observed in the data. Simulations of the model show that, in line with the data, parents in the model sort into neighbourhoods by income.

With parameters in hand, I assess the effects of school choice on opportunity by performing policy experiments where a choice school opens in specific neighbourhoods. While the choice school accepts students residing in any neighbourhood, families must pay a cost to attend. This cost structure represents the fact that choice schools usually have some barriers in the forms of not providing transportation or having complex enrollment processes.[6] A natural assumption I impose is that the cost is lower for families who live in the same neighbourhood as the choice school.

I focus on two scenarios for choice school location: (i) neighbourhoods with good local schools, and (ii) low-income neighbourhoods with poor performing local schools. In both cases, expanding school choice causes the relationship between house prices and local school quality to weaken, as found in the reduced-form results. The house price range shrinks: neighbourhoods that had low-quality schools and low house prices see their house prices rise. This is because demand for

[5] Arne Duncan, Education Secretary, emphasized the importance of charters for Race to the Top funds: "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.

[6] For more information on costs of choice schools, see Valant and Lincove (2018).

these areas increase since parents are no longer required to send their child to the low-quality school. In Scenario (ii) though, house prices in the low-income neighbourhood rise by more than in Scenario (i) because there is a greater influx of high-income households moving in.

The model highlights a trade-off when policymakers choose where choice schools can locate. For low-income families with high-ability children, they benefit when a good choice school opens in their neighbourhood because they choose to send their child to the choice school. However, around fifty percent of low-income families have low-ability children and they are worse off because their child stays in the local school and they have to pay higher housing costs. These families actually prefer that the choice school does not locate in their neighbourhood so that their house prices do not rise as much. The reason for this differential outcome is that the returns to school quality increase with child ability,[7] and so parents with low-ability children do not find it worthwhile to pay the cost for the choice school. This finding is in line with Singleton (2019), showing that choice schools tend to "cream-skim" by taking only the best students.

This paper highlights a negative unintended consequence of school choice. While school choice is intended as a way to provide more opportunities for low-income households, my results show that school choice drives up the housing costs where poorer families live. Segregation by income at lower-quality schools increases, since higher-income families switch to choice schools leaving a higher concentration of poor families behind. The impact on the housing market also reduces opportunity for low-income families because parents have to reduce their education investment in order to pay for higher housing costs. For children with parents in the bottom income quintile, I show that their chance of reaching the top two quintiles would be four percentage points higher when the choice school locates in the higher-income neighbourhood.

Looking forward, the insights in this paper suggest that policymakers should think carefully about the interplay between housing markets and school choice. While expanding school choice eliminates the link between house prices and school quality, it also induces residential sorting through changes to neighbourhood composition which can negatively affect current residents. Policies that could alleviate the effect of school choice on low-income households include free transportation to choice schools and helping low-income families access information about school choice options.

The remainder of the paper is structured as follows. The following section provides some background on the relevant literature, and gives a brief overview of school choice in the United States. Section 3 presents the empirical strategy and the data. The empirical results and robustness tests are in Section 4, and Section 5 outlines the structural model. Section 6 presents the model results, while Section 7 concludes.

[7]Supporting evidence that returns to school quality increase with child ability can be found in Aizer and Cunha (2012) and Attanasio, Boneva, and Rauh (2018).

2 Background

2.1 Relation to the Literature

This paper relates to three main strands of literature: estimating the willingness to pay for school quality, models of neighbourhood sorting, and the effects of school choice.

There is a long literature on estimating preferences for school quality. Black (1999) pioneered the boundary discontinuity design to estimate willingness to pay for school quality in Massachusetts. Kane et al. (2006) then used the boundary design to show that school quality is capitalized into house prices in North Carolina. Using a structural model with heterogeneous preferences, Bayer et al. (2007) identify the willingness to pay for school quality of both the average and the marginal buyer. Furthermore, their work showed the importance of controlling for sociodemographics along the boundary. Investigating how boundary discontinuities change, Fack and Grenet (2010) show that house prices across the boundary narrow with proximity to private schools.

Thus far though, most research on willingness to pay for local school quality has not studied the effect of public school choice. One exception is Schwartz et al. (2014), who use a difference-in-difference method to study the effect of choice schools in New York City. I extend this literature by embedding the boundary discontinuity design into an event study around the opening of charter schools. Furthermore, my data allows me to study changes in school choice spanning several states in response to “Race to the Top”.

The structural model builds on the work in the area of residential sorting, such as Fernández and Rogerson (1996,1998), Epple and Romano (2003), Benabou (1994, 1996), and Durlauf(1996a, 1996b). Nechyba (2003a) uses a model of schooling and housing to show that public schools create more income segregation than private schools. Durlauf and Seshadri (2017) study the relationship between cross-sectional inequality and mobility with a model of human capital and neighborhood formation. They model neighborhoods as formations of families who set an income requirement, whereas I do so through a housing market clearing condition. Fogli and Guerrieri (2018), study how neighbourhood segregation amplifies the effects of an increase in the skill premium on inequality and intergenerational mobility. Also related is Eckert and Kleineberg (2019) who study how public school financing mechanisms and neighbourhood sorting affect local opportunities. My work differs from the above in the sense that it is focused specifically on how school choice expansion affects sorting and inequality. As previously mentioned, Avery and Pathak (2015) showed that school choice could negatively affect poorer families through higher house prices and induce them to leave their neighbourhood. Furthermore, in Nechyba (2003b), he highlights how school choice in the form of private school vouchers can increase the value of poorer school districts. My work differs from these two papers in that I construct a dynamic overlapping generation model to quantify the long-term effects of school choice on inequality and intergenerational mobility.

Lastly, my work ties into the effect of school choice programs such as: Urquolia (2005), who shows that school choice programs do change the composition of peer groups in public schools, and Singleton (2019), who finds that charters tend to accept higher performing students. Mehta (2016) builds a model of charter school entry to assess how public school competition changes, while Gilraine, Petronijevic and Singleton (2019) study school response to heterogeneous charter entry with administrative data in North Carolina. This paper focuses less on how charters change public school quality, and instead concentrates on the channel through which school choice affects housing markets.

2.2 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 where they accept students from.

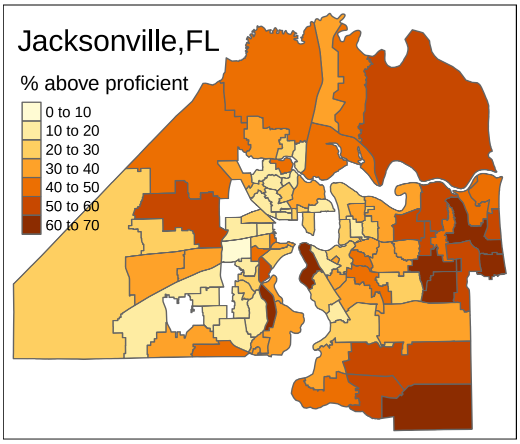


Figure 1: Elementary School Attendance Zones in Jacksonville, Florida. The school district is Duval County Public Schools. Each area represents an elementary school zone. The different colours represent the percentage of students who perform above proficient on standardized math tests (Florida Statewide 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 big changes in school quality as seen in Figure 1, which shows elementary school zones and their test performance in Jacksonville, Florida. Each area in 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 mean better test results. There are several cases where a high performing school is located next to a low performing one.

As a result of the capitalization of school quality into house prices, numerous reforms have been implemented to give families more options for public schools. One common school choice program is open enrollment, which gives students the option to be admitted to a school in a different neighbourhood. 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. Another prominent form of school choice is charter schools. These are publicly-funded schools that are independently operated but held accountable to the local school district or government. These charter schools cannot charge tuition and importantly, for the purposes of school choice, they do not have attendance zone areas.

In recent years several states introduced policies to expand access to charter schools. These changes were driven by the Obama administration's "Race to the Top" program, which gave funding to states that implemented education reforms. The "Race to the Top" program thus provides an exogenous shock that led to changes in charter school access.

I focus on four states, North Carolina, Florida, Tennessee, and Massachusetts, that expanded access to charter schools. In addition, these four states did not already have in place other prominent school choice options such as mandatory open enrollment. Therefore, the expansion of charter schools was a significant change in the school choice environment.

In practice, the legislation on charter schools took on a variety of forms. In 2011, North Carolina removed a state-wide cap on charter schools. The state subsequently went from having 100 charter schools in 2011 to 176 charter schools in 2016. Similarly, Tennessee eliminated caps on its charters in 2011 and also removed restrictions on what kind of students can attend charters. Florida made it easier for high performing charters to add additional campuses and Massachusetts facilitated the growth of charters in underperforming districts.[8]

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. For North Carolina, Tennessee, and Massachusetts, the process takes over a year.[9] Given the lengthy application process and the subsequent time it takes to open a new school, families would be aware about a charter school entering before it officially opens for classes.

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 there child will be allowed to attend. Studies on the percentage of charters with lotteries is limited. Tuttle, Gleason and Clark (2012) study middle school charters in the years 2005-2007 and find that only 10-15 percent of charter schools were oversubscribed. The authors compare charter schools with lotteries and those without, and find that the former 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 these will be oversubscribed.

Table 1 shows how the percentage of charter schools and the percentage of students in charters increased between 2010 and 2016. Comparing the 4th and 5th columns, the percentage of students enrolled in charter schools almost doubled in Florida and Tennessee between 2010 and 2016. North Carolina went from having 2.8 percent of its students attend charter schools in 2010, to 6 percent in 2016. Massachusetts also saw an increase, going from 3 percent to 4.5 per-

[8] For more information on North Carolina, see Gilraine et al. (2019); for Massachusetts, see Cohodes, Setren and Walters (2019) and Ridley and Terrier (2018); for Florida, see the 2011 Senate Bill CS/HB 1331— School Choice , for Tennessee, see SCORE (2012).

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

cent. The 2nd and 3rd columns show that the percentage of public schools classified as charters increased in this time period as well, highlighting that charters expanded relatively faster than traditional public schools.

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
North Carolina	3.9	6.4	2.8	6.0
Tennessee	1.6	5.9	3.3	5.8

Table 1: Changes in Charter School Enrollment, National Center for Education Statistics. 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.

3 Empirical Framework

3.1 Estimation Strategy

The goal of the estimation is to identify the willingness to pay (WTP) for local school quality and how it changes with the introduction of charter schools. The main challenge to identification is how to deal with unobservable neighbourhood characteristics that could influence house valuation. To handle this issue, Black (1999) 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 test score performance.

Figure 2 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. I compare the house prices of the "crosses" on opposite sides of their boundary. The house prices of the "triangles" are compared on both sides of the boundary.

