Win or Lose: Residential Sorting After a School Choice Lottery

Andrew Bibler*

Stephen B. Billings†

August 28, 2018

Abstract

We examine residential relocation and opting out of the public school system in response to school choice lottery outcomes. We show that rising kindergarten and sixth graders who lose a school choice lottery are 6 percentage points more likely to exit the district or change neighborhood schools (20-30% increase) and make up 0.14-0.35 standard deviations in average school test scores between lottery assignment and attendance the following year. Using hedonic-based estimates of land prices, we estimate that lottery losers pay a 9-11% housing price premium for access to a school with a one standard deviation higher mean test score.

*University of Alaska Anchorage, ajbibler@alaska.edu

†University of Colorado - Boulder, stephen.billings@colorado.edu

Acknowledgements: We thank seminar participants at Tulane University, University of Alaska Anchorage, University of Colorado, and University of Louisville as well as participants at 2017 Urban Economics Association Meetings, 2017 Association for Public Policy Analysis and Management Annual Meetings and the 2018 Association for Education Finance and Policy Annual Meetings. We are grateful to the North Carolina Education Research Data Center (NCERDC) and Charlotte-Mecklenburg School District (CMS) for providing data.

1 Introduction

School choice has become a popular tool for public school systems to compete with the large number of charter and private school options for families. In order to administer school choice programs, many large and diverse school districts (e.g. Boston, Charlotte, Chicago, New York, San Francisco) use lotteries to assign students to oversubscribed schools. Over the last 2 decades, the use of random school assignment has led to a proliferation of economics and education research that examines the impact of higher quality and specialized schools on the academic and behavioral outcomes of students. These studies find mixed evidence of impacts for lottery winners on short-term outcomes,[1] substantial benefits in long-term outcomes,[2] and heterogeneity in impacts across several dimensions including student attributes such as gender, as well as alternative measures of school quality such as school peers, teachers and other inputs.

In spite of this sizable literature on the impacts of winning a school choice lottery, little is known about how lottery participants reallocate housing and neighborhood consumption in response to school choice lottery outcomes. Scholars often recognize non-compliance with lottery assignment, but do not explicitly examine the behavior of losers who need to compensate for lower quality school assignment. Compensation may include moving to a neighborhood with higher assigned school quality, switching from public to private schooling, or moving to another public school district.[3] The cost of this compensation is non-trivial with private school tuition averaging over $11,000 a year (Snyder et al. [2016]) and homes assigned to higher quality schools commanding price premiums that approach the cost of private schooling.[4] The research presented here examines residential mobility and changes in school quality for lottery winners and losers that occur between lottery school assignment and actual school attended in the following year.

Results provide two new insights. First, we show that lottery outcomes impact residential mobility and estimate the degree to which lottery losers reduce the gap in assigned school quality between winners and losers by moving to better quality neighborhood schools. Second, we provide a new estimate of the value of school quality by examining incurred home price differentials to improve school quality. Thus, we provide an estimate of the value of school quality for a population that has strong preferences for school quality and an immediate need to purchase more school quality. This method for estimating school quality

[1] e.g. end-of-grade test scores (Abdulkadiroglu et al. [2015]; Cullen et al. [2006]; Hoxby and Murarka [2009]; Hastings et al. [2006]; Mills and Wolf [2017]; Rouse [1998]), and self-reported disciplinary issues (Cullen et al. [2006])

[2] e.g. adult crime (Deming [2011]), and high school graduation and college matriculation (Deming et al. [2014])

[3] Losers may also compensate in other ways such as extra tutoring or parental involvement in the classroom, but our focus is on changing school assignment and residential relocation.

[4] Housing price premiums for homes with good schools can be quite sizable based on the higher end estimates of the value of a standard deviation improvement in school quality (upwards of 10% - Nguyen-Hoang and Yinger [2011]) applied to expensive homes (>$500,000).

should be less sensitive to neighborhood quality as families have a clear need to move explicitly for access to a higher quality residentially assigned school. Relocation choices of winners also provide insight into housing consumption reallocation after gaining access to a higher quality school.

Specifically, we use the Charlotte-Mecklenburg Schools (CMS) open enrollment program school choice lottery, which has been incorporated in previous work (Deming [2011]; Deming et al. [2014]; Bibler [2017]). CMS began assigning students to oversubscribed schools through this lottery in 2002 after the end of racial-based busing. CMS is a large urban school district and its school choice lottery provides a number of options at all levels of primary education. We limit our analysis to applicants to oversubscribed lotteries in CMS in order to compare lottery winners and losers from the same lottery across a number of outcomes. Traditionally, school lottery papers provide two types of estimates. First, one can estimate an intent-to-treat (ITT) effect of winning the lottery on various outcomes. Second, one could use lottery assignment to estimate a local average treatment effect (LATE) on various academic and behavioral outcomes for students who comply with lottery assignment. The difference between these two estimators includes the endogenous reaction of students to the lottery results. The fact that winners and losers have different needs to alter school quality after the lottery is the focus of our analysis.

We find that rising kindergarten and sixth grade students who lose a school choice lottery are about 6 percentage points more likely to exit the district or change neighborhood schools, a 20-30% increase over baseline moving probabilities. These changes in mobility are almost entirely driven by exiting the public school system for kindergartners, but in relocating to a different neighborhood within the school district for 6th graders. Rising kindergartners and 6th graders who lost the lottery and change neighborhood schools make up between 0.23 and 0.46 standard deviations in average school test scores between lottery assignment and attendance the following year. Consistent with post lottery sorting based on student composition, we find that kindergarten lottery losers move to schools with a lower proportion of economically disadvantaged students and a higher proportion of white students, even after controlling for school quality. Given the link between neighborhood of residence and school assignment, sorting based on student composition may increase residential segregation more broadly. However, this sorting pattern does not hold for rising 6th grade lottery losers, which may be consistent with weaker preferences for student composition in more experienced public school students.[5] For the smaller sample of winners that move, we find limited evidence of sorting based on neighborhood home prices, or moving for proximity to their first choice school.

[5]While sixth grade lottery losers also move to schools with a lower proportion of economically disadvantaged students and a higher proportion of white students, the correlation is not statistically different from zero after conditioning on changes in school quality.

Our results complement previous literature on the non-market valuation of school quality, which estimates a 2 - 10% increase in home values for a 1 standard deviation increase in school quality (see Black [1999]; Andreyeva and Patrick [2017]; Figlio and Lucas [2004]; Fack and Grenet [2010]; Dhar and Ross [2012], etc.). We first verify that a standard boundary discontinuity estimate using our data and study area provide results in the range of the prior literature - a 7% premium in housing prices for a 1 SD increase in school quality. We also show a larger premium for the highest quality school neighborhoods.[6] We then estimate how changes in school quality for losers and winners relates to changes in neighborhood housing prices (conditional on structural and non-school neighborhood attributes). Using lottery losers that move, we estimate a housing price premium of 11% for Kindergartners and 9% for 6th graders for a 1 standard deviation increase in test scores. Our large estimates for school quality using lottery losers are quite plausible for two reasons. First, lottery applicants are living in neighborhoods with average school quality to begin with and thus increasing school quality by 1 standard deviation would represent moving from an average school to one of the best schools in the district. Thus, there may be a substantial premium for this type of school quality. Second, these estimates of the value of school quality are specifically for neighborhoods chosen by families that have a strong and immediate need to improve school quality which may generate substantial housing price premiums.

Our work also complements recent empirical evidence that households with strong preferences for school quality respond to changes in school choice through residential location decisions (Billings et al. [2017]; Brunner et al. [2012]; Cullen et al. [2013]; Mertens Horn [2017]). For example, Billings et al. [2017] show that households gentrify neighborhoods assigned to failing schools when they are allowed to opt out of their neighborhood school under No Child Left Behind. Cullen et al. [2013] and Cortes and Friedson [2014] find that households strategically move to neighborhoods located in lower-performing school attendance zones in order to improve their odds of qualifying for the Texas "Top Ten Percent Plan." Together, this work provides empirical evidence of theoretical assumptions and models used in Ferreyra [2007] and Nechyba [2000] to explain residential sorting based on school quality. In our context, lottery losers have a strong incentive to relocate to improve school quality, and based on their strong preferences for school quality revealed by participating in the lottery, this work predicts residential relocation. More broadly, a better understanding of how school choice policies affect residential location decisions will provide insight into the design of school choice programs.

Our results have important and timely implications for education policy as states and cities expand and

[6]Most of the more recent literature places estimates closer to 2-4%, but the large diversity in school quality within our study area may explain our higher estimates.

refine their school choice systems (Jordan and Gallagher [2015]). Often, little attention is paid to lottery losers who may be incurring substantial costs to improve school quality and thus policymakers may want to expand popular school choice options to minimize the number of families that are denied access to a school due to capacity constraints. Additionally, our higher estimates of the willingness to pay for school quality point to substantial heterogeneity in the value families place on school quality, and suggest that families with strong school preference and those coming from relatively high performing schools likely have nonlinear or larger marginal benefits from improving school quality. While our results cannot speak to the optimal distribution of school quality within a school district, they show that parents are willing to incur large costs for access to high quality schools. Given these costs, there may be large returns to public investments that expand access to high quality or specialized magnet school programs.

The paper proceeds as follows. Section 2 describes the school choice lottery in Charlotte-Mecklenburg Schools; Section 3 describes our student level data on lottery applications and performance; Section 4 outlines our empirical strategy to examine the impact of lottery results on residential relocation. Section 5 provides results, and Section 6 concludes.

2 Lottery

Every student enrolled in Charlotte-Mecklenburg Schools (CMS) is assigned to a neighborhood (home) school based on geographic boundaries.[7] CMS students can opt out of their neighborhood school through a centralized lottery, for which they can submit up to three program choices in order of preference. Non-guaranteed seats are assigned in three rounds.[8] Only first choices are considered in the first round. If there are fewer applicants than seats available to a given program, then all of the applicants to that program will be assigned to their first choice.[9] We focus on oversubscribed programs, because identification comes from comparing winners and losers from the same lottery. When the number of applicants is greater than the number of available seats (the choice is oversubscribed), seats are assigned quasi-randomly. Seat assignment is not completely random, because the probability of winning for a particular student depends on their priority group. Priority groups refer to sets of students that meet some pre-specified criteria. Over our sample period, priorities were based on geographic location and whether the student's neighborhood

[7] We will use the terms neighborhood school and home school interchangeably to refer to the school that the student is assigned to based on location of their residence, which is the school they would attend unless they opt out through the lottery, relocate, or exit the district.

[8] Students with an older sibling in a school are guaranteed a seat in that school by making it their first choice.

[9] We use the term program rather than school since students apply for specific grades at a school as well as special magnet programs that encompass only a portion of classrooms in a school.

school is a Title I *choice school.*[10] We use lottery (program of application by year) fixed effects and condition on other lottery rules to exploit the fact that winners should be randomly chosen within these groups.[11]

Our identification strategy relies on comparing students in the same priority groups who have different lottery outcomes. After going through all first choices, second and then third choices are considered in a similar fashion. If a student's second or third choice filled up in a previous round, then they remain unassigned in that round. If a student does not win any of their three choices, the student is assigned to their neighborhood school. The lottery considers student choices in sequence, so students are most likely to win a choice by picking it first, and almost all seats are awarded in the first round. The treatment assignment variable is a dummy variable for winning their first choice, which should be random after conditioning on the lottery fixed effects and rules.

The data contain up to three choices for every student in order of preference, as well as sibling placement, Title I choice placement, economic disadvantage status, and transportation zone.[12] We start with the sample of all applicants without a guaranteed seat and proceed in the following way. We generate lottery fixed effects as the program by year combinations.[13] We proxy for Title I choice school using whether or not any student from their neighborhood school was placed under the Title I choice option that year. In all specifications, we condition on lottery fixed effects, Title I choice school status by year, and economic disadvantage status by year.

In addition to conditioning on lottery rules, we must also consider the stated requirements for specific lottery programs. This is mainly a concern for the sixth grade sample, for which some programs restrict access to students who meet certain requirements. These requirements are generally based on whether or not the student scored at grade level or higher on end of grade exams in the prior year. For example, students who wish to enter one of the STEM programs in their sixth grade year must score at grade level in reading, math, and science on their fifth grade end of grade exams. In this case, we can check whether each student met the stated requirements for the program that they applied to with their first choice in

[10]Title I schools are those with a high percentage of economically disadvantaged students. A Title I school becomes a Title I *choice* school if they fail to meet adequate yearly progress in the same subject for two consecutive years. No Child Left Behind (NCLB) requires that the district allow students assigned to Title I choice schools the opportunity to attend a non-Title I choice school, but it does not require the district to allow students to choose the school they are offered.

[11]In addition to priority groups, all applicants are ordered based on randomly assigned numbers. When a choice is oversubscribed, the combination of priority groups and randomly assigned numbers determine who wins the lottery.

[12]CMS stopped reporting economic disadvantage after 2010. For years 2011-2012 we proxy for economic disadvantage at the time of application using economic disadvantage status from the NCERDC data. For kindergarten students, the economic disadvantage proxy comes from their third grade observation in NCERDC. For rising sixth grade students, we use their lagged (fifth grade) value for economic disadvantage.

[13]We also test moving, attrition, and balance using program-year-home school fixed effects as a robustness check. There are some lottery rules that these fixed effects might capture, whereas the more general fixed effects may not.

the lottery. We restrict to students who met the requirements for their first choice program.[14] Appendix Table A1 provides a breakdown of the portion of applicants that win access to an oversubscribed school by lottery application year. The share of applicants obtaining their first choice in each year averages about 42% for rising kindergartners and 48% for rising 6th graders over our sample period of 2009-2012, but there is some heterogeneity across years. The year-to-year variation in win probabilities does limit the ability of applicants (especially rising 6th graders) to accurately predict probabilities from past results.

3 Data

To examine residential movement for students that apply to a school choice lottery, we link student level data from the lottery in CMS to data on neighborhood location and student demographics provided by the North Carolina Education Research Data Center (NCERDC). These data are unique in that they allow us to define residential location for students based on geographic attendance boundaries for school assignment (home school) during the lottery application time period (the year prior to kindergarten and the 5th grade year) as well as the following year (K and 6th grade). For 5th and 6th graders, we can also determine Census Block Group (CBG) of residence.[15] Therefore, we can observe any changes in residential location across neighborhoods and/or school assignment zones. The home school is the school that a student will be assigned to in the following year, unless they opt out through the lottery or change residence and move into the boundary of a different school. NCERDC linked the lottery data from CMS with statewide education data, which provides additional information on end-of-grade exam scores, 3rd-8th grade CBG of residence, and student demographic data.[16] We focus on rising kindergarten and sixth grade students, because students are more likely to apply through the lottery in those years since they are at the beginning of elementary and middle school for most students in CMS. The analysis sample includes students entering kindergarten and sixth grade from the 2008-2009 through 2011-2012 school years who submitted an application for a program in the CMS school choice lottery and were linked from the CMS data to the NCERDC data. For the kindergarten lottery sample, we are limited to only CMS lottery data.[17] For the sixth grade sample, we include a combination of the CMS lottery data and the NCERDC data which provides a richer

[14] In some cases, we can not view whether the student met the stated requirements. Specifically, arts schools require an audition or portfolio assessment, and and leadership schools require an interview. We drop these programs from the analysis, because assignment is not random, conditional on observables.

