PATHWAYS TO AN ELITE EDUCATION: APPLICATION, ADMISSION, AND MATRICULATION TO NEW YORK CITY'S SPECIALIZED HIGH SCHOOLS

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Abstract

New York City's public specialized high schools have a long history of offering a rigorous, college preparatory education to the city's most academically talented students. Though immensely popular and highly selective, their policy of admitting students using a single entrance exam has raised questions about diversity and equity in access. In this paper, we provide a descriptive analysis of the "pipeline" from middle school to matriculation at a specialized high school, identifying group-level differences in application, admission, and enrollment. In doing so, we highlight potential points of intervention to improve access for underrepresented groups. Controlling for other measures of prior achievement, we find black, Hispanic, low-income, and female students are significantly less likely to qualify for admission to a specialized high school. Differences in application and matriculation rates also affect the diversity in these schools, and we find evidence of middle school "effects" on both application and admission. Simulated policies that offer admissions using alternative measures, such as state test scores and grades, suggest many more girls, Hispanics, and white students would be admitted under these alternatives. They would not, however, appreciably increase the share of offers given to black or low-income students.

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1. INTRODUCTION

New York City's (NYC's) elite specialized high schools have a long history of offering a rigorous, college preparatory education to the city's most academically talented students. Stuyvesant High School, the most well-known, was founded in 1904. Brooklyn Technical High School and The Bronx High School of Science opened in 1922 and 1938, respectively, and would eventually join Stuyvesant as the city's most selective public schools. The specialized high schools are aspired to by many—in a typical year in which 80,000 eighth graders apply to NYC high schools, 25,000 apply to the specialized high schools, and 5,000 are accepted.

Although there is mixed evidence on whether already high-achieving students are better off academically attending an elite high school,[1] the intense competition for entry into the specialized high schools has raised questions about equity in access to them. Unlike other NYC high schools, the specialized high schools admit students based on a single entrance exam. Many argue that this policy rewards intense test preparation and inhibits racial/ethnic and gender diversity at the schools. In the most recent year, for example, the three largest specialized high schools were predominately Asian (65 percent), white (21 percent), and male (58 percent).[2] Others contend that the city has failed to ensure that advanced students at all middle schools are competitive for admission (ACORN 1996). Supporters of the test, on the other hand, point to its objectivity and emphasis on higher-order skills. The admissions policy receives especially strong support from immigrant families, who view the specialized high schools as an affordable gateway to educational and labor market success.

Because the entrance exam is the sole criterion for admission, group differences in test performance are the primary explanation for the lack of gender, race, and ethnic representation in the specialized high schools. However, little is known about how these gaps relate to other measures of academic achievement, or about the roles application behavior, student preferences, and middle school context play in admissions to the specialized high schools. In this paper, we provide a descriptive analysis of the "pipeline" from middle school to matriculation at a NYC specialized high school. In doing so, we address three major questions, highlighting potential points of intervention to improve access for under-represented groups:

(1) Conditional on prior academic achievement, are there differences in student propensities to apply, to be admitted, and to matriculate to the specialized high schools that lead to an over- or underrepresentation of students by race/ethnicity, gender, family income, or educational need?
(2) To what extent are applicants and admitted students concentrated in the same set of middle schools? Are there "school effects" on application and admission, conditional on achievement and proximity, that potentially reflect differences in school supports for specialized high school admissions?

1. See, for example, Clark (2010), Abdulkadiroğlu, Angrist, and Pathak (2014), Dobbie and Fryer (2014), Lucas and Mbiti (2014), and Rokkanen (2015).
2. Authors' calculations using the 2014–15 New York City Department of Education Demographic Snapshot (NYCDOE 2014). In 2012, a coalition of educational and civil rights groups filed a complaint with the U.S. Department of Education claiming that the specialized high school exam is racially discriminatory (Treschan et al. 2013). This complaint is currently under review. See also Baker (2012).

(3) How might admissions criteria other than the single entrance exam alter the composition of specialized high schools, if at all?

