The Attraction of Magnet Schools: Evidence from Embedded Lotteries in School Assignment*

Umut Dur† Robert G. Hammond‡ Matthew A. Lenard§ Melinda Morrill¶
Thayer Morrill‖ Colleen Paeplow**

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Magnet schools provide innovative curricula designed to attract students from other schools within a school district, typically with the joint goals of diversifying enrollment and boosting achievement. Measuring the impact of attending a magnet school is challenging because students choose to apply and schools have priorities over types of students. Moreover, magnet schools may influence non-cognitive skill formation that is not well-reflected in test scores. This study estimates the causal impact of attending a magnet school on student outcomes by leveraging exogenous variation arising from tie breakers embedded in a centralized school assignment mechanism. Using a rich set of administrative data from a large school district, we find suggestive evidence that attending a magnet school led to higher performance in mathematics and non-language immersion magnet schools also increased students' reading scores. Student engagement was significantly higher, as measured through absenteeism and on-time progress rates. Further, students were significantly less likely to change schools when attending a magnet. These results provide robust evidence that magnet schools—a typically understudied school choice option—can benefit student learning and increase student engagement while enabling the system to achieve its goals of promoting racial and socioeconomic balance through school choice.

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†Department of Economics, North Carolina State University. Contact: udur@ncsu.edu

‡Department of Economics, Finance, and Legal Studies, University of Alabama. Contact: robert.hammond@cba.ua.edu.

§Harvard Graduate School of Education. Contact: mlenard@g.harvard.edu

¶Corresponding author. Department of Economics, North Carolina State University. Contact: melinda_morrill@ncsu.edu

‖Department of Economics, North Carolina State University. Contact: thayer_morrill@ncsu.edu

**Data, Research, and Accountability Department, Wake County Public School System. Contact: cpaeplow@wcpss.net

1 Introduction

Magnet schools represent an important, but understudied, form of school choice for school districts seeking to provide innovative instruction throughout an economically and racially diverse geographic area. These schools provide incentives such as enhanced curricula and specialized themes in order to attract (i.e., as a "magnet") parents and students.[1] Despite the large number of magnet schools and their celebrated history as a popular approach to desegregation, surprisingly little is known about the impact of magnet schools on human capital development. Magnet schools educate a similar number of students as charter schools, but research tends to focus on the effects of charter schools and voucher programs (e.g., Barrow and Rouse, 2009; Chabrier et al., 2016; Cohodes and Parham, 2021; Epple et al., 2016; Polikoff and Hardaway, 2017).

In this paper, we study the impacts of magnet schools in a large U.S. school system that enrolls a mix of base students and magnet students. Base students are drawn from the neighborhood attendance boundary, often from socioeconomically disadvantaged areas of the district. Magnet students apply for admission and are drawn from other parts of the district, often from socioeconomically advantaged areas. Both base and magnet students typically receive the same curricula in the same classrooms, which diversifies the student body at magnet schools relative to non-magnets. However, the costs associated with implementing magnet programs typically exceed those of non-magnets due to expenses related to transportation (Bifulco et al., 2009; Frankenberg et al., 2008), construction (Rossell, 1990), and programming.[2]

Identifying the causal effect of attending a magnet school on student performance is particularly challenging since base students assigned to magnet schools and magnet students interested in special curricular themes may differ in unobserved ways from their peers. Moreover, since the objective of a magnet program is to improve the racial and socioeconomic balance of student populations, school systems themselves set "priorities" over the types of students that will ultimately be admitted.[3] This introduces two types of selection: students choosing to attend alternative schools and schools

[1] See Rossell (1990) for more detail on the history of magnet schools.

[2] The federal Magnet Schools Assistance Program (MSAP) funds the establishment of new magnet schools and programs in districts that operate under court-ordered or federally approved voluntary desegregation plans. The program has made 111 awards since 2010 valued at $1.1 billion, or roughly $10.2 million each.

[3] For example, the Wake County Public School System, the context for our study, has four stated objectives for its magnet programs: (1) Reduce high concentrations of poverty; (2) Promote diverse populations; (3) Maximize the use of school facilities; and (4) Provide innovative and expanded educational opportunities.

choosing particular types of students from those who apply. We overcome these selection challenges by implementing a methodology introduced by Abdulkadiroğlu et al. (2017) for causal identification within centralized school assignment mechanisms. The approach applies when a school district uses a centralized, choice-based process for assigning students to schools. The inputs to a centralized assignment system are students' preferences over schools, schools' priorities over students, and schools' seat capacities. All of these features affect whether a student attends a school. However, a centralized assignment system maps its inputs into a probability of assignment due to lotteries used to deal with coarse priorities. The process introduced by Abdulkadiroğlu et al. (2017) utilizes the full extent of randomness embedded in a district's centralized assignment process to identify the probability of random assignment, conditional on the inputs to the assignment process. The conditional probability of random assignment is the propensity score and conditioning on this score eliminates selection bias.[4]

We implement Abdulkadiroğlu et al. (2017)'s approach to evaluate the impact of magnet schools in the Wake County Public School System (WCPSS, hereafter "Wake County"), which has one of the largest and oldest magnet programs among U.S. school systems. Wake County is the 14th largest school district in the nation and the largest in North Carolina with more than 160,000 students enrolled across roughly 190 schools in 2019 (Snyder et al., 2019). The district's magnet school program began shortly after the county and city school systems merged amid a flurry of court-ordered desegregation orders and local mobilization among education leaders. Since the establishment of Wake County's first magnet elementary school in 1978, the system has grown to include more than 40 magnets, which represent roughly a quarter of total schools in the district. Wake County is an advantageous setting in which to study magnet school impacts. First, the district's magnet school program is one of the largest in the nation, with the 12th largest number of magnet schools.[5] This feature permits us to explore magnet effect heterogeneity across a number of dimensions, including magnet school themes. Second, among large magnet districts, Wake County's magnet school enrollees represent a diverse cross section of students. Moreover, magnet enrollment in Wake County closely resembles national magnet enrollment across key demographic and socioeconomic

[4]Bergman (2018) uses this approach in his study of inter-district desegregation effects. Abdulkadiroğlu et al. (2018) combines this method with more traditional regression discontinuity design methods to study a full choice environment in New York City high schools.

[5]Public school and enrollment counts by school type (e.g., magnets and charters) are available through the National Center for Education Statistics' Elementary and Secondary Information System (ELSi).

groups.[6]

As is common in centralized assignment procedures, Wake County's schools have priorities over students that are coarse, which implies that many students have the same priority for assignment at a given school. To break ties, lotteries are embedded in the assignment process. Within the framework of Abdulkadiroğlu et al. (2017), we generate propensity scores that isolate exogenous variation from the lottery to provide causal estimates of the impact of magnet school attendance on a rich set of outcomes. We focus on kindergarten students who applied to the magnet school program for the 2015-16 (hereafter, 2016) school year and follow this cohort for four years into their third grade year. Kindergarten students are particularly interesting for several reasons. Kindergarteners are at the beginning of their compulsory schooling, so the "treatment" they receive by attending either a magnet or non-magnet school is cleanly identified without concerns regarding the type of feeder elementary school for middle schoolers, for example. Moreover, kindergarteners are at an especially important phase of their education where any benefits or harms may generate lifelong consequences.

This paper contributes to a growing literature leveraging random assignment to identify causal impacts of schools.[7] Much of this work utilizes lotteries at oversubscribed or open enrollment schools (e.g., Bui et al., 2014; Cullen et al., 2006; Engberg et al., 2014) and frequently uses exogenous variation from lotteries in charter school settings (e.g., Abdulkadiroğlu et al., 2011; Angrist et al., 2013, 2016).[8] Such schools run school-specific lotteries that are not necessarily part of a centralized assignment algorithm. Work closely related to ours, and set in Charlotte-Mecklenburg Schools, uses a first-choice instrumental variables strategy within a centralized school assignment algorithm (Deming, 2011; Deming et al., 2014). The Abdulkadiroğlu et al. (2017) methodology exploits the full extent of randomness in the assignment mechanism for causal identification. Thus, identification comes from assignment to schools that were not necessarily oversubscribed, as well as at schools that were not listed as first-choice preferences.

[6]Among school districts with more magnet schools than Wake County, only Florida's Hillsborough County Public Schools and the School District of Palm Beach County also closely resemble national enrollments across subgroups.

[7]For a few examples of papers that use lotteries to measure school effects, see Angrist et al. (2010, 2012); Clark et al. (2015); Curto and Fryer Jr (2014); Davis and Heller (2019); Dobbie and Fryer Jr (2011, 2015); Fryer Jr (2014); Kline and Walters (2016); Tuttle et al. (2015).

[8]In a related literature, several studies have used admission cut-offs for special schools to identify causal effects in a regression discontinuity design (RDD) framework (e.g., Abdulkadiroğlu et al., 2014; Dobbie and Fryer, 2014; Pop-Eleches and Urquiola, 2013; Jackson, 2010).

To preview our results, we find suggestive evidence that attending a magnet school improves performance in mathematics and reading achievement in second grade. These results are consistent with earlier work reporting cognitive returns to magnet enrollment (Betts, 2006; Bifulco et al., 2009; Engberg et al., 2014; Hastings et al., 2012). Results for third grade end-of-grade examinations are small and not statistically significant. We further measure the impact of magnet schools on non-cognitive skill formation and student engagement by using data on absenteeism, retention, and on-time progress. The student engagement outcomes capture aspects of human capital accumulation that influence students' longer-term performance in ways that are not well-measured by standardized tests alone (Jackson, 2018). We find that elementary school students enrolled in magnet schools had significantly lower rates of absenteeism and higher rates of on-time progress. Together, these results provide new estimates of the effects of magnet schools—an understudied school choice model—and provide robust evidence that they increase student engagement during the earliest stages of student human capital development.

This paper proceeds as follows. Section 2 describes magnet schools in more detail. Section 3 describes our data and analytic approach. Section 4 presents cognitive impacts, and Section 5 presents engagement and non-cognitive impacts. Section 6 explores both robustness and within sample heterogeneity. Section 7 concludes.

2 Background on Magnet Schools

The purpose of magnet schools is "to promote racial diversity and innovation, improve scholastic standards, and provide a range of curriculum options to satisfy parents' interests and priorities" (Smrekar and Goldring, 1999).[9] Magnets emerged in the wake of so-called voluntary desegregation orders that for the first time incentivized white students to transfer to predominantly black schools (Rossell, 1990).[10] Critics contend that selective magnet schools that admit students by merit over

[9] Definitions of magnet schools typically include some reference to racial balance, parental choice, academic advancement, and curriculum options. Magnet schools have also been defined as schools that "attract students of different racial/ethnic backgrounds or to provide an academic or social focus on a particular theme" (Grady et al., 2010) or "public schools which offer specialized subject themes or educational methodologies as a means of achieving desegregated student bodies" (Yu and Taylor, 1997).