[15] We use CBG 2000 or 2010 depending on the year of observation.

[16] NCERDC was able to link between 93% and 97% of all observations from the CMS data in each year. Even though in previous work, Billings et al. [2017] incorporated exact student addresses, this data could not be incorporated into this study due to restrictions by CMS in providing the lottery data. Additionally, all end-of-grade exams are scaled to have mean zero and standard deviation of one based on statewide testing results for each grade and year.

[17] NCERDC data coverage is low for students in kindergarten through second grade.

set of covariates. We restrict our lottery sample to students who made at least one choice in the 2009 - 2012 lotteries, did not receive a sibling placement, and applied to a program-year for which at least one individual won and one lost the lottery. We then drop students who applied to a program at their neighborhood school, applied to a program for which they did not meet the entrance requirement, or applied to a program with subjective entrance requirements. For the sixth grade sample, we also restrict to those with a lagged observation from the NCERDC data.

We also incorporate detailed data on home attributes (e.g. beds, baths, lot size, building area, etc.), CBG neighborhood attributes (e.g. median household income, population density, etc.) and information on the sale of a property (e.g. sales price, date of sale), which we use to construct neighborhood housing prices by CBG and neighborhood school attendance zones. This dataset represents an extract of all the tax assessor records from Mecklenburg County from 1995-2015. We later use all this information to generate an estimated average value of school quality by conditioning on all of our controls for housing and neighborhood attributes . Later, we describe the details of constructing our value of school quality.

3.1 Summary Statistics and Random Assignment Check

Tables 1 and 2 summarize all rising kindergarten and sixth grade students in CMS with breakdowns for winners and losers in our lottery samples. There is substantial mobility amongst all rising kindergarten and sixth grade CMS students with 27% of students moving by the following year. These mobility rates are somewhat lower for lottery applicants given by the *Won* and *Lost* column headings, which is consistent with a lottery applicant pool that is economically better off and has better than average housing stability. Relative to the district averages, lottery applicants are less likely to be hispanic, economically disadvantaged, or have higher end-of-grade exam scores.

These two tables summarize our lottery applicants by comparing the winners and losers. Columns 2 and 3 of each table report averages for lottery winners and losers, respectively. Columns 4 through 7 test for differences in outcomes and student attributes between the winners and losers. In column 4, we report unconditional differences between winners and losers, while column 5 adds lottery fixed effects (program of application by year) and controls for other variables that alter the probability of winning the lottery.[18] In addition, we add home school fixed effects in column 6 to deal with any priority group that is based on

[18]Other lottery controls include a number of controls for priority groups including economically disadvantaged status, title I choice status of assigned neighborhood school, interaction between economic disadvantage and title I choice status, and English second language eligibility status. For the sixth grade sample, we also include dummies for grade level achievement, gifted status, and an indicator for being below grade level in reading and applying to a non-magnet school.

home school or walk zone.[19] Alternatively, column 7 uses lottery fixed effects that are program by year by neighborhood school indicators.[20]

The first outcome, *Mover (Change HS + Exit)*, is a dummy variable indicating whether a student has a different neighborhood school in the following year, which includes those missing a lead neighborhood school (i.e. they exited CMS). As such, the first row in each table shows the estimates for the effect of winning the lottery on the probability of changing home schools or exiting CMS. After conditioning on lottery fixed effects (application choice by year of application), adding other covariates has little impact. For example, from column 4 of Table 1, we estimate that kindergarten lottery winners are 6.8 pp less likely to exit or change neighborhood schools conditional on lottery fixed effects and controls. In column 7, which uses application by year by home school indicators as lottery fixed effects, we estimate that lottery winners in the kindergarten sample are 5.7 pp less likely to exit CMS or change neighborhood schools. These estimates are about 25% of the average moving probability among all winners and losers in Table 1 .

The second outcome, *Change HS (Stay)*, is a dummy variable that is equal to one for students who show up in the CMS data the following year with a different home school than indicated in their application year. This allows us to isolate how much of the difference in exits plus moves is due to students who remain in the public school system, but change home schools. From Table 1, kindergarten lottery winners are between 0 and 2 pp more likely to remain in the district with a different home school, indicating that almost the entire win-lose difference in movement between lotteries comes from an increased probability of exiting for those who lost the lottery. The finding that the lottery results induce movement through district exits is consistent with students opting out of the public school system altogether to attend private schools or moving to attend more suburban school districts, which in this study area contain higher quality schools in terms of test scores. However, the fact that winning the lottery has a much smaller impact on the probability of moving to a different home school within the school district does not limit residential sorting in reaction to lottery results. Even if winners and losers move at the same rate, they might differ in location choices based on school and neighborhood quality. This could show up as an intensive margin difference, i.e. even though winners are just as likely to move, they care less about the school quality in their new

[19]There are at least two reasons why adding home school fixed effects or using application-year-home school combinations as lottery fixed effects could help control for lottery rules. First, full magnet schools have an additional priority for students who live in close proximity to a full magnet school. Since we don't have information on exact location of residence, the home school fixed effects may help mitigate any error from mis-measuring this priority. Second, magnet lotteries could, in theory, limit the number winners from a specific home school. Based on the magnet process explanation, students from a home school lose some priority if there are already a disproportionately high number of students admitted to that program from their home school. Anecdotally, this constraint is not generally binding in practice. Lastly, since the final priority is based on whether or not the magnet school serves the transportation zone of the students, conditioning on home school effectively controls for this priority criteria.

[20]Because the lottery groups are more restricted in this case, and we only use lotteries with at least one winner and one loser, the number of observations falls in column 7, relative to columns 4 - 6.

neighborhood because they have lotteried out of that school in favor of their first choice program.

Finally, the third variable in Table 1, *App Year HS*, is an indicator equal to one for students who attend the school that was their assigned home school prior to the initial lottery. Students are assigned a home school based on location of residence at the time of the lottery (the school year before entering kindergarten for the kindergarten sample). From Table 1, about 40% of lottery losers in the sample attended their initial home school assignment. There are several ways in which students who lost the lottery end up attending a different school. Students who lose their first choice are automatically placed on a wait list for their first choice program. The wait lists can be accessed through the first quarter of the school year to replace any students who exit the program. Alternatively, they could win their second or third choice in the lottery, which could also lead to a different school assignment. Of the lottery losers in the kindergarten sample, 80% made a second choice in the lottery, and almost 64% made a third choice. Among students who lost their first choice, 30% won their second or third choice in the lottery. Relocating residence into a different home school boundary, and exiting CMS are other ways in which a student can end up in a different school.[21] In comparison, only 6% of lottery winners attend their application year home school assignment. After conditioning on lottery fixed effects and lottery rules, we find that lottery winners are about 30 - 32 pp less likely to attend their application year home school.

The comparable estimates on moving, exiting, and application year home school attendance for the sixth grade sample are shown in the first three rows of Table 2. Lottery winners in the sixth grade sample are 5 - 6 pp less likely to change home school or exit the district, a similar number to that in the kindergarten sample. In contrast to the kindergarten sample, the estimated impact of winning the lottery on staying in the district with a different home school is almost identical to the impact on exiting plus moving, about 5 - 6 pp. That suggests that the entire difference in responses to the lottery outcomes between winners and losers is due to students remaining in the district, but changing home schools between school years. The main difference between the kindergarten and sixth grade samples is that lottery losers in the sixth grade sample are moving within the school district rather than exiting the school district. This result is inconsistent with families applying to enter a high quality public school, and opting out in favor of suburban school districts or private schools if they are unsuccessful. Sixth grade families are already invested in the public school system and may have other children that are in public schools, and thus are less likely to switch to a

[21] There is also a second lottery in the district that students can apply through. However, this lottery is typically designed for students who entered the district too late to participate in the first lottery. A student who participated in the first lottery could also apply through the second lottery, but they would forego any outcomes from the initial lottery process. It seems unlikely that many students will find it desirable to apply in the second lottery after losing the first, since most seats are assigned in the first lottery, and in particular, high demand programs are filled up in the first lottery.

private school or move to a suburban school district. Similar to the kindergarten sample, winning the lottery decreases the probability of attending their initial home school assignment by about a 30 pp among the sixth grade applicants.

Tables 1 and 2 include balance tests for some baseline characteristics, and F-tests for the joint significance of student characteristics that should not alter the probability of winning the lottery. Table 1 includes an F-test for joint significance of female, black, white, hispanic, and whether the student made a second or third choice in the lottery on predicting the lottery outcome. The p-value when using the program by year fixed effects is 0.47. When using the more restrictive program by year by neighborhood school lottery fixed effects in column 7, the p-value for joint significance of these variables is 0.8. In both cases, we fail to reject the null hypothesis that student characteristics do not explain winning the lottery. In Table 2, we also include balance tests for lagged achievement and limited english proficiency (LEP) status. The p-value for joint significance in the sixth grade sample is around 0.8 with both the basic and more restrictive lottery fixed effects. In both cases, student attributes do not explain lottery results.

Before we formally analyze how lottery winners and losers residentially sort, we consider how initial residential location relates to the schools that families apply to in the lottery. Traveling long distances to school can be costly for families, and in some cases families may have to provide transportation. The location of students and magnet schools of varying quality at the time of application may be important in interpreting the impacts of lottery results more broadly and in thinking about families on the margin of applying to the school choice lottery. However, distance to first choice school should have no bearing on our identification strategy since all of our results are conditional on applying to the lottery and balance results are robust to including home school fixed effects. Figure 1 provides an initial check that sixth grade winners and losers are similar in distance to their first choice school.[22] We see minimal differences between winners and losers in the distribution of distance from a student's first choice school and the CBG of their residence at the time of application. Losers appear to live slightly further away from their first choice school, because students are willing to travel further for higher quality schools and higher quality schools are more oversubscribed (lower probability of winning). Figures 2 and 3 confirm this empirical fact. Figure 2 shows that there is no relationship between potential gains in school test scores and distance to first choice school at the time of application for schools with high win probabilities ($\geqslant 0.5$). However, Figure 3 shows that students are willing to travel further to schools with higher test scores if the school is high quality in multiple dimensions, as suggested by the low win probability (< 0.5). In general, these statistics

[22] We focus on rising 6th graders since we have more disaggregate information of residence relative to rising Kindergartners.

show that distance matters, but many families are willing to incur travel costs for a high quality school.

4 Methodology

4.1 Lottery Outcomes, Moving, and School Quality

In this section, we formalize our empirical strategy to directly test the role of lottery outcomes on assigned and attended school quality, moving, and housing prices in new neighborhoods. We begin our analysis by estimating the impact of winning the lottery on assigned school quality using the following specification.

$$S_{it}^{as} = \alpha^{as} + \beta^{as} \cdot W_{it} + \Gamma^{as} \cdot X_{it} + \Omega_{i}^{as} + \varepsilon_{it}^{as} \tag{1}$$

Where S_{it}^{as} represents the average end of grade math and reading exam score in the school that student i was assigned to in the lottery at time t.[23] The assigned school is the final assignment that the student received in the lottery. For a student who won their first choice in the lottery, S_{it}^{as} is the average test score at their first choice school. Similarly, if a student won their second (third) choice, the quality measure will reflect the quality of the school the student specified with their second (third) choice. In equation 1, W_{it} is a dummy variable equal to one if student i won their first choice in the lottery, and Ω_{i}^{as} represents program by year fixed effects. Let X_{it} represent a vector of student level characteristics that influence the probability of winning the lottery including economically disadvantaged status, assignment to a title one choice school, and grade level status in math, reading, and science for sixth grade students, as well as student level characteristics including sex, race indicators, and lagged test scores for sixth grade students. So $\hat{\beta}^{as}$ represents the within lottery difference in average test scores of assignment schools between winners and losers. If $\hat{\beta}^{as} > 0$ it means that students who won the lottery were assigned to schools with higher average test scores than the students who lost the same lotteries, and represents a measurement of the assignment test score advantage of winners.

In our second specification, we replace the left hand side variable in equation 1 with the average test score of the school that the student actually attended in the following year, S_{it+1}^{at}. Now the analogous estimator, $\hat{\beta}^{at}$, represents the difference in average test scores between the schools that the winners and losers actually attended, or the attendance test score advantage. Similar to $\hat{\beta}^{as}$, $\hat{\beta}^{at} > 0$ indicates that lottery winners attend schools with higher average test scores than those who lost the same lotteries. We then combine the two measure of school quality to form a third measure of interest, $\Delta S_i = S_{it}^{as} - S_{it+1}^{at}$,

[23] Assignment is made at time t to a school that the student will attend in time $t+1$.

and provide estimates from the following specification.

$$\Delta S_i = \alpha^{\Delta} + \beta^{\Delta} \cdot W_{it} + \Gamma^{\Delta} \cdot X_{it} + \Omega_i^{\Delta} + \varepsilon_{it}^{\Delta} \tag{2}$$

Where ΔS_i represents the difference in the average score between the school that student i was assigned at time t and the school that student i actually attended at time $t+1$. This will equal zero for students who attend the school that they were initially assigned in the lottery, and will be non-zero when student i attends a different school than they were assigned in the lottery. Differences in average scores, i.e. non-zero values of ΔS_i, come from some form of non-compliance with lottery assignment. For example, a student could be admitted off of a waitlist to their first choice school or a family could alter the student's assigned neighborhood school by relocating. In such a case, if the student attends their new neighborhood school in the following year then the average assigned and attended scores will likely differ.[24]

In equation 2, $\hat{\beta}^{\Delta}$ provides a measurement of the school quality that lottery losers make up between the end of the lottery assignment and the following year. If $\hat{\beta}^{\Delta} = 0$, then any changes in school quality between assignment and attendance for the lottery losers are offset by equivalent changes for the lottery winners. This would be true, for example, if every student complied with their initial assignment. In that case, the assignment and attendance advantage for winners are equivalent, and lottery losers took no action to compensate for losing the lottery by finding a way into a different school than they were initially assigned. On the other extreme, if $\hat{\beta}^{\Delta} = \hat{\beta}^{as}$, that suggests that the assignment advantage disappears in the time between lottery assignment and school attendance in the following year. One way that this could happen is if every lottery loser attended a school with equivalent test scores as their first choice school in the lottery. In that case, there would be no attendance advantage for lottery winners. When $0 < \hat{\beta}^{\Delta} < \hat{\beta}^{as}$, there is some reduction of the assignment gap between the time of assignment and attendance. One way that this would occur is from lottery losers attending schools with higher test scores than they were initially assigned, although it is also possible that lottery winners attend schools with lower test scores than they were initially assigned.

We expand on equations (1) and (2) by incorporating the moving decisions of lottery winners and losers. We focus on whether or not the students had a change in their assigned home school between the time of the lottery and the following year. We construct a dummy variable to indicate whether or not a student changed home schools, $move_i = 1[HS_{it} \neq HS_{it+1}]$. Where HS_{it} represents the home (neighborhood)

[24]Unless the student was also assigned to their future neighborhood school in the inital assignment process, or in the unlikely event that the assigned and attended schools are different schools but have identical average test scores.

school that student i was assigned to in year t.[25] A change in neighborhood school between lotteries indicates changing residence because neighborhood schools are assigned based on geographic boundaries. We use the information on neighborhood school assignments to estimate versions of equation (2) that include interaction terms between $move_i$ and W_i, which allows us to estimate changes separately for students that win the lottery and move, win the lottery and stay, lose the lottery and move, and lose the lottery and stay.[26] Winners that comply with there assignment, and so have $\Delta\widetilde{S}_i = 0$, are the reference group in our moving analysis. However, we still provide estimates for winners that do not comply with their lottery assignment.

