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Do school buses make school choice work?☆,☆☆

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ABSTRACT

While school choice has been well studied, there is little existing research exploring the role of transportation, in general, and school buses, in particular, to school choice decisions. We examine the effect of school buses on school choice decisions using data on kindergarten students and their eligibility for transportation assistance in New York City public schools in 2017. Using both conditional logit school choice models and regression discontinuity designs, we provide both descriptive and credibly causal evidence on the impact of school proximity, bus eligibility, and their interaction on school choice decisions. Our results indicate that proximity and buses both matter. Specifically, while distance significantly deters choice, school bus eligibility increases the likelihood of choosing a school by 1.4–4 percentage points (or 12-30 percent). Compared to a high-quality school, we find that bus eligibility has twice as large an impact on reducing the negative distance effect in the 0.5 to 1 mile range from school (27 versus 12 percent). These results will be useful for policy makers looking to leverage school transportation policy to improve school choice decisions, and ultimately student outcomes.

1. Introduction

While the growth in public school choice has reduced reliance on residential attendance zones to assign students to schools and expanded opportunities to attend a school other than a zoned school, the "promise" of school choice to improve academic outcomes has, to some extent, remained elusive. A dismaying number of families enroll their children in low-performing zoned schools, even when higher performing alternatives – charters, say, or other non-zoned district choice schools – are available. One oft-cited potential explanation is that *distance matters* – that is, the difficulty (or disutility) of commuting to a school farther away than the local zoned school outweighs the potential benefits of a better school. In this case, *improving transportation* - by extending school bus services, for example - is a potential solution and a crucial policy lever to making school choice deliver on its promise. Despite the intuitive appeal of both the explanation and the solution – and the persuasive anecdotal evidence supporting this view – there is little rigorous research examining the causal link between school choice, distance to school, and pupil transportation.

This paper begins to close this gap using a unique dataset on public school students, their school, residential location, and eligibility for pupil transportation in the New York City public school district for 2017. These data allow us to construct student-level choice sets, which contain the set of schools that students consider when making school choice decisions. Each choice set includes individual- and school-level information and, for each student, distances from home to each school in the choice set.

We develop two models to examine the link between school choice, distance, and school bus availability. We begin with a regression discontinuity (RD) design, exploiting distance-based bus eligibility criteria to estimate the causal effect of bus eligibility on school choice. We then develop a discrete choice model to gain insight into choice decisions and estimate the corresponding conditional logit model, which uses each student's full choice set to provide a more complete description of school choice behavior than the RD model, which treats each school decision as independent of the others. Finally, we derive a hybrid specification - embedding an RD in the conditional logit model to identify the

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causal effect of the bus in the context of the complete choice set.

Our results suggest that school buses are influential in school choice decisions. Based on the RD results, we find bus eligibility increases the likelihood of attending a school by 4 percentage points (or 30 percent). Further, buses are especially important for zoned and charter schools, where the effect of the bus is equivalent to living 0.24 (0.14) miles closer to school for zoned (charter) schools. The conditional logit model yields similar results. While distance does significantly deter choice, buses can help overcome this impediment. For schools 0.5–1 mile from a student's residence, bus eligibility increases the likelihood of attending a school by 1.6 percentage points, which is equivalent to reducing the negative effect of distance by 27 percent. We find significant heterogeneity by school type, with the largest effect for charter schools; bus eligibility reduces the negative distance effect by 68–99 percent. Lastly, embedding the RD in the conditional logit model yields similar results. Bus eligibility increases the likelihood of attending a school 0.5–0.75 miles from home by 1.4 percentage points (or 12 percent). Taken together, these results shed light on how distance matters and how school buses can help families exercise choice, particularly for charter schools.

The remainder of this paper is organized as follows. We begin with a brief review of the literature focused on school choice and transportation, followed by Section 3, which describes school choice and transportation in New York City. Section 4 describes the data set construction and description, and we present empirical models in Section 5. Results are given in Section 6, followed by conclusions in Section 7.

2. Literature review

The economic literature on school choice has simmered since Milton Friedman championed school vouchers – and the weakening of the "monopoly" of local public schools – as a way to improve both equity and efficiency in education.[1] Much of the literature has focused on the impact of choice on student academic outcomes (see for example, Rouse (1998), Witte (1998), and Witte et al. (2014) on vouchers; Hastings et al. (2012), Cullen et al. (2005), on the impacts of the broader array of public alternatives to traditional zoned schools including charter schools, magnet schools, alternative schools, and specialized schools).

A small, but growing literature focuses on school choice itself, on understanding why students (or families) choose one school among other, available choices. Many of these studies focus on the role of school quality and find students and their families have strong preferences for high performing schools, often stating quality as a reason for exercising school choice (Ruijs and Oosterbeek, 2019; Urban Institute, 2017; Burgess et al., 2015; Hastings and Weinstein, 2008; Black, 1999). Distance also appears to be an important factor in school choice decisions, at all grades and across school types (Edwards, 2019; Ruijs and Oosterbeek, 2019; Lincove et al., 2018; Burgess et al., 2015; Hastings et al., 2005; Glazerman, 1998).

A growing body of research suggests families may be willing to travel farther to access higher quality schools. For example, Glazerman and Dotter (2017) find Washington, DC families are willing to travel an additional 1.2 miles to attend a school that has a 10-point higher proficiency rate on standardized tests. Dustan and Ngo (2018) find that a mass transit expansion raised the demand for more elite and more distant schools for high income students in Mexico. Finally, in a survey of 600 parents in Denver and Washington DC, 25 to 40 percent of parents said transportation options affected their school choice decisions, and 80 percent of parents would be willing to travel to higher quality schools if better transportation options were available (Teske et al., 2009).

Furthermore, transportation matters. Cordes and Schwartz (2018) examine the relationship between transportation and school choice for elementary school students in New York City. They find bus riders are more likely to attend a choice school (rather than their zoned school). And, among students who attend choice schools, those taking the bus attend significantly better schools than those who commute on foot or rely upon another form of transportation. In a different vein, Stein et al. (2020) and Blagg et al. (2018), report that long or stressful commutes to school cause some students to switch to schools closer to home.

Two recent papers explore the relationship between use of the school bus and absenteeism. Using the ECLS-K, Gottfried (2017) finds that kindergartners taking the bus are absent about 0.4 fewer days per year, a statistically significant difference that may have small, but potentially meaningful effects on academic outcomes. Cordes et al. (2019) use New York City student-level administrative data on bus ridership and absenteeism to examine the link between bus riding and attendance rates. They find that bus riders are absent about one fewer day per year than peers that do not ride the bus, and that much of the absenteeism gap for bus riders is driven by differences between, rather than within, schools. They also find that the absenteeism gap for Black (1.8 fewer days absent) and Hispanic (1.4 days) bus riders is three to four times larger than for Asian (0.4 days) students and 20 to 25 times larger than for White (0.1 days) students.

The paper most closely related to our work is Edwards (2019), which explores how distance and school quality affect the school choice decisions of students in grades K, 6, and 9 in Detroit Public Schools. Using a conditional logit model, she finds that families are more likely to choose schools closer to home and to choose neighborhood schools over charter or choice schools. Our study builds upon this work, using student-level data on access to school bus transportation, along with distance between home and school. Thus, we can shed light on how proximity and school buses affect school choice decisions.

Finally, this paper contributes to the growing literature in urban economics on the impact of transportation on various outcomes. Numerous studies find access to public transit improves job accessibility and employment (Fingleton and Szumilo, 2019; Mayer and Trevien, 2017; Boisjoly et al., 2017; Rotger and Nielsen, 2015; Holzer et al., 2003). There is mixed evidence on the effect of public transportation on land and housing values; some studies find access to new transit systems increase land and housing values (Billings, 2011; Kahn, 2007; Gibbons and Machin, 2008), while others find census tracts with greater access to public transit are more likely to be poor (Pathak et al., 2017; Glaeser et al., 2008). Additionally, public transit has been linked to reduced traffic congestion and accidents (Litchman-Sadot, 2019; Anderson, 2014) and has affected local crime (Phillips and Sandler, 2015; Billings et al., 2011). Finally, and more important to our context, public transit effects school choice outcomes; the introduction of new subway lines or trains increases the likelihood students attend schools further from home (Dustan and Ngo, 2018; Herskovic, 2020). While previous literature typically exploits expansions in public transportation, our work provides valuable insights into how extending transportation – and school buses, in particular - can shape school choice outcomes.