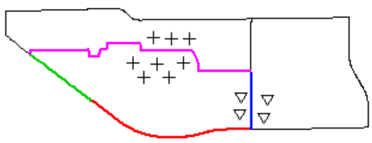


Figure 2: School Zones in Broward County, Florida. This example shows how the boundary discontinuity design works. The crosses and triangles represent individual houses. The lines represent boundaries. Each house is allocated to the closest boundary and compared to houses on the other side of that boundary. 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.

Bayer et al. (2007) highlighted the importance of controlling for sociodemographics at the boundary because of sorting. Think of a boundary where on one side there is a good school and on the other side a bad school. People of certain types (high income, high education attainment, those with children) are more likely to live on the good side of the boundary. Bayer et al. (2007) pointed out that demand for being on the good 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 a school being good, but may want to live on a specific side of the boundary because they want to have higher educated neighbours. Therefore, failing to control for neighbourhood sociodemographics would overstate the willingness to pay for local school quality.

The main empirical contribution of this paper is to show that the willingness to pay for local school quality falls significantly after a charter school opens in the neighbourhood. This is done by using an event study exploiting time variation in the entry of charter schools in combination with the boundary discontinuity design mentioned above. For each house, I take its geographic coordinates to match it to the census block group it belongs to and record the sociodemographic information for that area. 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 charter schools opened within 5 miles of the house, and if yes, what year they opened relative to the sale of the house. [10] Houses that never experienced a charter opening either before or after being sold are dropped from the sample.

Formally, the specification is:

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

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. As a reminder, I refer to the school that the house is zoned for as the "local school". X_{iab} is a vector of house and sociodemographic characteristics such as number of bedrooms/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. It is important to control for housing characteristics since it is possible that houses on different sides of a school zone boundary may be different. In the results section, I show that characteristics such as number of bedrooms do not vary across the boundary.

$test_a$ is the test score of the school that the house is zoned for. In this paper I use a school's performance on standardized tests as the measure of school quality. More specifically, I use the percentage of students in a grade who score above proficient in mathematics, averaged across the grades in a school. The reason for using standardized test performance as a measure of quality is that Macleod and Urquiola (2019) show parents value schools based on test achievement, and

[10] Gilraine et al. (2019) show that in North Carolina, seventy five percent of students who switched from a public school to a charter school did so to one within 5 miles of their residence.

not on achievement gains (such as value-added). I use the test score from the first year of data available (2009 for all states except for Tennessee which is 2010). Allowing test scores to vary creates some endogeneity concerns given that test scores could potentially change in response to nearby charter school entry. For instance, Urquiola (2005) shows that school choice programs can affect sorting of students. As a check, in the robustness section I also allow for test score variation over time.

I now shed some light on how to interpret the coefficients of this regression. Bayer et al. (2007) show that when households have homogeneous preferences, estimation of a structural discrete choice model of housing is equivalent to estimating (1). When households are heterogeneous in preferences, the estimated coefficients in (1) represent the willingness to pay for the marginal buyer.

θ_b is the 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 two terms represent the event study component of the analysis. $\mathbb{1}_{charteryear==j}$ 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 WTP for local school quality (captured by $test_a$) changes relative to the opening of the charter school. Fixed effects for each charter year (without interaction with the test variable) and year fixed effects are also included. This specification is similar to the difference-in-discontinuity techniques from Gilraine (2019) and Grembi, Nannicini, and Troiano (2016).

The event study focuses only on the set of houses exposed to charter entry and uses time variation in the sale of the house relative to the year the charter opened. The specification aims to identify how house price discontinuities across school boundaries change with respect to charter school openings. The key identifying assumptions are:

1. No sorting on unobservables that changes with respect to charter school entry.
2. Charters do not select into neighbourhoods whose price discontinuities are already falling (no pre-trend).

In the results section I present evidence showing that both of these assumptions are satisfied. First though, I describe the sources of data I use.

3.2 Data Sources

The period of data is from 2009 to 2018. Since charter laws changed in 2011, I have observations before and after the school choice expansion. While I use data from Florida, North Carolina, Massachusetts, and Tennessee, about sixty percent of my final data set consists of observations from Florida, given that it is the most populous state.

Individual house transaction data is provided by the real estate company Zillow Research, through its dataset Zillow Transaction and Assessment Dataset.[11] This dataset 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 drop all house sales that are either foreclosures, gifts, not at arm's length, with a sales price of less than ten thousand dollars or have missing price or characteristics information. To ensure that the estimation results are not driven by very high house prices, I also drop sales above 1.7 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.

The house price data spans the period of the Great Recession. This does not affect identification though, because the estimation relies on comparing houses on opposite sides of school attendance zone boundaries. It is unlikely that the financial crisis would have affected house prices differently from one side of the boundary versus the other, especially once controlling for neighbourhood sociodemographics.

Geographical data on school attendance zone boundaries is from the National Center for Education Statistics' (NCES) School Attendance Boundary Survey (SABS) for the year 2015-2016. This survey collected school boundaries for more than 70,000 schools in 12,000 school districts nationwide. Due to the limited time span of the boundary data, I make the assumption that throughout my period of study these boundaries have not changed. This assumption is corroborated by Black (1999) who provides evidence from interviews with school administrators in Massachusetts that boundaries are mostly unchanging, at least over the span of a few years. As an additional check, I compare boundaries for the year 2015-2016 to ones collected in 2013-2014 by SABS and find that the majority did not change in this time period.[13]

For each state, I drop any districts that voluntarily adopted an open enrollment policy (recall that none of the states have mandatory open enrollment) since that would weaken the importance of school attendance zone boundaries. I also 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 from the data. Following Black (1999), I ensure that the boundaries in my dataset are from intersecting school attendance zones in the same school district. This is important because school districts differ in their property tax rates and finances.

I restrict the school zone data only to elementary schools, since the recent reforms had the largest effect on elementary schools. High schools previously had popular choice options in the form of magnet schools, which are schools with specialized curricula.

[11] Coverage of the Zillow database for North Carolina is sparse. After completing the data cleaning, I find that there are zero observations for North Carolina's three most populous counties: Mecklenburg, Wake, and Guilford.

[12] This drops less than one percent of houses.

[13] See Table 10 in the Appendix for details on how I calculate this.

School zones may 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. Overlapping zones interfere with the identification strategy since each house in the dataset needs to be matched to a single school. Most elementary schools end in grades 4, 5, or 6, but it does vary by state. To minimize the chance of overlapping zones, I set restrictions on the highest grade a school can serve. Table 11 in the Appendix lists the restrictions for each state and the percent of elementary schools I keep. In addition, for each school zone that remains in my dataset, I check whether it overlaps with another zone and drop it if the overlapping area is larger than 300 square meters (roughly the size of a tennis court).

Information on the location of charter schools and the year they opened is also provided by the NCES. I only keep charter schools that serve elementary level grades. While charter schools can be heterogeneous in quality, a nationwide study of charter school performance shows that on average, students in charter schools do as well as students in traditional public schools.[14] I also drop any charter schools that closed during the period of study which eliminates especially low-performing schools.

The event study years I focus on are 5 years before and 4 years after a charter school enters which accounts for 97 percent of the observations I have. I also only keep boundaries that are in the dataset prior to and after charter school entry, so that the same set of boundaries are compared over time.

Data on individual school test score performance on standardized tests is from each of the four state's Department of Education website.[15] I focus on test scores in math and restrict the data to 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. While previous studies such as Black (1999) and Bayer et al. (2007) used raw test scores, I find that for a non-negligible number of years, only percentage statistics are available.

Each school's test score performance is mapped into a percentile ranking by state. In other words, for each school x, the percentile ranking is a number between 0 and 100 representing the percentage of schools that perform below school x in the same state. I do this to allow for a consistent mapping between the data and the model, since the model measures school quality in percentile ranks. For ease of interpretation, I also present results in standard deviation terms. Furthermore, I filter out boundaries that do not have very big differences in test score performance, since no sorting should occur in this case. I calculate the median test gap across boundaries and drop those that are less than half the median.[16]

Lastly, the empirical strategy requires controlling for neighbourhood sociodemographics. I

[14]See Cremata, Davis, Dickey, Lawyer, Negassi, Raymond and Woodworth (2013).

[15]The test for Florida is "Florida Statewide Assessment Program", for Massachusetts "Next Generation MCAS Achievement", and for Tennessee "TCAP". North Carolina does not name their standardized tests, but provides end-of-grade assessments, see `http://www.ncpublicschools.org/accountability/reporting/leaperformancearchive/`.

[16]This filtering is similar to the one used in Bayer et al. (2007).

use five-year census block group estimates from the American Community Survey (ACS) for the period 2009-2013 and then 2013-2017. The ACS is chosen rather than the decennial census since it reflects changing demographics over a smaller time frame. The selected sociodemographic variables at the census block group level are: percentage of families with children, racial composition, median household income, and education attainment.

Figure 3 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, which allows for a proper estimate of how sociodemographics change along school zone boundaries. When this is not the case, I drop 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.

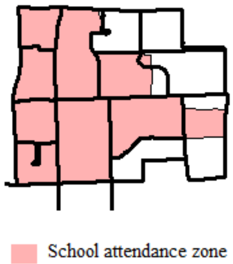


Figure 3: Stirling Elementary School, Broward County, Florida. The shaded area is a school attendance zone and the areas outlined in black are different census zones. Source: SABS 2015-2016, 2010 Census.

4 Empirical Results

4.1 Summary Statistics

I begin by discussing some characteristics of charter schools. First, I document the type of neighbourhoods that charters open in by combining data on charter school locations with census block group characteristics. The left image in Figure 4 plots the distribution of the median household income in thousands of dollars for census block groups with and without charters. The right image is identical except for that it shows the percentage of individuals with a bachelor's degree or higher. Neighbourhoods with charter schools tend to have a lower median household income and to be less educated. Furthermore, I find that census block groups with charters have a slightly lower homeownership rate, with a median of 66 percent, compared to a median of 72 percent in block groups without charters. [17]

Other characteristics I investigate are whether charter schools select into neighbourhoods with private schools. I look at the 350 charter schools that opened in my states of interest and

[17]Given that individuals renting are more mobile than homeowners we would expect to see a bigger response to changes in school choice for rents than house sales. Data on individual rental unit prices is unfortunately not available for the states of interest.

calculate whether there is a private school within a 5 mile radius of the charter. As in the rest of my data, I only search for private elementary schools. I also focus on private schools that are not extremely small and enroll more than 50 students. Out of the 350 charters, there are only 81 within 5 miles of a private school, and when restricting to non-religious private schools, this number drops to 58.