4.2 Lottery Outcomes, Moving, and Housing Prices

After considering the changes in assigned and attended school quality between lottery winners and losers, and movers and stayers, we consider differences in housing prices by home school zones. We focus on making analogous comparisons to the school quality results. That is, we estimate changes in housing prices for lottery winners and losers that move after the lottery. The analysis and results are slightly different in the case of housing prices, because we care about capitalized school quality, which would only be reflected in the home price of neighborhoods that have guaranteed access to a school, namely a resident's home school. Therefore, we focus on neighborhood school boundaries for home schools that students are geographically assigned to even if the student attends another school. For the purpose of computing average housing price residuals, we focus on the neighborhood school assignments in the year that a student applies for the kindergarten/sixth grade lottery and the following year after the student begins school. We begin by estimating hedonic housing price regressions for home sales in the county, as shown in equation (3).

$$Ln(P_{hst}) = \beta \cdot X_{hst} + \alpha \cdot N_{hst} + \delta_t + \varepsilon_{hst} \tag{3}$$

Where P_{hst} represents the sale price of home h in home school boundary s at time t.[27] X_{hst} rep-

[25] Home school assignments in the lottery data in year t refer to the home school that the student is assigned to for year $t+1$, based on location of current residence. The assigned home school of a student is the school that they will be assigned to attend unless they opt out through the school choice lottery, move into a different home school zone, or exit the district through relocation, or entering a charter/private school.

[26] For this analysis we use $\Delta\widetilde{S}_i = S^{at}_{it+1} - S^{as}_{it}$ as the outcome, which reverses the difference from equation 2. Since the focus is on the lottery losers in this specification, using $\Delta\widetilde{S}_i$ helps to compare these estimates for lottery losers with the estimates based on equation 2.

[27] In equation (3), t is quarter-year specific unlike the student-level lottery regression equations in which t refers to the year of the lottery.

resents characteristics of the home including lot size, home size, age of the home, and other structural attributes;[28] N_{hst} represents controls for neighborhood attributes including median household income, population density, percent unemployed, distance to central business district (CBD), distance to the interstate, indicators for being located on a busy road and in a floodplain, and distance to a park. δ_t indicates fixed effects for the year and quarter of sale. We then average residuals from the housing price regression to the home school attendance zone to get a measure of the average unexplained portion of the home sales, which reflects school quality.

$$\tilde{P}^s = \bar{\hat{\varepsilon}}_s = \frac{1}{n_s} \sum_{h=1}^{n_s} \hat{\varepsilon}_{hst} \tag{4}$$

Where $\tilde{P}^s$ represents the average residualized price in home school boundary s.[29] Let $\tilde{P}^s_{it}$ represent the average residualized price for the home school that student i is assigned to at time t. In the sample of rising 6th graders, we refine the price residual calculation by averaging to the CBG-home school level, which allows us to better control for neighborhood specific differences. We estimate housing price residual parameters for winners and losers that move based on Equation 5.

$$\Delta\tilde{P}^s_i = \alpha^p + \gamma^p_{lost} \cdot move_i \cdot (1 - W_{it}) + \gamma^p_{won} \cdot move_i \cdot W_{it} + \Gamma^p \cdot X_{it} + \Omega^p_i + \varepsilon^p_{it+1} \tag{5}$$

Where $\Delta\widetilde{P}^s_i = \tilde{P}^s_{it+1} - \tilde{P}^s_{it}$, and $\hat{\gamma}^p_{lost}$ and $\hat{\gamma}^p_{won}$ are estimators for the change in the average residual sale price in the neighborhood school boundary for those who moved after losing and winning the lottery, respectively. Since we are using changes in home school assignment to determine movers, the neighborhood school residual prices only vary for students who move. Estimates of γ^p_{lost} and γ^p_{won} based on equation (5) are relative to non-movers, for whom the change between old and new neighborhood average residual prices is zero by construction.

Estimates based on equation (5) tell us about changes in home price residuals, but do not directly link the price differences to differences in school quality. In order to estimate the housing premium directly in terms of school quality, we interact the observed changes in home price residuals with changes in school quality. This is effectively a slight extension of equation (5), but allows us to interpret the premium in terms of one standard deviation improvements in average school test scores, and thus provides a natural

[28] We include a series of dummies for different structural attributes of a home including foundation, heating, air conditioning, home style, plumbing and electrical.

[29] In our analysis, we use a value of $\tilde{P}^s$ that is fixed over time and represents average school quality from 2007-2013.

comparison with estimates based on the boundary discontinuity approach used in the previous literature.

5 Results

Our summary statistics highlight that winners and losers are balanced on observable characteristics, and that losers are more likely to leave the school district or move to another neighborhood school after losing the lottery, relative to winners. Next, we test for differential changes in school quality between lottery assignment and attendance the following year to determine whether lottery losers move to improve quality. Finally, using hedonic-based estimates of land value along with the differential changes in school quality, we estimate the housing premium that lottery losers pay for access to higher quality schools.

5.1 School Quality - Assignment to Attendance

Table 3 highlights differences in the quality (test scores) of assigned school based on the first round results of the school choice lottery, relative to the school quality actually attended in the next school year. Differences in the assignment and attendance gaps between lottery winners and losers are inclusive of student reactions to lottery outcomes. In particular, families may move to gain access to a different neighborhood school, gain access to a different school through a wait list or other school choice option, or simply choose not to attend the school assigned in the lottery and attend their home (neighborhood) school instead. Table 3 provides two dimensions of insight. First, row values for *Won* and *Lost* provide unconditional means for average math and reading test scores for the schools that the student's were assigned to and attended, as well as the difference in those two school scores.[30] Columns 3 and 6 display differences in the scores of the assigned and attended schools, which highlights a small decline between assigned and attended school test scores for lottery winners, but substantial improvements for losers. Second, this table highlights the conditional differences in school quality (test scores) for winners and losers from assignment to actual school attended after accounting for priority group rules in the lottery and individual level characteristics.

A couple elements of Table 3 are interesting. First, winners are clearly assigned to schools with higher test scores, which is consistent with the nature of the school choice lottery. The assignment difference, $\hat{\beta}^{as}$ from equation 1, is given in the *Conditional Difference* row for the assigned column and indicates an assignment advantage of 0.45 standard deviations for kindergarten and 0.61 standard deviations for 6th

[30]Differences between unconditional and conditional values are simply a result of the priority groups (e.g. economically disadvantaged; home school is Title 1 choice) that impact lottery results. As shown in Tables 1 and 2, winners are losers are not unconditionally balanced on student attributes, but winners and losers are balanced on observables after conditioning on lottery fixed effects and rules. Conditional means control for these priority groups and are consistent with later regression results.

grade. This substantial difference between winners and losers is expected, but our analysis focuses on the changes in this difference between assignment and the actual school attended. Columns 2 and 5 provide differences between winners and losers based on test scores of actual school attended in the school year following the lottery. Differences between winners and losers are now only 0.30 and 0.26 standard deviations for kindergarten and 6th grade students, respectively. This large decrease is summarized in columns 3 and 6 as difference-in-differences estimates, estimates of β^{Δ} from equation 2, and indicate the amount of the test score assignment gap between winners and losers that is made up between initial assignment and attendance in the following year. Results show that 0.14 and 0.35 standard deviations were made up between assignment and attendance by kindergartners and 6th graders, respectively.

Changes in school quality between assignment and attendance in Table 3 are almost entirely driven by the behavior of losers. Kindergarten and 6th grade winners attend schools of similar quality as they are assigned in the lottery, which is not surprising since 84 - 89% of lottery winners in our sample attend their first choice school. On the other hand, the unconditional improvement in school quality of losers is about 0.12 and 0.27 standard deviations, respectively. Even though most winners comply with lottery assignment, about 10% attend their neighborhood school or another school altogether, which only explains a small portion of the decrease in the test score gap between assignment and attendance.[31] Parents may forgo their winning lottery assignment for a number of reasons. They may instead decide to attend a school with their friends, change their preferences toward a neighborhood school after obtaining more information, or encounter transportation costs/issues in accessing the school they chose in the lottery.

Table 4 follows the same intuition from Table 3, but estimates differential effects for those who change neighborhoods and those who stay in the same neighborhood after lottery assignment. These results provide insight into the role of stayers and movers in narrowing the gap in school quality between winners and losers shown in Table 3. The results in Table 4 use a dependent variable that is equal to the average test score in the attended school minus the average test score in the assigned school. Our independent variables focus on four groups: Losers that move neighborhoods, Losers that stay, Winners that move neighborhoods and do not comply with lottery assignment, and Winners that stay in their neighborhood and do not comply with lottery assignment. Outcomes for these groups are relative to a group that has no difference between attended and assigned school - Winners that comply with their assignment. If residential relocation to improve school quality is the main driver of the results in Table 3, then moving should be correlated with gains in school quality from lottery assignment to actual school attended.

[31] The percentage of non-compliers is based on the the portion of winners that do not attend first choice school minus those students that left CMS.

Results for kindergarten in column 1 of Table 4 provide evidence that losers who move (*Change HS*) are able to generate large gains in average school test scores between lottery assignment and the following year, with this group attending schools that score 0.22 standard deviations higher than the schools that they were assigned in the lottery. These results are larger for losing 6th graders who move, a group which gains 0.43 standard deviations between assignment and attendance. Estimated effects for losers who do not move are about one-half to two-thirds of those who move, which is indicative of changing schools via followup lottery assignment, accessing a non-home school via waitlists, or opt-out provisions based on failing schools and No Child Left Behind education policy.[32]

Effects are very different for lottery winners that do not comply with assignment. Kindergartners that win the lottery but don't comply with their assignment see an average decrease of 0.20 standard deviations in test scores between assignment and attendance schools, whether they change home schools between the lotteries or not. Larger negative effects for non-complying winners is mostly a reflection of the high achievement in oversubscribed schools, relative to the achievement of other public school options. Since lottery assigned schools are high quality, attending any school but the lottery assigned school will likely result in attending a school with lower achievement than initially assigned.

The magnitude of the decrease in quality for non-complying winners in the 6th grade sample is more substantial. Among winners who stay in the same neighborhood school zone but forego their lottery assignment, the estimated decrease in school test scores is 0.36 standard deviations. This result is consistent with families applying to the lottery for the option value of attending another school. Applying for the lottery is costless and some families may apply to magnet schools or non-neighborhood schools with limited information, but decide to attend their neighborhood school after becoming more informed about the school or transportation costs. Non-complying winners that change home schools in sixth grade have the largest decrease in school quality, -0.58 standard deviations. These families may be moving for non-school reasons (e.g. rental lease expired, job opportunity) and thus may be less concerned with or not able to purchase better school quality in their new neighborhood.

Appendix Tables A2 and A3 show the dimensions on which movers and stayers differ by showing summary statistics after splitting the samples of lottery winners and losers further into those who do and do not change neighborhood schools. Among both lottery winners and losers, a higher proportion of movers are black and economically disadvantaged relative to non-movers. These results suggest that mobility may be limited by housing tenure with families that are economically disadvantaged moving at a

[32]Billings et al. [2017]show that about 30% of children are assigned to failing schools during a similar time period in CMS and about 1/3 of students opt out to a non-neighborhood or magnet school as allowed under NCLB.

higher rate. The fact that a higher proportion of moving winners are economically disadvantaged, relative to moving losers, may represent housing reallocation for winners who have limited benefits to moving for school quality, but want to reallocate housing and neighborhood consumption. We investigate this story further in the next section.

Additionally, Appendix Tables A4 and A5 examine differences between compliers and non-compliers for winners and losers. These means help interpret the type of individuals that are more likely to comply with lottery assignment and thus may have different preferences or reasons for entering the lottery. In kindergarten, lottery winners that comply with assignment tend to be black and have home schools with lower test scores.[33] For sixth graders, the only difference between the student attributes of compliers and non-compliers is home school test scores with students from lower scoring home schools more likely to comply if they win. Across both samples, losers that comply look similar to non-complying losers. Together, these two tables highlight that children assigned to lower scoring home schools are more likely to comply with winning the lottery. This result is not surprising, because the realized gains of winning the lottery are larger for applicants with lower performing home schools. Later results related to heterogeneity reinforce this point.

One other factor that may explain differences between movers and stayers is that movers may be relocating for proximity to the school they won admission to in the lottery. For movers, Figure 4 provides evidence that lottery applicants live closer to their future attended school in the year following the lottery. This figure indicates that either losers are moving closer to a school they want to gain access to, winners are moving closer to their first choice school in order to lower transportation costs, or both. Figure 5 breaks down the distribution of distance to school attended separately for movers that won and lost. Almost all of the movement is from lottery losers moving closer to the school they attend in the year following lottery application, consistent with moving to gain access to a new neighborhood school. Figure 5 also shows limited evidence that winners are moving to lower transportation costs of attending a non-neighborhood and likely further away school.

We also investigate heterogeneous effects in the changes in school quality between assignment and attendance across several dimensions. Specifically, we bisect our four groups by gender, race, a dummy for economic disadvantage, home school test score terciles, and neighborhood housing price terciles in Appendix Tables A6 and A7. For kindergartners, we see larger school quality gains for moving lottery losers that are wealthier and white, live in low or medium school quality neighborhoods, and those from medium

[33] Differences in means in Tables A4 and A5 are not equal to complier - non-complier because we report the *conditional* difference in means once we control for priority groups.

housing price neighborhoods. For lottery losers that stay, results are fairly consistent across groups. For non-complying winners, we see a different pattern. Poorer, non-white households living in neighborhoods with lower school quality and housing prices attend schools that are considerably worse than the average non-complying winner. These patterns are less pronounced for lottery losers in 6th grade, but consistent with non-complying winners in kindergarten. Altogether these results suggest that lottery losers living in neighborhoods with low school quality assignments can drastically improve school quality through residential relocation. The results for non-complying winners highlight a greater loss in school quality for lower income households that do not comply. Additionally, Appendix Tables A8 and A9 show that results are consistent across different types of magnet schools, and that they are similar for schools with both low and high win probabilities.

Ultimately, preferences over schools may depend on a number features other than school test scores. We provide estimates for a number of alternative school level attributes in Appendix Tables A10 and A11. We consider changes in school value-added, portion of students that are academically gifted, share economically disadvantaged, share designated limited English proficient, and percent of students that are white. Results highlight that alternative measures of school quality or attributes generate similar qualitative results for our groups of lottery losers and winners.