Drawing on individual-level data for nine cohorts of eighth graders participating in high school admissions between 2004–05 and 2012–13, we address each of these questions. For question 1, we use sequential logistic models to identify group differences in application, admission, and matriculation beyond those explained by prior academic achievement. Controlling for a flexible function of state math and English language arts (ELA) scores, we find girls and black and Hispanic applicants are substantially less likely to receive admissions offers than their male and white counterparts, whereas Asian applicants are much more likely. We further show that these gaps are attributable to group differences in entrance exam performance unexplained by other measures of academic performance or student background. For example, girls score much lower on the entrance exam than would be predicted by their prior achievement. The exam, however, is not the sole explanation for the race and gender imbalance in the specialized high schools. For instance, we find high-achieving girls are less likely to apply to the specialized schools—which are largely STEM (science, technology, engineering, mathematics)-focused—and are less likely to accept having received an offer. Higher-achieving low-income students are also less likely to apply than their nonpoor counterparts. Asian students, on the other hand, are substantially more likely to apply than all other racial/ethnic groups, at all levels of prior achievement, and are more likely to accept an offer if one is extended.

For question 2, we first show the distribution of applicants and admitted students across middle schools. We find roughly half of all public school students admitted to the specialized high schools in 2013 attended one of only twenty-four middle schools (4.5 percent of all middle schools in the city), and 85 percent attended one of eighty-eight schools (16 percent of all middle schools).[3] To assess whether this imbalance is due to sorting or to school influences on the specialized high school "pipeline," we estimate middle school "effects" on application and admission, net of student characteristics. We do find systematic differences across schools in these outcomes that are meaningful in size and suggest opportunities for intervention, but we cannot rule out sorting as an alternative explanation.

Finally, for question 3 we simulate alternative admissions rules that use state test scores, grades, and attendance as admissions criteria in lieu of the single entrance exam. Variants of these rules have been proposed by opponents of the single test policy in NYC, and/or are used by other selective high schools in the United States (Finn and Hockett 2012; Treschan et al. 2013). We find that awarding admission based on these alternative criteria would have little effect on the average achievement of specialized high school students, as measured by prior test scores and grades, but would increase diversity. A much larger fraction of female applicants would receive offers than under the current policy, fewer Asian students would be admitted, and a modestly higher fraction of white and Hispanic students would receive offers (though Asian and white students would still be significantly over-represented). The alternative criteria would do little to reduce the concentration of offers in a few middle schools, and would not appreciably

3. As we show later, this pattern is not due to variability in school size.

Table 1. Specialized High Schools in New York City, 2013

School (Founding Year)	Students Ranking School	Percent Ranking School	No. of Offers	Percent of Offers Accepted	Mean SHSAT Percentile	Min SHSAT Percentile
Stuyvesant High School (1904)	22,636	83.4	953	91.6	98.0	95.0
Brooklyn Technical High School (1922)	23,071	85.0	1,957	76.2	87.5	82.0
The Bronx High School of Science (1938)	19,530	72.0	973	83.2	92.9	88.0
Staten Island Technical High School (1988)[a]	15,187	56.0	337	92.9	93.5	88.0
High School of American Studies at Lehman College (2002)	16,746	61.7	161	70.8	91.5	87.0
High School for Math, Science, and Engineering at City College (2002)	19,009	70.0	180	66.1	89.7	86.0
Queens H.S. for the Sciences at York College (2002)	16,626	61.3	155	63.9	91.6	87.0
The Brooklyn Latin School (2006)	16,699	61.5	383	42.7	83.5	81.0
Total	27,139	–	5,099	78.1	90.9	81.0

Notes: Authors' calculations using Specialized High School Admissions Test (SHSAT) and High School Admissions Process data provided by the NYCDOE. See online Appendix tables A.1 and A.2 for detailed counts by year. Only eighth grade test takers are included.

[a]Staten Island Technical High School obtained specialized high school status in 2005.

increase the number of offers extended to black students. Admissions rules that set aside seats for high-achieving students in every middle school—such as a "Top 10%" rule—would have a larger impact on diversity, but at the cost of reducing the average achievement of incoming students.[4]

In the next section, we provide a brief history of specialized high schools in NYC, and describe their admissions process. In section 3 we describe mechanisms by which applications and admissions to the specialized schools may be associated with or influenced by student characteristics and the middle schools they attend. Section 4 describes our data and empirical methods, and sections 5 through 7 present our results. We conclude with policy implications in section 8.