The summary statistics presented so far highlight that charters tend to locate in neighbourhoods that are less educated and have lower income. This selection does not affect identification because the estimation focuses only on neighbourhoods where charters enter, and exploits time variation in when they enter to identify how house price discontinuities change.

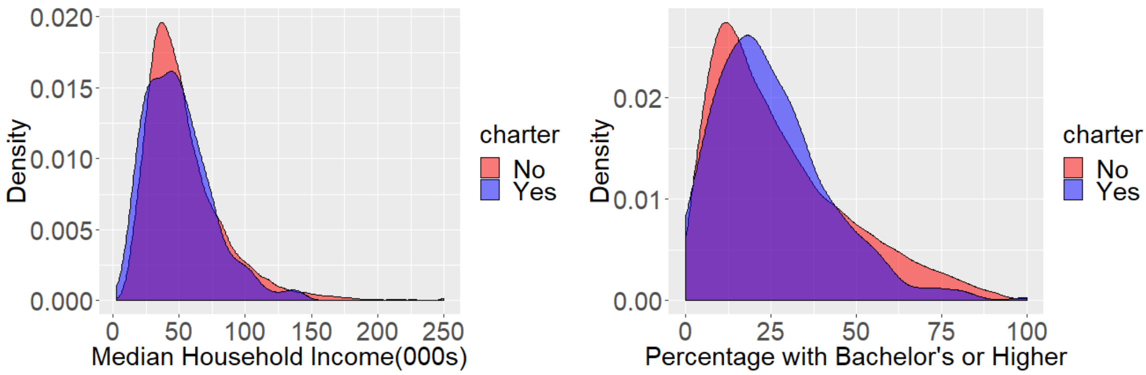


Figure 4: Charter School Neighbourhood Characteristics. The figure on the left shows the distribution of median household income in thousands of dollars for census block groups with and without a charter school. The figure on the right shows the distribution of the percentage of people with a bachelor's or higher for census block groups with and without a charter school. Source: American Community Survey 2009-2013, 2013-2017.

Table 2 presents the summary statistics for my sample of houses within 0.25 miles of the boundary. Columns (1) and (2) display the mean and standard deviation, respectively, for the entire sample of 62,254 observations. The average sale price in nominal dollars is \$ 222,595. The average school has thirty percent of students perform above proficient with a standard deviation of twenty percent. Columns (3) and (4) present summary statistics for the high test score side of the boundary, and columns (5) and (6), for the low test score side of the boundary.[18] Table 2 provides suggestive evidence that houses are roughly \$20,000 more expensive on the high test score side of the boundary and that sorting by sociodemographics happens along the boundary. The median household income is higher on the side of the boundary with the better schools and there is a larger proportion of individuals 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).

I provide further motivating evidence for how house prices and house characteristics behave around the boundary. Following the technique in Bayer et al. (2007), I regress house prices on a distance dummy for how many miles a house is to the boundary and a vector of boundary fixed effects. The distance dummies are in 0.05 mile bands, and I use the notation of negative distance bands to denote houses on the low test score side of the boundary.

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

Table 2: Summary Statistics

Sample	**All Observations**		**within 0.25 miles** **High Test Score Side**		**Low Test Score Side**	
Number of Observations	62,254		30,797		31,457	
	(1)	(2)	(3)	(4)	(5)	(6)
	Mean	S.D.	Mean	S.D.	Mean	S.D.
House Characteristics						
Sale Price (nominal dollars)	222,595	182,551	232,190	192,140	211,233	172,031
Total Bedrooms	3.02	0.82	3.03	0.81	3.02	0.83
Square Footage (logs)	8.93	1.02	8.92	1.00	8.95	1.03
Neighbourhood Characteristics						
% students above standard	30	20	38	21	23	17
Median Household Income (000s)	58	32	60	32	56	31
% white	72	28	74	26	69	29
% with bachelor's or higher	29	19	31	19	28	18
% with children	62	27	63	27	61	28

This table presents the summary statistics for some of the main variables included in the event study. All observations are for houses within 0.25 miles of a school attendance zone boundary. Columns (1) and (2) show the mean and standard deviation for variables in the sample of houses on both sides of the boundary. Columns (3) and (4) ((5) and (6))show the mean and standard deviation for the sample of houses that are on the side of the boundary with the higher (lower) test score. Neighbourhood characteristics are at the census block group level.

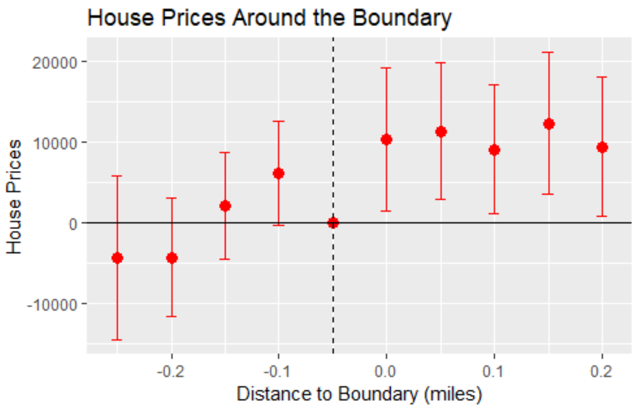


Figure 5: House Prices around the Boundary. This figure shows the results of the regression house prices on distance in 0.05 mile bins to the boundary and boundary fixed effects. Negative distance means the house is on the low test score side of the boundary. The coefficient at -0.05 miles is normalized to zero. The dots are the coefficients on the distance to boundary dummies, which represent the conditional mean of house prices at a given distance to the boundary. Error bars are 95% confidence intervals.

Figure 5 shows the coefficients of the distance dummies, which represent the conditional average of house sale prices in nominal dollars at a certain distance to the boundary. The coefficient at -0.05 miles is normalized to zero. There is a clear jump in house prices at the boundary of around ten thousand dollars.

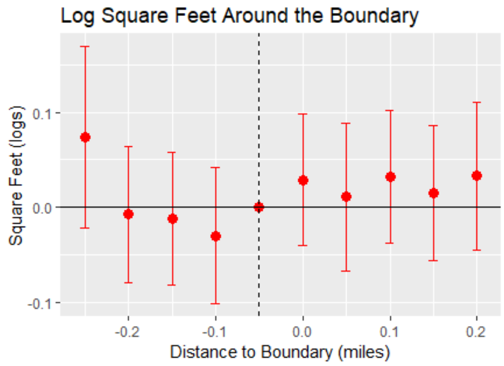
I also run a similar regression for house characteristics to show that houses from one side of the boundary to another are similarly built. Figure 6a shows the average square footage of houses (in logs) and Figure 6b shows the average number of bedrooms in houses on both sides of the boundary. Houses are similar in observables when comparing the high test score and low test score side of the boundary.

4.2 Event Study Results

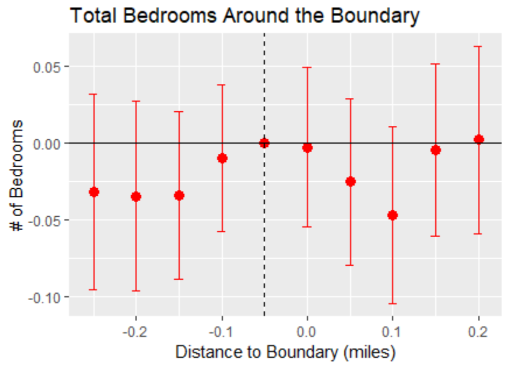
To investigate the causal effect of test performance and charter school entry on house prices, I run the specification in equation (1). I find that there is a premium paid for houses in high-performing school zones but that it drops after a charter school opens nearby. Column (1) of Table 3 shows the main coefficients from the specification in equation (1). Standard errors are clustered at the census block group level.[19] I present the δ_js - how the *test* coefficient changes relative to charter school openings in Figure 7.

Column (1) of Table 3 uses the percentile ranking measure of test scores. For ease of interpretation, in column (2) of Table 3 I present the results where the *test* variable is in standard deviation terms. The coefficient on *test* is 0.066 and statistically significant, suggesting that the marginal buyer is willing to pay 6.6 percent more for a house associated with a school that has twenty percent more students perform above the standard. In other words, at the average house price of roughly \$222,000, the willingness to pay for an increase in the percentage of students who exceed the standard by 20 points is around \$15,000 dollars.

[19] I also run the event study with standard errors clustered at the county level, since it is plausible that income shocks at the county level affect the sampling of house transactions. I find that the results are still significant.



(a) Log Square Feet around Boundary



(b) Total Bedrooms around Boundary

Figure 6: This figure shows the results of the regression of the house characteristic on distance in 0.05 mile bins to the boundary and boundary fixed effects. Negative distance means the house is on the low test score side of the boundary. The coefficient at -0.05 miles is normalized to zero. The dots are the coefficients on the distance to boundary dummies, which represent the conditional mean of the house characteristic of a house at a given distance to the boundary. Error bars are 95% confidence intervals.

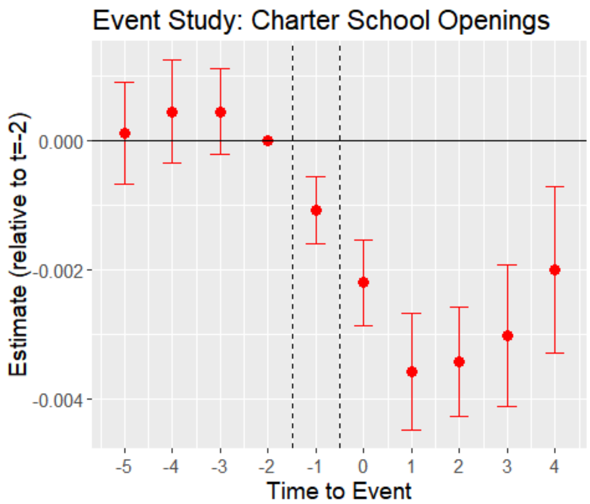


Figure 7: Main Event study. This figure plots the δ_j coefficients from Equation (1) On the x-axis is the year relative to the opening of the charter, which takes place at time 0. The coefficient at $t = -2$ is normalized to zero. These coefficients show how the willingness to pay for local school quality changes with charter entry. Error bars represent 95% Confidence Intervals.

As expected, households value the physical characteristics of their house and as in Bayer, Ferreira and McMillan (2007) they also care about the sociodemographic characteristics of their neighbours.[20] Individuals have a preference for living in areas with a higher proportion of children and educated households, and where the median income is higher.