[10] Magnets have been linked back to specialized school programs of the 1960s (e.g., Bronx High School of Science, Yu and Taylor (1997)). The term "magnet" originated in the 1970s when education stakeholders sought to design programs that would attract families and educators to a targeted region of a school system (Smrekar and Goldring, 1999). The court case *Morgan v. Kerrigan* ordered the Boston Public Schools to "assur[e] that no school is markedly worse than another by providing for the development of magnet programs, so that desegregation may as far as possible

lottery exacerbate academic, economic, and social differences among students. They also argue that there exists a large information gap between low-income and affluent families, and that the latter group can take advantage of school choice options in ways not available to the former group (Dur et al., 2018). Critics also argue that magnets receive a disproportionate share of resources that may otherwise be designated for chronically low-performing schools that are not well suited for magnet themes (Eaton and Crutcher, 1996; Moore and Davenport, 1988; Smrekar and Goldring, 1999).

Magnets are generally considered among other "alternative" school settings, such as charter schools, religious schools, and private schools. As shown in Figure 1, magnet student enrollment consistently exceeded that of public charter schools until 2014, when a growing enrollment gap began to emerge. The number of magnet schools roughly tripled during the two-decade period from 1999 to 2019, though charter school growth outpaced magnet school growth. In terms of market share, magnet schools represented 2 percent of total public schools in 2001, increasing to 3 percent by 2016. Over that same period, magnet school enrollment share increased from 3 percent to 5 percent. The growth seen in Figure 1 reflects not only absolute charter school growth, but also relative growth compared to magnets. Over the same time period, 2001-2016, charter school market share increased from 2 percent to 7 percent, while student enrollment correspondingly increased from 1 percent to 6 percent.

The costs associated with implementing magnet programs typically exceed those of non-magnets based on transportation (Bifulco et al., 2009; Frankenberg et al., 2008), construction (Rossell, 1990), and programing costs. To explore this, we reviewed awards granted through the federal Magnet Schools Assistance Program (MSAP) and estimate the MSAP-related magnet school costs based on their publicly available documentation.[11] Our setting, Wake County, received its most recent MSAP award in 2021, which provided \$3.5 million in the first year and \$14.1 million over the entire four-year grant period. This funding supported the establishment of new themes at two elementary and two middle schools. Thus, the per-school costs in the first year were \$875K and averaged a comparable amount annually over the next four implementation years. These estimates are in line with those provided by Rossell (1990) decades earlier and suggest that start-up and short-term implementation costs range from roughly \$500K-\$1 million in current dollars.

occur through voluntary choices." This case ushered in a wave of magnets across the country (Morgan v. Kerrigan, 1975).

[11]See https://msapcenter.ed.gov for more on awards granted and program information.

To attend a magnet school, students and their families use an application process to switch from one's assigned, "neighborhood" school that is based on school attendance boundaries. Proximate attendance boundaries may serve to minimize transportation costs and emphasize neighborhood schools, but many districts draw irregularly shaped attendance boundaries to achieve goals such as reducing socioeconomic isolation. Saporito and Sohoni (2006) find that when attendance zones were drawn to promote racial balance, there was some degree of district exit by white families, which increased segregation. In districts where magnet schools are present, there is evidence that they are effective in reducing racial isolation (Saporito and Sohoni, 2007; Sohoni and Saporito, 2009).[12]

To interpret magnet schools effects, it is important to distinguish between magnet school types. First, there is a difference between magnet "programs," which are initiatives *within* schools that impact select groups, and magnet "schools," which are *school-wide* magnet programs that include all students. Second, there is a difference between "traditional" and "destination" magnets (Betts et al., 2015). A traditional magnet is initially a low-performing school with a concentration of socioeconomically disadvantaged students; the magnet program is designed to attract socioeconomically advantaged students to promote socioeconomic balance. In contrast, a destination magnet is initially a high-performing school with a concentration of socioeconomically advantaged students; the magnet program is designed to attract students from other areas of the district, particularly students from low-performing schools with a concentration of socioeconomically disadvantaged students. The magnets we study are magnet *schools*—not programs within schools. Moreover, these magnet schools are a mix of traditional and destination magnets.

Table 1 illustrates the two types of magnet schools in Wake County and provides a comparison of average statistics for magnet and non-magnet schools. The largest distinction between traditional and destination magnets is the percent of the student body that have economic disadvantage status (EDS). About 62 percent of traditional magnet school students are economically disadvantaged, compared with only 33 percent of students attending destination magnet schools. The next rows of Table 1 show that both traditional and destination magnet schools receive additional resources relative to non-magnets. For magnet schools, there are more internet-connected computers per student,

[12] Irregularly shaped attendance zones are correlated with decreased income segregation (Saporito, 2017). Wake County is one of nine districts with less income segregation than their attendance zones would suggest and one of five with a difference greater than 2 standard deviations (Saporito, 2017). Richards (2014) finds that gerrymandered zones exacerbate racial segregation.

more teachers per student, and the average class size is slightly smaller. Teacher characteristics are similar between magnet and non-magnet schools, on average, with the exception that magnet schools attract less experienced teachers. Overall, these comparisons highlight that magnet schools are better resourced. But, a key advantage of our setting is that we are able to study two distinct types of magnet schools: those primarily focused on integration and serving a less advantaged population (traditional) versus those that serve a more advantaged population (destination).

3 Data and Methods

3.1 Study Setting: Wake County Public School System

The Wake County Public School System (WCPSS, hereafter "Wake County") was created in 1976 through the merger of the primarily socioeconomically advantaged Wake County school system with the primarily socioeconomically disadvantaged Raleigh City schools. Thus, it is a geographically large school district that encompasses the city of Raleigh and outlying suburban areas. The population is diverse in terms of race/ethnicity and socioeconomic status, resembling the nation along a number of key dimensions. Wake County is the largest school district in North Carolina and the 14th largest in the nation with more than 160,000 students enrolled across roughly 190 schools (Snyder et al., 2019). The first magnet school program in Wake County launched in 1978 and in 1982, the school board approved the district's first comprehensive "schools of choice" initiative that led to the designation of a number of new magnet schools. Through 2019, the district has established more than 40 magnet schools that serve more than 35,000 students. Our study includes 105 elementary schools in 2018, of which 26 were magnet schools.

In Wake County, magnet school assignment is partially choice-based. Most magnet schools were established in areas of the district with high concentrations of poverty or undersubscribed schools. The goal is to recruit children who are attracted to a magnet school by a special theme-based schooling option, such as a science, technology, engineering, and mathematics (STEM) or gifted and talented (GT) focus.[13] Magnet programs differ from charter schools in that about half of the student population is drawn from within the school attendance boundary (i.e., students who attend

[13] In terms of themes nationwide, science, technology, engineering, and mathematics (STEM) accounts for 30 percent of themes, followed by visual/performing arts (16 percent), International Baccalaureate (IB, 12 percent), gifted and talented (GT, 8 percent), and foreign/world languages (7 percent) (Nelson and Magnet Schools of America, 2018).

the magnet school as their base, or "neighborhood," school), while the remaining enrollees are drawn from different attendance zones.

All students are initially assigned to a base school within school attendance boundaries that link a student's residential address to a zoned school. Students who do not apply for a magnet school or an alternative calendar school (traditional versus year-round calendar) attend their default base school. Several of the authors of this paper worked with the district to redesign its centralized assignment process in 2015 and have administered the process since the 2015-16 cohort studied in this paper. The method uses the Deferred Acceptance algorithm (Gale and Shapley, 1962; Abdulkadiroğlu and Sönmez, 2003). Magnet seats are assigned (up to a school's capacity of magnet seats) using students' submitted lists of preferences over schools and schools' priorities over students. The construction of priorities in Wake County is based on the district's four pillars found in Board of Education Policy 6200: student achievement, stability ("stay where you start"), proximity, and operational efficiency.[14] The key feature of our approach that underlies the identification strategy is the embedded lottery used in assignment. In Wake County, the lottery is used in two distinct ways. First, a subset of seats, which we call lottery seats, are assigned solely based on students' lottery numbers. Second, lottery numbers break ties between students with the same priority for assignment. The same lottery draw is used for lottery seats and for lottery tie breaking. Further, students have the same lottery number at all magnet schools. A student is not shown her lottery number prior to applying or after assignments are released, which implies that a student's lottery number cannot affect her application behavior—only her assignment.

In the assignment, any siblings of a school's current students are guaranteed placement.[15] Then, 10 percent of the remaining seats are assigned as lottery seats (i.e., a pure lottery that is independent of a student's priority). Wake County introduced the 10 percent lottery to encourage more students to participate in the magnet application process, but it also provides additional variation that can be leveraged for causal inference.[16] The remaining 90 percent of seats are allocated according

[14]For the elementary schools that we study, priority is given based on sibling status, whether the students' catchment area (i.e., neighborhood) is high performing in terms of test scores during the last two years, and whether the students' zoned school is currently overcrowded.

[15]The *guaranteed* sibling priority refers to a set of siblings in which the older sibling will attend the school next year and the younger student applies for the entry grade (i.e., kindergarten, sixth, or ninth grade).

[16]Wake County policy dictates that non-priority students will not be assigned to a magnet seat (non-priority students are those who do not receive points from any priority class). As a result, some neighborhoods (i.e., those not in a high-performing area and whose base is not crowded) were excluded from the magnet process before the introduction of the 10 percent lottery.

to priorities. Because priority classes are coarse, magnet seat offers are made using tie breaking between students with the same priorities. This tie breaker uses the same lottery number as the 10 percent lottery. Therefore, conditioning on priorities allows identification to come directly from the lottery itself. Following Abdulkadiroğlu et al. (2017), we group students with equal *ex ante* priority, rather than simply controlling directly for preferences and priorities at each school. This provides a more powerful estimation strategy because we exploit the full extent of randomness in the assignment mechanism for causal identification. Further, our application of the Abdulkadiroğlu et al. (2017) methodology allows a straightforward extension to exploit the randomness from the lottery seats jointly with the randomness from lottery tie breaking.

Priorities are student-school specific and determine the order of consideration of each student's application at each school. Among students in a given priority class, assignment solely depends on the lottery. To group students with equal *ex ante* probability of receiving a magnet school assignment, we use a propensity score that is independent of the realization of the lottery at the time the assignment was made. These propensity scores are generated from one million iterations of the assignment algorithm with different lottery draws. This method identifies all students who are impacted by randomness, so that one student's probability of assignment can be affected by others' lottery draws. Further, assignment to undersubscribed schools also contributes to identification because tie breaking at a given oversubscribed school affects who is seated at other schools.