We extend this analysis further by estimating changes in percent economically disadvantaged and percent white between assignment and attendance schools for the four groups of applicants while controlling for changes in test scores in Tables 5 and 6. This additional analysis is informative for current policy debates about school choice lotteries and the role of lotteries in promoting or discouraging economic and racial diversity, because residential mobility in response to lottery outcomes may impact the composition of schools. We provide 2 sets of results for each outcome. Columns one and three replicate our main analysis, replacing changes in average test scores with the two additional outcomes. Columns two and four, which control for changes in school average test scores, provide the main insight. The results for kindergartners suggest that lottery losers move to schools with a lower percentage of economically disadvantaged students, and a higher percentage of white students, even after controlling for school quality. We see similar effects for non-compliers that win. These results suggest that some of the post lottery sorting among kindergarten students may influence student composition. These results are weaker for movers in 6th grade and may indicate less race and income based residential sorting for kids with prior exposure to public schools. Among sixth grade applicants, students who lose the lottery and remain in the same home school attend schools with a higher proportion of economically disadvantaged students and a lower

proportion of white students than their initial assignment. However, winning sixth grade applicants who do not move and do not comply, attend schools with a lower proportion of economically disadvantaged students and a higher proportion of white students than they were initially assigned.

5.2 Housing Prices and School Quality

Given higher relocation rates to neighborhoods with higher quality schools for lottery losers, we test whether housing prices reflect neighborhood school quality and then directly link changes in school quality to differences across neighborhood property values. Given the range of estimates in the extant literature on valuation of school quality, we first provide a hedonic based estimate of the value of school quality using a boundary discontinuity design. Table 7 provides hedonic estimates of the impact of a one standard deviation increase in one year lagged school average test scores on housing prices. We present estimates from four specifications with different controls for structural and neighborhood attributes. As we include progressively smaller Census 2000 geography fixed effects, our approach mimics a boundary discontinuity design by limiting identification to differences in sale prices of homes that are in the same census geography, but on opposites sides of an elementary school attendance zone that bisects that census geography. Even though we provide estimates for a smaller geography, our preferred estimate includes the larger CBG (census block group) fixed effects, because this is the finest level of location data that we have for the students in our sample. Our preferred estimates suggests that a one standard deviation increase in test scores generates a 7% increase in housing prices, which is in the higher range of previous estimates in other school districts.[34]

To examine potential nonlinearities in the valuation of school quality, in the final column of Table 7 we use the boundary discontinuity deisgn to estimate heterogeneous valuations by school quality quartile. These estimates are for the increase in housing prices for a 1 SD increase in test scores by quartile of neighborhood school quality relative to the lowest neighborhood school quality quartile. We calculate quartiles based on the lowest average school test score for a given neighborhood, which allows discontinuities in test scores within a CBG and within each quartile. The estimated valuations are similar in the bottom three quartiles, but increase to 18% for the highest school quality neighborhood. The 4th quartile of school quality neighborhood is similar in quality to the destination CBG of a number of our lottery losers.

Next, we focus on estimating the value of school quality in our sample of lottery applicants. In the first

[34]The literature finds a range of estimates between 2-10% with more recent estimates falling in the 2-4% range. The fact that we find a 7% premium for 1 SD increase in test scores is consistent with our study area which contains a large range of school quality within the same school district. The average housing price in our sample of all single-family homes with transacted sales between 2007 and 2013 is $226,752.

step, we average home price residuals to the neighborhood level using the sample of housing transactions in Table 7. This provides a fixed measure of neighborhood school quality across all the years of the lottery and does not account for any impacts of neighborhood prices due to our small group of lottery movers. We regress the natural log of prices on structural and neighborhood attributes, and average the residuals up to the neighborhood level. For the sample of rising kindergarten students, the elementary school attendance zone is the smallest geographical area of residence that we can place the lottery applicants in, so their assigned neighborhood price residuals are at the neighborhood school zone level. For the sample of rising sixth graders, we average to the attendance zone by CBG level.[35]

Table 8 reports estimates of changes in neighborhood price residuals from assignment to attendance for 3 groups: movers who lose, movers who win and comply with lottery assignment, and winners who move but do not comply with their lottery assignment.[36] The omitted group is non-movers who by construction do not have a change in neighborhood price residuals. The first column for each sample omits neighborhood controls in the first stage, but columns 2 and 4 include these controls. For the sixth grade sample, we further refine our estimates by conditioning on destination CBG fixed effects, and these estimates are shown in column 5 of Table 8. All groups exhibit some positive price premium relative to non-movers, but the estimates for lottery losers are more precise and often larger than for lottery winners. Table 8 estimates show that lottery losers who move pay a 4.1% premium in housing prices for kindergartners and 5.1% for sixth graders, highlighting that movers relocate to neighborhoods with higher quality schools. Winners that comply with assignment and move tend to relocate to neighborhoods with a smaller and less precise premium for school quality, but conclusions are somewhat limited by the small sample size of winners that move. From earlier results, winners did not appear to move closer to their attended school, and thus any incurred price premiums for winners may simply be housing consumption reallocation to nicer neighborhoods.

To test the importance of neighborhood appreciation and/or bargaining power of lottery movers, we estimate a different version of Table 8 in Appendix Tables A12 and A13 in which we focus on changes in neighborhood housing price residuals. Specifically, we use changes in residuals from the application year (t-1) to attendance year (t), and attendance year (t) to the following year (t+1) for a mover's destination neighborhood, as the outcomes. As shown in Appendix Table A12, we estimate that the neighborhoods that lottery losers move to are not appreciating at a different rate than other neighborhoods. In Appendix Table A13, we estimate greater depreciation in the new neighborhoods of kindergarten lottery winners

[35] NCERDC address data include the CBG of student residence, but coverage is only adequate in the sixth grade sample.
[36] All estimates in Table 8 use the same controls as all of our previous tables on changes in school quality.

who complied with assignment in the year following the lottery. However, there are only 3 significant coefficients across these two tables with 30 coefficients total, which generally alleviates concerns that loser and winners are moving to different types of neighborhoods based on prior or expected appreciation. Additionally, these results provide little support that the immediate need for losers to move into a higher school quality neighborhood leads to a poor bargaining position and a higher transacted home price. Of course, using neighborhood price residual aggregates limits our ability to rule out this explanation, but the results suggest that the high values of school quality are more likely due to nonlinear premiums in school quality (shown in Table 7) as lottery losers try and gain access to high quality home schools.

In order to directly test whether changes in neighborhood prices map to changes in school quality, we interact the dummy variable for each group by the change in (attended - assigned) test scores. Table 9 provides results for these 2 groups with the omitted group being non-movers. Columns 1 and 3 in Table 9 highlight the price premium for lottery losers in kindergarten and sixth grade. Estimates without controls for neighborhood quality are shown in columns 1 and 3, which estimate a relatively high value of school quality. Our preferred estimates include CBG controls and are shown in columns 2 and 4. Based on this specification, we estimate that lottery losers move to neighborhoods with an 11% price premium for elementary school and a 13% price premium for middle school for a one standard deviation increase in test scores. For our sixth grade sample, we include estimates from an additional specification in which we include destination CBG fixed effects. In the sixth grade sample, the neighborhood residuals are at the CBG by school attendance zone. By including CBG fixed effects, we are identifying the school quality value estimates from the subset of destination CBGs that are bisected by school attendance zones. These estimates are shown in the last column of Table 9. We estimate that lottery losers in the sixth grade sample move to neighborhoods that are 9% more expensive per one standard deviation increase in average test scores. In all specifications, winners who do not comply experience a noisy and near zero relationship between incurred changes in school quality and changes in neighborhood housing prices. This result shows that changes in school quality are only correlated with changes in neighborhood housing prices for lottery losers, and supports the idea that the families of lottery winners are moving for non-neighborhood school quality reasons.

Appendix Table A14 extends the results on the kindergarten sample to examine whether estimates for the value of school quality for losers and winners that move vary by gender, race, economic disadvantage, school test score terciles, and neighborhood housing price terciles. We focus our discussion on losers since we only have a small sample of moving winners that do not comply with lottery assignment, so the related

results are imprecise. In most subgroups, there is limited heterogeneity among losers, but we do estimate a larger and more precise effect for students that are wealthier (not economically disadvantaged). Turning to rising 6th graders in Appendix Table A15, we again find limited heterogeneity in our price effects, but do find some evidence of heterogeneous effects by school quality and average neighborhood housing price. In these 2 sets of terciles, we find no price effect for households moving out of more expensive and higher quality neighborhoods based on residence at the time of lottery applications. This suggests that families with relatively good home school options are less willing to pay for access to better home schools, especially in 6th grade with a shorter time span to realize the potential benefits of an improved home school.

Appendix Tables A16 and A17 examine heterogeneity by the type of magnet school program and the probability of winning the lottery. Most effects are similar across different types of oversubscribed schools. However, there is notable heterogeneity related to how oversubscribed the lottery is: more oversubscribed ($p < 0.5$) versus less oversubscribed ($p > 0.5$). Applicants to less oversubscribed schools generate larger estimates of the value of school quality than applicants to more oversubscribed schools. This result suggests that students who lose unexpectedly ($p > 0.5$) pay a higher premium for access to a higher quality school, which could result from a more immediate need and/or higher willingness to pay for an increase in quality among this group. This premium is also higher in th kindergarten sample, which is consistent with the longer potential stream of benefits from accessing a higher quality school.

6 Conclusion

We examine the responses of school choice lottery losers, with a primary focus on residential relocation and opting out of the public school system in response to the results of a school choice lottery. Despite a large literature on the benefits to lottery winners, little is known about the behavior of losers who need to compensate for the lower quality school assignment, a population who may be incurring substantial costs to improve school quality. We show that rising kindergarten and sixth grade students who lose a school choice lottery are about 6 percentage points more likely to exit the district or change neighborhood schools, which represents an increase of about 30% over baseline moving probabilities. Lottery losers are assigned to schools with substantially lower average performance on end of grade exams, but those who lost the lottery and change neighborhood schools make up 0.23-0.46 standard deviations in average school test scores between lottery assignment and attendance the following year. Using hedonic-based estimates of land prices, we estimate a housing price premium of 9-11% for a one standard deviation increase in

school test scores.

Results provide two new insights. First, we estimate how much of the gap in school quality is made up by lottery losers through residential relocation. Second, we provide a new estimate of the value of school quality by examining incurred home price differentials for losers to improve school quality after losing the school choice lottery. Together, these findings provide insight on the potential benefits to expanding popular school choice options to minimize the number of families that are denied access to oversubscribed schools. Additionally, our large estimates of the value of school quality point to substantial heterogeneity in how families value school quality, suggesting that families with strong school preference and high performing neighborhood schools likely have nonlinear or high marginal benefits from gaining access to a high quality school. Given the large costs incurred by lottery losers to improve school quality, there are likely large returns to public investments that expand access to high quality or specialized magnet school programs.

References

Atila Abdulkadiroglu, Parag A Pathak, and Christopher R Walters. Free to choose: Can school choice reduce student achievement? Technical report, National Bureau of Economic Research, 2015.

Elena Andreyeva and Carlianne Patrick. Paying for priority in school choice: Capitalization effects of charter school admission zones. *Journal of Urban Economics*, 100:19–32, 2017.

Andrew Bibler. Dual language education and student achievement. *Unpublished Draft*, 2017.

Stephen B Billings, Eric J Brunner, and Stephen L Ross. Gentrification and failing schools: The unintended consequences of school choice under nclb. *Review of Economics and Statistics*, (0), 2017.

Sandra E Black. Do better schools matter? parental valuation of elementary education. *The Quarterly Journal of Economics*, 114(2):577–599, 1999.

Eric J Brunner, Sung-Woo Cho, and Randall Reback. Mobility, housing markets, and schools: Estimating the effects of inter-district choice programs. *Journal of Public Economics*, 96(7):604–614, 2012.

Kalena E Cortes and Andrew I Friedson. Ranking up by moving out: the effect of the texas top 10% plan on property values. *National Tax Journal*, 67(1):51, 2014.

Julie Berry Cullen, Brian A Jacob, and Steven Levitt. The effect of school choice on participants: Evidence from randomized lotteries. *Econometrica*, 74(5):1191–1230, 2006.

Julie Berry Cullen, Mark C Long, and Randall Reback. Jockeying for position: Strategic high school choice under texas' top ten percent plan. *Journal of Public Economics*, 97:32–48, 2013.

By David J Deming, Justine S Hastings, Thomas J Kane, and Douglas O Staiger. School Choice, School Quality, and Postsecondary Attainment. *The American Economic Review*, 104(3):991–1013, 2014.

David J Deming. Better schools, less crime? *The Quarterly Journal of Economics*, 126(4):2063–2115, 2011.

Paramita Dhar and Stephen L Ross. School district quality and property values: Examining differences along school district boundaries. *Journal of Urban Economics*, 71(1):18–25, 2012.

Gabrielle Fack and Julien Grenet. When do better schools raise housing prices? evidence from paris public and private schools. *Journal of public Economics*, 94(1):59–77, 2010.

Maria Marta Ferreyra. Estimating the effects of private school vouchers in multidistrict economies. *The American Economic Review*, 97(3):789–817, 2007.

David N Figlio and Maurice E Lucas. What's in a grade? school report cards and the housing market. *American economic review*, 94(3):591–604, 2004.

Justine S Hastings, Thomas J Kane, and Douglas O Staiger. Preferences and heterogeneous treatment effects in a public school choice lottery. Technical report, National Bureau of Economic Research, 2006.

Caroline M Hoxby and Sonali Murarka. Charter schools in new york city: Who enrolls and how they affect their students' achievement. Technical report, National Bureau of Economic Research, 2009.

Reed Jordan and Megan Gallagher. Does school choice affect gentrification? *Posing the Question and Assessing the Evidence. Washington, DC: The Urban Institute*, 2015.

Keren Mertens Horn. School accountability and residential location patterns: Evaluating the unintended consequences of no child left behind. 2017.

Jonathan N Mills and Patrick J Wolf. Vouchers in the bayou: The effects of the louisiana scholarship program on student achievement after 2 years. *Educational Evaluation and Policy Analysis*, 39(3):464–484, 2017.

Thomas J Nechyba. Mobility, targeting, and private-school vouchers. *American Economic Review*, pages 130–146, 2000.

Phuong Nguyen-Hoang and John Yinger. The capitalization of school quality into house values: A review. *Journal of Housing Economics*, 20(1):30–48, 2011.

Cecilia Elena Rouse. Private school vouchers and student achievement: An evaluation of the milwaukee parental choice program. *The Quarterly Journal of Economics*, 113(2):553–602, 1998.

Thomas D Snyder, Cristobal de Brey, and Sally A Dillow. Digest of education statistics 2014, nces 2016-006. *National Center for Education Statistics*, 2016.