Figure 7 shows the δ_j coefficients from equation (1) - how the WTP for neighbourhood school quality decreases relative to a charter school opening within 5 miles, for the specification run in column (1). Time 0 is when the charter opens. The coefficient at time -2 is normalized to 0.

The year before the charter school opens, there is a drop in the WTP for local school quality. This represents an information effect - families are aware that a charter school is going to enter prior to its opening date. Recall that charters need to be approved through an application

[20] All sociodemographic variables in Table 3 are standardized.

process before they can open. Once households are aware of an option for a charter school, the importance of local school quality falls significantly. Living on one side of the boundary versus another is not as valuable because there are other options for schooling now.

Table 3: Event Study Results:

	Dependent variable:					
	ln House Price					
	Main Specification	Main Specification (Test std)	Houses on Both Sides (0.05 miles)	Distance to Boundary (0.10 miles)	Boundary Length 4km	Test by Year
	(1)	(2)	(3)	(4)	(5)	(6)
test	0.0019***	0.0664***	0.0014***	0.0014***	0.0016***	0.0022***
	(0.0004)	(0.0135)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
log(square ft)	0.0435***	0.0435***	0.0456***	0.0644***	0.0446***	0.059***
	(0.0100)	(0.0098)	(0.0111)	(0.0117)	(0.0101)	(0.012)
% asian	0.0111	0.0111	0.0100	0.0095	0.0080	0.017***
	(0.0072)	(0.0071)	(0.0080)	(0.0085)	(0.0077)	(0.007)
% white	0.0851***	0.0846***	0.0962***	0.0847***	0.0799***	0.083***
	(0.0110)	(0.0111)	(0.0118)	(0.0125)	(0.0112)	(0.011)
Bedrooms	0.1049***	0.1049***	0.1065***	0.0945***	0.0943***	0.131***
	(0.0076)	(0.0075)	(0.0087)	(0.0066)	(0.0065)	(0.009)
Bathrooms	0.1314***	0.1307***	0.1309***	0.1300***	0.1314***	0.131***
	(0.0076)	(0.0075)	(0.0082)	(0.0094)	(0.0085)	(0.009)
% bachelor's	0.1122***	0.1124***	0.1022***	0.1119***	0.1104***	0.105***
	(0.0130)	(0.0130)	(0.0142)	(0.0167)	(0.0150)	(0.010)
% with children	0.0218***	0.0220***	0.0211***	0.0203***	0.0213***	0.012*
	(0.0058)	(0.0058)	(0.0064)	(0.0072)	(0.0066)	(0.006)
Median HH income(000s)	0.0362***	0.0345***	0.0336***	0.0351***	0.0464***	0.046***
	(0.0107)	(0.0106)	(0.0116)	(0.0121)	(0.0116)	(0.011)
Observations	62,254	62,254	52,304	36,158	42,073	39,145
Adjusted R^2	0.6570	0.6575	0.6524	0.6643	0.6514	0.680

Note: *p<0.1; **p<0.05; ***p<0.01

This table presents the results from the event study for all the coefficients except for the δ_j, which are shown in the figures below. Column (1) shows the results from Equation (1) where *test* is measured in percentile terms. Column (2) is identical except for *test* is measured in standard deviation terms. Column (3) checks for physical and natural boundaries by ensuring that there are houses within 0.05 miles on both sides of the boundary. Column (4) restricts the distance to the boundary to 0.10 miles. Column (5) restricts the boundary length to be less than 2.5 miles. Column (6) allows for variation in test scores, measured as percentiles. All sociodemographic variables are always in standard deviation terms.

4.3 Response for Different School Qualities

Here I show that the response to the opening of charter schools in the neighbourhood depends on local school quality. House prices should be more responsive when a charter school comes in that is better than the local schools. I divide my sample up into houses zoned for schools that perform below and above the median. There should be stronger results for poor performing schools below the median because it is more likely that a charter will perform better than them.[21]

$$\underbrace{\log p_{iab}}_{\text{house prices}} = \alpha X_{iab} + \beta test_a + \underbrace{\theta_b}_{\text{boundary FE}} + test_a \times aftercharter + aftercharter + \varepsilon_{iab} \quad (2)$$

I run the difference-in-difference specification in Equation (2), where I interact the test score performance of the local school quality with an indicator variable, $aftercharter$, which equals 1 if the house is sold before the charter opens, and 0 after. Column (1) in Table 4 presents the response for houses in school zones above the median performance. The coefficient on $test_a \times aftercharter$ is insignifcant, meaning there is no change in the willingness to pay for local school quality. In Column (2), are the houses in school zones that perform below the median. The coefficent on $test_a \times aftercharter$ is -0.005 and significant at the 5 percent level. When a charter school enters in these neighbourhoods, the willingness to pay for local school test performance falls significantly. This result lines up with intuition suggesting that only good charter schools should lead to changes in residential location. Table 12 in the Appendix presents the other coefficients in the regression.

[21] Data on charter school test scores in my data is sparse, so I do the split by local school quality

Table 4

	Dependent variable:	
	ln House Price (real)	
	Schools Above Median	Schools Below Median
	(1)	(2)
test	0.004***	0.004***
	(0.001)	(0.001)
test x after charter	−0.001	−0.005***
	(0.001)	(0.001)
Observations	23,460	38,412
Adjusted R^2	0.640	0.623
Note:		*p<0.1; **p<0.05; ***p<0.01

This table shows results from equation (1) when the sample is divided into houses zoned for schools that perform above the median, in column (1), and below the median, in column (2). *test* is the percentile of the zoned school, and *test* x *aftercharter* is a variable interacting the percentile of the zoned school with a dummy for if the house sold before or after a charter entered. See Table 12 in the Appendix for the other coefficients in the regression.

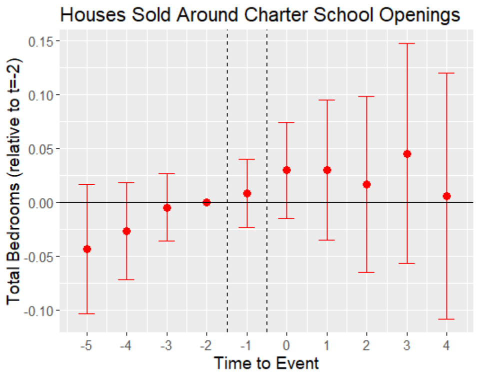
4.4 House Transactions around Charter School Openings

The event study results show that the difference in house prices across school boundaries falls with charter openings. Here I show that this finding is not driven by a change in the type of houses that sell in response to charter school entry. I run the event study in equation (3) of how house characteristics change around the opening of charter schools.

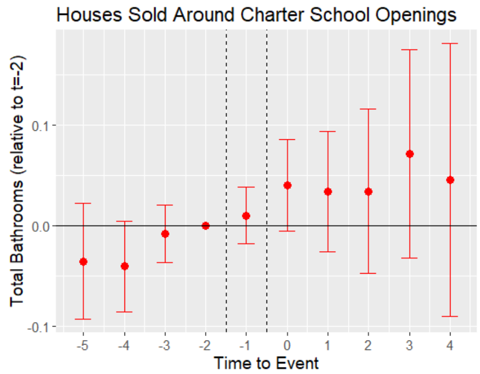
$$\underbrace{Y_{iab}}_{\text{house char.}} = \alpha X_{iab} + \underbrace{\theta_b}_{\text{boundary FE}} + \underbrace{\sum_{j=-5}^{4} \psi_j \mathbb{1}_{charteryear==j}}_{\text{charter years}} + \varepsilon_{iab} \tag{3}$$

Y_{iab} is the characteristic of house i sold in attendance zone a close to boundary b. X_{iab} is a vector of sociodemographics in the census block group of the house, and $\sum_{j=-5}^{4} \psi_j \mathbb{1}_{charteryear==j}$ is an indicator for the year j the house sold relative to when a charter opened. If $j < (>) 0$ the house sold before (after) the charter entered.

Figure 8a and Figure 8b show the number of bedrooms and bathrooms, respectively, in houses sold relative to charter schools starting up. The coefficient two years before the charter opened is normalized to zero. In both figures, none of the coefficients change significantly after time 0, indicating that charter openings did not induce changes to the types of houses sold.



(a) Number of Bedrooms



(b) Number of Bathrooms

The figures on the left and right show how the average number of bedrooms and bathrooms, respectively, in houses sold changes relative to charter openings. The house characteristic in question is regressed on a set of dummies indicating when the house sold relative to when the charter opened and those coefficients are plotted here. The coefficient at $t = -2$ is normalized to zero. $t = 0$ is when the charter opens. Sociodemographic controls are also included. Error bars represent 95% Confidence Intervals.

4.5 Robustness Tests

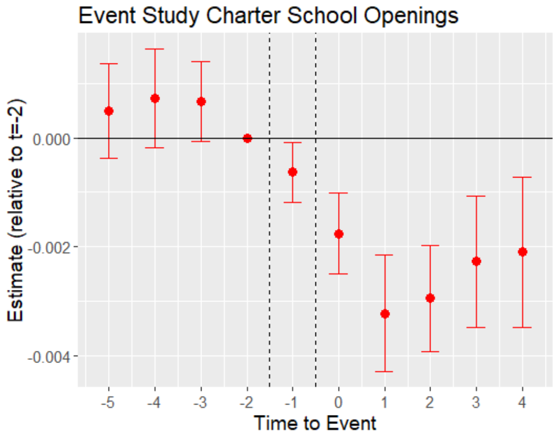
In this section I show that my main empirical result, the fall in WTP for local school quality after charter schools open, stands up to a variety of robustness tests, which are shown in Figure 9.

I start by running a test to ensure that none of the boundaries in my dataset consist of natural boundaries such as forests, lakes or man-made boundaries like major highways. While the presence of physical or natural boundaries may affect the estimate of the initial willingness to pay for school quality, note that time-invariant boundaries do not affect the estimate of the change in willingness to pay in response to charter school entry.

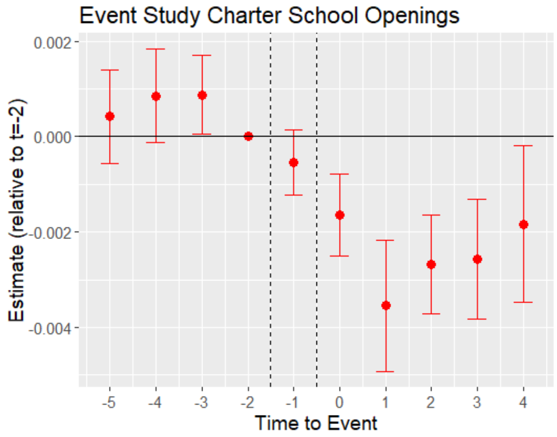
To implement a check for physical and natural boundaries I make the additional restriction that there must be houses within 0.05 miles of the boundary on both sides. This reduces my sample size from 62,254 observations to 52,304, suggesting that most of the boundaries in my data do not represent physical barriers. The intuition here is that if there was a natural boundary such as a lake then there would not be houses close to both sides of the boundary. Applying this filter results in very similar estimates presented in column (3) of Table 3 , and Figure 9a shows that the event study coefficients are similar as well.