3.2 Econometric Strategy

Magnet school attendance is likely correlated with unobserved student characteristics that are also correlated with outcomes. The identification strategy, outlined in Abdulkadiroğlu et al. (2017), uses receiving a magnet school offer as an instrument for magnet school attendance conditioning on a propensity score. Receiving a magnet school offer is a function of a student's preferences over schools, her priority at each school, and a random lottery number. A propensity score is generated from one million iterations of the assignment algorithm with different lottery draws. The propensity score, therefore, mechanically accounts for how preferences and priorities affect the probability of receiving an offer to attend a magnet school. Thus, receiving an offer to attend a magnet school is a valid instrument for attending a magnet school when conditioning on propensity scores. By controlling for propensity scores, the magnet seat offer is itself exogenous to any action that a student might take to increase the probability of receiving an offer. Any unobserved differences between students in the probability of attendance are in the error term and, by construction, uncorrelated with the probability of receiving a magnet school offer.

The key equation of interest indicates the effect of magnet attendance on student outcomes. The equation takes the following form:

$$Y_i = \beta MagAttend_i + G(PS_i) + X_i\gamma + \epsilon_i. \tag{1}$$

Here, i indexes students, and $G(\cdot)$ is a flexible function of propensity scores. We include demographic characteristics, X_i, such as gender, race/ethnicity, and the presence of siblings (who also applied to attend a magnet school). A key concern is that attending a magnet school is correlated with the error term, ϵ. Receiving a magnet school offer is an instrumental variable that predicts magnet attendance in our first-stage equation:

$$MagAttend_i = \alpha MagOffer_i + G(PS_i) + X_i\sigma + \mu_i. \tag{2}$$

The effect of attending a magnet school is identified only off of compliers: those who attend a magnet school or not due to receiving an offer. Thus, students whose parents petition and ultimately enroll in a magnet school even when not receiving an offer (i.e., "always takers") and those that do not attend a magnet school even when offered (i.e., "never takers") do not bias the estimation of the local average treatment effect (LATE). These non-compliers simply reduce the statistical power of the estimation. In this setting, bias is only introduced if there are defiers: those who attend a magnet if not offered and do not attend if offered. The argument for the presence of defiers is if parents can successfully petition for admission to a magnet school if not offered a seat, but refuse to attend a magnet school if offered, which seems highly implausible.[17]

Our main specification uses propensity score fixed effects where the scores are rounded to

[17]The process for petitions is called transfer requests, and district officials state that there is no reason for a parent who did not receive an offer to have a more successful transfer request relative to a parent who received an offer. In auxiliary data on transfer requests and outcomes from the year of study (assignments for 2015-16), we estimate the determinants of transfer request success using similar controls as in our later regressions as well as an indicator for magnet applicants who were not offered a magnet seat and an indicator for those who were offered a magnet seat. Relative to non-magnet-applicants, unsuccessful magnet applicants are much less likely to be successful in their transfer request and successful magnet applicants are similarly likely to be successful in their transfer request. The "transfer success" point estimates are -27.7 percentage points for unsuccessful magnet applicants (p-value = 0.00) and 2.8 percentage points for successful magnet applicants (p-value = 0.50).

the nearest 10th decimal place, yielding 11 possible bins.[18] The propensity scores control for all aspects of priorities and preferences over magnet school offers that affect magnet school attendance. Including the propensity score controls ensures that magnet offers are a valid instrument for magnet attendance.

3.3 Magnet Offers and Enrollment Destinies

We focus on kindergarten students who applied to the magnet school program for the 2015-16 (hereafter, 2016) school year. To begin, we consider how the propensity scores and magnet offers predict magnet school attendance. Table 2 shows the *enrollment destinies* for magnet school applicants for the 2016 school year. The school enrollment information is from the 2016 school year when the students would be kindergarteners. Not all applicants ultimately attend a Wake County school in kindergarten, so there are more students in Table 2 than in our analysis sample. The first column presents statistics for the 1,347 magnet applicants, while Columns (2) and (3) include those offered a magnet seat (N= 657) and those not offered a magnet seat (N=690), respectively. On average, 54.3 percent of magnet applicants attend a magnet school in kindergarten. Receiving a magnet seat offer is associated with a higher rate of magnet attendance: 81.6 percent of those offered a seat attend a magnet school compared to only 28.4 percent of those not offered a seat. However, these statistics make clear that a "first stage" is necessary to account for the fact that many students are able to attend a magnet school even if not initially assigned.[19]

Next, we see that 18.6 percent of all magnet applicants do not ultimately matriculate to kindergarten in 2016. Parents may have moved out of the district or enrolled their child in a charter school, private, or home school. While 13.5 percent of those offered a seat attrit from the sample, nearly twice as many (23.5 percent) of those not offered a seat ultimately chose not to attend kindergarten in Wake County. We return to this issue later in Section 6.1, where we show in a regression framework that this difference is not statistically significant after conditioning on propensity scores. Further, we provide evidence that the results are robust to attrition corrections.

[18] The results are not sensitive to the choice of $G(PS_i)$. Estimates using alternative functional forms are presented in the Appendix.

[19] Most students in the non-offered group who attend a magnet school are admitted via the magnet application waitlist. Students may be assigned to a magnet school as their zoned school but apply to a different magnet school. It is also possible to petition to transfer or receive an administrative reassignment due to hardship or special requirements.

The penultimate row presents the mean propensity scores.[20] The average propensity score is substantially higher for those offered a seat, which highlights the importance of controlling for the propensity score in a regression framework. In sum, Table 2 highlights that receiving a magnet offer does lead to a higher probability of magnet attendance but is not perfectly correlated with magnet attendance. Further, those offered magnet seats are different from those not offered magnet seats such that controlling for the propensity score will be essential to recover unbiased estimates of the effects of magnet schools.

3.4 Summary Statistics

The baseline sample includes students who enrolled in kindergarten in AY2015-16 (2016). Table 3 presents summary statistics. The first column includes all Wake County kindergarten students. Column (2) includes the subset of students who applied to attend a magnet school when matriculating to kindergarten in Fall 2016. Columns (3) and (4) separate the analysis sample into students who attended a magnet school in 2016 and students who attended a non-magnet school in Wake County that same year. About 19 percent of all Wake County kindergarteners attend a magnet school, and 67 percent of magnet applicants attend a magnet school. In the second row of Table 3, Column (2), 51.8 percent of magnet applicants are offered a seat at a magnet school for the 2016 school year. Interestingly, only 73.2 percent of magnet applicants attending a magnet school were originally offered a seat, while 8.8 percent of those not initially offered a seat ultimately attend a magnet school.

Our identification strategy relies on the offer instrument resulting in magnet school attendance. If the assignment does not always translate into attendance, that weakens the first stage. As described in more detail above, the propensity score is the conditional probability of random assignment. As anticipated, students attending a magnet school have, on average, a higher propensity score than those not attending. All regressions control for these propensity scores.

Table 3 next presents the student demographic characteristics observed in the administrative data.[21] Demographics such as gender and race/ethnicity are important controls in our analysis, but

[20] In our sample, 48.8 percent of students received a magnet offer (i.e., 657 out of 1,347 applicants). The average propensity score is identical to the percent receiving an offer. This is true by construction of the propensity scores. In particular, we repeatedly run the assignment procedure with different lottery draws and calculate the propensity score as the percent of draws in which the student is assigned to any magnet school across all lottery draws.

[21] Appendix Table A2 presents further evidence supporting identification. The estimates are generated by regressing

these characteristics do not directly affect magnet priorities. In the raw means, slightly fewer boys are magnet applicants and magnet attendees than girls. Magnet applicants are more likely to be white, but the racial/ethnic differences in magnet attendance are not large. In Wake County, students are assigned a catchment area, based on residential address, that determines their base school assignment. Students whose base school is high performing receive higher priority in the assignment process. We include an indicator for whether a student's catchment area is associated with a high performing school, which is only available to us for students who applied to a magnet school. Students from high-performing catchments are more likely to attend magnet schools, reflecting their higher priority in the assignment process. The magnet assignment process allows us to impute sibling information for students who apply. *Has sibling* identifies whether another magnet applicant lives at the same residential address. We cannot determine if these students are, in fact, siblings, but they are treated as such in the assignment algorithm. *Twin* is an indicator for having another same-grade applicant in the household. This twin indicator represents a proxy for actual twins and is not restricted to include only those of the same age or having the same parents.[22]

3.5 Compliance Probabilities

The results in Table 2 illustrate clearly that magnet school offers are not binding, thus we should not anticipate that the first-stage coefficient is near one. As described in Section 3.2, identification is derived from the group of compliers: students who attend a magnet if they receive an offer and do not attend if they do not receive an offer. We follow the method introduced by Abadie (2002, 2003) to characterize the population of compliers.[23] Since only one state of the world is realized, we cannot explicitly identify compliers within the data. The Abadie method recognizes that the population of magnet attendees is composed of both always-takers (those who attend irrespective of offer) and treated compliers, while the population of non-magnet attendees is composed of never-takers (those who do not attend irrespective of offer) and control compliers.

To better understanding identification, Table 4 presents the probability of compliance. The first four columns report the sample size, probability of attending a magnet (i.e., $D = 1$), the first

each covariate on receiving an offer, conditioning on propensity score. Although the racial/ethnic groups Black and other are individually marginally significant, the joint p-value is 0.236, indicating satisfactory covariate balance.

[22]According to the CDC, about one in thirty infants born in 2009 was a twin: https://www.cdc.gov/nchs/data/databriefs/db80.pdf, [accessed April 2020].

[23]See Angrist et al. (2016) for a detailed description of how to apply the method to determine complier distributions.

stage estimate, and the probability of receiving a magnet offer (i.e., $Z = 1$), respectively. Column (5) presents the probability of being a complier for the treatment group, while Column (6) is the probability for the control group. The first row indicates that for the full sample of 942 students, 67.5 percent attend a magnet school and 39.2 percent receive a magnet offer. The first stage estimate implies that receiving a magnet school offer increases the probability of attending a magnet school by 39.2 percentage points. Using these estimates, Column (5) indicates that the probability of being a complier amongst magnet attendees is 30.3 percent, while the probability of being a complier amongst non-attendees is 57.8 percent. This is consistent with many students ultimately enrolling in magnet schools from the waitlist, so that the group of non-attendees is more compliant with the instrument.