Tables and Figures

Table 1: Kindergarten Summary

	CMS	Won	Lost	Won - Lost			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes							
Mover (Change HS + Exit)	0.27	0.20	0.27	-0.070***	-0.068***	-0.053**	-0.057**
	(0.44)	(0.40)	(0.44)	(0.019)	(0.020)	(0.020)	(0.022)
Change HS (Stay)	0.20	0.15	0.18	-0.023	-0.022	-0.007	-0.007
	(0.40)	(0.36)	(0.38)	(0.016)	(0.016)	(0.016)	(0.020)
Attend App Year HS	0.55	0.06	0.40	-0.336***	-0.316***	-0.321***	-0.308***
	(0.50)	(0.24)	(0.49)	(0.022)	(0.021)	(0.022)	(0.020)
Attend First Choice Schl	0.16	0.84	0.19	0.651***	0.636***	0.642***	0.656***
	(0.37)	(0.37)	(0.39)	(0.028)	(0.030)	(0.032)	(0.023)
Attend Assigned Schl	0.71	0.84	0.55	0.291***	0.301***	0.300***	0.317***
	(0.45)	(0.37)	(0.50)	(0.019)	(0.019)	(0.020)	(0.025)
Won Any Choice	0.20	1.00	0.31	0.693***	0.686***	0.676***	0.659***
	(0.40)	(0.00)	(0.46)	(0.020)	(0.021)	(0.020)	(0.019)
Student Attributes							
Made Second Choice	0.19	0.84	0.81	0.034	0.039*	0.029	0.003
	(0.39)	(0.37)	(0.39)	(0.024)	(0.021)	(0.020)	(0.021)
Made Third Choice	0.15	0.68	0.64	0.043*	0.032*	0.018	-0.016
	(0.36)	(0.47)	(0.48)	(0.023)	(0.017)	(0.018)	(0.026)
Female	0.48	0.49	0.50	-0.013	-0.006	-0.000	-0.005
	(0.50)	(0.50)	(0.50)	(0.019)	(0.018)	(0.018)	(0.026)
Black	0.42	0.46	0.38	0.080**	0.030	0.012	0.015
	(0.49)	(0.50)	(0.49)	(0.035)	(0.024)	(0.018)	(0.021)
White	0.21	0.25	0.33	-0.086**	-0.026	0.009	0.014
	(0.41)	(0.43)	(0.47)	(0.035)	(0.023)	(0.016)	(0.018)
Hispanic	0.27	0.18	0.14	0.035***	0.001	-0.004	-0.009
	(0.44)	(0.38)	(0.35)	(0.013)	(0.010)	(0.011)	(0.017)
Ec. Disadvantage	0.52	0.42	0.30	0.111***			
	(0.48)	(0.48)	(0.44)	(0.028)			
Joint Test (P-value)				.004	.470	.420	.813
Program-Year FE				-	✓	✓	-
Program-Year-Nbhd School FE				-	-	-	✓
Nbhd School FE				-	-	✓	-
Other Lottery Controls				-	✓	✓	✓
Observations	26,966	1,254	1,751	3,005	3,005	3,005	1,693

Notes: Lottery fixed effects are program by year indicators (columns 4 and 5) or program by year by neighborhood school indicators (column 6). HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. Columns 4 - 6 include controls for economic disadvantage, English second language status, a proxy for having a title I choice neighborhood school, and an interaction between economic disadvantage and title I choice neighborhood school. For 2010 - 2012, economic disadvantage status at the time of application is not available, so status in third grade is used, and an indicator for missing is included. Joint Test based only on student attributes at the time of lottery application (e.g. gender, race, econ. disadv). In the tests, standard error are clustered at the level of the lottery fixed effect, i.e. the application-year level for columns 4 - 6.

Table 2: Sixth Grade Summary

	CMS	Won	Lost	Won - Lost			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes							
Mover (Change HS + Exit)	0.26	0.13	0.20	-0.069***	-0.057***	-0.060***	-0.051***
	(0.44)	(0.34)	(0.40)	(0.020)	(0.018)	(0.016)	(0.017)
Change HS (Stay)	0.14	0.11	0.17	-0.062***	-0.054***	-0.057***	-0.051***
	(0.35)	(0.31)	(0.37)	(0.016)	(0.015)	(0.012)	(0.015)
Attend App Year HS	0.60	0.05	0.38	-0.339***	-0.300***	-0.294***	-0.305***
	(0.49)	(0.21)	(0.49)	(0.053)	(0.053)	(0.051)	(0.032)
Attend First Choice Schl	0.11	0.89	0.31	0.584***	0.536***	0.543***	0.544***
	(0.31)	(0.31)	(0.46)	(0.054)	(0.049)	(0.049)	(0.028)
Attend Assigned Schl	0.72	0.89	0.52	0.367***	0.403***	0.400***	0.408***
	(0.45)	(0.31)	(0.50)	(0.054)	(0.056)	(0.056)	(0.031)
Won Any Choice	0.13	1.00	0.29	0.710***	0.700***	0.695***	0.686***
	(0.34)	(0.00)	(0.45)	(0.016)	(0.016)	(0.017)	(0.017)
Student Attributes							
Made Second Choice	0.15	0.75	0.75	-0.001	0.005	-0.004	-0.020
	(0.35)	(0.43)	(0.43)	(0.036)	(0.023)	(0.020)	(0.017)
Made Third Choice	0.11	0.51	0.52	-0.001	0.009	-0.004	-0.032*
	(0.31)	(0.50)	(0.50)	(0.032)	(0.022)	(0.022)	(0.019)
Female	0.50	0.54	0.53	0.002	0.010	0.010	0.008
	(0.50)	(0.50)	(0.50)	(0.016)	(0.018)	(0.018)	(0.020)
Black	0.41	0.48	0.52	-0.040	-0.001	-0.006	-0.014
	(0.49)	(0.50)	(0.50)	(0.039)	(0.024)	(0.020)	(0.018)
White	0.34	0.28	0.27	0.006	0.002	0.004	0.009
	(0.47)	(0.45)	(0.45)	(0.031)	(0.017)	(0.016)	(0.013)
Hispanic	0.16	0.14	0.11	0.036**	0.010	0.008	0.016
	(0.36)	(0.35)	(0.31)	(0.016)	(0.011)	(0.010)	(0.012)
Ec. Disadvantage	0.52	0.46	0.43	0.033			
	(0.49)	(0.50)	(0.50)	(0.025)			
Math (t-1)	0.14	0.52	0.50	0.021	-0.015	-0.015	-0.004
	(1.02)	(0.90)	(0.90)	(0.084)	(0.028)	(0.028)	(0.028)
Read (t-1)	0.10	0.50	0.48	0.026	-0.012	-0.014	0.001
	(1.01)	(0.82)	(0.85)	(0.083)	(0.029)	(0.027)	(0.029)
LEP (t-1)	0.10	0.06	0.04	0.014	0.007	0.006	0.007
	(0.30)	(0.23)	(0.21)	(0.009)	(0.007)	(0.008)	(0.009)
Joint Test (P-value)				.666	.852	.909	.808
Progrm-Year FE				-	✓	✓	-
Program-Year-Nbhd School FE				-	-	-	✓
Nbhd School FE				-	-	✓	-
Other Lottery Controls				-	✓	✓	✓
Observations	36,342	1,637	1,798	3,435	3,435	3,435	2,540

Notes: Lottery fixed effects are program by year indicators (columns 4 and 5) or program by year by neighborhood school indicators (column 6). HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. Columns 4 - 6 include controls for achieving at grade level, academically gifted status, interaction between grade level in reading and applying to a non-magnet school, economic disadvantage, English second language status, a proxy for having a title I choice neighborhood school, and an interaction between economic disadvantage and title I choice neighborhood school. Joint Test based only on student attributes at the time of lottery application (e.g. gender, race, econ. disadv, lagged test scores, LEP). LEP = Limited English Proficiency. Standard errors are clustered at the level of the lottery fixed effect, i.e. the program-year level for columns 4 - 6.

Table 3: Lottery Outcomes, Moving, and School Quality (Avg Test Scores)

	Kindergarten Sample			*Sixth Grade Sample*		
	Assigned (1)	Attended (2)	Difference (3)	Assigned (4)	Attended (5)	Difference (6)
Won	0.294	0.270	0.024	0.507	0.470	0.037
	(0.305)	(0.333)	(0.195)	(0.259)	(0.311)	(0.200)
Lost	-0.033	0.089	-0.122	-0.087	0.184	-0.271
	(0.364)	(0.393)	(0.323)	(0.443)	(0.473)	(0.465)
Unconditional Diff	0.327	0.181	0.146	0.594	0.286	0.308
	(0.052)	(0.047)	(0.014)	(0.048)	(0.041)	(0.050)
Conditional Difference	0.446***	0.301***	0.144***	0.616***	0.263***	0.354***
	(0.041)	(0.037)	(0.015)	(0.046)	(0.031)	(0.048)
Observations	2690	2690	2690	3244	3244	3244

Notes: This table reports unconditional means for assigned and attended school scores, unconditional differences in scores, and the conditional difference in scores between winners and losers. *Conditional Differences* are coefficients from regressions of (assigned - attended) school quality measures on winning the lottery. The dependent variable is either the average test score at the school the student was assigned in the lottery (columns 1 and 4), the average test score at the school the student was attending at the time of the lottery the following year (columns 2 and 5), or the difference in average test scores between the school the student was assigned and attended (columns 3 and 6). Rows labeled *Won* display unconditional means for winners. Rows labeled *Lost* are unconditional means for lottery losers. Rows labeled *Unconditional Difference* display unconditional means in the score difference, i.e. the difference between winning and losing. A student will have a difference of zero if they attend the school that they were assigned to in the lottery. All conditional regressions control for lottery fixed effects, and all other lottery controls (e.g. priority groups). Lottery fixed effects are application choice by year indicators. Standard errors clustered by lottery. There are 66 and 46 lotteries (program-year combinations) in the kindergarten and sixth grade samples, respectively.

Table 4: Lottery Outcomes and Moving

	Attended - Assigned Score (Avg Test Scores)	
	Kindergarten (1)	Sixth Grade (2)
Lottery Loser		
Change HS	0.224***	0.429***
	(0.024)	(0.031)
Same HS	0.099***	0.294***
	(0.014)	(0.053)
Lottery Winner		
Non-Complier X Change HS	-0.199***	-0.582***
	(0.064)	(0.102)
Non-Complier X Same HS	-0.199**	-0.360***
	(0.087)	(0.098)
Observations	2,690	3,244

Notes: The omitted category is winners who complied with their assignment, for whom the outcome is zero by definition. All regression are conditional on application choice by year fixed effects, and all other lottery controls. Standard errors clustered by lottery. There are 66 and 46 lotteries (program-year combinations) in the kindergarten and sixth grade samples, respectively.

Table 5: Sorting Based on Student Attributes (Kindergarten)

	School Characteristics (Attended - Assigned)			
	Change in Ec. Disad.		Change in Pct. White	
		Cond Scores		Cond Scores
	(1)	(2)	(3)	(4)
Lottery Loser				
Change HS	-0.126***	-0.012*	0.128***	0.033**
	(0.014)	(0.007)	(0.016)	(0.013)
Same HS	-0.044***	0.007	0.028***	-0.013**
	(0.006)	(0.005)	(0.006)	(0.005)
Lottery Winner				
Non-Complier X Change HS	0.084**	-0.017	0.004	0.088**
	(0.032)	(0.023)	(0.037)	(0.041)
Non-Complier X Same HS	0.065*	-0.036**	0.066**	0.150***
	(0.035)	(0.017)	(0.028)	(0.030)
School Quality Measure				
Change in Test Scores		-0.508***		0.421***
		(0.017)		(0.033)
Observations	2,690	2,690	2,690	2,690

Notes: Estimates for differences in school characterstics (Attended - Assigned) for kindergarten sample. Alternative measures, comparable with Tables 8 and 9. Uses interaction terms between lottery outcomes and moving decisions. Dependent variable is change (Attended - Assigned) in percent economically disadvanted students for columns 1 and 2. Dependent variable is change (Attended - Assigned) in percent white students for columns 3 and 4. Columns 2 and 4 condition on the change (Attended - Assigned) in average school test scores. Standard errors clustered by lottery.

Table 6: Sorting Based on Student Attributes (Sixth Grade)

	School Characteristics (Attended - Assigned)			
	Change in Ec. Disad.		Change in Pct. White	
		Cond Scores		Cond Scores
	(1)	(2)	(3)	(4)
Lottery Loser				
Change HS	-0.155***	0.002	0.127***	0.008
	(0.018)	(0.010)	(0.030)	(0.018)
Same HS	-0.086***	0.022***	0.031***	-0.050***
	(0.011)	(0.007)	(0.009)	(0.013)
Lottery Winner				
Non-Complier X Change HS	0.189***	-0.032	-0.122*	0.046
	(0.055)	(0.026)	(0.068)	(0.045)
Non-Complier X Same HS	0.077*	-0.056**	0.061	0.163***
	(0.040)	(0.024)	(0.042)	(0.031)
School Quality Measure				
Change in Test Scores		-0.369***		0.280***
		(0.015)		(0.032)
Observations	3,244	3,244	3,244	3,244

Notes: Estimates for differences in school characterstics (Attended - Assigned) for sixth grade sample. Alternative measures, comparable with Tables 8 and 9. Uses interaction terms between lottery outcomes and moving decisions. Dependent variable is change (Attended - Assigned) in percent economically disadvanted students for columns 1 and 2. Dependent variable is change (Attended - Assigned) in percent white students for columns 3 and 4. Columns 2 and 4 condition on the change (Attended - Assigned) in average school test scores. Standard errors clustered by lottery.

Table 7: Hedonic Pricing of School Quality

	Log(Price) (1)	Log(Price) (2)	Log(Price) (3)	Log(Price) (4)	Log(Price) (5)
Avg. Elem. Test Scores (t-1)	0.2884***	0.1296***	0.0717***	0.0412	0.0771***
	(0.0054)	(0.0106)	(0.0130)	(0.0323)	(0.0225)
Avg. Elem. Test Scores (t-1)*2nd Qt. Neigh Test Scores					-0.0216
					(0.0367)
Avg. Elem. Test Scores (t-1)*3rd Qt. Neigh Test Scores					-0.0263
					(0.0306)
Avg. Elem. Test Scores (t-1)*4th Qt. Neigh Test Scores					0.1037**
					(0.0454)
R-squared	0.7388	0.7891	0.8003	0.8441	0.8003
Observations	81,186	81,186	81,186	81,186	81,186
Tract FEs	-	✓	-	-	-
CBG FEs	-	-	✓	-	✓
Block FEs	-	-	-	✓	-

Notes: Regressions of log(price) on neighborhood school quality for Mecklenburg County home sales. Basic controls include structural attributes for age, building area, lot size, number of bathrooms, indicator for fireplace and indicators for building material/structure types. Neigh Controls include Census Block Group (CBG) 2000 median household income, population density, percent unemployed, indicator for floodplain, indicator for on busy road, distance to CBG, distance to Highway and distance to park. All models include year by quarter fixed effects and standard errors clustered at the CBG level. This model include only arm's length transactions of between $10,000 and $1,000,000 for properties sold between 2009-2013. Neigh School Quality quartiles based on quartiles of CBG minimum state standardized tests (mean zero, standard deviation one).