3. School choice and transportation in New York City

With over 1.1 million students, the New York City Department of Education (NYCDOE) oversees the nation's largest school district. Its Office of Pupil Transportation (OPT) oversees the largest pupil transportation operation in the country, including 9,500 school buses serving more than 100,000 students in roughly 1800 schools – including two-thirds of the 940 elementary schools that have kindergarten classes. NYC neighborhoods span a wide range, including very dense areas such as in Manhattan and much lower-density areas dominated by single-family homes on Staten Island and portions of Brooklyn, Queens, and the Bronx.

3.1. School choice in New York City

NYCDOE allows a considerable amount of choice for kindergarten

[1] "The Role of Government in Education," Milton Friedman. From *Economics and the Public Interest,* ed. Robert A. Solo, 1955

students. In some areas, open enrollment is a formal policy.[2] During our study period, for example, one of the sub-city "Community School Districts" (CSD) eliminated attendance zones entirely, moving to district-wide open enrollment. In other areas, each student is assigned a zoned school based upon their residential location, but an array of formal and informal policies and practices allow students to attend a different school. NYCDOE offers an extensive array of gifted and talented programs, magnet schools, and dual-language programs (among others) that do not rely on catchment areas, although there may be location-based preferences.[3] Further, families may be granted a waiver from the principal of another zoned school to allow their child to attend due, perhaps, to the proximity to parents' employment, after-school family care, or schools attended by siblings. We refer to these schools as *traditional public schools*.

Since New York City's first charter school opened in 1999, the number of charters has risen steadily to serve roughly ten percent of public-school students (Sattin-Bajaj, 2018). Many were designed and located with an eye toward improving access to good quality schools in low-income areas and, as a result, they are disproportionately located in relatively low-income areas. These schools typically give preference to students living in the same CSD as the charter school and, if oversubscribed, use lotteries to allocate admissions offers (see Cordes and Laurito, 2019 for more on charter schools and school choice in NYC elementary and middle schools.)

We will refer to four types of schools in our analysis - *zoned, charter*, *other zoned schools* (zoned schools in attendance zones other than the one where the student resides), and *non-zoned district schools* (all other traditional public schools, including magnets and specialty schools) – where the distinction between *zoned* and *other zoned* designations depend upon student residential location. Notice that one student's zoned school will be another student's other zoned school and many schools will be designated a zoned school for some students and other-zoned for others. Zoned and non-zoned district schools are financed and governed as traditional public schools. Furthermore, we will refer to *other zoned* and *non-zoned district* schools as *district choice schools*. In 2017, 58 percent of NYC kindergarten students attended their zoned school, leaving 42 percent of students who attended a charter or district choice school.

3.2. Pupil transportation in New York City

A combination of district- and school-level factors determine student eligibility for transportation assistance. District-wide pupil transportation operations and policies are set by OPT. This includes determining eligibility for service, contracting with vendors, developing and setting school bus routes, and managing and oversight of subsidized MetroCards for students to use on public transit. Eligibility for transportation assistance depends upon the distance between schools and student residential location and criteria vary by grade. For grades K-2, students living more than one-half mile from school are eligible for school bus transportation or a full-fare MetroCard, which allows for up to three free rides on public transit (buses or subways) each school day. For grades 3–6 (3–8 in Staten Island), eligibility is limited to students living more than one mile away.[4] District policy places a series of relevant restrictions on bus routes: bus routes are limited to five miles from first stop to school; bus routes serving traditional public schools cannot cross CSD boundaries, and bus routes serving charter schools cannot cross borough boundaries.

There are a limited set of important exceptions to these rules. First, students residing in temporary housing are eligible for school bus services to the school they attended prior to entry into temporary housing (following McKinney Vento).[5] Second, exceptions may be granted due to medical or emergency conditions, hazardous travel conditions (such as unsafe traffic), or for students whose zoned school failed No Child Left Behind accountability criteria. Finally, eligibility for transportation for students with disabilities typically follows different criteria, often mandated on their Individualized Education Plan, and involves "door to door" service on specialized buses rather than traditional service from a designated school bus stop.

School-level administrators have considerable discretion over bus services. Although the district foots the bill, school principals can decide to not offer school bus services to anyone not mandated (i.e. students with disabilities or temporary housing). Indeed, in 2015, only 57 percent of elementary and middle school principals chose to offer school bus service to students eligible for transportation assistance. These students may choose a MetroCard instead of the bus if they prefer. In the other 43 percent of schools, distance-eligible students are only offered a MetroCard.

How do schools offering buses differ from those that do not? Cordes et al. (2020) examine the relationship between the availability of school bus services and school characteristics. Elementary schools, charter schools, and schools with gifted and talented programs are more likely to provide buses. The probability a school offers a bus is increasing in the share of the student body that is White or Asian, eligible for pupil transportation, or live outside the attendance zone. Finally, schools in lower density areas are more likely to offer the bus. For example, schools in Queens and Staten Island are 20 and 50 percentage points more likely to offer bus services than schools in Manhattan (Cordes et al., 2020).

4. Data set construction & sample

4.1. Data

We draw on rich student-level administrative data, provided by the NYCDOE, on all NYC public school students for academic year 2016–17. Our analysis focuses on students in kindergarten since this is typically the first year of enrollment in public school and families have usually made this choice recently. Data include sociodemographic characteristics such as gender, race/ethnicity, eligibility for free or reduced-price meals, English language learner status, participation in special education, and residential location. Data from OPT, includes categorical measures of distance between home and school that are used to determine transportation eligibility, and transportation assignment (bus or MetroCard) for the school the student attends. Finally, this data contains information on transportation exceptions, where distance ineligible students are provided transportation services due to special circumstances. We use these student-level data on transportation assignment to create a school-level measure of bus availability. *Bus* is an indicator variable that takes the value of one if there are five or more students assigned a bus by OPT, and at least one of those students does not have a transportation exception. We later use this variable to determine student bus eligibility.

Data on school characteristics are available from the New York State School Report Cards (SRC). The SRC contains school-level information such as the gender and racial/ethnic composition of students, total enrollment, and teacher characteristics, including years of experience

[2] New York City divides elementary schools into 32 geographic community school districts (CSD), each with its own superintendent and some autonomy in setting educational policies. Three of these CSDs are designated as choice districts, allowing resident children to attend any school in that community school district.

[3] In addition, when students make a residential move to a different school zone, they can choose not to change schools. See "Your Options," InsideSchools, accessed September 6, 2018, https://insideschools.org/elementary/your-options.

[4] In addition, students in K-2 (3–6) who live less than a half-mile (one) from school are eligible for a half-fare MetroCard, allowing them to ride public buses at half price. Few students take advantage of this option.

[5] For more information on the provisions of McKinney Vento on student transportation, see https://nche.ed.gov/wp-content/uploads/2019/01/transportation.pdf.

and teacher education levels. It also includes school-level measures of academic performance, including English Language Arts (ELA) and math proficiency rates on NYS standardized tests; we use the average of these two to measure school performance and, ultimately, to distinguish high performing schools. Specifically, we define *high-quality schools* as those with average proficiency at or above the 75th percentile of NYC schools serving kindergarten. Furthermore, we define an indicator variable, *High-Quality Zone,* which takes a value of one if students live in an attendance zone with a high-quality zoned school. Finally, we have school address data from the National Center for Education Statistics Common Core of Data.[6] We use these data to calculate the *distance* between a student's residence and each school in their choice set using *Open Source Routing Machine* (OSRM).[7]

4.2. Defining the choice set

A critical part of investigating school choice decisions is defining the choice set – that is, the set of schools a student considers when choosing a school to attend. In a city such as New York, the choice set is potentially quite large, including all the 1,800 schools within in the city. However, many of these schools are prohibitively far away, do not serve the student's grade, or the student does not meet the admissions criteria (i.e. schools that serve specialized populations in specific geographic areas). Thus, the "effective" choice set for any student is more limited.

We define a unique choice set for each attendance zone which consists of all schools chosen by more than one student within a given attendance zone.[8] To construct the choice sets for kindergarten students, we create an attendance zone by school data set with the number of students enrolled in each attendance zone-school combination. We then delete any attendance zone-school observation with only one student and any attendance zone served by more than one zoned school (due, perhaps, to open enrollment policies in the CSD).[9] The resulting data set has 4,458 attendance zone by school observations. For each attendance zone, there is one observation for each school in the choice set. Put differently, the choice set for each attendance zone is, then, the set of schools associated with that attendance zone in this data set.

We then attach data on school characteristics including bus availability (*Bus*) and match this attendance zone-school data set to the student-attendance zone data set to create a student-attendance zone-school level data set (509,395 observations). Our final step is to calculate the distance between the student's residence and each school in their choice set.