Next, to ensure that houses have the same access to amenities, I restrict the distance that houses are to the boundary to 0.10 miles. Imposing this criteria drops about 40 percent of the observations. Although the coefficients change slightly, the main results stand: local school quality affects house prices until the year before a charter school opens. The coefficients are in column (4) of Table 3 and the event study results are in Figure 9b.

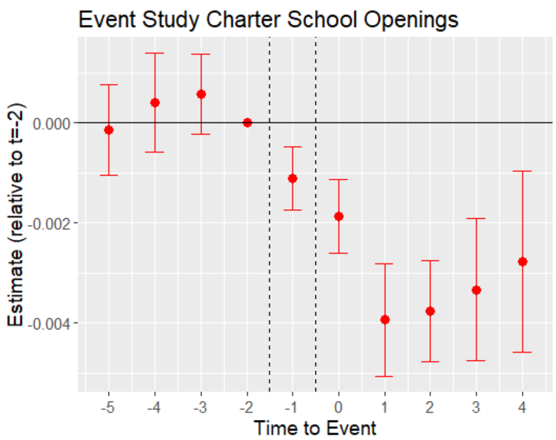
I also run a test where I restrict the length of the boundary. If a boundary is very long, houses at one end of the boundary may not have the same amenities as houses at the other end. To address this issue, I run the event study only for boundaries less than 2.5 miles. This leaves me with 42,073 observations out of the original 62,254. The estimates do change by a small



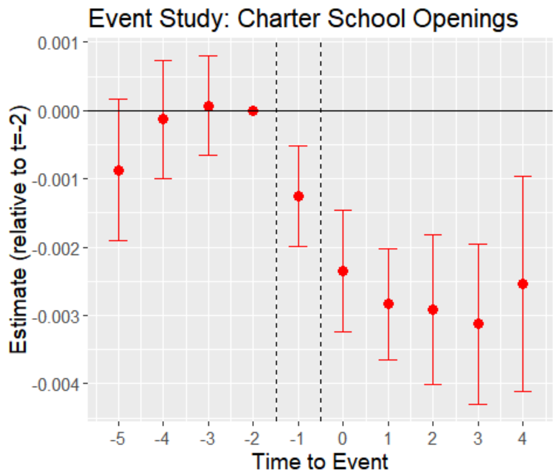
(a) Event Study: No Natural Boundaries



(b) Distance to Boundary 0.10 miles



(c) Boundary Length $<$ 2.5 miles



(d) Variation in Test Score

Figure 9: Robustness Tests. The above four pictures show the δ_j coefficients from Equation (1) with different sample restrictions to test for robustness. Figure 9a checks for natural and physical boundaries. Figure 9b restricts the distance to the boundary to 0.10 miles. Figure 9c only keeps boundaries less than 2.5 miles. Figure 9d allows for annual variation in test scores.

amount, however, the overall effect of charter schools remains. See column (5) of Table 3 for the coefficients and Figure 9c for the event study.

Finally, recall that the test score measure used in the main specification did not vary over time. The reason for this was concerns over test scores responding endogenously to charter school entry. However, test scores may change for other reasons. I do a robustness test where I allow for test scores to vary across the years. This only slightly changes the quantitative results. See coefficients in column (6) of Table 3 and Figure 9d for the event study.

5 Mapping the Data to a Structural Model

The empirical results indicate that house price discontinuities exist at school attendance zone boundaries, supporting previous results in the literature. The main contribution here is that these discontinuities effectively disappear with the opening of charter schools nearby. Intuitively, this makes sense; as households have more schooling options, they value their local school less.

Previous work have highlighted that the capitalization of local school quality into house prices can have negative implications for inequality and intergenerational mobility.[22] What happens to these outcomes with school choice? To investigate this, I build a structural model with neighbourhood sorting and entry of choice schools.

5.1 Environment

I build an overlapping generations model with neighbourhoods, human capital formation, and school choice. The economy is characterized by four different neighborhoods that vary in terms of house prices and school quality.

Agents in the model live for three periods, one as a child, and two periods as an adult. The child's role is passive; she does not consume and simply earns human capital. Children are born with some innate ability that is persistent across generations through an AR1 process. In the first period of adulthood, adults have one child and choose a neighborhood to live in. They earn labour income, consume, invest privately in the education of their child and pay for the house. In the second period, their child becomes an adult and the parent leaves them a bequest. Parents are altruistic towards their children, meaning that they explicitly value their child's utility.

This is a partial equilibrium model. I do not model the firm-side of the economy and take interest rates as given.

5.2 Neighbourhoods and Housing

There are four neighbourhoods called N_i with $i \in \{1, 2, 3, 4\}$ and associated housing cost p_i. Housing is supplied inelastically with an equal mass of agents living in each neighbourhood. p_i adjusts until the housing market in each neighbourhood clears. I think of p_i as the imputed rental rate of housing. N_i has local school quality $Q_i \in [0, 100]$ which represents the percentile rank in the school quality distribution, as in the data.

An agent who lives in N_i has the option of sending her child to the local school with quality Q_i or sending her child to the choice school with quality Q_c. I think of the choice school as any program that allows students to attend a school other than their zoned school, such as, charters, magnet schools, and open enrollment programs. The choice school is located in one of the neighbourhoods, and if someone lives in N_i and the choice school is in N_j, it costs τ_i^j to attend. This represents transportation and/or information costs that are usually associated with sending a child to a school other than their local one. The cost is neighbourhood dependent, with the assumption that it is cheaper to go to a choice school if it is located in your own neighbourhood. Agents also have idiosyncratic preferences for each neighbourhood which are

[22]See for example, Fernández and Rogerson (1996,1998), Fogli and Guerrieri (2018), Eckert and Kleineberg (2019)

modeled as Type 1 Extreme value shocks.

5.3 Human Capital Accumulation

A child's human capital accumulation is built from three components: her ability, a_c, the quality of her school, Q, and private education investment by her parents, e. If the child attends her local school in N_i, then $Q = Q_i$. If she attends a choice school, $Q = Q_c$.

The functional form for her human capital h_c, is then:

$$h_c = a_c Q^{\gamma} e^{\xi} \tag{4}$$

Equation 4 has the property that the returns to private education investments increase with ability and school quality. Supporting evidence for this can be found in Aizer and Cunha (2012) and Attanasio et al. (2018).

When the child becomes an adult, she earns first period income equal to her level of human capital, $y_1 = h_c$. Next period, her income is $y_2 = \rho y_1 + \varepsilon$ where $\rho < 1$ and ε is a normally distributed shock.

5.4 Detailed Description

I now describe in detail the problem of the agent. They start life in period 1 and choose a neighbourhood, but do not yet know the ability of their child. At the start of this period their states are m_1, cash-on-hand, y_1 their income, and a their own ability.

Ability of their child, a_c, follows an AR1 process from their parent's process with persistence ρ_a and normally distributed shock ε_a.

$$\log a_c = \rho_a \log a + \varepsilon_a$$

Individuals have idiosyncratic preference shocks ε_i for living in neighbourhood i that are Type 1 Extreme Value.

$$V_{nbhd}(m_1, y_1, a) = \max_i \{\mathbb{E}_{a_c} V_{school}(m_1, y_1, a_c, i) + \varepsilon_i\} \tag{5}$$

Agents choose the neighbourhood i that maximizes $V_{nbhd}(m_1, y_1, a)$. Next, the ability of their child is revealed and the agent chooses whether to send their child to the local neighbourhood school or to pay a cost, τ_i^j, and send their child to a choice school in N_j:

$$V_{school}(m_1, y_1, a_c, i) = \max\{V_1(m_1, y_1, a_c, i, local), V_1(m_1, y_1, a_c, i, choice)\} \tag{6}$$

In the baseline model I set $\tau_i^j \ \forall i, j \in \{1, 2, 3, 4\}$ to be high enough so that no one chooses school choice. This is then relaxed during the policy experiments on school choice expansion.

If the agent chooses the *local* school, she then chooses consumption c_1, education investment, e, and savings z_1' such that:

$$V_1(m_1, y_1, a_c, i, local) = \max_{c_1, e, z_1' \geq 0} \{u(c_1) + \beta \mathbb{E}_{y_2} V_2(m_2, h_c, a_c)\} \tag{7}$$

$$c_1 + e + z_1' + p_i = m_1 \tag{8}$$

$$h_c = a_c {Q_i}^{\gamma} e^{\xi} \tag{9}$$

$$\log y_2 = \rho \log y_1 + \eta \tag{10}$$

$$m_2 = (1 + r) z_1' + y_2 \tag{11}$$

Equation (8) is the budget constraint and states that the agent uses her cash-on-hand, m_1, for consumption, education, savings, and to pay for her house, p_i. Equation (9) is the human capital accumulation function, note that the school quality is Q_i for neighbourhood i. Equation (10) stipulates how income evolves, and equation (11) shows how her cash-on-hand next period is determined. $V_2(m_2, h_c, a_c)$ is the continuation value for the agent in period 2.

If the agent chooses the *choice* school, the problem is identical to the above except that the school quality her child receives is Q_c, which shows up in the human capital for the child in equation (14) and she has to pay a cost τ_i^j, which shows up in the budget constraint in equation (13). The agent's problem is:

$$V_1(m_1, y_1, a_c, i, choice) = \max_{c_1, e, z_1' \geq 0} \{u(c_1) + \beta \mathbb{E}_{y_2} V_2(m_2, h_c, a_c)\} \tag{12}$$

$$c_1 + e + z_1' + p_i + \tau_i^j = m_1 \tag{13}$$

$$h_c = a_c {Q_c}^{\gamma} e^{\xi} \tag{14}$$

$$\log y_2 = \rho \log y_1 + \eta \tag{15}$$

$$m_2 = (1 + r) z_1' + y_2 \tag{16}$$

In the second period of life the agent's states are m_2, her cash-on-hand, h_c, the human capital level of her child, and a_c, the ability of her child. The agent needs to keep track of the last two state variables because she is altruistic towards her child with intensity α, and explicitly values the continuation value of her child.

$$V_2(m_2, h_c, a_c) = \max_{c_2, b \geq 0} \{u(c_2) + \alpha V_1(m_1, y_1, a_c)\} \tag{17}$$

$$c_2 + b = m_2 \tag{18}$$

$$y_1 = h_c \tag{19}$$

$$m_1 = b + h_c \tag{20}$$

She chooses consumption c_2 and an intervivo transfer to her child in order to maximize Equation (17). Equation (18) is the budget constraint, which states that she divides her cash-on-hand between consumption and the bequest. Equation (19) states that the child's first period income is just the human capital she accumulated. Finally, the cash-on-hand that her child starts out with is their income and the bequest they received, shown in Equation (20). $V_1(m_1, y_1, a_c)$ is the continuation value of her child.