2. BACKGROUND—SPECIALIZED HIGH SCHOOLS IN NEW YORK CITY

There are currently eight specialized high schools in NYC (table 1). Stuyvesant High School, The Bronx High School of Science ("Bronx Science"), and Brooklyn Technical High School ("Brooklyn Tech") are the oldest, largest, and most well-known (we collectively refer to these as the "Big 3"). The remaining five are smaller, and four of these were established since 2002. A ninth elite school, the Fiorello H. LaGuardia High School of Music & Art and Performing Arts, does not use an admissions test, but instead requires an audition or portfolio.[5]

4. Based on their own simulations and evidence from this study, the NYC Community Service Society put forth a proposal that would use Common Core–aligned New York State tests to award admission to the specialized high schools. The proposal also called for seats to be set aside for the top 3 percent of test-takers in each middle school, so long as they were above a certain threshold (Treschan 2015).
5. Our analysis is restricted to the exam schools, and thus excludes LaGuardia applications. Nevertheless, we do examine enrollment in LaGuardia as a potential destination for students who do not accept their specialized high school offer.

Admission to the specialized schools is based strictly on the Specialized High School Admissions Test, or SHSAT, which students can opt to take in the fall of eighth grade.[6] On exam day, applicants provide their ranking of up to eight specialized high schools. SHSAT scores are sorted from highest to lowest and students are assigned, in order, to the highest-ranked school on their list with seats available (Abdulkadiroğlu et al. 2014; Dobbie and Fryer 2014; NYCDOE 2014). Accordingly, cut scores for admission vary by school and year depending on the score distribution, student preferences, and available seats. Cut scores are not made public, but there is a well-known hierarchy of selectivity among the Big 3, with Stuyvesant having the highest cut score, followed by Bronx Science and Brooklyn Tech (table 1; Feinman 2008; Abdulkadiroğlu et al. 2014).[7]

Specialized high school admissions are separate from, but run concurrently with, traditional high school choice. In that process, all eighth graders provide a list of up to twelve high schools they would like to attend, ranked in order of preference. A centralized mechanism matches applicants to schools, taking into account preferences, space, admissions priorities, and schools' rankings of students where applicable (Abdulkadiroğlu, Pathak, and Roth 2009; Bloom, Thompson, and Unterman 2010; Corcoran and Levin 2011). Students who apply to specialized high schools and/or LaGuardia also participate in the traditional choice process.[8] Admissions offers are extended in the spring, at which point students offered a seat in one of the specialized high schools (and/or LaGuardia) decide whether to accept or reject the offer. A student may reject, for example, if they decide their main high school match is preferable to their specialized school offer or if they decide to enroll in a private or charter school. Details on offers and acceptance rates during our study period are provided in table 1 and in a separate online appendix that can be accessed on *Education Finance and Policy's* Web site at http://www.mitpressjournals.org/doi/suppl/10.1162/EDFP_a_00220.

The SHSAT is a product of the Hecht-Calandra Act, a 1972 state law that sought to bring greater equity and transparency to admissions.[9] Its use, however, has been challenged by advocates and debated for years in local media (Hammack 2010). Two 1990s reports entitled *Secret Apartheid* and *Secret Apartheid II* claimed that specialized high school admissions perpetuated a de facto racially segregated school system by admitting mostly white and Asian students from a small number of middle schools (ACORN 1996, 1997). Those reports called for greater middle school support to help poor and minority students prepare for the SHSAT. More recently, the National Association for the Advancement of Colored People (NAACP) Legal Defense Fund and others filed a complaint with the U.S. Department of Education, claiming that the exclusive use of the SHSAT for specialized high school admissions is racially discriminatory (Treschan et al. 2013). Whatever the merits of these arguments, there is little question that the

6. Ninth graders may also take the SHSAT for tenth-grade admission. In this paper, we focus exclusively on eighth-grade applicants.
7. In a few cases, the cut score for admission to the smaller specialized high schools exceeds that of Brooklyn Tech High School. These schools are much smaller, however, and are able to fill up quickly with high-scoring students (table 1).
8. According to the *Specialized High School Student Handbook* (NYCDOE 2014) students must complete a traditional high school application in order to receive their SHSAT or LaGuardia audition results. This policy is intended to prevent students from betting entirely on admission to a specialized school.
9. The SHSAT is intended to test for high-level ability and logical reasoning skills, and consists of ninety-five multiple-choice questions—forty-five for verbal ability and fifty for mathematics.