The other rows in Table 4 show compliance probabilities across the propensity score distribution, using the same bins as used in our propensity score controls (i.e., bin width of 0.10 with finer detail near 0 and 1). The propensity score is the conditional probability of random assignment, which is the link between the propensity score and the mechanics of identification. In the lowest propensity score bin, 83 students have propensity scores of 0 while 220 have propensity scores strictly between 0 and 0.05. Among these students with a very low conditional probability of random assignment, the group of magnet attendees is composed almost entirely of "always takers," with only 6.4 percent of that sample being compliers. Most non-magnet attendees are compliers and very few are "never takers." At the other extreme, 410 students have propensity scores of exactly 1 while 17 have propensity scores strictly between 0.95 and 1. Table 4 shows that these students with the highest probability of receiving an offer do not contribute to identification because all received an offer in the actual assignment. In the interior of the propensity score distribution, no students had propensity scores in some bins (0.45-0.55 or 0.85-0.95), and other bins contain only a small number of students. As such, we group together all students with propensity scores between 0.05 and 0.95 in the final row of Table 4. For these students, the probability of compliance is 12.9 percent among magnet attendees and 60.9 percent among non-attendees. Thus, most attendees with intermediate propensity scores are "always takers" but there is still a meaningful fraction of compliers, while non-attendees with intermediate propensity scores are relatively evenly split between compliers and "never takers." Overall, identification is not concentrated on a small subset of students but comes from all but the students with the very highest probability of assignment.[24]

3.6 Test Score Measures

All Wake County third graders complete standardized end-of-grade (EOG) exams in both reading and mathematics. These exams are "high stakes" in that low performance on the reading EOG can result in summer school remediation or retention, while both tests contribute to teacher- and school-level accountability. Second grade students, on the other hand, do not take standardized EOG exams, but instead take shorter mathematics and reading assessment three times annually. The purpose of these exams is to provide teachers with updates throughout the school year, which they use to inform instruction. For this study, we focus on two of these "lower stake" exams, which are typically given in May or June of second grade, and use the end-of-year (EOY) administration as an outcome measure.

The first second grade measure, the Number Knowledge Test (NKT), is a screening assessment for early elementary mathematics progress and is designed to measure conceptual knowledge of numbers. The raw test score ranges from 1 to 30 and represents grade-level equivalents for pre-school through fifth grade.[25] The examination is used as a screening tool to identify students who might require remediation in the future. Thus, we consider whether the student is identified as scoring "proficient," meaning they are not identified as requiring specific intervention.

The second measure, Text Reading Comprehension (TRC), is a designed to measure early literacy skills—specifically fluency, accuracy, and comprehension. Wake County has long used normed literacy probes in elementary school to screen students for reading difficulties.[26] The scores for the TRC represent reading levels ranging from A to Z+ (our sample includes levels B through U).[27] The TRC assessment recommends using the "far below proficient" threshold to identify

[24]Appendix Table A4 presents the main estimates on a sample that excludes students with propensity scores of exactly 0 or 1, and the results are robust to this restriction.

[25]See https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/school/explore/sites/number-worlds/number-worlds-number-knowledge-test.pdf, [accessed January 2020]. The NKT has been found to have strong predictive validity for the nationally-normed Stanford Achievement Test (9th edition) and select subtests, with correlations ranging from 0.64 to 0.73 (Baker et al., 2002; Gersten et al., 2005).

[26]The district used DIBELS 6th Edition prior to passage of the state's Read to Achieve (RtA) legislation, and DIBELS NEXT and TRC afterwards. RtA required students to demonstrate grade-level reading mastery by the end of third grade or risk retention. To monitor student progress toward this goal, the district required the use of DIBELS and TRC in grades K-3 and offer it as a mainly optional assessment in grades 4-5.

[27]Using the Fountas and Pinnell published literacy-level equivalent chart to convert the scale to grade-level goal equivalence, the mean reading level in our data is 2.6 by the end of second grade (Fountas et al., 2001; Fountas and Pinnell, 2017).

students who may require intervention, so we parameterize reading proficiency as not "well below" the proficient level.[28]

4 Results: Test Scores

4.1 Test Score Results

The main results are presented in Table 5. Panel A presents estimates for math and reading derived from the NKT and TRC, respectively. Panel B presents estimates from the third grade EOG as a standardized score with mean zero and unit standard deviation. Each panel is restricted to students with on-time grade progression and valid scores who applied to a magnet school for kindergarten in the 2016 school year. As described in Section 3.4, all regressions include controls for gender, race/ethnicity, residing in a high-performing catchment area, and presence of siblings. Propensity scores are rounded to the nearest 10th decimal place. Standard errors are clustered by school. The first column of Table 5 reports the first-stage estimate of how receiving an offer of a magnet school seat affects magnet school attendance in second and third grade (i.e., the 2018 and 2019 school years, respectively). Receiving a magnet school offer raises the probability of attending a magnet school by 34.7 (35.2) percentage points in second (third) grade.

Section 3.6 provides background and definitions of our test score measures. Columns (2) and (4) present the OLS estimates of magnet attendance on mathematics and reading, respectively. Columns (3) and (5) presents the IV estimates that use the magnet offer as an instrument for magnet attendance and include propensity score controls. All specifications include controls for demographics. Column (3) shows that magnet school attendance leads to a 28.0 percentage point higher probability of being proficient in mathematics. The point estimate is similar for reading but not statistically significant. Panel B shows a similar pattern for students who are on-time to third grade, but no test score effects are statistically significant.

Appendix Tables A3 and A4 presents a host of further robustness check. In the former, we see that the results are robust to adding a control for the length of magnet applicants' rank ordered list and to excluding the demographic controls.[29] For a subset of students, Kindergarten beginning of

[28] Figlio and Hart (2014) and Dhuey et al. (2019) operationalize scores on the comparable DIBELS assessment as a dichotomous readiness indicator in a similar fashion.

[29] Applicants may submit a list of ranked preferences over schools that includes between one and five schools.

year (BOY) mathematics and reading proficiency are recorded. When restricting to this smaller sample, the estimates are somewhat diminished, but including controls for math and reading proficiency do not qualitatively change the estimates. Interestingly, these estimates suggest that mathematics proficiency predicts later success better than reading proficiency, although this may be simply due to the quality of the exam rather than the underlying cognitive differences. In Appendix Table A4, results are not sensitive to alternative functional forms for $G(PS_i)$, restricting the sample to students with propensity scores strictly between 0 and 1, or to excluding base magnet students who applied to other magnet schools. The table also presents alternative estimates that use the *first choice lottery* instrument, as described in Appendix Section A.2. This approach finds similar benefits of magnet attendance, despite having a different complier population.

4.2 Magnet School Themes

By design, magnet schools differ from non-magnets because magnets have special curricular themes. However, magnet schools also differ by base student population, capacity, location, and myriad other characteristics. Thus, when analyzing subsets of magnet schools, we must recognize that many school attributes are correlated and may differentially impact student performance. Still, it is worthwhile to consider several distinctions among magnet schools.

First, we consider the classification of Betts et al. (2015) that separates "traditional" and "destination" magnet schools, which we discuss in detail in Section 2. Traditional magnets have a base student population with a larger number of students qualifying for free and reduced price lunch (FRPL), while traditional magnets receive additional resources that may be directed toward improving student outcomes relative to non-magnet schools. Destination magnets also receive additional resources but typically have fewer disadvantaged students in the base student population. The distinction is important because Betts et al. (2015) present descriptive evidence suggesting that traditional magnets tended to outperform destination magnets. To explore whether variation in magnet school effects along this dimension, we use Wake County's magnet group classification that

Applicants who submit a longer rank ordered list may differ from other applicants in terms of strategic sophistication or in terms of preferences for magnet schools relative to their base school. As such, we do not include length of rank ordered list in our main specification. However since propensity scores control for any endogenous differences among applicants, we can ensure the robustness to including length of rank ordered list as an additional control. The results are robust, which is consistent with the propensity score capturing all relevant aspects of preferences and priorities.

defines destination magnets as “Group 2” or “Group 2A.”[30]

Tables 6 and 7 present results disaggregated by magnet type. Following Abdulkadiroğlu et al. (2017), we define two instruments (an offer at a traditional and an offer at a destination magnet), two endogenous variables (attendance at a traditional and attendance at a destination magnet), and two sets of propensity scores. Like Abdulkadiroğlu et al. (2017), we include the propensity scores separately for each magnet type and do not interact them. Table 6 presents separate first-stage regressions in Columns (1) and (2), with the instrumental variables estimates in columns (3) and (4) for mathematics and reading, respectively.

While we find no statistically significant effects on third grade EOG test scores, the estimates for second grade test scores are statistically significantly larger for traditional magnet schools. Attendance at a traditional magnet yields a statistically significantly higher probability of scoring above the threshold in second grade for both subjects. Relative to destination magnets, assignment priorities at traditional magnets typically are more focused on socioeconomic balance. These results, therefore, may be due either to heterogeneity by school or by the student population served. These results indicate that at least some of the benefit of magnet attendance derives from the additional resources and alternative programming provided at these schools. Further, the results imply that the focus on socioeconomic balance with traditional magnets does not undermine these benefits. In contrast, it suggests that some part of the benefits to students in terms of test score gains may be coming from the integrative role that magnet schools play in their aim to reduce racial segregation.

Three elementary schools in Wake County provide language immersion programs.[31] While students attending these programs may have delayed English language skill development, we anticipate gains along other dimensions. To observe whether the English language test scores are improved for non-language immersion programs, we estimate the model again with separate variables by language immersion status. Table 7 shows that language immersion programs have similar gains in mathematics performance in second grade. But, for reading, language immersion programs cause a large and statistically significant lower probability of scoring above the threshold level in reading

[30]However, base student population demographics change over time, so this classification may not perfectly capture the contemporaneous characteristics of the base population.

[31]Hodge Road Elementary and Jeffreys Grove Elementary are Spanish dual language immersion programs, while Stough Elementary is a Mandarin-Chinese immersion program. Another magnet school, Joyner Elementary, also has a theme that includes a language focus, but it offers language instruction (Spanish, in particular) for 45 minutes a day, while the immersion programs we study offer language instruction for approximately 80 percent of the academic day.

in second grade. At the same time, we now find a larger and more significant effect of non-immersion magnet attendance on reading performance. This suggests that the reduced statistical power we see in the main reading results in second grade, relative to the mathematics results, may be due to heterogeneity in the impact by magnet theme.[32]

5 Results: Student Engagement and Non-Cognitive Outcomes

It is perhaps not surprising that magnet schools yield only marginal gains on test scores, as their primary objective is integration and expanded educational opportunities. Therefore, we next turn to other measures of student success and student engagement. A recent literature has established an important role for student engagement measures in predicting longer-term success of students (see, e.g., Jackson, 2018). The aims of magnet schools include providing enhanced curriculum that might challenge and ultimately benefit students in ways that are not well-measured by the test score measures analyzed above. Indeed, we predict that magnet schools might improve students' longer-term outcomes by increasing student engagement and improving non-cognitive skills such as executive function and perseverance (e.g., grit). To provide evidence on this, Table 8 presents IV estimates of the effect of magnet attendance on our key non-cognitive outcome: absences over 2016-2019 as a function of magnet attendance in 2019. Column (1) reports the first stage for this sample, which is slightly larger because it no longer requires students to have valid exam scores. The sample is still restricted to include only those continuously enrolled in a Wake County school for all four years. In Columns (2) and (3), the dependent variable is the total number of absences experienced during the first four years of elementary school, with Column (2) estimated as a linear model and Column (3) estimated as a Poisson model. Column (4) estimates the model on the log of total absences plus one.[33] The estimates in Columns (2) and (3) suggest that magnet school attendance reduces absences by about 16-17 days, which is about 65 percent of the sample mean of 26.0 days. When considering the log, we find that magnet attendance reduces absences by about 64

[32]Bibler (2021) estimates the impact of attending language immersion magnet schools in the Charlotte-Mecklenburg School District on performance on third through eighth grade EOG's. That study finds benefits for both dual language and non-dual language students. It may be that elementary school students initially lag in reading through second grade, but then improve and exceed non-magnet students in later grades.