There is an equal amount of fixed inelastic housing supply in each neighbourhood. In equilibrium all agents solve their optimization problems and house prices adjust until the mass of agents in each neighbourhood equals the available supply.

6 Results

6.1 Calibration

I model these four neighbourhoods as school attendance zones in the school district of Jacksonville, Florida. The school quality percentiles are 80th, 60th, 40th, and 20th, for N_1, N_2, N_3 and N_4, respectively. Some parameters are set externally and I calibrate others to match certain moments of the data. Table 5 summarizes the parameters that I set externally. A period is set to 25 years. I choose an annual discount factor of 0.97 and an annual interest rate of 0.025. I assume logarithmic utility, so $\sigma = 1$. For the income process I set the annual persistence of income ρ_h to be 0.91 following estimates from Floden and Lindé(2001). I make the appropriate conversions of β, r, and ρ_h, for each time period.

Table 5: External Parameters

Parameter	Description	Value	Source
β	Annual Discount Factor	0.97	
r	Annual Interest Rate	0.025	
σ	CRRA coeff.	1.0	
ρ_h	Annual income persistence	0.91	Floden and Lindé (2001)
Q	School Quality Grid	[80,60,40,20]	

I internally calibrate the parameters of the ability process, the altruism parameter, α, the return to neighbourhood school quality, γ, and the return to education investment, ξ, to match several moments from the Jacksonville, Florida school district (Duval County). First, I match two moments on income inequality and mobility using Chetty et al. (2014). I target the Gini coefficient of income for Duval County of 0.51 and an intergenerational mobility coefficient of income of 0.373. Intergenerational mobility is calculated by regressing the percentile rank of the parent in the income distribution on the percentile rank of the child.

The parameter ξ, governs how important parental education investment is. I use it to match the share of consumer expenditure on education goods. The Consumer Expenditure Survey run by the Bureau of Labor Statistics has data on household consumption including education purchases. I calculate the average share of education expenditure in 2010 for Florida for a target of 0.027.

γ, the return to neighbourhood school quality is calibrated to match the difference in house prices across boundaries, before school choice, that was calculated in the first part of the paper. I regress log prices on log school quality in my model, and target a value of 0.002.

The parameter α governs the strength of altruism towards children and determines the transfer to wealth ratio. Both the Health and Retirement Survey and the Survey of Consumer Finances have data on transfers and wealth; however, they do not allow users to see the data by state of residence. For now, I target a ratio of 0.17 from Gale and Scholz (1994) and Nishiyama (2002).

Lastly, I use the standard deviation of the income shock, η, to match the dispersion in incomes across school attendance zones in Jacksonville. For each school attendance zone in Jacksonville in my data, I calculate the average median household income across the census block groups that fall into a school zone. I then rank the school zones by income, and aim to match the ratio of incomes between the 80th percentile and 20th percentile.

Calibration results are presented in Table 6. The model is able to match the coefficient of intergenerational mobility and the gini coefficient well. However, it overstates the share of spending on education goods and understates the dispersion of income across neighbourhoods.

Table 6: Calibration

	Data	Model	Source
IGM income	0.37	0.36	Chetty et al. (2014)
Gini	0.51	0.51	Chetty et al. (2014)
Consumption share of education goods	0.027	0.039	CEX, 2010
Intervivo transfers/wealth	0.17	0.21	Nishiyama (2002) Gale and Scholz (1994)
log price on Q	0.002	0.0024	Data work
Highest Inc. to Lowest Inc.	1.8	1.4	ACS 2009-2013

Table 7 presents some neighbourhood characteristics. There is sorting in the model, in the sense that parents with more income prefer neighbourhoods with higher house costs. The fourth and fifth columns of Table 7 show the ratio of income and average education investment, respectively, in each neighbourhood relative to the level in N_4. The average income level of adults who choose to go into N_1 is higher than for the other neighborhoods. In addition, parents in neighbourhoods with better local school quality invest more private education in their child. This is because the returns to investing in education increase with ability and school quality. Unequal school quality thus exacerbates other disparities. Children in the worse schools have even less opportunity to accumulate human capital because their parents do not find it worth it to invest in their education.

Table 7: Neighbourhood Characteristics

Neighborhood (1)	House Price (2)	School Quality (3)	Income Ratio (4)	Education Investment Ratio (5)
N_1	0.66	80	1.40	1.07
N_2	0.616	60	1.31	1.07
N_3	0.566	40	1.19	1.04
N_4	0.47	20	–	–

Simulations of the model. Column (1)lists the neighbourhoods, Column (2), their house prices in equilibrium, and Column (3), their school quality. In Column (4) is the ratio of median income between a neighbourhood and N_4. Column (5) has the ratio of average education investment between a neighbourhood and N_4.

6.2 Policy Experiment

I use the model to give some insights into how expanding school choice can affect the level of house prices, and some implications for spatial inequality. Let me begin by discussing the former. Recall that the empirical exercise relied on comparing houses across school attendance zone boundaries. This boundary comparison was key for identification, with the argument being that houses close to a boundary should be similar in neighbourhood unobservables. While I have shown that expanding school choice is associated with a decrease in the differences in house prices across the boundary, I have not analyzed how the level of house prices changes. This is difficult to identify due to unobserved neighbourhood characteristics, and therefore, the model is used instead.

I run a policy experiment where I study how school choice affects house price levels and welfare. To start, I assume that a choice school opens up with quality $Q_c = 75$. I choose a high level of school quality, since a poor performing choice school opening is unlikely to affect neighbourhood sorting. I first assess how households respond when a choice school enters into N_4, the one with the worst local school quality. This policy is in line with the data showing that choice schools tend to locate in neighbourhoods that have lower income and are less educated.

To model a choice school in N_4, I set τ_4^4 to be less than $\tau_i^4, i \in \{1, 2, 3\}$. τ_4^4 is calibrated to match the proportion of students in Florida who attended charter schools in 2016, which was ten percent. Currently my model gives a value of fourteen percent. I then set $\tau_1^4 = \tau_2^4 = \tau_3^4$, so that the commuting cost from the other neighbourhoods is identical but higher than τ_4^4. $\tau_i^4, i \in \{1, 2, 3\}$ targets the percentage of students who attend a charter in a different neighbourhood. This number is twenty-five percent, from Gilraine et al. (2019) and the model has a value of fifteen percent.

When I solve for the stationary equilibrium in this version of the model, and compare it to my original results, I find that the range of housing costs shrink. See Column (2) of Table 8 for the new equilibrium house prices in the environment with a charter school in N_4. Regressing log house prices on log school quality gives a value of 0.0019, a decrease from the baseline value of 0.0024. As in the data, the model shows that school choice expansion weakens the relationship between local school quality and house prices.

Table 8: Choice School Location and House Prices

	Baseline (1)	Choice School in Nbhd 4 (2)	Choice School in Nbhd 1 (3)
House Price Nbhd 1	0.66	0.69	0.654
House Price Nbhd 2	0.616	0.65	0.614
House Price Nbhd 3	0.566	0.59	0.561
House Price Nbhd 4	0.47	0.53	0.484
lnp on Q	0.0024	0.0019	0.0021

Since the driving motivation behind school choice is to improve outcomes for low-income households, I focus on what happens to agents in the low-income neighbourhood, N_4. House prices rise in N_4 when the choice school opens here because higher-income households move in and send their child to the choice school. This result is similar to that in Avery and Pathak (2015) and Nechyba (2003b).

I calculate the change in welfare values between these two steady states. More specifically, I compute the percentage increase in cash-on-hand that you have to give an agent in order to make her indifferent between living in the baseline economy and the economy with the choice school.[23] More precisely, I take the value function, $V_{school}(m_1, y_1, a_c, i)$ defined in Equation (6) and for each agent in period 1 compute $\zeta(m_1, y_1, a_c, i)$ such that:

$$\underbrace{V_{school}(m_1 \times \zeta(m_1, y_1, a_c, i), y_1, a_c, i)}_{\text{Baseline}} = \underbrace{V_{school}(m_1, y_1, a_c, i)}_{\text{School Choice}} \tag{21}$$

where the value function on the left is from the baseline environment and the value function on the right is the environment with school choice. For an agent defined by states (m_1, y_1, a_c, i), if $\zeta(m_1, y_1, a_c, i) > (<)1$ the agent prefers the baseline (school choice) environment.

Figure 10 shows the $\zeta(\cdot)$ values for an agent in the neighbourhood with the worst school quality, N_4. I plot two lines, the solid (dashed) is for someone whose child is of low (high) ability. Even with the expansion of school choice, some agents in N_4 prefer the baseline environment, due to the negative impact coming from house price rises. High-income people move into N_4 because they can live there but send their child to the choice school. For some households, especially those with low asset levels, the rise in the cost of living is not outweighed by the option of the choice school.

The benefits of school choice expansion also depend on the ability of the child. Moving from the baseline case to when the choice school opens in N_4, agents with lower ability children do not switch to the choice school and are therefore worse off. Some parents with high ability children are better off, because they switch their child to the choice school, knowing that the returns to schooling increases with childhood ability.

I now consider the choice school opening in the high income neighbourhood, N_1. The cost

[23] These are steady state comparisons. A complete welfare analysis requires looking at changes along the transition path and is currently in progress.