To illustrate what a typical student choice set looks like based on our definition, Fig. 1 maps a choice set for a randomly selected kindergarten student from our sample. The star indicates where the student lives, while the map markers represent the schools in the choice set. The black marker indicates zoned schools, dark grey markers indicate charter schools, and district choice schools are colored light grey. The school the student chooses to attend is a square shape, while map markers indicate other schools in the choice set. Finally, schools that provide a bus for students have a circle icon within their map marker. This student has eight schools in his or her choice set – one zoned school, three district choice schools, and four charter schools. Five of these schools provide a bus. Although there are schools closer to the student's residence, this student chooses to attend his or her zoned school.

Table 1 presents summary statistics for the choice sets used in our analyses. Our kindergarten sample has just over 580 unique choice sets, with the average choice set including approximately 8 schools. By construction, each choice set has one zoned school, but there is considerable variation in the number of charter and district choice schools. For example, the average choice set for kindergarten has 2 charter and 4 district choice options, with some choice sets including as many as 17 charter or district choice schools for students to consider.

Table 2 presents descriptive statistics for traditional public and charter schools in our sample. Charters are disproportionately Black (56 percent), while traditional public schools are disproportionately Hispanic and White (41 and 17 percent, respectively). Traditional public schools also have higher proportions of limited English proficient (LEP) students and students with disabilities (SWDs). There are noteworthy differences in the characteristics of teachers. Charters have a higher percentage of inexperienced teachers and traditional public schools have a higher representation of teachers with a Master's degree or more. Of greatest interest for our study, there are significant differences in the availability of the school bus. Virtually all charter schools offer a bus (98 percent) while only about two-thirds (65 percent) of traditional public schools do.

4.3. Sample

Table 3 presents descriptive statistics for student-level variables for the sample of all students in kindergarten in 2017. As shown, over half of NYC public school students are poor, with roughly 70 percent eligible for free or reduced-price lunch (FRPL). These students are also predominately minority – Hispanics represent 40 percent, followed by 25 percent Black. Finally, approximately 20 percent of students are English Language Learners (ELL), and 13 percent are SWD.

We make several restrictions to create our analytic sample. In addition to the restrictions described earlier when creating the choice sets, we exclude students in full-time special education schools and ungraded special education because the school choice process, and school bus eligibility and service differs significantly. Next, we exclude a small number of students who attend a new school (due to missing school-level data) or who live more than a mile away from their zoned school, because they are idiosyncratically located.[10] Finally, we exclude students with special education or temporary housing transportation exceptions. Our final sample consists of 56,761 kindergarten students, and over 455,000 student-school-attendance zone observations.

As shown in Table 3, our sample is very similar to all NYC public school kindergarten students. Roughly 70 percent are FRPL, 38 percent are Hispanic, 22 percent Black, 21 percent Asian, and 18 percent are white. Roughly 20 percent of students are ELL or SWD. Almost three quarters attend their zoned school, while one in ten attend a charter school. The remaining 17 percent attend a district choice school.

Table 3 also provides student summary statistics by school type. The composition of charter school students differs from the other three types of schools - charters school students are disproportionately Black and FRPL, and ELL students are underrepresented. Students attending charter schools have higher scoring peers – the average performance in a charter

[6] The Common Core is the National Center for Education Statistics' (NCES) comprehensive database on public elementary and secondary schools in the US, providing annual, descriptive data on staff and students at the school, school district, and state level. Data can be found at https://nces.ed.gov/ccd/.

[7] OSRM uses geographic data on latitude and longitude to determine travel time and distance between two coordinate pairs using a user-imported map of NYC from *OpenStreetMaps*. We calculate the fastest walking route for each school in the student's choice set, which is also the shortest walking route (OSRM assumes a constant walking speed of 3 MPH).

[8] Additionally, we have explored the robustness of the results to constructing the choice set to include all schools chosen by more than 5 students within a given attendance zone. Results are similar to the baseline results presented in the paper when using this alternate choice set definition for the CL and CLRD models (and are available upon request).

[9] To some extent, the singletons reflect individual idiosyncratic circumstances, such as residential mobility, location of parental employment, or placement in temporary housing, that are unlikely to be relevant to the larger groups. From a practical standpoint, this significantly reduces the number of schools in a choice set which facilitates the estimation of the conditional logit model.

[10] Note that there are very few students who live more than 1 mile from their zone school (1331 students in kindergarten or 2 percent).

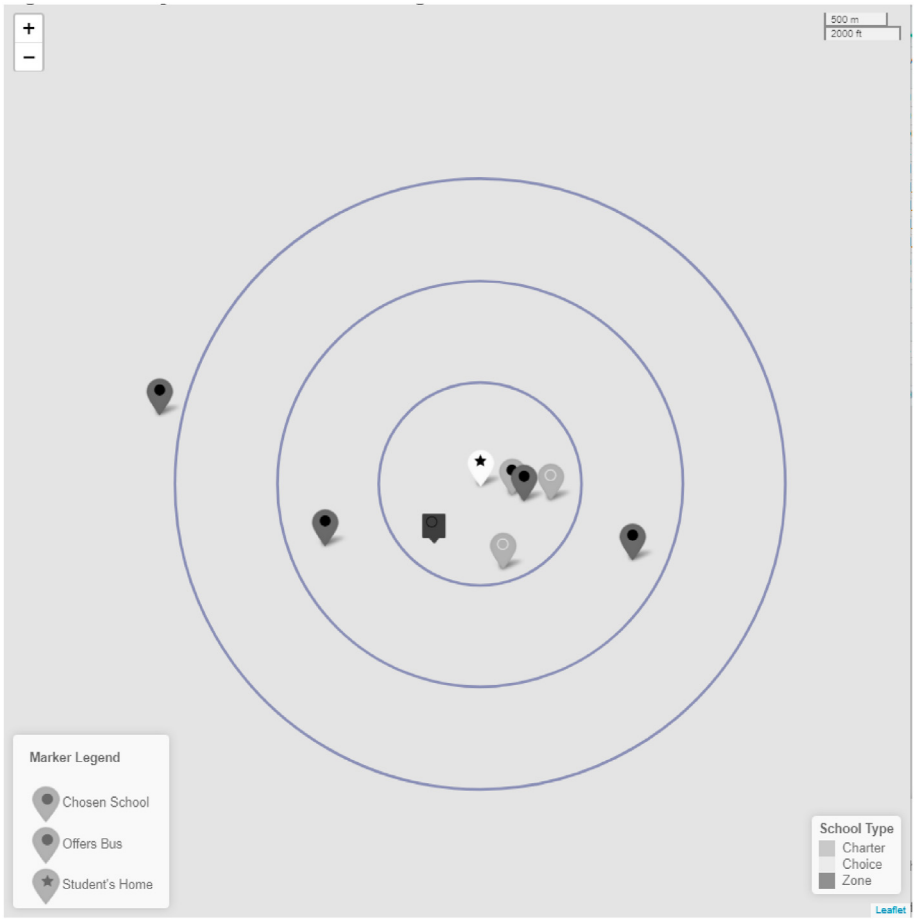

Fig. 1. Example choice set for kindergarten.

Table 1
Characteristics of choice sets.

	N	Mean	Min	Max
Number of Schools in Choice Set				
All Schools	582	7.44	2	29
Zoned Schools	582	1	1	1
Charter Schools	582	2.35	0	17
Other Zoned School	582	2.87	0	15
Non-Zoned District Schools	582	1.19	0	6

Notes: Each choice set must contain a zoned school, however they do not always include charter or district choice options, hence the number of choice sets with these schools is smaller.

Table 2
Characteristics of schools.

	Traditional Public Schools	Charter Schools
ELA Proficiency	0.37	0.42
Math Proficiency	0.37	0.48
School Quality	0.37	0.45
K-2 Schools (missing proficiency rates)	0.05	0.12
Enrollment (in hundreds)	6.41	4.89
Percent Black Students	26.32	55.60
Percent Hispanic Students	40.87	34.86
Percent White Students	16.52	5.08
Percent Free/Reduced Price Lunch	71.48	76.03
Percent Students with Disabilities	21.93	16.38
Percent Limited English Proficiency	15.00	6.65
Teachers < 3 Years of Experience	11.41	30.83
Teachers with Masters' or Higher Edu	47.50	7.41
Bus	0.65	0.98
Number of Schools	**747**	**143**

Notes: Schools that opened in 2017 were removed from the choice sets due to missing 2016 SRC data (15 schools). For our kindergarten sample, schools missing school performance data only offer instruction for grades K-2, and thus do not administer reading or math tests to these students.

school is 0.45, meaning 45 percent of the students scored proficient in ELA and math on NYS tests, which is slightly higher than the average performance for zoned and district choice schools. As shown in Table 3, the average kindergarten student attending a zoned school lives 0.35 miles from school while the average distance to a charter, other zoned, or a non-zoned district school is more than a mile. Thus, students attending choice schools travel further than students attending zoned schools.