specialized high schools in NYC lack the gender, racial, and socioeconomic diversity of the district. In 2014–15, enrollment at the three largest specialized schools was 58 percent male, 86 percent Asian and white, 4 percent black, and 6 percent Hispanic. By comparison, ninth graders citywide were 51 percent male, 26 percent Asian and white, 32 percent black, and 41 percent Hispanic. At Stuyvesant High School in 2014–15, only 28 of the school's 3,296 students were black.[10]

Although the specialized high schools are immensely popular, there is mixed evidence as to whether attending an elite school has measurable educational benefits for already high-achieving students. Abdulkadiroğlu et al. (2014) and Dobbie and Fryer (2014) used regression discontinuity designs to compare the outcomes of students just above and below the threshold for admission to exam schools in NYC and Boston. They found little to no effect of exam school admission on Advanced Placement or state test scores, PSAT or SAT performance or participation, or college enrollment, graduation, or quality, for students on the margin. Similarly, Lucas and Mbiti (2014) found no effects of attending an elite high school in Kenya, where students are also admitted via an entrance exam. Clark (2010), on the other hand, found students had better long-run outcomes, including university enrollment, when admitted to an elite secondary school in the United Kingdom. Recent evidence in Rokkanen (2015) using admissions data from Boston schools suggests the returns to elite high school attendance may be greater for inframarginal candidates. If true, well-identified regression discontinuity studies likely underestimate the benefits of attending a selective high school.[11] For this paper we set aside the question of whether elite high schools have value added for students beyond their next best alternative, and proceed on the basis that these schools provide an educational good that many students and their families value.

3. THEORY: FACTORS AFFECTING APPLICATION, ADMISSION, AND MATRICULATION TO THE SPECIALIZED HIGH SCHOOLS

Our empirical analysis follows students as they progress from middle school to enrollment in a specialized high school. This pipeline includes several milestones: the decision to apply to a specialized school (i.e., taking the SHSAT), the awarding of an admissions offer, the decision to accept or reject an offer, and ninth-grade enrollment. We refer to the decision to accept an offer of admission as "matriculation." Although there is some attrition between matriculation and ninth-grade enrollment, it is low (less than 4 percent).

In a narrow sense, applying to a NYC specialized high school is relatively costless—students simply sign up for the SHSAT and give up 2.5 hours on a weekend in October for the test. Indeed, nearly a third of rising ninth graders do so. Nevertheless, a competitive score will, for most, require significant advance preparation, which can increase

10. This fact was captured in a prominent 2012 article in the *New York Times* that profiled the experience of an African American girl enrolled at Stuyvesant High School (see Santos 2012). Diversity at the specialized high schools has declined markedly over the past twenty years as the schools have become more competitive (Treschan et al. 2013).

11. Related studies include Berkowitz and Hoekstra (2011), who find a positive effect of attending a single elite private high school on the selectivity of college attended, and Jackson (2010), who finds large effects on exam performance of attending a selective high school in Trinidad and Tobago. At the postsecondary level, Dale and Krueger (2002) document modest returns to attending an elite college, suggesting most achievement differences between graduates of elite and less-selective institutions are due to selection.

the explicit and implicit costs of applying. Students who perceive a low likelihood of success may choose not to make this investment. Curricular appeal may play an important role in application behavior, as the specialized high schools emphasize math and science. To the extent that girls are less drawn to STEM fields, they may be less willing to apply (e.g., Schneeweis and Zweimüller 2012; Buser, Niederle, and Oosterbeek 2014; Legewie and DiPrete 2014). As with any school choice, proximity will also influence students' willingness to apply to a specialized high school.

Conditional on applying, admission offers are awarded based on SHSAT scores and students' ranked preferences. Consequently, group differences in offers must be attributable to differences in SHSAT performance or their rankings of the specialized schools.[12] Math and ELA achievement as measured by state tests are strong predictors of SHSAT performance (as we show later), but the SHSAT may be sensitive to higher-order skills for which the state test is not. Controlling for other achievement measures, gaps in SHSAT scores and admissions offers may reflect differences in these skills. Notably, the scaling of the SHSAT has been claimed by some to advantage students with exceptionally high ability in one content area, such as mathematics, over students with high ability in both content areas (Feinman 2008). If true, this could influence group differences in admission, not to mention test-taking strategy. Students' own efforts in preparing for the SHSAT will influence their score, and these efforts are likely to be aided by resources available to them at home or in school.[13]