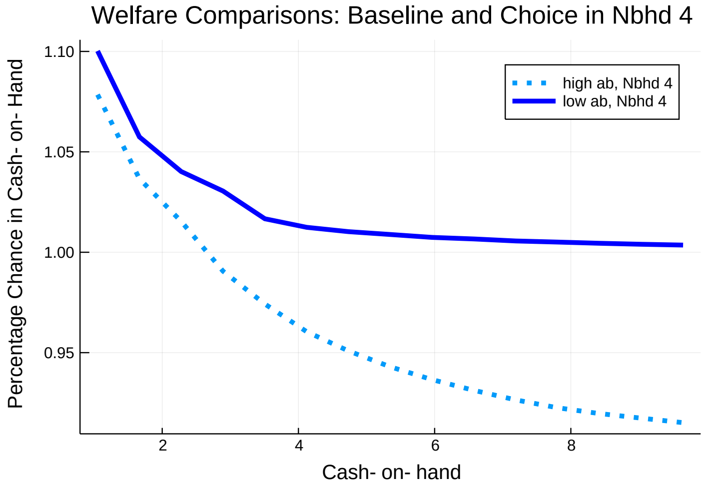


Figure 10: This figure shows the percentage change in cash-on-hand needed to compensate agents living in N_4 in the baseline environment to switch to the environment where the choice school opens in N_4. The dashed line is for someone with a high ability child, and the solid line is for someone with a low ability child. A value greater (less) than 1 means the agent is worse (better) off in the environment with school choice than in the baseline.

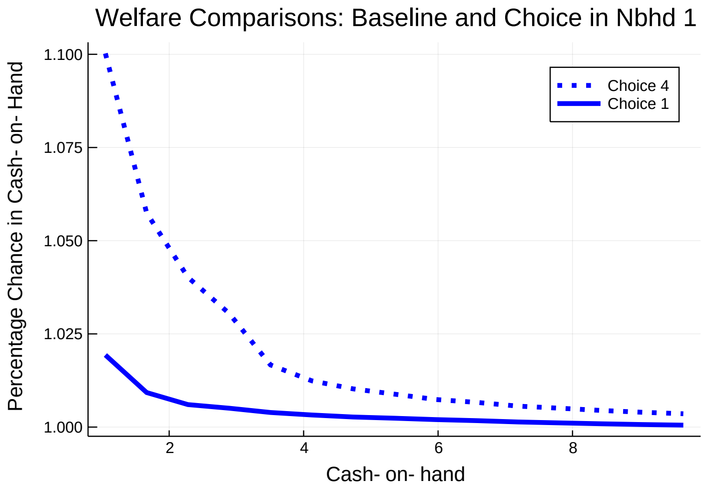


Figure 11: The solid (dashed) line is the percentage change in cash-on-hand needed to compensate agents living in Neighbourhood 4 to switch from the baseline to the environment where the choice school opens in N_1 (N_4).

parameters I keep from the previous case except now τ_1^1 is the lowest. When I solve for the equilibrium here and compare it to the case where the choice school is located in N_4, I find that low-income households living in N_4 prefer that the choice school locate in N_1. The dotted (solid) line in Figure 11 shows the percentage change in cash-on-hand that has to be given to individuals in order to make them indifferent between the baseline and switching to the environment where the choice school is in N_4 (N_1). Both lines are for an agent with a low ability child.

The plot for when the choice school is in N_4 is higher, meaning these agents have to be compensated more in this case. When the choice school locates in N_4 versus N_1, more high-income people move into N_4 and drive house prices up higher. Poor parents with low ability children do not take up the option to go to the choice school because the returns are not worth the cost, and therefore prefer that house prices rise by less.

I also study how opportunity for low-income households living in N_4 changes when a choice

Table 9

Outcome	Baseline	Choice Nbhd 4	Choice Nbhd 1
Probability of Reaching Top Two Quintiles (Parent in Bottom Quintile)	17.64 %	13.49 %	17.5%

These numbers show the probability that someone who goes to the local school in Neighbourhood 4 and whose parent is in the bottom income quintile will reach the top income quintile. The number is presented for the baseline case, when the choice school locates in Neighbourhood 4, and when the choice school locates in Neighbourhood 1.

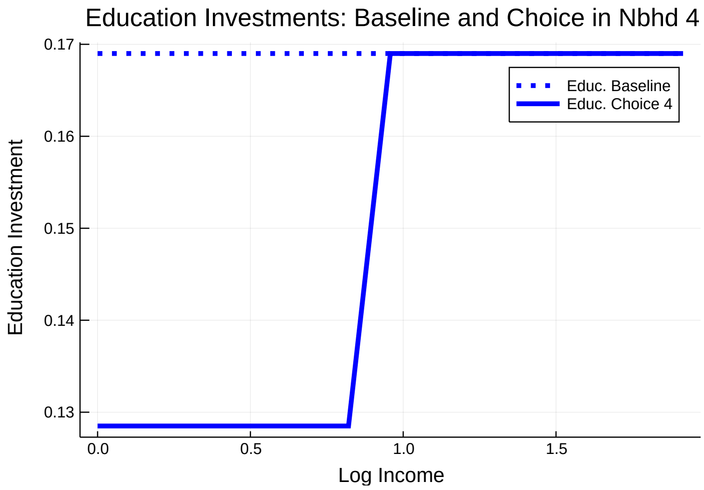


Figure 12: This figure shows how the education investment policy function changes from the baseline case, shown in the dotted line, to the case when a choice school opens in N_4 , shown in the solid line. The x-axis has the log income of the parent making the education decision.

school enters a certain neighbourhood. The measure of opportunity is the probability that someone whose parent is in the bottom income quintile reaches the top two income quintiles. The opportunity outcomes I calculate in Table 9 are for the agents who send their child to the local school in N_4.

Locating a choice school in N_4 reduces opportunity for individuals who live there and send their child to the local school. The probability that someone will reach the top two income quintiles given that there parent is in the bottom quintile falls from 17.64 % to 13.5 %. This is because children in N_4 end up accumulating less human capital when the choice school is there. Due to the rising house costs, parents cannot spend as much on education investment for their child. When the choice school is in N_1 though, house prices in N_4 rise by less and opportunity for children in N_4 only falls by a small amount.

The dotted (solid) line in Figure 12 shows the level of education investment that parents choose across different income levels in the baseline (choice school in N_4) case. Low-income households choose less education investment in the case with the choice school because of the higher house prices that they must pay.

Lastly, I study how the composition of the local school in N_4 changes. Opponents of school choice have argued that it does not necessarily benefit those in poorer areas, because choice programs tend to "cream skim" by taking only the best students. As a result, local schools could become more segregated after the entry of a choice school. In Figure 13 I present the share of parents in each income quintile who send their child to the N_4 local school under each scenario.

The first quintile is the lowest one. When the choice school locates in N_4, the share of people in the lowest income quintile increases significantly. This is because higher income people and higher ability people switch to the choice school. House prices in N_4 go up so only people with more assets can afford both the cost of living increase and the cost of going to the choice school. There is less segregation when the choice school locates in N_1 since house prices rise by less.

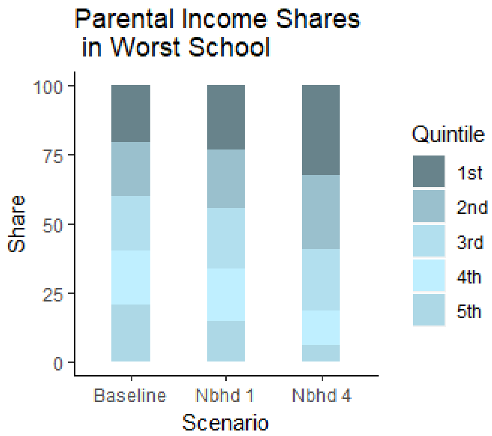


Figure 13: These bar graphs show the share of each income quintile that send their child to the local school in N_4. The left graph is for the baseline environment, the middle for when the choice school locates in Neighbourhood 1, and the right one for when the school locates in Neighbourhood 4.

7 Conclusion

School choice is seen as a way to foster opportunity for low-income households, and policymakers have pushed to expand these programs. This paper studies how school choice programs affect housing markets and opportunity for low-income households, which has not been widely assessed thus far.

First, I combine an event study of charter school entry with the existing boundary discontinuity design. My estimation shows that the willingness to pay for a one standard deviation increase in local school quality falls by six percentage points upon charter school entry. 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.

The finding that school choice leads to a significant reduction in boundary discontinuities implies that the literature may need to find a new way to measure preferences for school quality. Currently, the methods for identifying the marginal willingness to pay for school quality rely on the importance of school attendance zone boundaries. The boundary discontinuity design allows researchers to cleanly measure preferences for school quality by controlling for neighbourhood unobservables. However, given that most states now have some form of school choice, it is unlikely that the boundary discontinuity design method will continue to be effective in identifying how households value school quality.

Second, I build a structural model of heterogeneous agents and neighbourhood sorting, to study the implications of school choice for opportunity and welfare. The structural model, calibrated to the school district level, highlights that the consequences of school choice vary across neighbourhoods, the income distribution, and the ability of children. Locating a choice school in a low-income neighbourhood causes house prices to rise there, as more people move in to take advantage of the new school. While parents with high-ability children benefit by sending their child to the choice school, parents with low-ability children keep their child in the local school, because the returns to switching are not high enough. These parents are then worse off because they have higher costs-of-living. I find that parents with low-ability children prefer that the choice school locate elsewhere, so that their house prices do not rise as much.

These results suggest that policymakers need to understand the tradeoffs from school choice: while these programs help higher-ability children, they cause changes in neighbourhood composition that drive up house prices in low-income neighbourhoods. Potential policies that could mitigate the negative effect of school choice on low-income families include free transportation to choice schools and helping these families access information on choice schools. Research so far has focused on the short-run impact of school choice. This work points towards more research on long-run impacts whereby school choice changes sorting across neighbourhoods and schools.

8 References

1. Aizer, A., and F. Cunha. (2012): "The Production of Human Capital: Endowments, Investments and Fertility." NBER Working Paper 18429.

2. Asmar, M. May 25, 2018: "In Denver's gentrifying neighborhoods, some middle-class parents are avoiding the school down the block." *Chalkbeat*.

3. Attanasio, O., Boneva, T., and Rauh, C. (2018): "Parental Beliefs about Returns to Different Types of Investments in School Children." HCEO Working Paper Series 2018-032.

4. Avery, C. and P. Pathak (2015): "The Distributional Consequences of Public School Choice." NBER Working Paper 2125.

5. Bayer, P., F. Ferreira, and R. McMillan(2007): "A Unified Framework for Measuring Preferences for Schools and Neighborhoods." *Journal of Political Economy*, 115(4): 588-638.

6. Barnum, M. March 18, 2018: "School choice lets wealthy families gentrify neighborhoods, avoid local schools." *Connecticut Mirror*.

7. Bénabou, R. (1994): "Human capital, inequality, and growth: A local perspective." *European Economic Review* 38(3-4): 817-826.