Next, we present descriptive statistics for the distance distribution of schools within each student's choice set, in Table 4. While all students in the same attendance zone are assigned the same choice set, the distance between a student's home and each school varies within the choice set and is the key variation for our analyses. On average, kindergarten students have 10.31 schools in their choice sets, and over half of these options are over 0.75 miles from home. We see considerable variation across school types, particularly noteworthy are differences between zoned schools and the other three types. Over half of all students live within a half mile of their zoned school, and the average distance to the zoned school is 0.35 miles. Students live farther from charter and district choice schools; over half live more than 0.75 miles from these schools,

Table 3
Characteristics of kindergarten students.

	(1) All Students	(2) Analytic Sample	(3) Zoned Schools	(4) Charter Schools	(5) Other Zoned Schools	(6) Non-Zoned District
Female	0.50	0.50	0.49	0.52	0.49	0.52
Black	0.24	0.22	0.17	0.55	0.25	0.21
White	0.17	0.18	0.20	0.07	0.19	0.16
Asian	0.19	0.21	0.23	0.06	0.23	0.18
Hispanic	0.40	0.38	0.39	0.33	0.32	0.45
English Language Learner	0.21	0.21	0.23	0.11	0.19	0.20
Students with Disabilities	0.13	0.14	0.15	0.10	0.11	0.13
Free or Reduced-Price Lunch	0.69	0.68	0.68	0.77	0.64	0.66
Average Peer Performance		0.42	0.42	0.45	0.43	0.36
Distance to School		0.55	0.35	1.19	1.01	1.09
Distance <0.25 Miles		0.29	0.35	0.11	0.09	0.18
Distance 0.25–0.50 Miles		0.40	0.46	0.19	0.27	0.27
Distance 0.5–0.75 Miles		0.16	0.15	0.14	0.20	0.15
Distance >0.75 Miles		0.16	0.04	0.56	0.45	0.41
Number of Unique Students	81,216	56,761	41,726	5599	6043	3393

Notes: Summary statistics are presented for students in kindergarten in 2017. Students enrolled in special education (District 75 or ungraded special education) or students who live in district wide choice districts (districts 1, 7, and 23) are not included in the sample. We exclude students who attend a school that opened in 2017, students whose zoned schools are further than one mile away from their residence, and students with special education or temporary housing transportation exceptions from this sample. The first column presents summary statistics for all kindergarten students in NYC in 2017. Some of these students are dropped from our sample due to the restrictions described above, and thus we do not calculate the distance between their home and school.

Table 4
Characteristics of student choice sets.

	Mean	SD
Average Number of Schools	10.31	4.99
<0.25 Miles	1.30	0.61
0.25–0.50 Mile	1.81	1.11
0.50–0.75 Miles	1.81	1.05
>0.75 Miles	5.14	3.57
Proportion of Schools		
<0.25 Miles	0.07	0.25
0.25–0.50 Mile	0.16	0.37
0.50–0.75 Miles	0.15	0.36
>0.75 Miles	0.61	0.49
Zoned Schools		
Average Distance to Zoned School	0.35	0.19
Proportion <0.25 Miles	0.34	0.47
Proportion 0.25–0.50 Miles	0.45	0.50
Proportion 0.50–0.75 Miles	0.16	0.37
Proportion >0.75 Miles	0.05	0.21
Charter Schools		
Average Distance to Charter School	1.77	1.45
Proportion <0.25 Miles	0.03	0.17
Proportion 0.25–0.50 Miles	0.09	0.28
Proportion 0.50–0.75 Miles	0.11	0.31
Proportion >0.75 Miles	0.77	0.42
Other Zoned Schools		
Average Distance to District Choice School	1.41	1.26
Proportion <0.25 Miles	0.02	0.14
Proportion 0.25–0.50 Miles	0.13	0.34
Proportion 0.50–0.75 Miles	0.18	0.38
Percent >0.75 Miles	0.67	0.47
Non-Zoned District Schools		
Average Distance to District Choice School	1.43	1.44
Proportion <0.25 Miles	0.07	0.25
Proportion 0.25–0.50 Miles	0.16	0.37
Proportion 0.50–0.75 Miles	0.15	0.36
Proportion >0.75 Miles	0.61	0.49

Notes: Data is at the student-choice set level and includes 455,368 observations for kindergarten students.

and on average, live 1.77 miles from a charter school. Thus, while students are more likely to be eligible for buses to charter schools since they are located further from home, they may also be less likely to attend these schools if they have strong preferences for proximity.

5. A model of school and transportation choice

In this section, we develop two models for analyzing the relationship between school choice, distance, and the availability of the school bus. We begin with a regression discontinuity (RD) design to isolate the causal effect of school bus eligibility on the decision to attend a particular school. In the RD model, we identify the impact of bus eligibility by comparing students living just below and just beyond the 0.5-mile bus eligibility cutoff for kindergarten students. By focusing on students living "near" the eligibility criterion – which we define with a quarter mile bandwidth – we can derive a credibly causal estimate of the impact of the bus on school choice at the cutoff. Unfortunately, these offer little guidance about interpretation (there is no theoretical framework) or insight into the importance of other school characteristics – such as the characteristics or availability of alternative school options. Furthermore, these are estimated using only the schools in student's choice set that are 0.25–0.75 miles away from the student's home, so shed no light on the relationship between distance and choice outside this bandwidth.

To address these limitations, we develop a model of school choice, based on McFadden's discrete choice model in a standard random utility framework and derive a theoretically grounded conditional logit regression model. In this case, students are viewed as choosing a school from their full choice set of schools, to maximize their own utility, based upon the characteristics of the schools and their own, student-specific characteristics.

While this approach is well-grounded in the standard choice theoretic framework and offers an excellent description of actual school choice behavior, it does not necessarily provide a compelling identification strategy for isolating the causal effects of school bus eligibility on school choice, beyond the potential for a rich set of control variables to minimize omitted variables bias. Thus, we embed an RD in this model that is,

again, based on the 0.5-mile bus eligibility cutoff for kindergarten. Identification is based on the choices of students above and below this bus eligibility cutoff for zoned, charter, and district choice schools.

5.1. RD model

To identify the causal effect of transportation on school choice, we use an RD framework and exploit the distance-based eligibility criteria for school bus services. We estimate the following model:

$$\text{Choice}_{ija} = \alpha + f\left(\text{Distance}_{ij}, \beta_b\right) \cdot \text{Before\_Cutoff}_{ij} + f\left(\text{Distance}_{ij}, \beta_a\right) \cdot \text{After\_Cutoff}_{ij} + \beta \cdot \text{After\_Cutoff}_{ij} + \tau \text{BusElig}_{ij} + X_i\delta + \eta_j + \varepsilon_{ija} \quad (1)$$

where $Choice_{ija} = 1$ if student i chooses school j from the choice set associated with attendance zone a (0 otherwise), $Distance_{ij}$ is the distance from student i's residence to school j (centered at 0.5 miles), $Before\_Cutoff_{ij}$ and $After\_Cutoff_{ij}$ are indicators of being before and after the eligibility cutoff (0.5 miles), X_i is a vector of student demographic characteristics, and $f(\cdot)$ is a function of higher-order polynomials in $Distance_{ij}$. We allow for different parameters for $f(\cdot)$ before and after the distance cutoff (β_b and β_a)

Our variable of interest is $BusElig_{ij}$, which takes a value of one if school j offers a bus ($Bus_j = 1$) and student i lives more than 0.5 miles from school.[11] Since we use a centered distance measure, the polynomials before and after the cutoff are zero at 0.5 miles, and we can interpret τ as the treatment effect of bus eligibility. Moreover, the inclusion of $After\_Cutoff_{ij}$ means that τ captures the effect of the school bus *per se,* over and above the offer of a MetroCard (recall that all students living more than a half mile from school are offered a MetroCard regardless of school attended). Finally, since the decision to offer a bus is not necessarily random (principals decide whether to offer a bus), τ should be interpreted as causal *conditional* on schools' decisions about bus service.

One of the potential drawbacks of this model is that it treats each choice as independent of all other choices in each student's choice set. In an alternative specification, we address this issue by including characteristics of the student's choice set for attendance zone a, CS_a. These include the number of other schools that offer the bus, the number of schools in the choice set, and the minimum distance to school among the other choices in the choice set.