Table 8: Lottery Outcomes, Moving, and Housing Prices

	HS(t+1) - HS(t) Price Residuals				
	Kindergarten (1)	Kindergarten (2)	Sixth Grade (3)	Sixth Grade (4)	Sixth Grade (5)
Lost X Change HS	0.082***	0.041**	0.080***	0.060***	0.051***
	(0.021)	(0.019)	(0.018)	(0.015)	(0.017)
Winners X Change HS					
Complier	0.059**	0.044*	0.054	0.032	0.058*
	(0.029)	(0.024)	(0.042)	(0.033)	(0.031)
Non-Complier	0.045	0.017	0.044	0.042	0.057
	(0.035)	(0.034)	(0.047)	(0.046)	(0.048)
Destination CBG FE	-	-	-	-	✓
1st Stage CBG Controls	-	✓	-	✓	✓
Observations	2690	2690	3244	3244	3084

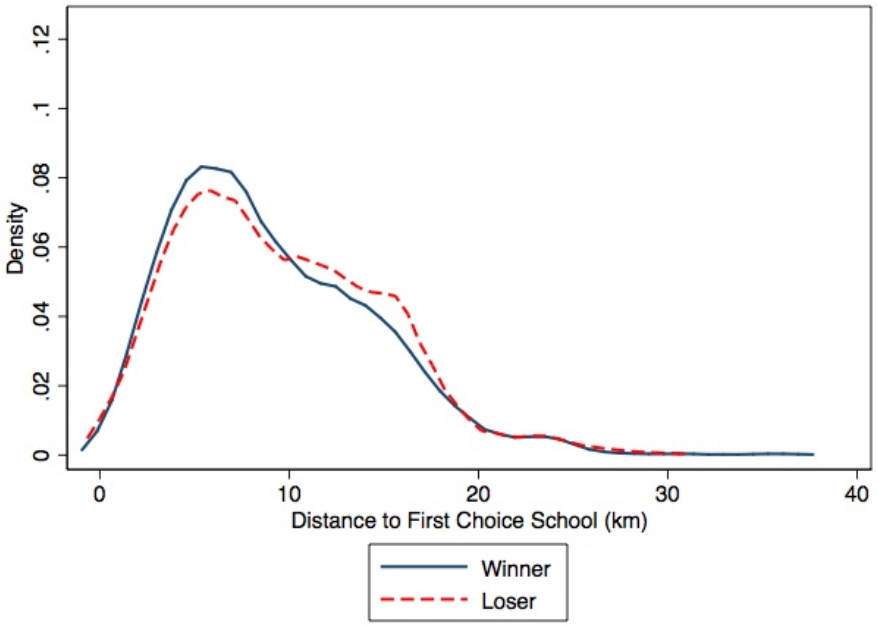
Notes: All regressions include application choice by year fixed effects, and other controls. The outcome variable is the difference in the average home price residual aggregated to either the home school level (for kindergarten sample) or home school by census block group level (for sixth grade sample) for students who changed home schools between lotteries. For students who did not change neighborhood schools, the outcome variable is zero. The omitted category is all applicants who had the same home school in applicant and following year. For the sixth grade sample, the school-CBG level residual difference is imputed using the neighborhood school level residuals when data are missing. The last column includes CBG fixed effects for the CBG that the student was in for the year following the lottery. The drop in observations in the final column is due to missing data on CBG and dropping singleton sets of the absorbed set of fixed effects, i.e. lottery and destination CBG. Standard errors clustered by lottery. First stage neighborhood controls include the same variables as column 2 in Table 7 and models without 1st stage neighborhood controls are equivalent to column 1 in Table 7.

Table 9: Lottery Outcomes, Moving, and Housing Prices II

	HS(t+1) - HS(t) Price Residuals				
	Kindergarten (1)	Kindergarten (2)	Sixth Grade (3)	Sixth Grade (4)	Sixth Grade (5)
Change HS X Score Diff					
Lost	0.238***	0.112***	0.155***	0.128***	0.090***
	(0.038)	(0.034)	(0.032)	(0.028)	(0.028)
Won X Non-Complier	0.010	-0.019	-0.003	-0.008	-0.007
	(0.084)	(0.084)	(0.069)	(0.064)	(0.069)
Destination CBG FE	-	-	-	-	✓
1st Stage CBG Controls	-	✓	-	✓	✓
Observations	2690	2690	3244	3244	3084

Notes: Same as Table 8, but with the inclusion of All Lottery Outcome X Moving decision dummies which are interacted by the change in school average test scores (Attended - Assigned) to scale the estimates according to a one standard deviation change in school quality. The drop in observations in the final column is due to missing data on CBG and dropping singleton sets of the absorbed set of fixed effects, i.e. lottery and destination CBG. Standard errors clustered by lottery. First stage neighborhood controls include the same variables as column 2 in Table 7 and models without 1st stage neighborhood controls are equivalent to column 1 in Table 7.

Figure 1: Distance Between Census Block Group and First Choice School (km)



Notes: Distance in kilometers between census block group centroid and first choice school by lottery outcome for the sixth grade sample. Census block group is from the spring of the application year, i.e. their 5th grade year.

Figure 2: Potential Test Score Gains and Distance to Application School (Win Probability >= 0.5)

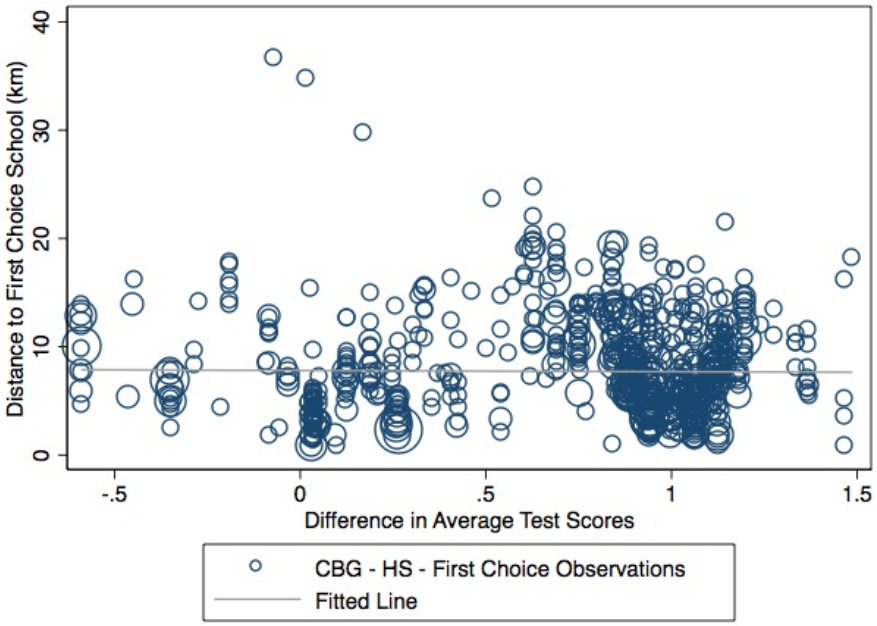
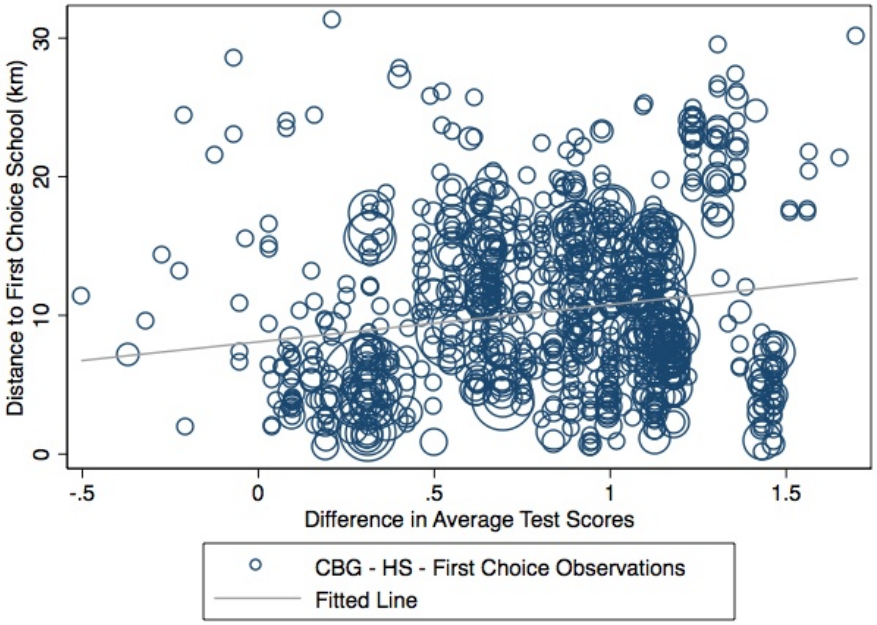
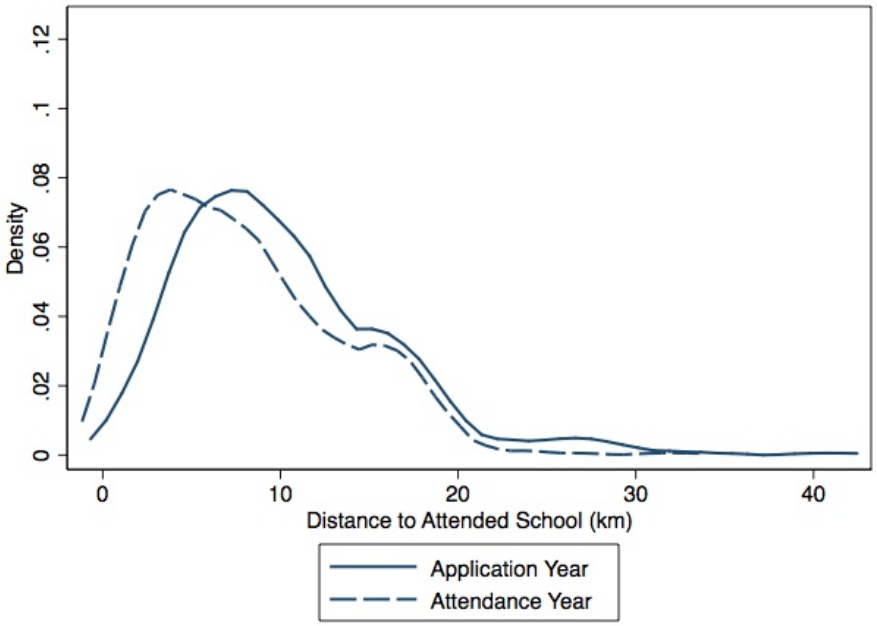


Figure 3: Potential Test Score Gains and Distance to Application School (Win Probability < 0.5)



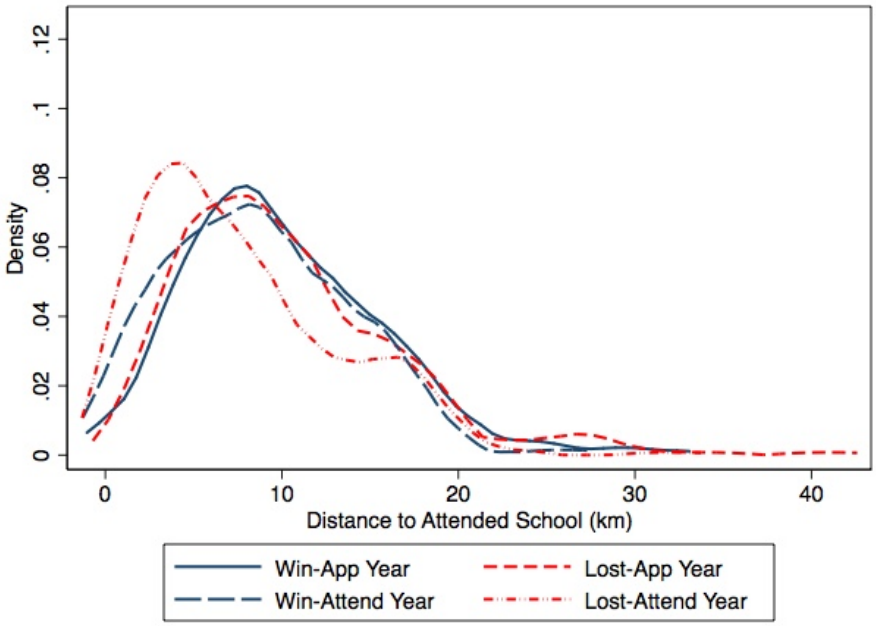
Notes: The figures above shows distance from centroid of CBG to first choice application school, and the difference in school math/reading scores between the application school and student's neighborhood school for the sixth grade sample. Each circle represents a CBG - Neighborhood School - First Choice School cell, weighted by the number of individuals, i.e. the size of a circle reflects the number of students it represents. Figure 2 is for those with average win probability of 0.5 or greater. Figure 3 if for those with win probability greater less than 0.5.

Figure 4: Distance Between Census Block Group and Attended School for Movers



Notes: Densities of the distance (km) between the census block group of the student's residence and the school they end up attending at two points in time: The year of the application and the year of attendance. Distances are measured in the spring of the corresponding year. These are based on the sixth grade sample of movers only.

Figure 5: Distance to Attended - Before and After Moving



Notes: Densities of the distance (km) between the census block group of the student's residence and the school they end up attending by lottery outcome at two points in time: The year of the application and the year of attendance. Distances are measured in the spring of the corresponding year. These are based on the sixth grade sample of movers only.

Online Appendix Tables and Figures

Table A1: Proportion of Lottery Winners by Year

	Kindergarten Sample			
	2009 (1)	2010 (2)	2011 (3)	2012 (4)
Proportion Won First Choice	0.37	0.33	0.46	0.49
	(0.48)	(0.47)	(0.50)	(0.50)
Win Probabilities				
25th Pctile	0.23	0.24	0.28	0.37
50th Pctile	0.33	0.28	0.40	0.45
75th Pctile	0.40	0.41	0.56	0.64
Observations	775	603	862	767

	Sixth Grade Sample			
	2009 (1)	2010 (2)	2011 (3)	2012 (4)
Proportion Won First Choice	0.33	0.61	0.41	0.62
	(0.47)	(0.49)	(0.49)	(0.49)
Win Probabilities				
25th Pctile	0.12	0.40	0.30	0.52
50th Pctile	0.31	0.40	0.43	0.55
75th Pctile	0.47	1.00	0.43	0.83
Observations	1,203	793	636	803

Notes: Proportion of analysis sample applicants who won their first choice in each year. The analysis sample includes applicants who did not have a guaranteed seat to their first choice option, and who applied to a program which had at least one winner and one loser in that lottery.

Table A2: Summary Stats by Lottery Outcome and Moving

	Kindergarten Sample					
	Lottery Winners			Lottery Losers		
	Full Sample (1)	Same HS (2)	Change HS (3)	Full Sample (4)	Same HS (5)	Change HS (6)
Outcomes						
Mover (Change HS + Exit)	0.15	0.00	1.00	0.17	0.00	1.00
	(0.36)	(0.00)	(0.00)	(0.37)	(0.00)	(0.00)
Change HS (Stay)	0.15	0.00	1.00	0.17	0.00	1.00
	(0.36)	(0.00)	(0.00)	(0.37)	(0.00)	(0.00)
Attend Lagged HS	0.07	0.08	0.02	0.45	0.52	0.09
	(0.25)	(0.26)	(0.13)	(0.50)	(0.50)	(0.28)
Attend First Choice School	0.88	0.91	0.73	0.20	0.21	0.15
	(0.33)	(0.29)	(0.45)	(0.40)	(0.41)	(0.36)
Attend Assigned School	0.88	0.91	0.73	0.60	0.68	0.24
	(0.33)	(0.29)	(0.45)	(0.49)	(0.47)	(0.43)
Won Any Choice	1.00	1.00	1.00	0.32	0.32	0.33
	(0.00)	(0.00)	(0.00)	(0.47)	(0.47)	(0.47)
Student Attributes						
Made Second Choice	0.84	0.84	0.86	0.81	0.80	0.85
	(0.36)	(0.37)	(0.34)	(0.39)	(0.40)	(0.35)
Made Third Choice	0.69	0.68	0.72	0.64	0.62	0.73
	(0.46)	(0.47)	(0.45)	(0.48)	(0.49)	(0.44)
Female	0.49	0.50	0.43	0.50	0.50	0.50
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Black	0.47	0.45	0.60	0.39	0.38	0.47
	(0.50)	(0.50)	(0.49)	(0.49)	(0.49)	(0.50)
White	0.24	0.26	0.11	0.31	0.33	0.20
	(0.42)	(0.44)	(0.31)	(0.46)	(0.47)	(0.40)
Hispanic	0.18	0.18	0.18	0.16	0.15	0.20
	(0.39)	(0.39)	(0.39)	(0.37)	(0.36)	(0.40)
Ec. Disadvantage	0.42	0.41	0.50	0.32	0.30	0.42
	(0.48)	(0.48)	(0.49)	(0.45)	(0.44)	(0.48)
Observations	1168	992	176	1522	1267	255

Notes: Summary stats for estimation sample by lottery outcome and moving decision. HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. For 2010 to 2012, economic disadvantage status at the time of application is not available, so status in third grade is used.