8. Bénabou, R. (1996): "Equity and Efficiency in Human Capital Investment: The Local Connection." *Review of Economic Studies* 63(2): 237-264.

9. Black, S. (1999):"Do Better Schools Matter? Parental Valuation of Elementary Education." *The Quarterly Journal of Economics*, 114(2):577-599.

10. Chetty, R., N. Hendren, P. Kline, and E. Saez. (2014): "Where is the Land of Opportunity? The Geography of Intergenerational Mobility in the United States." *Quarterly Journal of Economics* 129(4): 1553-1623.

11. Cohodes, S., E. Setren, and C. Walters. "Can Successful Schools Replicate? Scaling up Boston's Charter School Sector." Working Paper 25796.

12. Consumer Expenditure Survey, U.S. Bureau of Labor Statistics, 2010. `https://www.bls.gov/cex/pumd_data.htm`.

13. Cremata,E., D. Davis, K. Dickey, K. Lawyer, Y. Negassi, M. Raymond and J. Woodworth. (2013):"National Charter School Study."Center for Research on Education Outcomes, Stanford University.

14. Durlauf, S. (1996a): "A Theory of Persistent Income Inequality." *Journal of Economic Growth*, 1: 75-93.

15. Durlauf, S. (1996b): "Neighborhood feedbacks, endogenous strafication and income inequality." In *Dynamic Disequilibrium Modeling,* edited by W. Barnett, G. Gandolfo, and C. Hillinger. Cambridge: Cambridge University Press.

16. Durlauf, S. and A. Seshadri. (2018): “Understanding the Great Gatsby Curve.” In *NBER Macroeconomics Annual 2017, volume 32*, edited by M. Eichenbaum and J. Parker. University of Chicago Press: National Bureau of Economic Research.

17. Eckert, F. and T. Kleineberg. (2019): “Can we save the American Dream? A dynamic general equilibrium analysis on the effects of school financing on local opportunities.” Working Paper.

18. Epple, D. and R. Romano. (2003): “Neighborhood Schools, Choice, and The Distribution of Educational Benefits.” In *The Economics of School Choice*, edited by Caroline Hoxby, 227-285. University of Chicago Press: National Bureau of Economic Research.

19. Epple,D. , R. Romano, R. Zimmer. (2016):“Chapter 3 - Charter Schools: A Survey of Research on Their Characteristics and Effectivenes.” *Handbook of the Economics of Education*, Volume 5, 139-208.

20. Fack, G., and J. Grenet. (2010): “When do better schools raise housing prices? Evidence from Paris public and private schools.” *Journal of Public Economics*, 94(1-2): 59-77.

21. Fernández, R. and R. Rogerson. (1996): “Income Distribution, Communities, and the Quality of Public Education.” *Quarterly Journal of Economics* 111(1): 135-164.

22. Fernández, R. and R. Rogerson. (1998): “Income Distribution and Public Education: A Dynamic Quantitative Analysis of School Finance Reform.” *American Economic Review* 88(4): 813-833.

23. Floden, M. and Lindé, J. (2001): “Idiosyncratic Risk in the United States and Sweden: Is there a role for government insurance.” Review of Economic Dynamics, **4**(2), 406-437.

24. Florida Department of Education. Florida Standards Assessment Results. `http://www.fldoe.org/accountability/assessments/k-12-student-assessment/results/`‘

25. Fogli, A. and V. Guerrieri. (2019): “The End of the American Dream? Inequality and Segregation in US cities : Inequality and Segregation in US Cities.” Working Paper.

26. FRED Economic Data. 2012. “Consumer Price Index for All Urban Consumers.” Economic Research Federal Reserve Bank of St. Louis. `https://fred.stlouisfed.org/tags/series?t=cpi%3Bmsa` .

27. Gale, W. and Scholz, J. (1994): “Intergenerational Transfers and the Accumulation of Wealth.” *Journal of Economic Perspectives*, 9(4): 145-160.

28. Gilraine, M., 2019. “A Method for Disentangling Multiple Treatments from a Regression Discontinuity Design.” Forthcoming at *Journal of Labor Economics.*

29. Gilraine, M., U. Petronijevic, and J. Singleton. (2019): “Horizontal Differentiation and the Policy Effect of Charter Schools.” Working Paper.

30. Grembi, V., T. Nannicini, U. Troiano. (2016): “Do Fiscal Rules Matter?” *American Economic Journal: Applied Economics*, 8(3): 1-30.

31. Harris, E. December 15, 2015: "School Segregation Persists in Gentrifying Neighborhoods, Maps Suggest." *New York Times.*

32. Kane, T.J., S.K. Riegg, D.O. Staiger. (2006): "School Quality, Neighborhoods, and Housing Prices." *American Law and Economics Review*, Advance Access.

33. MacLeod, W. and M. Urquiola. (2019): "Is Education Consumption or Investment? Implications for School Competition." *Annual Review of Economics*, 11: 563-589.

34. Manson, S., J. Schroeder, D. Van Riper, and S. Ruggles. IPUMS National Historical Geographic Information System: Version 14.0 [Database]. Minneapolis, MN: IPUMS. 2019. `http://doi.org/10.18128/D050.V14.0` .

35. Massachusetts Department of Elementary and Secondary Education. "Next Generation MCAS Achievement Results." `http://profiles.doe.mass.edu/statereport/nextgenmcas.aspx`.

36. Mehta, N. (2017): "Competition in Public School Districts: Charter School Entry, Student Sorting, and School Input Determination." *International Economic Review*, 58(4): 1089-1116.

37. National Center for Education Statistics. "Education Demographic and Geographic Estimates, School Locations and Geoassignments." `https://nces.ed.gov/programs/edge/Geographic/SchoolLocations`.

38. Nechyba, T. (2003a): "School finance, spatial income segregation and the nature of communities." *Journal of Urban Economics*, 54(1): 61-88.

39. Nechyba, T. (2003): "Introducing School Choice into Multidistrict Public School Systems" In *The Economics of School Choice*, edited by Caroline Hoxby, 145-194. University of Chicago Press: National Bureau of Economic Research.

40. Nishiyama, S. (2002): "Bequests, Inter Vivo Transfers, and Wealth Distribution," Review of Economic Dynamics, 5: 892-931.

41. Public Schools of North Carolina, Accountability Services Devision. "State/LEA and School Test Performance." `http://www.ncpublicschools.org/accountability/reporting/leaperformancearchive/`.

42. Ridley, M. and C. Terrier. (2018): "Fiscal and Education Spillovers from Charter School Expansion." NBER Working Paper 25070.

43. Schwartz, A., I. Voicu, K. Mertens Horn. (2014): "Do choice schools break the link between public schools and property values? Evidence from house prices in New York City." *Regional Science and Urban Economics*, 49: 1-10.

44. School Attendance Boundary Survey (SABS). 2013-2014, 2015-2016. U.S. Department of Education. Washington, DC: National Center for Education Statistics.

45. Singleton, J. (2019): "Incentives and the Supply of Effective Charter Schools." *American Economic Review*, 109(7): 2568-2612.

46. State Collaborative on Reforming Education (SCORE). 2012. "The State of Education in Tennessee 2011-2012." `https://tnscore.org/wp-content/uploads/2017/02/2011-12-State-of-Educ pdf`

47. Tennessee Department of Education. "2016 TCAP Results at a Glance." `https://www.tn.gov/education/data/tcap-results-at-a-glance.html`.

48. Tuttle,C., P. Gleason, and M. Clark. (2012): "Using lotteries to evaluate schools of choice: Evidence from a national study of charter schools." *Economics of Education Review*, 31: 237-253.

49. U.S. Census Bureau; American Community Survey (ACS), Five-Year Sample, 2009-2013.

50. U.S. Census Bureau; American Community Survey (ACS), Five-Year Sample, 2013-2017.

51. Urquiola, M. (2005): "Does School Choice Lead to Sorting? Evidence from Tiebout Variation." *American Economic Review*, 95(4): 1310-1326.

52. Valant, J. and J. Lincove.(2018): "The barriers that make charter schools inaccessible to disadvantaged families." Brookings Papers.

9 Appendix

Table 10

State	# 2015-16 Schools	Total Matches	# (%) of Schools : Centroid less than 0.05 miles
(1)	(2)	(3)	(4)
Florida	1437	1392	1207 (87%)
Massachusetts	267	224	193 (86%)
North Carolina	1034	962	772(80%)
Tennesee	404	314	265(84%)

Comparison of School Attendance Zones between the 2013-14 and 2015-16 School Attendance Zone Boundary Survey (SABS). In column (2) are the number of elementary schools for each state in the 2015-16 SABS that I keep in my dataset. Column (3) has the number of schools in Column (2) that are present in the 2013-14 SABS. Column (4) then shows the number and percentage of schools present in both surveys whose centroid is within 0.05 miles of each other. I use 0.05 miles because small changes in inputs of boundaries could result in centroids of identical school zones not matching precisely.

Table 11

State	Highest Grade for Elementary School	Percentage of Total Elementary Schools
(1)	(2)	(3)
Florida	Grade 5	87
North Carolina	Grades 5 and 6	88
Massachusetts	Grades 5 and 6	73
Tennessee	Grades 4 and 5	75

Coverage of Elementary Schools by State. In my dataset I restrict the highest grade for elementary schools. Column (2) shows what the restriction is by state and Column (3) shows the percentage of elementary schools I keep.

Table 12

	Dependent variable:	
	ln House Price (real)	
	Schools Above Median	Schools Below Median
	(1)	(2)
test	0.004***	0.004***
	(0.001)	(0.001)
test x after charter	−0.001	−0.005***
	(0.001)	(0.001)
ln (lotsqft)	0.059**	0.034***
	(0.023)	(0.009)
% asian (std)	0.016	0.015
	(0.011)	(0.009)
% white (std)	0.136***	0.071***
	(0.029)	(0.011)
Bedrooms	0.129***	0.085***
	(0.016)	(0.007)
Bathrooms	0.125***	0.129***
	(0.012)	(0.010)
% Bachelor's (std)	0.080***	0.117***
	(0.022)	(0.016)
% Married with children (std)	0.003	0.025***
	(0.010)	(0.007)
Median HH Inc (000s)(std)	0.025	0.051***
	(0.016)	(0.014)
Observations	23,460	38,412
R^2	0.644	0.627
Adjusted R^2	0.640	0.623
Note:		*p<0.1; **p<0.05; ***p<0.01

Results from estimation of Equation (2) when the sample is split into schools performing above (1st column) and below the median (2nd column). Sociodemographics are in standard deviation terms. *test* is in percentile rank terms.