Finally, we include η_j, a school effect, in equation (1). In this case, the treatment effect is identified by comparisons of the school choices between students on either side of the cutoff for the same school.[12] In this way, we control for all school characteristics that might affect bus eligibility and school choice. In an alternative specification, we substitute choice set fixed effects, identifying the treatment effect by comparing the school choices of students on either side of the cutoff within the same choice set, (i.e. who live in the same attendance zone). In this way, we control for all characteristics of the choice set that might affect bus eligibility and school choice.

We explore the robustness and heterogeneity of our results in several ways. First, we estimate (1) using a 0.1-mile bandwidth. Second, we interact *After_Cutoff* and *BusElig* with indicators for student race/ethnicity and gender. Third, we explore how the effect of bus eligibility varies by school type; we stratify the sample and estimate models separately for zoned, charter, other zoned, and non-zoned district schools. Fourth, we investigate the impact of the bus separately for students who live in attendance zones with high and average/low quality zoned schools. Finally, we estimate models using a 0.25-mile bandwidth around one mile – the bus eligibility cutoff for 3rd grade – to explore whether eligibility for the school bus in 3rd grade (when the cutoff moves to 1 mile) influences school choice decisions in kindergarten, shedding light on whether families are forward looking.

5.2. Conditional logit model

While the regression discontinuity model will produce results that capture the causal effect of school bus availability on school choice decisions, it provides little insight into the school choice decision process within the context of the full school choice set. To develop such a model, we rely on McFadden's random utility model (1974). Assume that the utility for student i from choosing school j is

$$U_{ij} = w_j'\beta + \sum_{g=1}^{G} x_{ig} \cdot w_j'\alpha + \varepsilon_{ij} \quad j = 1, \ldots J_a \quad (2)$$

where w_j is a vector of M school-specific characteristics, x_i is a vector of G individual characteristics, and ε_{ij} is a stochastic error term. The individual (household) chooses school k from the J_a schools in the choice set $CS_a = \{S_j;\ j = 1, \ldots, J_a\}$ for attendance zone a if it provides the maximum utility across all S_a choices

$$S_i = k \text{ if } U_{ik} > U_{ij} \quad \forall j \neq k \quad (3)$$

The probability that choice k is made by student i is

$$P\left(U_{ik} > U_{ij};\ \ \forall j \neq k\right) \quad (4)$$

To evaluate this probability, we need to assume a distribution for ε_{ij}. We follow McFadden (1974) and assume ε_{ij} has an i. i.d. Gumbel (type 1 extreme value) distribution

$$F\left(\varepsilon_{ij}\right) = \exp\left(-\exp\left(-\varepsilon_{ij}\right)\right)$$

This results in the conditional logit (CL) model

$$P\left(S_i = k | w, x_i\right) = \frac{\exp\left(w_k'\beta + \sum_{g=1}^{G} x_{ig} \cdot w_k'\alpha\right)}{\sum_{j=1}^{J_a} \exp\left(w_j'\beta + \sum_{g=1}^{G} x_{ig} \cdot w_j'\alpha\right)} \quad k = 1, \ldots J_a \quad (5)$$

where

[11] One caveat is that students who attend a district choice (charter) school and are far enough away to be bus eligible but live in a different CSD (borough) are not offered a bus. Bus eligibility rules can be found on the NYCDOE's website at https://www.schools.nyc.gov/school-life/transportation/bus-eligibility.

[12] Students can be in the sample more than once if they live within the bandwidth distance of more than one school. Introducing student fixed effects would identify impacts using the subset of these students for whom these include both the school the student attends and schools the student did not choose – otherwise there will be no within student variation. Estimates based upon this selected sample are unlikely to be representative or meaningful.

$$w_k\beta + \sum_{g=1}^{G} x_{ig} w_k' \alpha_g = \beta_0 + Type_k\beta_1 + Type_k \cdot f(Distance_{ik}, \beta_t) + Type_k \cdot BusElig_{ik} \cdot f(Distance_{ik}, \tau_t) + School\_Characteristics_k\beta_3 \quad (6)$$

and $Type_k$ is a set of school type indicators distinguishing *Zoned, Charter, Other Zoned,* and *Non-Zoned District Schools* (*Zoned* is excluded as the reference group) for the chosen school *k*. Notice that the index *t* is for school type reflecting the fact that the impacts for all variables related to distance (including *BusElig*) vary by school type. We also create three indicators that capture distance from a student's residence to school, following the categories used to determine subsidized transportation eligibility: *Distance_0.5to1*, *Distance_1to1.5* and *Distance_>1.5*.[13]

Finally, we include $School\_Characteristics_k$ for school *k*, including an indicator for *high-quality school*, total enrollment, percent FRPL, percent SWD, and percent LEP. The percent of teachers with 3 or fewer years of experience and the percent of teachers with a Masters' or higher level of education capture teacher quality, while percent female, Black, Hispanic, and white capture school gender and racial/ethnic composition, which previous research suggests is influential in choice decisions. (Edwards, 2019; Glazerman and Dotter, 2017; Glazerman, 1998).

5.3. CL with embedded RD model

The treatment effect estimated in equation (6) may not capture the causal effect of the bus because there may be unobserved factors that influence school choice decisions and are correlated with *BusElig*. To address this and derive a credibly causal estimate of the impact of *BusElig* on school choice, we embed an RD in the CL model. In doing so, we estimate the impact by the variation around the bus eligibility cutoff within a narrow bandwidth such that *After_Cutoff* is quasi-randomly assigned around the treatment eligibility cutoff (conditional on school characteristics). Thus, we adapt (6) as follows:

$$\begin{aligned} w_k\beta + \sum_{g=1}^{G} x_{ig} w_k' \alpha_g = \; & \beta_0 + Type_k\beta_1 + Type_k \cdot f(Distance_{ik}, \beta_{bt}) \cdot Before\_Cutoff_{ik} + Type_k \cdot f(Distance_{ik}, \beta_{at}) \cdot After\_Cutoff_{ik} \\ & + Type_k \cdot After\_Cutoff_{ik}\beta_{2t} + \tau_t Type_k \cdot BusElig_{ik} + School\_Characteristics_k\beta_3 \end{aligned} \quad (7)$$

To mimic the RD setup of a 0.25 to 0.75 bandwidth used in the simple RD, we include the following distance indicators: *Distance_0to0.25*, *Distance_0.25to0.5, Distance 0.5to0.75,* and *Distance_>0.75*. We also allow the distance impact to differ in each distance interval by interacting them with both distance and distance squared. In this way, we can estimate a credibly causal effect of bus eligibility. Finally, we standardize the coefficients by calculating the corresponding elasticities, to shed light on the economic significance of the impacts on school choice. The formulas are provided in the Appendix.

6. Results

We first present the results for the simple RD model, along with a set of analyses of the validity of the RD model assumptions. Next, we turn to results for the conditional logit (CL) model, followed by results for CL with the embedded RD (CLRD).

6.1. RD results

6.1.1. RD assumptions

We begin with evidence supporting the validity of the RD. First, we explore the potential discontinuity in the density of the distance to school around the bus eligibility cutoff as shown in Fig. 2. A McCrary test shows that the density of distance to school is continuous at the cutoff as we are unable to reject the null hypothesis that the density function is continuous at 0.5 miles (p-value = 0.193).

We next graph the outcome (school choice) against distance (Fig. 1 in the Online Appendix). While there is not a distinct increase in school choice at the cutoff, there is a flattening of the slope in the relationship between choice and distance. To show that 0.5 miles is a relevant cutoff for bus eligibility, we graph bus assignment (students who take the bus) for the schools students attend against distance (Fig. 2 in the Online Appendix). Here we see a distinct increase at the cutoff. Note that the probability is not one after the cutoff since not all schools offer the bus. Moreover, we see a small percentage of students taking the bus who live less than 0.5 miles from school, which is due to transportation exceptions (such as hazardous walking routes or an emergency medical issue). Next, we check the balance of student and school characteristics around the cutoff. Online Appendix Figs. 3–8 graph the binned means of these covariates, and there is no evidence that these variables change discontinuously across the bus eligibility cutoff. Finally, we compare the mean values of student characteristics below and above 0.5 miles. Again, we find no evidence that the students just below the eligibility cutoff are significantly different from students just above the cutoff.[14]

6.1.2. RD results

Table 5 presents results for all schools with a 0.25-mile bandwidth around the bus eligibility cutoff. Baseline models are presented in Panel 1 with semi-elasticities in brackets.[15] In the model without school fixed effects, bus eligibility has a positive and significant effect on the likelihood a student chooses that school.[16] The magnitude of the coefficient falls with the addition of school fixed effects, but still suggests bus eligibility increases the likelihood of selecting a school by 3–4 percentage points or around 30 percent.[17]

[13] For K-2 (3–6), students must live 0.5 (1) miles from school to receive a school bus or full-fare MetroCard. For grades 7–12, students must live 1.5 miles or further from school to receive a full-fare MetroCard.