[33]A Poisson model of total absences and a model of the log of total absences plus one are alternative ways to handle the distribution of count data variables such as absences. Coefficients estimated using Poisson are interpreted in levels, while those estimated using log absences are interpreted in percentage terms. Estimates from an inverse hyperbolic sine transformation are quite similar.

percent.

The final two columns of Table 8 present estimates for dichotomous indicators of chronic absenteeism. Wake County highlights students with 3 unexcused absences in a given year as "chronically" absent, while students with more than 20 unexcused absences in a given year are termed "excessively" absent. Our data do not allow us to distinguish excused and unexcused absences. Aggregating over the four years, Column (5) presents estimates for a dichotomous indicator of being absent more than 12 days over the course of the first four years of elementary school (mean is 83.6 percent), while Column (6) presents estimates for more than 80 days total (mean is 1.2 percent). The impact of magnet attendance on missing more than 12 days is not statistically significant, but magnet attendance substantially reduces the probability of being "excessively" absent. The results in Table 8 are important as they indicate magnet schools are significantly improving student engagement, even among students motivated to apply for magnet schools.

Table 9 presents an analysis of on-time progress through elementary school to ask if magnet schools enhance student engagement and facilitate timely grade completion. For this exercise, the key explanatory variable is magnet attendance in kindergarten in 2016. The first column presents the first stage for this expanded sample: the effect of receiving a magnet offer on attending a magnet school as a kindergartener in 2016, controlling for demographics and propensity scores.

While switching schools may be a disruptive event for many students, they may do so for a variety of reasons. The family may have moved within district, may have reapplied to the magnet program, or petitioned for a transfer. Table 9, Column (2), considers whether students switch schools between kindergarten and third grade as a function of magnet attendance in kindergarten. About 17.7 percent of all students switch schools between kindergarten and third grade, and magnet attendance in kindergarten lowers the probability of switching schools by 54.9 percentage points. Thus, students who initially enroll in magnets are significantly less likely to switch schools, indicating that parents and students have a revealed preference for attending a magnet school. The sample is students who applied to attend a magnet school in kindergarten, so it might not be surprising that they demonstrate a strong preference for attending a magnet school. Recall that our IV strategy implies that the effect of magnet school attendance in 2019 is estimated only off of "compliers": those who attend a magnet school in 2019 or not based on receiving a magnet seat offer in 2016. Thus, switching schools will not bias the estimates but will only weaken the first stage.

Column (3) presents estimates of attending a magnet school in kindergarten on attriting any time between kindergarten and third grade. Note that students not attending kindergarten in Wake County are not in the sample. Attending a magnet school in kindergarten due to receiving a magnet offer yields a large and statistically significant lower probability of leaving Wake County schools between kindergarten and third grade. Column (4) similarly considers the probability of progressing "on-time" to third grade, defined as having a valid third grade test score in 2019 and being continuously enrolled in the school system between 2016 and 2019. Thus, this includes both attrition and retention effects. Magnet attendance led to a 27.0 percentage point increase in on-time progress to third grade, which is roughly 33 percent of the sample mean. Magnet schools are clearly impacting students' engagement and development along important non-cognitive dimensions, such as preventing marginal students from falling behind. Moreover, the retention of marginal students implies that in the absence of improved learning, test scores would be predicted to fall as marginal students are included in the data when they otherwise would be omitted. As a result, the test score gains we observe may be an underestimate of the true benefit of magnet schools.

6 Heterogeneity and Robustness

6.1 Bounding for Attrition

Table 2 showed that the probability of not attending any Wake County school is higher for those who do not receive a magnet offer relative to those who did. Those receiving a magnet offer are different in observed and unobserved ways relative to those not receiving an offer, which is exactly why our use of the Abdulkadiroğlu et al. (2017) methodology is an important contribution in studying magnet schools. However, this also implies that differential attrition by magnet offer status could threaten internal validity. Students who exit the district may be positively selected, for example, if parental engagement is correlated both with student performance and with the decision to seek enrollment in schools other than traditional public schools. Positive selection implies that differential attrition will bias our results away from zero because more students with highly engaged parents have exited the district from our sample of non-magnet students.

However, other types of selection might operate in the opposite direction. First, if magnet schools improve on-time progress and the analysis of test scores relies on the sample of on-time progressing students, then we have negative selection in our sample of non-magnet students because it includes more marginal students who, without the benefits of magnet schools, would have underperformed, on average. This would bias our results towards zero. In Section 5, we show some evidence of this latter type of selection, whereby magnet attendance led to higher rates of on-time progress. Appendix Table A5 presents an analysis of attrition as a function of receiving a magnet offer, with and without propensity score controls, for kindergarteners and for third graders, conditional on kindergarten attendance. Without propensity scores, the probability of attriting is significantly lower for those receiving a magnet school offer, but that relationship is small and statistically insignificant once propensity scores are included. The propensity scores control for all characteristics of students (student preferences and school priorities) that are correlated with receiving a magnet offer. Even with propensity score controls, the estimates in Appendix Table A5, Column (4) indicate that, conditional on attending kindergarten, students are less likely to attrit between kindergarten and third grade if receiving a magnet school offer. This result parallels the IV estimates for the causal effect of magnet attendance on on-time progress to third grade, presented in Table 9. Together, the estimates in Appendix Table A5 illustrate that negative, not positive, attrition is the predominant problem. Negative attrition would lead us to understate any beneficial effects of magnet schools.

To explore the affects on the test score estimates, we present a simplified version of "bounding" described in Horowitz and Manski (2000).[34] We cannot estimate an instrumental variables model in this case, because magnet attendance is not observed for students who have attrited from the sample. Therefore, in Table 10 we present estimates from a version of Equation (1), the "reduced form" specification, which estimates the effect of being offered a magnet seat on mathematics and reading performance. This model also does not include gender, race/ethnicity, high-performing catchment, or sibling controls, which are not observed for students who do not ultimately enroll in a Wake County school. The standard errors are robust, but cannot be clustered as school attended is not observed for attrited students. Consistent with the main estimates described above, being offered a magnet seat leads to a non-significant 7.7 percentage point higher probability of mathematics proficiency and 6.6 percentage point higher probability of reading proficiency in the reduced form.

[34]Note that attrition is not monotonically related to the propensity score, so application of a structural trimming procedure is not ideal in this setting (Horowitz and Manski, 2000). For example, one could potentially tighten the confidence intervals using additional assumptions, as described in Lee (2009) and employed by Engberg et al. (2014) and Abdulkadiroğlu et al. (2018). Because our treatment and second grade test score outcomes are dichotomous, we instead employ a simple bounding procedure that does not impose distributional assumptions.

The estimates remain small and not statistically significant for third grade mathematics and reading standardized EOG's.

First, we simply assume that all students who attrited (i.e., did not have valid on-time test scores) are positively selected. For second grade proficiency outcomes, this is operationalized by imputing values of one where test scores are missing. For third grade EOG, we impute the 90th percentile scores. This represents the case that students solely exit Wake County because of better outside options. If this is more likely for students who do not receive a magnet offer, then our estimated effect of magnet offer will fall when we impute high performance for attriters. This exercise yields estimates presented in Panel B of Table 10. Under this extreme positive selection assumption, the estimated effect sizes are diminished, but the estimate for second grade mathematics is now statistically significant. Interestingly, the point estimate for mathematics 3rd grade EOG is now negative and statistically significant. Panel B is consistent with positive attrition biasing estimates upward, but the estimates for second grade mathematics are still positive and statistically significant.

Alternatively, Panel C presents estimates that assume all of those who attrit were negatively selected and would have scored below the threshold or at the 10th percentile. This would represent the other extreme case where attrition is solely due to negative performance. In this case, if magnet schools help to retain the weakest students, then our estimates of magnet school effects are biased towards zero. Indeed, for second grade mathematics, the point estimate is slightly larger and still statistically significant. We do not detect any significant effects for second grade reading or either mathematics or reading third grade EOG.

Overall, the estimates do not provide clear bounds. Rather, these results suggest both positive and negative selection may be occurring. The key conclusion is that differential attrition does not invalidate our main results that magnet schools yield higher mathematics performance when measured in second grade.[35]

As a final exercise, we employ a method in the spirit of Krueger (1999) whereby students who attrit are assigned their most recent prior test score achievement level. Our data include NKT and TRC test scores for prior years, although the coverage is not complete even for those students who

[35] An alternative exercise would be to impute "worst case" scenario whereby the attrition is negative for those who are offered a magnet seat and positive for those not offered a magnet seat, while the "best case" scenario assumes the converse. These bounds are too large to be meaningful.

attend regularly. We continue to use the dichotomous classification of being above or below the threshold for remediation at the appropriate grade and time of year level. In practice, this means that we impute "well-below" or not in an iterative fashion using the following decision rule: use the first grade end-of-year exam, if available; if not then use the kindergarten end-of-year exam, if available; and, if not, use the kindergarten beginning-of-year exam, if available. This yields a more complete sample, but does not account for the attrition that occurs prior to the beginning of kindergarten. For the third grade EOG exams, there is no prior percentile rank that can be used. Panel D of Table 10 presents estimates on the sample of students who have at least one non-missing NKT or TRC score, respectively. The point estimates are similar to the main estimation results, and the point estimate for second grade reading is now marginally statistically significant.