Finally, at the matriculation stage, students decide whether to accept or reject their specialized high school offer or to opt for a different public, private, or charter school. In theory, students only rank specialized schools they would like to attend, but in practice may rank all eight, given that there is no cost to do so (they can always turn down an offer).[14] The decision to accept or reject therefore depends on the student's specific offer and his alternatives. All students applying to specialized high schools participate in traditional high school choice, and may find they prefer their main high school match. Presumably, students with access to higher-quality neighborhood schools or opportunities to attend other selective programs are more likely to turn down an offer. Until 2014, the traditional match had a provision that guaranteed admission to an "educational option" school (traditional schools that sometimes have highly regarded honors programs) to students scoring in the top 2 percent on the seventh-grade ELA test, provided they listed that school as their first choice.

It is easy to see how middle schools might influence the propensity to apply and be admitted to the specialized high schools. For example, schools could vary in resources devoted to counseling or preparing students for the SHSAT. In some middle schools—such as those with an honors or gifted program—the curriculum may be better aligned with the SHSAT than in others. Schools can create a culture of high expectations and

12. It is possible for a student to score high enough to qualify for *one of* the specialized high schools, but not high enough to qualify for one on his list. A student in this case would not receive an offer.
13. The district offers a free Specialized High School Institute (SHSI) to low-income sixth graders with sufficiently high attendance and fifth grade test scores. This 22-month program involves more than 100 meetings during the summer and on Saturdays at 18 locations throughout the city. Though there has not yet been a formal evaluation of the SHSI, those who choose to take advantage of its intense preparation plausibly increase their chances of admission.
14. The average applicant in 2014–15 ranked 5.5 schools on their SHSAT. Forty-three percent ranked all eight, and 5 percent ranked only one.

aspirations to attend the specialized schools, and peers may influence students' likelihood of applying (Lauen 2007; Langenkamp 2009). As observed in college admissions, high-achieving students in lower-performing schools may underestimate their odds of admission to an elite school (Hoxby and Avery 2013). Collectively, these factors could yield middle school "effects" on the composition of students at each stage of the specialized high school pipeline.

The next section describes the data we use and our empirical approach.

4. DATA AND EMPIRICAL APPROACH

Our analysis focuses on nine cohorts of eighth graders who participated in high school admissions between 2004–05 and 2012–13, about 80,000 students per year. We rely primarily on High School Admissions Process (HSAPS) data provided by the NYC Department of Education, which reports whether a student applied to a specialized high school (i.e., took the SHSAT), whether he or she was offered a seat (and to which school), and whether the offer of admission was accepted. These data include students' ranked and matched schools from the traditional choice process, their final assignment, and other student information. We also observe SHSAT scores and student rankings of the specialized high schools for five cohorts (2008–09 through 2012–13).

Using anonymous identifiers, we linked these data to administrative data on students' background and academic history. These include scores on the New York State tests in math and ELA, race/ethnicity, gender, age, eligibility for free or reduced-price lunch, English language learner (ELL) status, country of birth and immigration year, attendance rates, days late, course grades (2008–09 only), special education status, middle school (called "feeder," because not all apply from a traditional middle school), ninth-grade school of record (if a public school), and geocoded residential address. As a measure of proximity to specialized high schools, we used the Google Maps application programming interface to calculate travel time via public transportation from students' feeder schools to each of the specialized high schools.[15]

Our baseline sample consists of 727,372 eighth graders, and includes applicants from both public and private feeder schools. Because demographic characteristics are unavailable for most private school students, the greater part of our analysis focuses on applicants from public schools, who represent more than 90 percent of the baseline sample ($N = 658{,}164$).

We begin section 5 by showing how the composition of applicants and admitted students evolves at each stage of the pipeline. This analysis reveals populations that may be overrepresented or underrepresented at each milestone. To further examine group differences in application, admission, and matriculation, we estimate sequential logistic regression models for each outcome. These models are estimated conditional on having reached the previous stage. For example, our model for admissions is conditional on application (taking the SHSAT), and our model for matriculation is conditional on receiving an offer to attend a specialized high school. These models

15. This serves as an approximation of travel time from home. As a robustness check on this measure, we also calculated travel time via public transportation from every student's home address to each specialized high school, in 2013 only. As we describe below, our regression models also control for residential neighborhood, which should also capture differences in proximity.