[14] Results are in Table 1 in the Online Appendix.

[15] The semi-elasticity equals the marginal effect divided by the proportion of schools chosen, 0.125 in this case.

[16] We also estimate models using a 0.1-mile bandwidth (distance range 0.40–0.60 mile). Results are similar with this smaller bandwidth and are available in Online Appendix Table 3.

[17] Results with choice set fixed effects are very similar to school fixed effects and can be found in Table 2 of the Online Appendix.

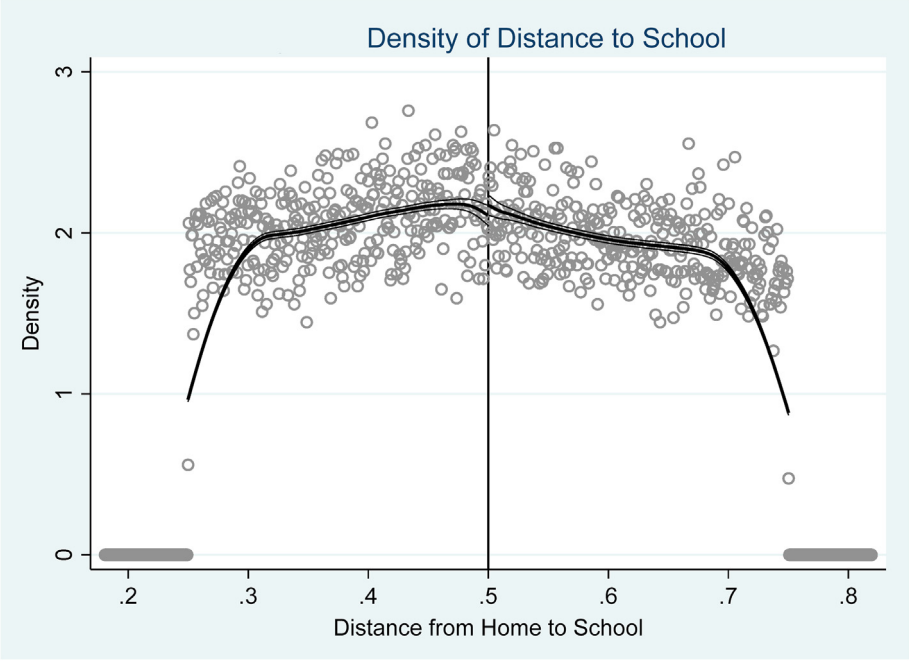

Fig. 2. Density of distance to school.

As mentioned in Section 5, one of the potential drawbacks of the simple RD model is that it treats each choice as independent of all other choices in each student's choice set. Thus, as a robustness check, we also estimate a specification that includes three variables that characterize the choice set; the number of other schools offering the bus in the choice set, the number of schools in the choice set, and the minimum distance to school among the other choices in the choice set. While these variables are significant, their addition has little impact on the previous results (see Table 3 in the Online Appendix).

Next, we examine the heterogeneity in estimated effects across student characteristics. As shown in Panel 2, the effect of the bus varies by student race/ethnicity. Bus eligibility has a larger impact on school choice for white and Asian students (6.5 and 6.8 percentage points) than for Black or Hispanic students (2.3 and 3.7 percentage points). Moreover, the bus has a larger impact for girls; girls are approximately 6 percent more likely to choose a school if they are eligible for the bus than boys.

Table 5
Effects of bus eligibility for all schools.

	(1) No FE	(2) School FE
Panel 1: Baseline Model		
Bus Eligible	0.090***	0.038***
	[0.722]	[0.305]
Panel 2: Heterogeneity by Race/Ethnicity		
Black	0.082***	0.023**
	[0.871]	[0.244]
White	0.119***	0.065***
	[0.112]	[0.383]
Hispanic	0.064***	0.037***
	[0.518]	[0.300]
Asian	0.163***	0.068***
	[1.117]	[0.466]
Panel 3: Heterogeneity by Gender		
Male	0.085***	0.035***
	[0.677]	[0.279]
Female	0.095***	0.042***
	[0.758]	[0.335]

Notes: Semi-elasticities are presented in brackets. All results estimated using a 0.25-mile bandwidth (distance range 0.25–0.75 miles) with distance and distance squared on either side of the bus eligibility threshold, *After_Cutoff*, *BusElig*, student characteristics (race/ethnicity, gender, student disability status, limited English proficiency, FRPL status, and primary language spoken at home) and school characteristics (school quality, enrollment, racial/ethnic and gender composition of student body, and teacher characteristics). Heterogeneity models in panels 2 and 3 are estimated by interacting *After_Cutoff* and *BusElig* with the race/ethnicity or gender indicator variables.
***p < 0.01, **p < 0.05, *p < 0.1.

6.1.3. RD results by school type

Table 6 presents the results for the four school types with and without

Table 6
Impact of bus eligibility by schooling option.

	(1) No FE	(2) School FE
Panel 1: Zoned Schools		
Bus Eligible	0.060***	0.030*
	[0.082]	[0.041]
Observations	34,346	34,346
Panel 2: Charter Schools		
Bus Eligible	0.033***	0.030**
	[0.333]	[0.303]
Observations	25,598	25,598
Panel 3: Other Zoned Schools		
Bus Eligible	0.005**	−0.007
	[0.047]	[-0.066]
Observations	55,909	55,909
Panel 4: Non-Zoned District Schools		
Bus Eligible	0.017***	0.008
	[0.283]	[0.133]
Observations	25,520	25,520

Notes: Semi-elasticities are presented in brackets. All results are estimated separately by school type using a 0.25-mile bandwidth around the bus eligibility cutoff, distance and distance squared on either side of the cutoff, *After_Cutoff*, *BusElig*, and student and school characteristics.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 7
Impact of bus eligibility by school quality and at 1 mile from school.

	Charter Schools		Other Zoned Schools		Non-Zoned District Schools	
	(1) No FE	(2) School FE	(3) No FE	(4) School FE	(5) No FE	(6) School FE
Panel 1: Heterogeneity by Quality of Zoned School/Attendance Zone						
High-Quality Zone	0.066***	0.062***	0.014***	0.006	−0.008	−0.004
	[0.667]	[0.626]	[0.169]	[0.007]	[-0.222]	[-0.111]
Average/Low-Quality	0.032***	0.029**	0.005**	−0.008	0.019***	0.010
	[0.256]	[0.232]	[0.044]	[-0.070]	[0.279]	[0.147]
Observations	25,598	25,598	55,909	55,909	25,520	25,520
Panel 2: Forward Looking? Bus Eligibility at 1 Mile						
Bus Eligible	0.028***	0.028***	0.008***	−0.002	0.020***	0.014**
	[0.283]	[0.283]	[0.075]	[-0.019]	[0.333]	[0.233]
Observations	28,053	28,053	49,409	49,409	15,681	15,681

Notes: Semi-elasticities are presented in brackets. Panel 1 uses a 0.25-mile bandwidth around 0.5 miles and interacts *After_Cutoff* and *BusElig* with indicators for high and average/low quality zoned schools. High-quality zoned schools are defined as those with average proficiency rates at or above the 75th percentile, while average/low quality zoned schools have proficiency rates below the 75th percentile. Panel 2 uses a 0.25-mile bandwidth around 1 mile (0.75–1.25 miles) to estimate the effect of bus eligibility using the 3rd grade cutoff (1 mile). All models include distance and distance squared on either side of the cutoff, and student and school characteristics. ***p < 0.01, **p < 0.05, *p < 0.1.