6.2 Heterogeneity by Student Demographics

To get a more complete picture of the impact of magnet schools, we explore heterogeneity by student characteristics. While understanding which students benefit most from magnet attendance is a key policy concern, we are somewhat limited in our ability to answer with an identification strategy that estimates off of compliers. We obtain causal estimates with exogenous variation using compliers, but this reduces the statistical power to identify heterogeneity in subgroups of students. In other words, comparisons across subgroups are influenced both by heterogeneity in the effect of magnet schools and by the first stage of how a magnet offer predicts magnet attendance. Table 11 presents the first-stage estimates for the third graders in Column (1). Second grade mathematics and reading proficiency are presented in Columns (2) and (3), while third grade standardized EOG's are in Columns (4) and (5). Absenteeism rates in Column (6) parallel Table 8, Column (3) and are estimated using a Poisson model. Column (7) presents estimates for having on-time, valid third grade test scores.

It is instructive to consider whether any groups especially benefit from magnet schools, particularly in the context of magnet school priorities. Estimates are reported separately for non-Hispanic Black and non-Hispanic White students and for students from a low performing or high-performing catchment.[36] Note that the sample size is not sufficient to estimate on other racial or ethnic groups separately. When comparing Black and White students, we find that the effects are concentrated on

[36]Note that when disaggregating by gender, boys and girls experience similar benefits from magnet school attendance.

the former, despite having a smaller first stage.

The district sets priorities to attract high performing students to attend magnet schools because these students strengthen these formerly struggling schools and promote racial and socioeconomic balance. If certain groups of students are most likely to benefit from magnet school attendance, priorities can be updated accordingly. In the district's current priorities, one component of priorities is the recent (i.e., past two years) test score performance of past students in a catchment area (i.e., neighborhood). Students who live in a high-performing catchment area (i.e., top tercile) have higher priority for magnet schools that have high concentrations of minorities in their base populations. The bottom panel of Table 11 explores heterogeneity in terms of catchment performance. Students who live in low-performing catchment areas appear to benefit much more from magnet attendance, while for students from high-performing catchments, we fail to find a benefit in terms of test scores, absenteeism, or on-time progress. Note, again, that magnet priorities are set to achieve the goals of integration. These estimates suggest that benefits to application students are largest among Black students and those from low-performing catchments, but also we do not detect any test score declines or worse student engagement for the students who are White or who are from a high-performing catchment area.

7 Conclusion

Magnet schools are typically designed to "attract" suburban students (who are traditionally more likely to be socioeconomically advantaged) to apply to attend a school in an inner-city location (in traditionally socioeconomically disadvantaged parts of the district). Magnet schools are pervasive. They are also widely celebrated for curricular innovations and promotion of socioeconomic balance. The related literature has largely focused on schools with a very different set of features, such as charter schools that do not typically aim to achieve socioeconomic balance (e.g., Cohodes and Parham, 2021; Epple et al., 2016); academically selective schools like the exam schools in Boston and New York City (Abdulkadiroğlu et al., 2014; Dobbie and Fryer, 2014); or voucher programs that financially incentivize families to enroll in private schools (e.g., Barrow and Rouse, 2009; Figlio and Hart, 2014; Ladd, 2002; Rouse, 1998).

Estimating the effects of magnet schools is challenging since students must actively choose to apply, and thus likely differ in unobservable ways from their non-magnet peers. Further, students' magnet admission probability is a function of student characteristics. We overcome these challenges by applying the innovative methodological approach outlined in Abdulkadiroğlu et al. (2017) to provide causal estimates of magnets on important measures of human capital development. This method uses the magnet offer as an instrument for attendance, conditioning on a propensity score which accounts for how student preferences and system priorities affect the probability of receiving an offer. This approach provides robust identification by ensuring that unobserved factors in the residual are uncorrelated with the probability of receiving a magnet school offer.

Our results fill an important gap in the school choice literature alongside examinations of charter schools, exam schools, and vouchers. Magnet schools represent an important contributor to education equity efforts. Thus, understanding the causal effects of magnet schools is important as school districts struggle to reconcile stakeholder preferences amid creeping resegregation (Billings et al., 2014; Clotfelter et al., 2021; Reardon et al., 2012; Weinstein, 2016). While there is only weak evidence of test score gains, there is robust evidence that magnet schools significantly increase student engagement. Magnet school attendance reduces absenteeism rates and increases on-time progress through the early elementary grades. Heterogeneous effects show that achievement effects accrue in large part to Black students and that there are important differences across magnet school types.

Our findings are consistent with previous work finding larger impacts from "traditional" versus "destination" magnet school types (Betts et al., 2015). Traditional magnets typically have a higher proportion of students from low-income or minority households in their school attendance boundary, and incoming magnet students typically serve to reduce racial isolation. Destination magnets typically do not have this feature and instead serve to provide enhanced choice options within the district. Wake County has both types of magnets, which allows us to observe whether magnet school effects are driven by traditional or destination magnets. We find that the benefits are larger for traditional magnet schools. This suggests that traditional magnet schools raise test scores in addition to promoting racial and socioeconomic balance—implications that have particular policy relevance for districts considering the conversion of traditional schools or implementation of new magnets.

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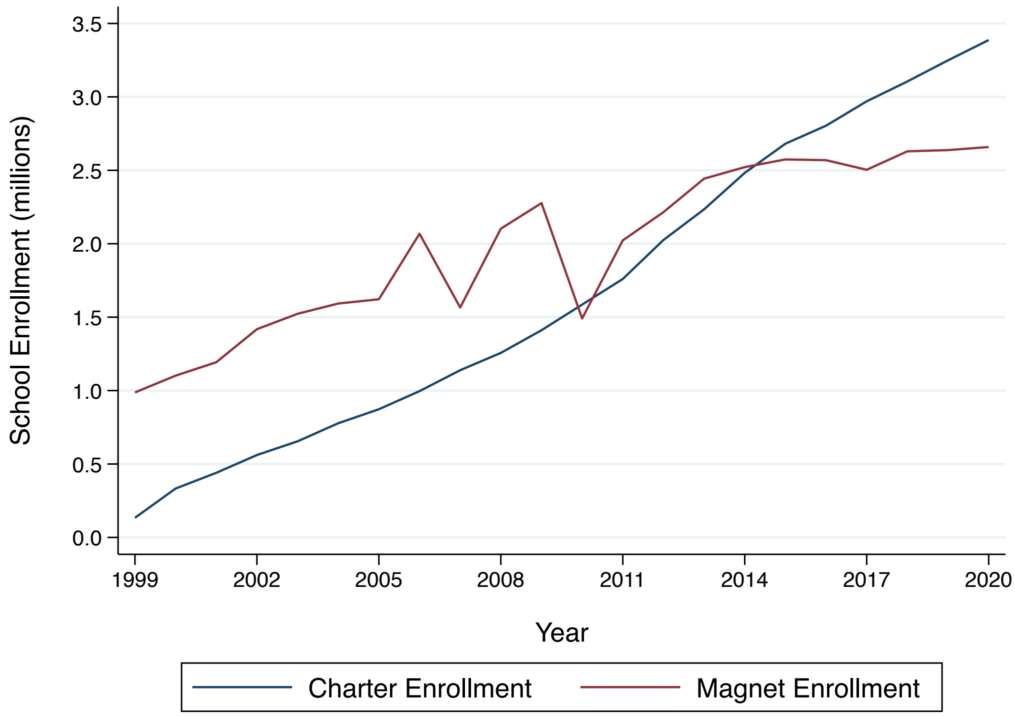

Figure 1: Magnet and Charter School Enrollment Growth in the United States, 1998-99 to 2019-20

Notes: Author calculations drawn from the Common Core of Data (CCD) Elementary/Secondary Information System (ElSi) Table Generator. Our magnet school counts are slightly higher—up to 1 percent—than the official counts for select years reported by USED through 2019 (e.g., Table 216.20 prepared in September 2020), which adjusts its school counts based on the inclusion or exclusion of certain grade levels. Our charter school counts exceed those of reported by USED by roughly 4-8 percent, depending on the year. The variation between our and USED's counts do not change the overall trends shown in the figure.

Table 1: School Characteristics

	Elementary Schools			
	Non-Magnets (1)	All Magnets (2)	Traditional Magnet (3)	Destination Magnet (4)
Schools	81	26	17	9
Students	59K	14K	9K	5K
Pct Applicant	.	41%	44%	37%
Student Body				
Pct. Disadvantaged	37%	52%	62%	33%
Resources				
Students:Computers w/Broadband	2.2	1.7	1.6	1.9
Student:Teacher Ratio	14.5	12.3	11.7	13.3
Average Class Size	20.3	19.5	19.1	20.2
Teacher Characteristics				
Pct Board Certified	16%	13%	11%	18%
Pct w/ Advanced Degree	36%	37%	37%	35%
Pct 0-3 Years Experience	19%	25%	25%	25%
Pct 4-10 Years Experience	30%	30%	30%	28%
Pct 11+ Years Experience	51%	45%	45%	47%

Table 2: Enrollment Destinies

	Magnet Applicant (1)	Offered Seat (2)	Not Offered Seat (3)
Attend Magnet 2016	0.543	0.816	0.284
Attend Non-Magnet 2016	0.270	0.049	0.481
Never Attended Wake	0.186	0.135	0.235
Propensity Score	0.486	0.910	0.083
Observations	1,347	657	690

Table 3: Summary Statistics

	All K Students (1)	Magnet Applicants (2)	Attend Magnet 2016 (3)	Attend Non-Magnet 2016 (4)
Magnet 2016	0.194	0.668	1.000	0.000
	(0.004)	(0.014)	(0.000)	(0.000)
Offered Seat	0.047	0.518	0.732	0.088
	(0.002)	(0.015)	(0.016)	(0.015)
Propensity Score	0.047	0.515	0.702	0.140
	(0.002)	(0.014)	(0.015)	(0.014)
Male	0.518	0.492	0.492	0.492
	(0.005)	(0.015)	(0.018)	(0.026)
White	0.473	0.518	0.511	0.533
	(0.005)	(0.015)	(0.018)	(0.026)
Black	0.219	0.220	0.217	0.225
	(0.004)	(0.013)	(0.015)	(0.022)
Hispanic	0.182	0.099	0.109	0.080
	(0.004)	(0.009)	(0.012)	(0.014)
Other Race	0.127	0.162	0.163	0.162
	(0.003)	(0.011)	(0.014)	(0.019)
High Performing Catchment		0.451	0.505	0.341
		(0.015)	(0.018)	(0.025)
Has Sibling		0.345	0.384	0.266
		(0.014)	(0.018)	(0.023)
Twin		0.065	0.051	0.093
		(0.007)	(0.008)	(0.015)
Observations	12,055	1,096	732	364

Notes: The sample is restricted to Wake County students who attended kindergarten in 2016. Column (1) includes all kindergarten students, while Columns (2)-(4) include only students who applied to at least one magnet school. High-performing catchment and sibling information is derived from the magnet assignment data and is not available for students who did not apply to magnet schools.