Table A3: Summary Stats by Lottery Outcome and Moving

	Sixth Grade Sample					
	Lottery Winners			Lottery Losers		
	Full Sample (1)	Same HS (2)	Change HS (3)	Full Sample (4)	Same HS (5)	Change HS (6)
Outcomes						
Mover (Change HS + Exit)	0.09	0.00	1.00	0.16	0.00	1.00
	(0.29)	(0.00)	(0.00)	(0.36)	(0.00)	(0.00)
Change HS (Stay)	0.09	0.00	1.00	0.16	0.00	1.00
	(0.29)	(0.00)	(0.00)	(0.36)	(0.00)	(0.00)
Attend Lagged HS	0.05	0.05	0.01	0.40	0.46	0.10
	(0.21)	(0.22)	(0.08)	(0.49)	(0.50)	(0.31)
Attend First Choice School	0.91	0.93	0.73	0.32	0.31	0.34
	(0.28)	(0.26)	(0.44)	(0.47)	(0.46)	(0.47)
Attend Assigned School	0.91	0.93	0.73	0.54	0.61	0.20
	(0.28)	(0.26)	(0.44)	(0.50)	(0.49)	(0.40)
Won Any Choice	1.00	1.00	1.00	0.29	0.29	0.29
	(0.00)	(0.00)	(0.00)	(0.45)	(0.45)	(0.45)
Student Attributes						
Made Second Choice	0.74	0.74	0.83	0.75	0.73	0.83
	(0.44)	(0.44)	(0.37)	(0.43)	(0.44)	(0.38)
Made Third Choice	0.51	0.50	0.62	0.51	0.49	0.60
	(0.50)	(0.50)	(0.49)	(0.50)	(0.50)	(0.49)
Female	0.54	0.54	0.46	0.53	0.53	0.54
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Black	0.47	0.45	0.65	0.52	0.51	0.58
	(0.50)	(0.50)	(0.48)	(0.50)	(0.50)	(0.49)
White	0.29	0.31	0.08	0.28	0.30	0.19
	(0.45)	(0.46)	(0.27)	(0.45)	(0.46)	(0.39)
Hispanic	0.14	0.14	0.12	0.10	0.10	0.09
	(0.35)	(0.35)	(0.32)	(0.30)	(0.30)	(0.28)
Ec. Disadvantage	0.45	0.43	0.71	0.42	0.41	0.49
	(0.50)	(0.49)	(0.46)	(0.49)	(0.49)	(0.50)
Math Lag 1	0.54	0.57	0.24	0.50	0.51	0.47
	(0.90)	(0.90)	(0.87)	(0.90)	(0.90)	(0.91)
Read Lag 1	0.52	0.54	0.29	0.49	0.49	0.47
	(0.83)	(0.82)	(0.82)	(0.85)	(0.85)	(0.86)
LEP Lag 1	0.06	0.06	0.07	0.04	0.05	0.03
	(0.23)	(0.23)	(0.26)	(0.20)	(0.21)	(0.16)
Observations	1541	1402	139	1703	1434	269

Notes: Summary stats for estimation sample by lottery outcome and moving decision. HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. LEP = Limited English Proficiency.

Table A4: Summary Stats by Lottery Outcome and Compliance

	Kindergarten Sample					
	Lottery Winners			Lottery Losers		
	Complier (1)	Non-Complier (2)	(1) - (2) (3)	Complier (4)	Non-Complier (5)	(4) - (5) (6)
Outcomes						
Change HS (Stay)	0.12	0.34	-0.206***	0.07	0.32	-0.266***
	(0.33)	(0.48)	(0.040)	(0.25)	(0.47)	(0.023)
Attend Lagged HS	0.00	0.55	-0.566***	0.67	0.10	0.572***
	(0.00)	(0.50)	(0.042)	(0.47)	(0.31)	(0.033)
Attend First Choice School	1.00	0.00		0.03	0.47	-0.439***
	(0.00)	(0.00)		(0.16)	(0.50)	(0.017)
Won Any Choice	1.00	1.00		0.33	0.30	0.042
	(0.00)	(0.00)		(0.47)	(0.46)	(0.033)
Made Second Choice	0.85	0.82	0.041	0.80	0.82	-0.021
	(0.36)	(0.39)	(0.034)	(0.40)	(0.39)	(0.022)
Made Third Choice	0.69	0.65	0.038	0.63	0.65	-0.040
	(0.46)	(0.48)	(0.045)	(0.48)	(0.48)	(0.023)
Student Attributes						
Female	0.49	0.49	-0.015	0.50	0.50	-0.012
	(0.50)	(0.50)	(0.068)	(0.50)	(0.50)	(0.020)
Black	0.48	0.43	0.126**	0.40	0.39	-0.000
	(0.50)	(0.50)	(0.037)	(0.49)	(0.49)	(0.020)
White	0.24	0.21	-0.003	0.31	0.30	0.014
	(0.43)	(0.41)	(0.036)	(0.46)	(0.46)	(0.024)
Hispanic	0.18	0.22	-0.077*	0.17	0.16	0.017
	(0.38)	(0.42)	(0.036)	(0.37)	(0.36)	(0.014)
Ec. Disadvantage	0.42	0.45		0.33	0.30	
	(0.48)	(0.49)		(0.46)	(0.45)	
Avg. Math/RD HS Score	-0.22	-0.08	-0.155***	-0.11	-0.14	0.042*
	(0.36)	(0.45)	(0.034)	(0.40)	(0.37)	(0.021)
Observations	1027	141	1168	919	603	1522

Notes: Summary stats for estimation sample by lottery outcome and whether the student attends the school that they were assigned in the lottery. HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. LEP = Limited English Proficiency. All tests are conditional on lottery fixed effects and other lottery controls.

Table A5: Summary Stats by Lottery Outcome and Compliance

	Sixth Grade Sample					
	Lottery Winners			Lottery Losers		
	Complier (1)	Non-Complier (2)	(1) - (2) (3)	Complier (4)	Non-Complier (5)	(4) - (5) (6)
Outcomes						
Change HS (Stay)	0.07	0.27	-0.191***	0.06	0.28	-0.240***
	(0.26)	(0.45)	(0.048)	(0.24)	(0.45)	(0.027)
Attend Lagged HS	0.00	0.55	-0.556***	0.68	0.08	0.515***
	(0.00)	(0.50)	(0.047)	(0.47)	(0.27)	(0.041)
Attend First Choice School	1.00	0.00		0.01	0.69	-0.611***
	(0.00)	(0.00)		(0.08)	(0.46)	(0.051)
Won Any Choice	1.00	1.00		0.29	0.28	0.029
	(0.00)	(0.00)		(0.46)	(0.45)	(0.024)
Made Second Choice	0.75	0.70	0.012	0.71	0.79	-0.014
	(0.43)	(0.46)	(0.038)	(0.45)	(0.41)	(0.025)
Made Third Choice	0.51	0.48	-0.006	0.47	0.55	-0.035
	(0.50)	(0.50)	(0.038)	(0.50)	(0.50)	(0.027)
Student Attributes						
Female	0.54	0.52	0.011	0.54	0.53	0.030
	(0.50)	(0.50)	(0.046)	(0.50)	(0.50)	(0.032)
Black	0.47	0.44	0.025	0.48	0.56	0.025
	(0.50)	(0.50)	(0.057)	(0.50)	(0.50)	(0.021)
White	0.29	0.30	-0.024	0.31	0.24	-0.025
	(0.45)	(0.46)	(0.044)	(0.46)	(0.43)	(0.015)
Hispanic	0.14	0.13	0.026	0.11	0.08	0.018
	(0.35)	(0.34)	(0.027)	(0.32)	(0.28)	(0.018)
Ec. Disadvantage	0.45	0.49		0.42	0.42	
	(0.50)	(0.50)		(0.49)	(0.49)	
Avg. Math/RD HS Score	-0.30	-0.14	-0.109*	-0.21	-0.33	0.022
	(0.36)	(0.48)	(0.050)	(0.41)	(0.33)	(0.017)
Math Lag 1	0.53	0.59	-0.022	0.48	0.53	-0.041
	(0.90)	(0.99)	(0.105)	(0.93)	(0.86)	(0.042)
Read Lag 1	0.52	0.52	0.007	0.46	0.51	-0.046
	(0.83)	(0.84)	(0.058)	(0.89)	(0.80)	(0.035)
LEP Lag 1	0.06	0.04	0.014	0.05	0.03	0.005
	(0.23)	(0.21)	(0.019)	(0.22)	(0.18)	(0.009)
Observations	1406	135	1541	926	777	1703

Notes: Summary stats for estimation sample by lottery outcome and whether the student attends the school that they were assigned in the lottery. HS = home school/neighborhood school. Ec. Disad. = economically disadvantaged. LEP = Limited English Proficiency. All tests are conditional on lottery fixed effects and other lottery controls.

Table A6: School Quality - Heterogeneity - Kindergarten

	Avg. Math & Reading Score Difference (Attended - Assigned)											
	Ec. Disad.		Sex		Race		HS (t) Quality			Avg HS Price (t)		
	Yes	No	Male	Female	White	Non-white	Low	Middle	High	Low	Middle	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lottery Loser												
Change HS	0.099***	0.286***	0.215***	0.229***	0.310***	0.198***	0.275***	0.274***	0.070	0.152***	0.366***	0.125**
	(0.035)	(0.039)	(0.040)	(0.038)	(0.067)	(0.030)	(0.040)	(0.040)	(0.054)	(0.037)	(0.040)	(0.055)
Same HS	0.074***	0.129***	0.099***	0.101***	0.118***	0.097***	0.128***	0.145***	0.049***	0.097***	0.151***	0.073***
	(0.027)	(0.014)	(0.014)	(0.016)	(0.022)	(0.020)	(0.025)	(0.025)	(0.014)	(0.021)	(0.027)	(0.015)
Lottery Winner												
Non-Complier X Change HS	-0.355***	-0.056	-0.200*	-0.196**	0.195	-0.274***	-0.291***	-0.265**	0.223*	-0.426***	-0.018	-0.005
	(0.120)	(0.096)	(0.115)	(0.095)	(0.188)	(0.077)	(0.096)	(0.130)	(0.123)	(0.106)	(0.092)	(0.122)
Non-Complier X Same HS	-0.412***	-0.029	-0.320***	-0.094	0.036	-0.279***	-0.626***	-0.426***	0.161**	-0.529***	-0.399***	0.148**
	(0.112)	(0.083)	(0.097)	(0.085)	(0.087)	(0.103)	(0.113)	(0.083)	(0.074)	(0.095)	(0.068)	(0.069)
Observations	913	1,612	1,358	1,332	743	1,947	941	875	874	933	898	859

Notes: Estimates of Attended - Assigned School Score by lottery outcome and moving decision. The omitted category is winners who complied with their assignment, for whom the outcome is zero by definition. All regression are conditional on application choice by year fixed effects, and all other controls. The *HS Quality* and *Avg HS Price (t)* heterogeneity refer to the level of test scores and mean home price at the student's application year neighborhood school. Standard errors clustered by lottery.

Table A7: School Quality - Heterogeneity - Sixth Grade

	Avg. Math & Read Score Difference (Attended - Assigned)													
	Ec. Disad.		Sex		Race		HS (t) Quality			Avg HS Price (t)			Avg Lag Score (t)	
	Yes	No	Male	Female	White	Non-white	Low	Middle	High	Low	Middle	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Lottery Loser														
Change HS	0.424***	0.438***	0.413***	0.429***	0.487***	0.414***	0.386***	0.568***	0.280***	0.458***	0.523***	0.293***	0.431***	0.420***
	(0.030)	(0.050)	(0.057)	(0.046)	(0.085)	(0.030)	(0.053)	(0.058)	(0.100)	(0.053)	(0.082)	(0.072)	(0.040)	(0.052)
Same HS	0.253***	0.327***	0.296***	0.296***	0.238***	0.319***	0.343***	0.343***	0.191***	0.359***	0.317***	0.186***	0.271***	0.314***
	(0.054)	(0.059)	(0.058)	(0.049)	(0.056)	(0.054)	(0.074)	(0.048)	(0.041)	(0.073)	(0.061)	(0.023)	(0.051)	(0.061)
Lottery Winner														
Non-Complier X Change HS	-0.700***	-0.372***	-0.468***	-0.738***	-0.043	-0.591***	-0.586***	-0.638***	-0.313*	-0.494***	-0.718***	-0.634***	-0.642***	-0.450**
	(0.111)	(0.115)	(0.111)	(0.112)	(0.079)	(0.096)	(0.136)	(0.132)	(0.174)	(0.160)	(0.108)	(0.137)	(0.105)	(0.206)
Non-Complier X Same HS	-0.646***	-0.161	-0.279***	-0.420***	-0.159	-0.478***	-0.647***	-0.708***	-0.102	-0.830***	-0.213	-0.214***	-0.663***	-0.132
	(0.089)	(0.107)	(0.096)	(0.119)	(0.140)	(0.088)	(0.102)	(0.147)	(0.109)	(0.090)	(0.222)	(0.065)	(0.068)	(0.112)
Observations	1,412	1,832	1,512	1,732	928	2,316	1,082	1,144	1,018	1,247	971	1,026	1,648	1,596

Notes: Estimates of Attended - Assigned School Score by lottery outcome and moving decision. The omitted category is winners who complied with their assignment, for whom the outcome is zero by definition. All regression are conditional on application choice by year fixed effects, and all other controls. The *HS Quality* and *Avg HS Price (t)* heterogeneity refer to the level of test scores and mean home price at the student's application year neighborhood school. Standard errors clustered by lottery.