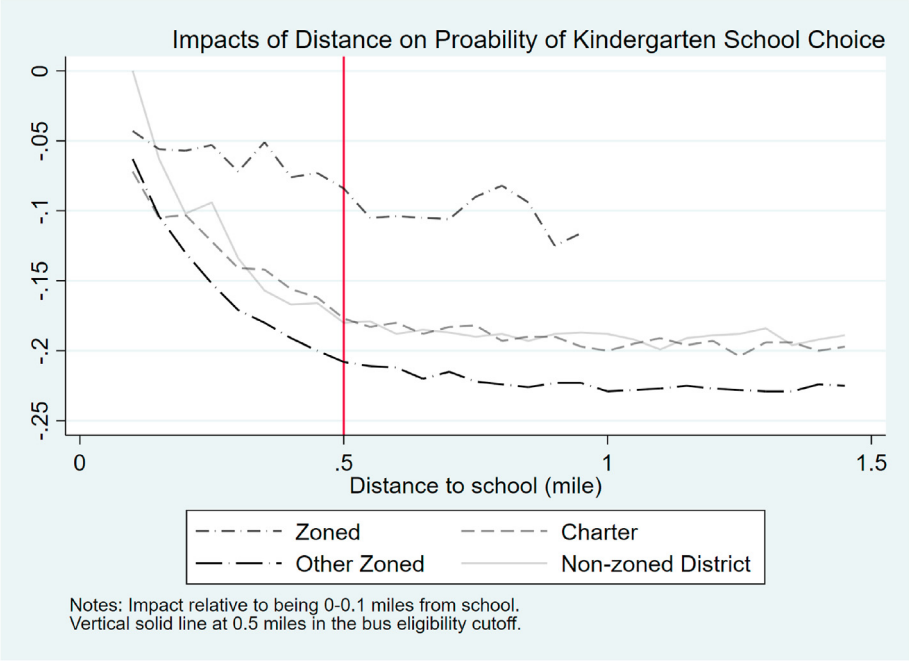

Fig. 3. Impacts of distance on proability of kindergarten school choice.

school fixed effects. Results for zoned schools, shown in Panel 1, suggest bus eligibility increases the likelihood of choosing a school by 6 percentage points without school fixed effects or 3 percentage points with school fixed effects (the semi-elasticity is 4 percent). We find similar results for the sample of charter schools. Bus eligibility increases the likelihood of selecting a school among charters by 3 percentage points (results are not sensitive to the inclusion of school fixed effects). The semi-elasticity of the charter school estimate is much larger, 30 percent, because the proportion of students attending a zone school is much higher than attending a charter school (0.735 versus 0.099). Finally, we estimate the effect of bus eligibility for alternate schooling choices - other zoned schools and non-zoned district schools. The effects are small though they are significant in models without school fixed effects.

As shown, the drop in the impact of bus eligibility when adding school fixed effects only obtains for zoned schools. Note that, by construction, these schools only serve students living in the same attendance zones, so including school fixed effects also controls for potential unobserved neighborhood characteristics of students related to bus eligibility and school choice.

We then explore how the effect of the bus differs by the quality of the student's zoned school, following the idea that students with low-quality zoned schools have greater incentives to consider another school and therefore are less sensitive to commuting costs and the bus than students with high-quality zoned schools. Table 7 shows the results of our heterogeneity analyses by zoned school quality for charter, other zoned, and non-zoned district schools. For charter schools, the impact of bus eligibility is larger for students living in attendance zones with high-quality zoned schools than for students with average- or low-quality zoned schools (6.2 vs 2.9 percentage points). For other zoned or non-zoned district schools, models without school fixed effects yield mixed, small effects, those with school fixed effects yield insignificant coefficients.

Finally, we investigate the possibility that families may be forward

Table 8
Basic CL model.

	(1)	(2)
School Type		
Charter	−0.115***	−0.109***
	[-1.162]	[-1.101]
Other Zoned	−0.191***	−0.170***
	[-1.802]	[-1.604]
Non-Zoned District	−0.116***	−0.109***
	[-1.933]	[-1.817]
High-Quality School	0.007***	0.007***
	[0.058]	[0.010]
Distance & Bus Eligibility		
Dist 0.5–1	−0.059***	
	[-0.471]	
Dist 0.5–1*Bus	0.016***	
	[0.130]	
Dist 1–1.5	−0.092***	
	[-0.735]	
Dist 1–1.5*Bus	0.028***	
	[0.226]	
Dist>1.5	−0.114***	
	[-0.913]	
Dist>1.5*Bus	0.022***	
	[0.176]	
Zoned Schools		
Dist 0.5–1*Zoned		−0.034***
		[-0.046]
Dist 0.5–1*Bus*Zoned		0.008**
		[0.011]
Charter Schools		
Dist 0.5–1*Charter		−0.088***
		[-0.889]
Dist 0.5–1*Bus*Charter		0.060***
		[0.606]
Dist 1–1.5*Charter		−0.113***
		[-1.141]
Dist 1–1.5*Bus*Charter		0.085***
		[0.859]
Dist>1.5*Charter		−0.184***
		[-1.859]
Dist>1.5*Bus*Charter		0.183***
		[1.848]
Other Zoned Schools		
Dist 0.5–1*Other Zoned		−0.065***
		[-0.613]
Dist 0.5–1*Bus*Other Zoned		0.011***
		[0.104]
Dist 1–1.5*Other Zoned		−0.087***
		[-0.821]
Dist 1–1.5*Bus*Other Zoned		0.017***
		[0.160]
Dist>1.5*Other Zoned		−0.089***
		[-0.755]
Dist>1.5*Bus*Other Zoned		0.003
		[0.003]
Non-Zoned District Schools		
Dist 0.5–1*Non-Zoned		−0.066***
		[-1.100]
Dist 0.5–1*Bus*Non-Zoned		0.018***
		[0.300]
Dist 1–1.5*Non-Zoned		−0.081***
		[-1.350]
Dist 1–1.5*Bus*Non-Zoned		0.026***
		[0.433]
Dist>1.5*Non-Zoned		−0.089***
		[-1.483]
Dist>1.5*Bus*Non-Zoned		0.019***
		[0.317]
Observations	455,368	455,368

Notes: Table presents marginal probabilities and elasticities in brackets. High-quality schools are those with average proficiency rates in the top quartile. All models include school characteristics.
***p < 0.01, **p < 0.05, *p < 0.1.

looking when choosing a school – that is, they may choose a school based upon student eligibility for the bus in 3rd grade. To do so, we estimate the RD model with a 0.25-mile bandwidth around one mile, the bus eligibility cutoff for 3rd grade. As shown in Panel 2 of Table 7, results suggest families may indeed look ahead to 3rd grade eligibility when making school choice decisions in kindergarten. The effect is positive and significant for charter and non-zoned district schools, suggesting bus eligibility at one mile increases the likelihood of attending a school by 1–3 percentage points (or 23–33 percent).[18]

6.1.4. Distance effects

As previously discussed, our results indicate that families and students prefer schools closer to home and bus eligibility increases the likelihood of attending a school. But can the bus overcome the negative effect of distance and enable families to choose schools farther from home? To shed light on this question, we first estimate simple models regressing school choice on a set of 0.05-mile distance bins (regression results are in Appendix Table 1). As shown in Fig. 3, families are less likely to choose schools farther from home; coefficient estimates on the distance bins decrease monotonically with distance. The negative impact of distance on school choice is much greater (in magnitude) for charter and other district choice schools, than for zoned schools. Compared to living within 0.1 miles from school, living 1 mile from school reduces the probability of school choice by 20 percentage points for charter, other zoned, and non-zoned district schools whereas it reduces the probability by 10 percentage points for zoned schools.

Based on the distance effects given in Appendix Table 1, the impact on school choice from living 0.95–1.0 miles from school rather than 0–0.10 miles from school is −0.116 (−0.197) for zoned (charter) schools. Looking at the model with school fixed effects, then the coefficient estimate of 0.030 (0.030) for bus eligibility in zone (charter) schools is equivalent to being 0.24 (0.14) miles closer to school.

Taken together, our RD results indicate that bus eligibility in important in school choice decisions and increases the likelihood of attending a school by 3 percentage points for zoned and charter schools. While the RD model allows us to estimate the causal effect of the bus, it provides no guidance in understanding how the presence of other schooling options affects choice decisions, or the effect of distance and bus availability outside this bandwidth. We next turn to our conditional logit model, in which we consider the students' full choice set of schools and how bus eligibility influences school choice decisions. Further, it allows us to examine potential tradeoffs between distance, bus eligibility, and other school characteristics, including school quality.

6.2. Conditional logit results

We now present estimation results for the CL model. We begin with models for all schools and then by school type, by interacting *BusElig* and the distance bins with indicators for the four school types.

Table 8 presents results for the conditional logit models transformed into marginal probabilities.[19] Column 1 provides the results for all schools. First, we find families have a strong preference for zoned schools – as indicated by the negative and significant coefficients for the other three school types. Specifically, marginal probabilities suggest families are 12, 19, and 12 percentage points less likely to choose charter, other zoned, or non-zoned district schools than the student's zoned school. Further, school quality matters too. Families are 1 percentage point (or 6 percent) more likely to choose a high-quality school than a lower-quality school.