Table 4: Probabilities of Compliance

	(1)	(2)	(3)	(4)	(5)	(6)
		Magnet 2016	First Stage	Offered Seat	Compliance Probabilities	
	N	$P[D=1]$	$P[D_1 > D_0]$	$P[Z=1]$	$P[D_1 > D_0 \mid D=1]$	$P[D_1 > D_0 \mid D=0]$
Full Sample [0,1]	942	0.675	0.392	0.521	0.303	0.578
PScore [0, 0.05)	303	0.317	0.685	0.030	0.064	0.973
PScore [0.05, 0.15)	63	0.492	0.279	0.079	0.045	0.506
PScore [0.15, 0.25)	62	0.694	0.362	0.242	0.126	0.896
PScore [0.25, 0.35)	44	0.818	0.139	0.295	0.050	0.538
PScore [0.35, 0.45)	11	0.273	0.000	0.182	0.000	0.000
PScore [0.55, 0.65)	13	0.615	0.741	0.615	0.741	0.741
PScore [0.65, 0.75)	13	0.615	1.000	0.692	1.125	0.800
PScore [0.75, 0.85)	6	0.500	0.000	0.500	0.000	0.000
PScore [0.95, 1)	427	0.956	0.000	1.000	0.000	0.000
PScore [0.05, 0.95)	212	0.623	0.310	0.259	0.129	0.609

Notes: The sample is restricted to Wake County public school students attending kindergarten in 2016. Treatment, D, is defined as attending a magnet school. The instrumental variable, Z, is receiving a magnet offer. Propensity scores are derived from simulating the assignment one million times. Note that no magnet applicants had propensity scores between 0.45-0.55 or 0.85-0.95. First stage estimates include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings.

Table 5: Elementary School Test Results

Panel A: Second Grade, NKT and TRC Proficiency, N = 941

	First Stage	OLS Math	IV Math	OLS Reading	IV Reading
	(1)	(2)	(3)	(4)	(5)
Offered Seat	0.347***				
	(0.0740)				
Magnet 2018		0.0299	0.280*	-0.0165	0.259
		(0.0259)	(0.167)	(0.0276)	(0.188)
Mean of Dep Var	0.685	0.876	0.876	0.849	0.849

Panel B: Third Grade, EOG Math and Reading Standardized Score, N = 891

	First Stage	OLS Math	IV Math	OLS Reading	IV Reading
	(1)	(2)	(3)	(4)	(5)
Offered Seat	0.352***				
	(0.0735)				
Magnet 2019		-0.0280	0.00651	-0.0144	0.278
		(0.0914)	(0.293)	(0.0866)	(0.320)
Mean of Dep Var	0.682	0.256	0.256	0.288	0.288

Notes: Each panel restricts to students on-time to grade with valid scores in both reading and mathematics. Magnet attendance at the time of test taking is instrumented with having received a magnet offer in 2016. The specifications include propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Standard errors, clustered by school at test taking, are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Test Scores by Magnet Type: Traditional vs. Destination

Panel A: Second Grade, N = 941

	Attend Traditional (1)	Attend Destination (2)	Math 2nd Proficient (3)	Reading 2nd Proficient (4)
Offer Traditional Magnet	0.322***	-0.0996**		
	(0.0938)	(0.0458)		
Offer Destination Magnet	-0.203***	0.754***		
	(0.0557)	(0.0792)		
Attend Traditional Magnet			0.498**	0.520**
			(0.249)	(0.248)
Attend Destination Magnet			0.168	0.00544
			(0.114)	(0.138)
Mean of Dep Var	0.393	0.292	0.876	0.849

Panel B: Third Grade, N = 891

	Attend Traditional (1)	Attend Destination (2)	Math 3rd EOG (3)	Reading 3rd EOG (4)
Offer Traditional Magnet	0.305***	-0.0791*		
	(0.0950)	(0.0409)		
Offer Destination Magnet	-0.206***	0.752***		
	(0.0600)	(0.0788)		
Attend Traditional Magnet			0.0657	0.649
			(0.516)	(0.529)
Attend Destination Magnet			-0.0224	0.107
			(0.277)	(0.278)
Mean of Dep Var	0.393	0.290	0.256	0.288

Notes: Each panel restricts to students on-time to grade with valid scores in both reading and mathematics. Column headings indicate the test score dependent variable. Magnet attendance is defined as attending a magnet school of a certain type and is instrumented with having received a magnet offer at each type. The specifications include type-specific propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Standard errors, clustered by school, are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Test Scores by Magnet Type: Language Immersion

Panel A: Second Grade, N = 941

	Attend Immersion (1)	Attend Non-Immersion (2)	Math 2nd Proficient (3)	Reading 2nd Proficient (4)
Offer Immersion Magnet	0.676***	-0.391***		
	(0.191)	(0.118)		
Offer Non-Immersion Magnet	-0.014	0.354***		
	(0.011)	(0.073)		
Attend Immersion Magnet			0.285*	-0.668***
			(0.173)	(0.255)
Attend Non-Immersion Magnet			0.280*	0.327*
			(0.169)	(0.172)
Mean of Dep Var	0.022	0.662	0.876	0.849

Panel B: Third Grade, N = 891

	Attend Immersion (1)	Attend Non-Immersion (2)	Math 3rd EOG (3)	Reading 3rd EOG (4)
Offer Immersion Magnet	0.745***	-0.250**		
	(0.167)	(0.108)		
Offer Non-Immersion Magnet	-0.016	0.350***		
	(0.011)	(0.076)		
Attend Immersion Magnet			-0.124	-0.017
			(0.242)	(0.257)
Attend Non-Immersion Magnet			-0.052	0.212
			(0.323)	(0.335)
Mean of Dep Var	0.042	0.641	0.256	0.288

Notes: Each panel restricts to students on-time to grade with valid scores in both reading and mathematics. Column headings indicate the test score dependent variable. Magnet attendance is defined as attending a magnet school of a certain type and is instrumented with having received a magnet offer at each type. The specifications include type-specific propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Standard errors, clustered by school, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Total Absences Time 2016-2019

	(1) Magnet 2019	(2) Tot Abs	(3) Poisson	(4) Ln(Abs + 1)	(5) Abs ≥12	(6) Abs ≥80
Offered Seat	0.354***					
	(0.074)					
Magnet 2019		-17.617**	-15.928**	-0.641**	-0.133	-0.102**
		(7.310)	(6.593)	(0.282)	(0.127)	(0.051)

Notes: N = 899. The dependent variables are: Columns (2) and (3) total absences over the four years; Column (4) the log of total absences plus one summed over the four years; Column (5) indicator for more than 12 total absences over four years (mean is 83.6 percent); and Column (6) indicator for more than 80 total absences over four years (mean is 1.2 percent). The average of students' absences over the four years is 26.0. The sample is restricted to individuals who are in the Wake County data continuously over the four years and not retained with non-missing absence information over all four years. Magnet attendance in 2019 is instrumented with having received a magnet offer. The specifications include propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Standard errors, clustered by school, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: On-time Progress 2016-2019

	(1) First Stage Magnet 2016	(2) Switch Schools 2016-2019	(3) Attrit Sample 2016-2019	(4) On-time 3rd Grade 2019
Offered Seat	0.409***			
	(0.051)			
Magnet 2016		-0.549***	-0.215**	0.270***
		(0.139)	(0.097)	(0.102)
Observations	1096	975	1096	1096
Mean of Dep Var	0.668	0.177	0.169	0.816

Notes: The sample is students attending Wake County kindergarten in 2016 with outcomes measured over the following four years. Magnet attendance in 2016 is instrumented with having received a magnet offer. The specifications include propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Standard errors, clustered by school attended in 2016, are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Bounding for Attrition

	(1) Math 2nd Proficient	(2) Reading 2nd Proficient	(3) Math 3rd EOG	(4) Reading 3rd EOG
Panel A: Baseline, No Imputation				
Offered Seat	0.077	0.066	-0.089	0.027
	(0.047)	(0.049)	(0.123)	(0.122)
Observations	941	941	891	891
Panel B: Highest Quality Attrition, Impute 90^{th} Percentile				
Offered Seat	0.058*	0.043	-0.205*	-0.105
	(0.034)	(0.036)	(0.114)	(0.109)
Observations	1347	1347	1347	1347
Panel C: Lowest Quality Attrition, Impute 10^{th} Percentile				
Offered Seat	0.109*	0.053	0.024	0.117
	(0.058)	(0.059)	(0.111)	(0.110)
Observations	1347	1347	1347	1347
Panel D: Impute Prior Performance, If Available				
Offered Seat	0.064	0.081*		
	(0.047)	(0.045)		
Observations	1088	1088		

Notes: Estimated coefficients are the reduced form of receiving a magnet offer on test performance in 2018 (Columns 1 and 2) and 2019 (Columns 3 and 4). Panel A includes the baseline data. Panels B and C impute values for students who attrit any time between application and test taking, who are not on-time to grade, or who do not have a valid score for both tests. Panel B assumes high quality attrition and imputes the 90th percentile of performance for missing values, while Panel C assumes low quality attrition and imputes the 10th percentile. Panel D imputes the most recent test score available for students missing second grade exams. The specifications include propensity score controls rounded to the 10th decimal place. Robust standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Heterogeneity by Student Characteristics

	(1) Magnet 2019	(2) Math 2nd Proficient	(3) Reading 2nd Proficient	(4) Math 3rd EOG	(5) Reading 3rd EOG	(6) Absences	(7) On-time 3rd
				Non-Hispanic Black			
Offered Seat	0.244**						
	(0.109)						
Magnet 2018		0.597	1.250**				
		(0.409)	(0.571)				
Magnet 2019				0.341	1.231	-45.689**	0.191*
				(0.575)	(0.886)	(18.162)	(0.112)
Observations	195	207	207	195	195	198	202
				Non-Hispanic White			
Offered Seat	0.404***						
	(0.101)						
Magnet 2018		0.184	-0.082				
		(0.129)	(0.182)				
Magnet 2019				0.168	0.210	-6.938	0.067
				(0.371)	(0.341)	(9.370)	(0.044)
Observations	457	487	487	457	457	460	463
				Low Performing Catchment			
Offered Seat	0.211**						
	(0.087)						
Magnet 2018		0.646	0.756*				
		(0.402)	(0.457)				
Magnet 2019				-0.163	0.474	-47.647**	0.173*
				(0.612)	(0.654)	(19.349)	(0.090)
Observations	471	504	504	471	471	479	488
				High Performing Catchment			
Offered Seat	0.603***						
	(0.102)						
Magnet 2018		-0.017	-0.151				
		(0.053)	(0.106)				
Magnet 2019				0.030	0.011	0.645	0.001
				(0.236)	(0.321)	(5.777)	(0.004)
Observations	420	437	437	420	420	420	423