Table A8: Test Score Het by Type and Win Prob (Kindergarten)

		School Type			*Win Probability*	
	Full Sample	Magnet	DL	Trad.	<0.5	>=0.5
	(1)	(2)	(3)	(4)	(5)	(6)
Lottery Loser						
Change HS	0.224***	0.230***	0.211***	0.202***	0.215***	0.296***
	(0.023)	(0.023)	(0.059)	(0.036)	(0.024)	(0.067)
Same HS	0.099***	0.103***	0.135***	0.086***	0.104***	0.079**
	(0.014)	(0.014)	(0.026)	(0.020)	(0.014)	(0.030)
Lottery Winner						
Non-Complier X Change HS	-0.199***	-0.219***	-0.679**	-0.296***	-0.243**	-0.157**
	(0.063)	(0.067)	(0.268)	(0.080)	(0.106)	(0.070)
Non-Complier X Same HS	-0.199**	-0.201**	-0.369**	-0.072	-0.184	-0.212*
	(0.086)	(0.087)	(0.141)	(0.072)	(0.125)	(0.115)
Observations	2,690	2,535	599	890	1,940	750

Notes: School quality heterogeneity by program type and win probability (comparable with Table 4). Only displaying Magnet applicants, because that is the vast majority of applications, 2,535/2690 in estimation sample. Only displying the two most common magnet types for separate analyses, Dual Language and Traditional. Estimates of (Attended - Assigned) School Score by lottery outcome and moving decision. Scores are averages of math and reading scores. The omitted category is winners who complied with their assignment, for whom the outcome is zero by definition. All regression are conditional on application choice by year fixed effects, and all other controls. Standard errors clustered by lottery.

Table A9: Test Score Het by School Type and Win Prob (Sixth Grade)

		School Type			*Win Probability*	
	Full Sample	Non-Mag.	Magnet	IB	<0.5	>=0.5
	(1)	(2)	(3)	(4)	(5)	(6)
Lottery Loser						
Change HS	0.426***	0.425***	0.416***	0.394***	0.420***	0.399***
	(0.031)	(0.056)	(0.036)	(0.041)	(0.044)	(0.080)
Same HS	0.292***	0.093**	0.342***	0.365***	0.283***	0.285***
	(0.052)	(0.039)	(0.057)	(0.062)	(0.072)	(0.081)
Lottery Winner						
Non-Complier X Change HS	-0.599***	-0.621***	-0.616***	-0.591***	-0.882***	-0.440***
	(0.103)	(0.185)	(0.122)	(0.136)	(0.098)	(0.125)
Non-Complier X Same HS	-0.361***	-0.572**	-0.330***	-0.335**	-0.649***	-0.234*
	(0.098)	(0.217)	(0.104)	(0.125)	(0.072)	(0.113)
Observations	3,244	660	2,584	2,142	1,907	1,337

Notes: School quality heterogeneity by program type and win probability (comparable with Table 4). Only displaying IB magnets on their own, because they are the vast majority of magnet applications, 2,142 of 2,584 magnet applications in the estimation sample. Only displying the two most common magnet types for separate analyses, Dual Language and Traditional. Estimates of (Attended - Assigned) School Score by lottery outcome and moving decision. Scores are averages of math and reading scores. The omitted category is winners who complied with their assignment, for whom the outcome is zero by definition. All regression are conditional on application choice by year fixed effects, and all other controls. Standard errors clustered by lottery.

Table A10: Differences in Attended and Assigned School Chars (Kindergarten)

	School Characterstics (Attended - Assigned)					
	Avg Test Score (1)	School VA (2)	Ec Disad. (3)	Ac. Gifted (4)	LEP (5)	White (pct) (6)
Lottery Loser						
Change HS	0.224***	0.031***	-0.126***	0.051***	-0.031***	0.128***
	(0.023)	(0.009)	(0.014)	(0.007)	(0.005)	(0.016)
Same HS	0.099***	0.027***	-0.044***	0.023***	-0.013***	0.028***
	(0.014)	(0.007)	(0.006)	(0.004)	(0.002)	(0.006)
Lottery Winner						
Non-Complier X Change HS	-0.199***	-0.030	0.084**	-0.075**	0.086***	0.004
	(0.063)	(0.030)	(0.032)	(0.031)	(0.017)	(0.037)
Non-Complier X Same HS	-0.199**	-0.104***	0.065*	-0.032*	0.046***	0.066**
	(0.086)	(0.029)	(0.035)	(0.019)	(0.011)	(0.028)
Dep Var Mean	0.059	0.012	-0.028	0.014	-0.006	0.027
Dep Var SD	(0.284)	(0.088)	(0.157)	(0.088)	(0.057)	(0.154)
Observations	2,690	2,690	2,690	2,690	2,690	2,690

Notes: Estimates for differences in school characterstics (assigned - attended) for kindergarten sample. Alternative measures, comparable with Table 4. Uses interaction terms between lottery outcomes and moving decisions. *School VA* = Estimated school level value-added, conditional on student level characteristics, including lagged test score. *Ec. Disad.* = proportion of economically disadvantaged students in school. *Ac. Gifted* = percent of students in school who are academically gifted. *LEP* = percent of students in school with limited English proficiency. *White* = percent of students in school who are white. Standard errors clustered by lottery.

Table A11: Differences in Assigned and Attended School Chars (Sixth Grade)

	School Characterstics (Attended - Assigned)					
	Avg Test Score (1)	School VA (2)	Ec Disad. (3)	Ac. Gifted (4)	LEP (5)	White (pct) (6)
Lottery Loser						
Change HS	0.429***	0.071***	-0.156***	0.105***	-0.034***	0.128***
	(0.031)	(0.007)	(0.018)	(0.009)	(0.004)	(0.030)
Same HS	0.294***	0.049***	-0.087***	0.090***	-0.022***	0.032***
	(0.052)	(0.010)	(0.011)	(0.017)	(0.004)	(0.009)
Lottery Winner						
Non-Complier X Change HS	-0.582***	-0.072***	0.181***	-0.165***	0.046***	-0.113*
	(0.101)	(0.021)	(0.054)	(0.024)	(0.008)	(0.066)
Non-Complier X Same HS	-0.360***	-0.028	0.076*	-0.146***	0.039***	0.062
	(0.097)	(0.026)	(0.039)	(0.028)	(0.009)	(0.041)
Dep Var Mean	0.124	0.022	-0.039	0.034	-0.009	0.022
Dep Var SD	(0.395)	(0.068)	(0.149)	(0.109)	(0.039)	(0.146)
Observations	3,244	3,244	3,244	3,244	3,244	3,244

Notes: Estimates for differences in school characterstics (assigned - attended) for kindergarten sample. Alternative measures, comparable with Table 4. Uses interaction terms between lottery outcomes and moving decisions. *School VA* = Estimated school level value-added, conditional on student level characteristics, including lagged test score. *Ec. Disad.* = proportion of economically disadvantaged students in school. *Ac. Gifted* = percent of students in school who are academically gifted. *LEP* = percent of students in school with limited English proficiency. *White* = percent of students in school who are white. Standard errors clustered by lottery.

Table A12: Housing Price Growth (t - 1) to (t)

	(t) - (t-1) Price Residuals for HS at time (t)				
	Kindergarten (1)	Kindergarten (2)	Sixth Grade (3)	Sixth Grade (4)	Sixth Grade (5)
Lost X Change HS	-0.002	0.004	0.019	0.022	-0.021
	(0.007)	(0.008)	(0.015)	(0.014)	(0.015)
Winners X Change HS					
Complier	-0.008	0.003	0.024	0.028	-0.020
	(0.018)	(0.017)	(0.038)	(0.039)	(0.020)
Non-Complier	0.007	0.025**	0.059	0.050	0.032
	(0.011)	(0.010)	(0.048)	(0.051)	(0.028)
Destination CBG FE	-	-	-	-	✓
1st Stage CBG Controls	-	✓	-	✓	✓
Observations	2591	2591	2908	2888	2783

Notes: Estimates for the change in residual prices in the recieving home school or CBG-homeschool boundary. Outcome variable is the price residual in the year that the student applied/moved minus the residual in the same boundary from the prior year.

Table A13: Housing Price Growth (t) to (t + 1)

	(t+1) - (t) Price Residuals for HS at time (t)				
	Kindergarten (1)	Kindergarten (2)	Sixth Grade (3)	Sixth Grade (4)	Sixth Grade (5)
Lost X Change HS	0.002	-0.004	-0.009	-0.000	0.016
	(0.009)	(0.012)	(0.021)	(0.023)	(0.023)
Winners X Change HS					
Complier	-0.052***	-0.055***	-0.031	-0.022	0.070
	(0.012)	(0.011)	(0.048)	(0.057)	(0.067)
Non-Complier	-0.001	-0.009	-0.057	-0.060	-0.106
	(0.016)	(0.022)	(0.065)	(0.061)	(0.074)
Destination CBG FE	-	-	-	-	✓
1st Stage CBG Controls	-	✓	-	✓	✓
Observations	2615	2615	2895	2856	2746

Notes: Estimates for the change in residual prices in the recieving home school or CBG-homeschool boundary. Outcome variable is the price residual in the year after the student applied/moved minus the residual in the same boundary from the year of the lottery.

Table A14: Price Residuals, Heterogeneity - Kindergarten

	Difference in Price Residuals, HS(t+1) - HS(t)											
	Ec. Disad.		Sex		Race		HS (t) Quality			Avg HS Price (t)		
	Yes	No	Male	Female	White	Non-white	Low	Middle	High	Low	Middle	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Change HS X Score Diff												
Lost	0.096	0.150***	0.105**	0.173***	0.139***	0.142***	0.140**	0.124**	0.170**	0.264***	0.075	0.101***
	(0.099)	(0.030)	(0.044)	(0.047)	(0.036)	(0.049)	(0.058)	(0.051)	(0.071)	(0.073)	(0.048)	(0.035)
Won X Non-Complier	0.033	-0.012	-0.037	0.021	-0.038	0.005	-0.153	0.325***	-0.233	-0.017	-0.002	0.133
	(0.183)	(0.097)	(0.130)	(0.171)	(0.094)	(0.115)	(0.146)	(0.092)	(0.171)	(0.142)	(0.135)	(0.201)
1st Stage CBG Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	913	1612	1358	1332	743	1947	941	875	874	933	898	859

Notes: All regressions include application choice by year fixed effects, and other controls. The outcome variable is the difference in the average home price residual aggregated to the home school level and interacted with the change in school average test scores (Attended - Assigned) to scale the estimates according to a one standard deviation change in school quality (comparable to column 2 from Table 6). The omitted category is all applicants who had the same home school in both lotteries, i.e. they did not move and so have a difference in neighborhood school zone price residuals of zero by definition. The *HS Quality* and *Avg HS Price (t)* heterogeneity refer to the level of test scores and mean home price at the student's application year neighborhood school. Standard errors clustered by lottery.

Table A15: Price Residuals, Heterogeneity - Sixth Grade

	Difference in Price Residuals, HS(t+1) - HS(t)													
	Ec. Disad.		Sex		Race		HS (t) Quality			Avg HS Price (t)			Avg Lag Score (t)	
	Yes	No	Male	Female	White	Non-white	Low	Middle	High	Low	Middle	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Change HS X Score Diff														
Lost	0.135**	0.137**	0.141***	0.123**	0.108*	0.134***	0.158**	0.180***	-0.066	0.195***	0.128**	0.049	0.129***	0.129**
	(0.051)	(0.055)	(0.036)	(0.054)	(0.057)	(0.036)	(0.068)	(0.034)	(0.044)	(0.049)	(0.059)	(0.064)	(0.043)	(0.054)
Won X Non-Complier	0.013	0.049	0.023	-0.012	-0.112	0.016	0.042	-0.071	0.100	0.008	-0.005	0.071	0.036	-0.007
	(0.087)	(0.063)	(0.046)	(0.108)	(0.092)	(0.072)	(0.091)	(0.088)	(0.085)	(0.164)	(0.065)	(0.076)	(0.091)	(0.045)
1st Stage CBG Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1412	1832	1512	1732	928	2316	1082	1144	1018	1247	986	1011	1648	1596

Notes: All regressions include application choice by year fixed effects, and other controls. The outcome variable is the difference in the average home price residual aggregated to the home school by CBG level and interacted with the change in school average test scores (Attended - Assigned) to scale the estimates according to a one standard deviation change in school quality (comparable to column 4 from Table 6). For students who did not change neighborhood schools, the outcome variable is zero. The omitted category is all applicants who had the same home school in both lotteries, i.e. they did not change school zones and so have a difference in neighborhood school zone price residuals of zero by definition. The school-CBG level residual difference is imputed using the neighborhood school level residuals when data are missing. The *HS Quality* and *Avg HS Price (t)* heterogeneity refer to the level of test scores and mean home price at the student's application year neighborhood school. Standard errors clustered by lottery.

Table A16: Price Heterogeneity by Type and Win Prob (Kindergarten)

		School Type			*Win Probability*	
	Full Sample	Magnet	DL	Trad.	<0.5	>=0.5
	(1)	(2)	(3)	(4)	(5)	(6)
Change HS X Score Diff						
Lost	0.140***	0.152***	-0.000	0.270***	0.119***	0.293***
	(0.038)	(0.038)	(0.070)	(0.059)	(0.042)	(0.039)
Won X Non-Complier	-0.014	0.002	-0.473**	-0.093	-0.143	0.173
	(0.103)	(0.104)	(0.179)	(0.115)	(0.140)	(0.128)
1st Stage CBG Controls	✓	✓	✓	✓	✓	✓
Observations	2690	2535	599	890	1940	750

Notes: Price residual heterogeneity by program type and win probability (comparable with Table 6). Only displaying Magnet applicants, because that is the vast majority of applications, 2,535/2690 in estimation sample. Also, only displying the two most common magnet types for separate analyses, Dual Language and Traditional. All regressions include application choice by year fixed effects, and other controls. The outcome variable is the difference in the average home price residual aggregated to the home school level and interacted with the change in school average test scores (Attended - Assigned) to scale the estimates according to a one standard deviation change in school quality (comparable to column 2 from Table 6). The omitted category is all applicants who had the same home school in both lotteries, i.e. they did not change school zones and so have a difference in neighborhood school zone price residuals of zero by definition. Standard errors clustered by lottery.

Table A17: Price Heterogeneity by School Type and Win Prob (Sixth Grade)

		School Type			*Win Probability*	
	Full Sample	Non-Mag.	Magnet	IB	<0.5	>=0.5
	(1)	(2)	(3)	(4)	(5)	(6)
Change HS X Score Diff						
Lost	0.132***	0.134***	0.130***	0.110*	0.110**	0.191***
	(0.032)	(0.034)	(0.044)	(0.054)	(0.042)	(0.040)
Won X Non-Complier	0.024	0.228***	-0.128	-0.125	-0.049	0.123**
	(0.073)	(0.055)	(0.081)	(0.080)	(0.116)	(0.056)
1st Stage CBG Controls	✓	✓	✓	✓	✓	✓
Observations	3244	660	2584	2142	1907	1337

Notes: Price residual heterogeneity by program type and win probability. Only displaying IB magnets on their own, because they are the vast majority of magnet applications, 2,142 of 2,584 magnet applications in the estimation sample (comparable with Table 6). All regressions include application choice by year fixed effects, and other controls. The outcome variable is the difference in the average home price residual aggregated to the home school by CBG level and interacted with the change in school average test scores (Attended - Assigned) to scale the estimates according to a one standard deviation change in school quality (comparable to column 4 from Table 6). For students who did not change neighborhood schools, the outcome variable is zero. The omitted category is all applicants who had the same home school in both lotteries, i.e. they did not change school zones and so have a difference in neighborhood school zone price residuals of zero by definition. The school-CBG level residual difference is imputed using the neighborhood school level residuals when data are missing. The omitted category is all applicants who had the same home school in both lotteries, i.e. they did not change school zones and so have a difference in neighborhood school zone price residuals of zero by definition. Standard errors clustered by lottery.