[18] We do not estimate RD models using the bus eligibility cutoff for 3rd grade (1-mile) because we remove the few students who live more than a mile away from their zoned school from our sample.

[19] Coefficient estimates for all conditional logit models are presented in Online Appendix Table 9.

Table 9
CL with embedded RD model.

	(1) All Schools	(2) School Type
Dist 05–0.75*Bus	0.014***	
	[0.117]	
Dist 05–0.75*Bus*Zoned		0.010***
		[0.014]
Dist 05–0.75*Bus*Charter		0.049***
		[0.495]
Dist 05–0.75*Bus*Other Zoned		0.007**
		[0.066]
Dist 05–0.75*Bus*Non-Zoned		0.028***
		[0.467]
Observations	455,368	455,368

Notes: Table presents marginal probabilities and elasticities in brackets for select variables of interest. Full results are in Online Appendix Tables 10 and 11. All models include indicators for each distance bin (0.25–0.50, 0.50–0.75, 0.75+ with 0–0.25 as the reference group), distance and distance squared interacted with each of the distance bins, indicators for school type (charter, other zoned, non-zoned district), and school characteristics.
***p < 0.01, **p < 0.05, *p < 0.1.

Next, we find that families prefer proximity: the effect of distance is negative and monotonically decreasing across three distance bins. That said, bus eligibility moderates the negative effect of distance; estimates for the bus-distance interactions are positive. To be concrete, students are 1.6 percentage points more likely to attend a school 0.5–1 mile away from home that offers a bus than a school 0.5–1 miles away that does not offer a bus. We see a similar pattern for schools 1–1.5 miles and greater than 1.5 miles from home (2.8 and 2.2 percentage points, respectively). Perhaps unsurprisingly, the impact is somewhat larger farther away from school. Overall, the results are like those of the RD model with school fixed effects (3.0 percentage points).

Our results indicate that while distance deters choice, school bus eligibility and school quality can help overcome this impediment. For schools 0.5–1 mile from home, the estimates suggest buses can reduce the negative effect of distance by 27 percent, while a high-quality school reduces this effect by approximately 12 percent.[20]

6.2.1. Results by school type

Column 2 of Table 8 provides results that allow for a separate effect of distance and bus eligibility by school type. Once again, we find a significant, negative, and monotonically decreasing effect of distance for all schools, although the effect appears to be largest for charter schools. While the effect of bus eligibility is positive and significant, its impact is relatively small, increasing the likelihood of attending a zoned school by 0.8 percentage points (or 1.1 percent). Bus eligibility has a large impact for charter schools, ranging from 6 to 18 percentage points. For example, students are 2.8 percentage points less likely to choose a school 0.5–1 mile away if they are eligible for the bus, compared to 8.8 percentage points less likely if bus ineligible, which translates to a 68 percent decline in the effect of distance. The effect of the bus increases as schools move farther from home, reducing the negative distance effect for schools 1–1.5 mile away by 75 percent, and nearly canceling out the negative effect for schools farther than 1.5 miles. Finally, we find a positive and significant effect of buses for other zoned and non-zoned district schools, with relatively smaller effects for other zoned schools. Bus eligibility increases the likelihood of attending an other zoned (non-zoned) choice school by 1.1–1.7 (1.8–2.6) percentage points.

[20] We calculate these by dividing the marginal probabilities for Dist0.5_1*Bus and High-Quality school by the marginal probability for Dist0.5_1.

6.3. CL with embedded RD model

We now present results for the CLRD model. Unlike the simple RD model, we do not exclude any choices to maintain the full choice set. As before, we estimate effects for all schools and then by school type. The impact of bus eligibility is the coefficient estimate on bus interacted with school type and the 0.5 to 0.75 miles indicator. Results for the coefficients of interest are presented in Table 9.[21]

The first column of Table 9 presents results for all schools. Bus eligibility is positive and significant for schools 0.5–0.75 miles from home, and the bus increases the probability of enrolling in these schools by 1.4 percentage points (or 12 percent). Column 2 presents results by school type. The effect of bus eligibility at 0.5–0.75 miles is positive and significant for all 4 school types, ranging from 0.7 percentage points for other zoned schools to 4.9 percentage points for charter schools.

While the estimates from our CL model are not necessarily causal, embedding the RD in the CL model allows us to obtain credibly causal estimates of the effect of bus eligibility on school choice. Both models yield similar results. For all schools, the CL results suggest bus eligibility increases the probability of attending a school by 1.6 percentage points (or 13 percent), while the RDCL model estimates suggest buses increase this probability by 1.4 percentage points (or 12 percent). We see a similar pattern when exploring heterogeneous effects of the bus by school type.

7. Conclusion

The "promise" of school choice to improve academic outcomes has, to a large extent, not been fully realized. One explanation is that distance to school matters; travelling to a school farther away than the local zoned school outweighs the potential benefits of a better school. In this paper, we look at whether the availability of a school bus can switch the net benefits in favor of choosing a higher performing school that is farther away than the local zoned school. This adds to the relatively small literature on the link between school choice, distance to school, and pupil transportation.

We first estimate the causal impact of bus eligibility on school choice using a regression discontinuity (RD) model based on the bus eligibility distance cutoff. We note that this approach does not take the full school choice set into consideration and that leads us to model the school choice and transportation decisions using a conditional logit (CL) specification. While the CL model does take the full choice set into consideration, it does not provide causal estimates. We solve this problem by embedding the RD in the CL model (RDCL). We know of no previous paper that has specified and estimated such a model and we view this as an important contribution of our study. We estimate these models using a comprehensive dataset on students and their transportation choices in the New York City public school district for 2017. We focus on kindergarten as it is the first school choice decision for families.

To set up the CL model, we construct student choice sets, which is another important innovation of this paper. We define a unique choice set for each attendance zone which consists of all schools chosen by more than one student within a given attendance zone. Each student who resides in the attendance zone is assigned this choice set. These choice sets consist of, on average, 7.44 schools.

The results from the RD model show that bus eligibility has a positive and significant impact on school choice, increasing the likelihood of attending a school by approximately 30 percent. We find that the impact of living 0.95–1.0 miles from school relative to 0–0.10 miles from school for zoned (charter) schools is equivalent to being 0.24 (0.14) miles closer to school. Results from the CL model find distance has an increasingly negative impact on school choice and the effect of bus eligibility also increases with distance. Compared to a high-quality school, bus eligibility has twice as large an impact on reducing the negative distance

[21] The full set of results is available in Online Appendix Tables 10 and 11.

effect in the 0.5 to 1 mile range (27 versus 12 percent).

We now compare the impacts from the CLRD and RD models. For the full set of schools, we find significant and large impacts from the RD (3.8 ppt) and significant but smaller impacts when using CLRD (1.4 ppt). We find a significant and relatively large impact for charter schools when using the RD (3.0 ppt) and an even larger impact from CLRD (4.9 ppt). We find similar small results for other zoned choice schools (0.5 versus 0.7 ppt; RD results without school fixed effects) and slightly larger effects for non-zoned choice schools (0.8 versus 2.8 ppt).

Generally, the effects for the district choice schools are relatively small compared to those for zoned and charter schools. We believe that the circumstances that would lead a student to attend an other zoned district school or a non-zoned district school would tend to dominate and make the value of a bus in affecting this choice less important. For example, students may attend other zoned schools if their parents work nearby or if an older sibling attend this school (perhaps because the family moved after the older sibling began school). Non-zoned schools include magnet and other specialty schools where the characteristics of these schools may be relatively more important in determining school choice.

We see these results as providing relatively small ranges of the impacts of bus eligibility due to the different specifications of the two models; the RD model is limited to observations in the 0.25 to 0.75 mile range and includes school fixed effects whereas the CLRD model includes all observations and takes into account each student's choice set.[22] Overall, we find bus eligibility plays a significant role in school choice decisions and increases the likelihood of attending a school.

Thirty-five percent of traditional public schools – zoned schools, magnet schools, or specialty schools – do not offer the bus in NYC. Our results suggest that expanding access to school buses or relaxing the bus eligibility rules would induce more students to attend a school other than their zoned school – a charter school or another school in the district. Whether or not this would lead to better matches between students and schools or better outcomes for students is a matter for future studies.

Author statement

All authors have seen and approved the final version of the manuscript being submitted. The article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

Declaration of competing interest

The authors have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.regsciurbeco.2020.103607.

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[22] While it is theoretically possible to add school fixed effects to the CL model, this model fails to converge when we try to estimate it.