Notes: The specifications in Columns (1)-(5) parallel Table 5. Column (6) parallels Table 8, Column (3), while Column (7) parallels Table 9, Column (4). Magnet attendance at the time of test taking is instrumented with having received a magnet offer in 2016. The specifications include propensity score controls rounded to the 10th decimal place. All regressions include controls for gender, race/ethnicity, residence in a high-performing catchment area, and the presence of siblings. Clustered standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A Appendix

A.1 Complier Characteristics

To characterize the population of compliers, we apply the methods introduced by Abadie (2002) and Abadie (2003). Essentially, the means are weighted to recover values for the complier population. In our setting, the distribution of values of the outcome are discrete, so we do not apply kernel density smoothing. We estimate the following equations for treated and control compliers, respectively:

$$I(Y_i = v) * (MagAttend_i) = \alpha_0(MagAttend_i) + G(PS_i) + X_i\Gamma + \mu_{0iv}, \tag{A1}$$

$$I(Y_i = v) * (1 - MagAttend_i) = \alpha_1(1 - MagAttend_i) + G(PS_i) + X_i\Gamma + \mu_{1iv}, \tag{A2}$$

In words, the treatment complier group mean is calculated by estimating a regression of the dichotomous variable of interest multiplied by treatment status on the probability of being treated (i.e., magnet status) using receiving a magnet offer as an instrument, as in Equation (A1). The control complier group mean is calculated by estimating a regression of the dichotomous variable of interest multiplied by one minus treatment status on the probability of not being treated (i.e., attending a non-magnet school) again using receiving a magnet offer as an instrument, as in Equation (A2).

A.2 First Choice Lottery Instrument

It is useful to compare the results from the Abdulkadiroğlu et al. (2017) model with the more standard first choice instrument (e.g., Deming et al., 2014). In our setting, an additional lottery happens after the "guaranteed" students are seated for 10 percent of the remaining seats. Then, the rest of the seats are allocated according to the Deferred Acceptance algorithm. The standard first choice instrument defines a dummy variable for whether the student was offered a seat at their first choice school. Rather than the propensity score, this model includes a lottery fixed effect. To guarantee exogeneity, a full control for student type would be required, which is not feasible in this setting. Thus, the first choice instrument is not strictly valid as entering the lottery itself may be endogenous to student characteristics. Still, we provide a simplified first choice instrument specification as a comparison point. In this case, this would be simply the first choice school because we only consider students entering at kindergarten and all students subject to randomization are eligible for the 10 percent lottery. We define the instrument Z_i as whether the student received an offer from her first choice school and include first-choice school lottery fixed effects, in addition to the demographic controls. Note that this specification may be biased without a full set of controls for student type.

The main equation of interest is similar to equation (1), but we exclude the propensity scores.

$$Y_i = \beta MagAttend_i + X_i\gamma + FirstChoiceSchool_i\rho + \epsilon_i. \tag{A3}$$

Again, i indexes students. We include demographic characteristics, X_i: gender, race/ethnicity, and the presence of siblings (who also applied to attend a magnet school). Here ρ is a vector of coefficients and $FirstChoiceSchool$ are fixed effects indicating which school was listed first. Now, the first stage is estimated from an instrument on whether the student received an offer from her first choice school, conditioning on first choice school fixed effects.

$$MagAttend_i = \alpha FirstChoiceOffer_i + X_i\sigma + FirstChoiceSchool_i\kappa + \mu_i. \tag{A4}$$

As discussed in Abdulkadiroğlu et al. (2017), the first choice instrument captures a different local average treatment effect as it only utilizes variation stemming from first choice schools. Appendix Table A3 shows results are similar using this alternative, simplified version of the first choice lottery instrument.

Table A1: Enrollment Destinies for Students Attending Wake County in 2016

	Magnet Applicant (1)	Offered Seat (2)	Not Offered Seat (3)
Attend Magnet 2019	0.459	0.648	0.278
Attend Non-Magnet 2019	0.218	0.093	0.336
Never Attended Wake	0.186	0.135	0.235
Left Between K-3	0.137	0.123	0.151
Propensity Score	0.486	0.910	0.083
Observations	1,347	657	690

Table A2: Tests of Balance

	Difference (1)	S.E. (2)
Black	0.111	(0.065)
Hispanice	-0.016	(0.036)
Other Race	-0.062	(0.048)
Male	0.003	(0.072)
High Performing Catchment	-0.011	(0.056)
Joint p-value race variables	0.236	
Joint p-value all covariates	0.699	
N	1,096	

Notes: Each row presents estimates of a regression of the covariate indicated on receiving a magnet offer with propensity score controls rounded to the 10th decimal place.

Table A3: Specification Checks

	(1) Magnet 2019	(2) Math 2nd	(3) Reading 2nd	(4) Math 3rd	(5) Reading 3rd	(6) Absences	(7) On-time 3rd
Preferred specification							
Offered Seat	0.352***						
	(0.074)						
Magnet 2018		0.280*	0.259				
		(0.167)	(0.188)				
Magnet 2019				0.007	0.278	-17.617**	0.076**
				(0.293)	(0.320)	(7.310)	(0.033)
Observations	891	941	941	891	891	899	911
Add controls for the length of the rank ordered list							
Offered Seat	0.354***						
	(0.073)						
Magnet 2018		0.277*	0.251				
		(0.168)	(0.183)				
Magnet 2019				0.010	0.258	-16.519**	0.074**
				(0.298)	(0.319)	(7.012)	(0.032)
Observations	891	941	941	891	891	899	911
Exclude demographic and socioeconomic covariates							
Offered Seat	0.356***						
	(0.072)						
Magnet 2018		0.213	0.183				
		(0.157)	(0.168)				
Magnet 2019				-0.249	0.075	-18.244**	0.069**
				(0.370)	(0.307)	(7.793)	(0.033)
Observations	891	941	941	891	891	899	911
Preferred specification for students with non-missing Kindergarten Beginning of Year (BOY) test scores							
Offered Seat	0.341***						
	(0.073)						
Magnet 2018		0.251	0.259				
		(0.178)	(0.209)				
Magnet 2019				-0.102	0.069	-18.961**	0.084**
				(0.278)	(0.322)	(7.929)	(0.036)
Observations	841	891	891	841	841	847	858
Add controls for Kindergarten Beginning of Year (BOY) math and reading proficiency							
Offered Seat	0.340***						
	(0.073)						
Magnet 2018		0.209	0.218				
		(0.143)	(0.198)				
Magnet 2019				-0.211	-0.037	-18.523**	0.074**
				(0.215)	(0.281)	(8.021)	(0.034)
K Math Proficiency	0.049	0.267***	0.268***	0.841***	0.810***	-3.856*	0.068***
	(0.057)	(0.041)	(0.042)	(0.077)	(0.109)	(2.123)	(0.026)
K Reading Proficiency	-0.015	0.074***	0.063***	0.429***	0.413***	1.639	0.010
	(0.030)	(0.020)	(0.024)	(0.052)	(0.046)	(1.311)	(0.007)
Observations	841	891	891	841	841	847	858

Notes: Sample and specifications are parallel to the IV results in Table 5,Table 8, Column (3), and Table 9 Column (4), except where indicated. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: Specification Checks

	(1) Magnet 2019	(2) Math 2nd	(3) Reading 2nd	(4) Math 3rd	(5) Reading 3rd	(6) Absences	(7) On-time 3rd
Propensity Scores (0,1)							
Offered Seat	0.348***						
	(0.074)						
Magnet 2018		0.323*	0.262				
		(0.178)	(0.201)				
Magnet 2019				-0.001	0.285	-17.844**	0.079**
				(0.278)	(0.318)	(7.429)	(0.036)
Observations	422	449	449	422	422	421	429
No Base Magnet							
Offered Seat	0.341***						
	(0.078)						
Magnet 2018		0.236	0.260				
		(0.173)	(0.210)				
Magnet 2019				-0.164	0.072	-20.610***	0.090**
				(0.301)	(0.295)	(7.963)	(0.041)
Observations	721	762	762	721	721	725	735
Propensity Score Bins 100's							
Offered Seat	0.321***						
	(0.070)						
Magnet 2018		0.184	0.225				
		(0.182)	(0.211)				
Magnet 2019				-0.160	0.057	-22.759***	0.114**
				(0.320)	(0.382)	(8.237)	(0.052)
Observations	891	941	941	891	891	899	911
Linear Propensity Score							
Offered Seat	0.352***						
	(0.072)						
Magnet 2018		0.298*	0.220				
		(0.153)	(0.180)				
Magnet 2019				-0.039	0.241	-14.249**	0.073**
				(0.276)	(0.326)	(6.648)	(0.031)
Observations	891	941	941	891	891	899	911
First Choice Lottery							
FC Offer	0.363***						
	(0.052)						
Magnet 2018		0.106*	0.038				
		(0.057)	(0.065)				
Magnet 2019				0.273	0.397**	-9.427**	-0.031
				(0.194)	(0.186)	(4.267)	(0.024)
Observations	891	941	941	891	891	899	911

Notes: Sample and specifications are parallel to the IV results in Table 5, Table 8, Column (3), and Table 9 Column (4), except where indicated. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: Magnet Offer and Attrition

	(1) Attrit K	(2) Attrit K + P-Score	(3) Attrit 3rd	(4) Attrit 3rd + P-Score
Offered Seat	-0.099***	-0.009	-0.054**	-0.088**
	(0.021)	(0.050)	(0.023)	(0.040)
PScore [0, 0.05)		-0.092		0.121
		(0.106)		(0.073)
PScore [0.05, 0.15)		-0.310***		0.057
		(0.107)		(0.081)
PScore [0.15, 0.25)		-0.283***		0.040
		(0.108)		(0.078)
PScore [0.25, 0.35)		-0.158		0.098
		(0.114)		(0.085)
(Reference category PScore [0.35, 0.45))				
PScore [0.45, 0.55)		0.633***		
		(0.104)		
PScore [0.55, 0.65)		-0.228*		0.035
		(0.137)		(0.100)
PScore [0.65, 0.75)		0.003		0.252*
		(0.147)		(0.141)
PScore [0.75, 0.85)		-0.362***		-0.052
		(0.104)		(0.070)
PScore [0.95, 1)		-0.232**		0.141**
		(0.110)		(0.072)
Observations	1347	1347	1096	1096

Notes: The dependent variables in Columns (1) and (2) are attrition before kindergarten as a function of receiving a magnet offer. The dependent variables in Columns (3) and (4) are attrition before third grade and the sample is restricted to students attending kindergarten in 2016. The even numbered columns include controls for the propensity score. The specifications do not include any demographic variables. Propensity score controls are rounded to the 10th decimal place. Robust standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$