take the form:

$$\Pr(AP_{it} = 1) = \text{logit}^{-1}(X_{it}\beta + \eta_t + g(ELA_{it}) + h(math_{it})), \quad (1)$$

$$\Pr(OF_{it} = 1 | AP_{it} = 1) = \text{logit}^{-1}(X_{it}\gamma + \eta_t + g(ELA_{it}) + h(math_{it})), \quad (2)$$

$$\Pr(AC_{it} = 1 | OF_{it} = 1) = \text{logit}^{-1}(X_{it}\delta + \eta_t + g(ELA_{it}) + h(math_{it})), \quad (3)$$

where AP_{it}, OF_{it}, and AC_{it} are binary outcomes equal to one if student i applied to a specialized high school, was admitted, and was accepted, respectively, and equal to zero otherwise. Because we are primarily interested in variation in outcomes conditional on prior achievement, the explanatory variables include cubic functions of student i's eighth grade ELA and math scores [$g(ELA)$ and $h(math)$, respectively], allowing for nonlinearities in the relationship between achievement on the state test and these outcomes. Other student characteristics in $\boldsymbol{X}$ include indicators for gender, race/ethnicity, special needs (e.g., ELL and special education status), and socioeconomic status (eligibility for free and reduced-price lunch). Other controls include a cohort effect (η_t) and indicators for the student's residential neighborhood, to capture effects of proximity to the specialized high schools and the quality of other nearby school options.[16] In models 1 and 2 we include a measure of travel time in minutes from i's middle school to the nearest Big 3 specialized high school. In model 3, we instead use travel time to the *offered* school. For ease of interpretation, we report average marginal effects for the explanatory variables, rather than logit coefficients.[17] These are interpreted as the change in predicted probability of the outcome, for the average student, given a marginal change in the explanatory variable (other things held constant).

Section 6 examines variability across middle schools in the propensity to apply and be admitted to a specialized high school. We first look at the distribution of applicants and admitted students across middle schools to assess the extent of concentration. We then estimate random effects linear probability models to quantify the school-level variation in admissions outcomes unexplained by student predictors. These models use the same controls as models 1 through 3, including neighborhood indicators and travel time, to ensure that the school effects are not capturing effects of proximity.

We defer a description of our simulations of alternative admissions criteria to section 7.

5. THE PIPELINE: AN OVERVIEW OF ADMISSIONS TO NYC'S SPECIALIZED HIGH SCHOOLS

Between 2005 and 2013, almost one third of students applying to NYC public high schools took the SHSAT (32 percent), or roughly 25,000 per year. Of those, 19 percent

16. The neighborhood variables are indicators for the thirty-two geographic school districts in NYC. Although these are not strictly aligned with neighborhoods—and some are larger in area than others—they are more local than borough of residence. They also correlate with students' school choice opportunity set, since admissions preferences are sometimes given to students living in the same geographic district. The HSAPS data do not report students' residential district; instead, we use geocoded home addresses to map each student to his residential district.

17. Logit coefficients are reported in the online appendix, along with ordinary least squares linear probability model coefficient estimates.

received an offer of admission to a specialized high school. The Big 3 together accounted for 74 percent of these offers. Perhaps surprisingly, not all students who received an offer matriculated. Indeed, only 73 percent during this period did so. Rates of matriculation varied from a high of 88 percent (to Stuyvesant) to a low of 27 percent (to Brooklyn Latin). Private school students—only 9.5 percent of the baseline sample—represented 14.4 percent, 16.3 percent, and 11.5 percent of specialized high school applicants, offers, and matriculants, respectively.[18] Taken together, specialized high school students represented a very select group of eighth graders, with only 6.2 percent of the baseline population receiving offers.

Table 2 provides descriptive statistics for applicants from public schools at various stages of the pipeline. In this table, the first column describes all public-school applicants in the baseline sample; the second describes applicants to specialized high schools; the third and fourth describe students receiving offers (the latter for Big 3 schools only); and the fifth describes matriculators.

There are notable, if unsurprising, differences in the composition of students at each stage.[19] For example, specialized school applicants scored significantly higher on state tests than the baseline population—about 0.66 standard deviations (SD) in ELA, on average, and 0.74 SD in math. Students receiving a specialized school offer scored higher still—about 1.5 SD in ELA, on average, and 1.7 SD in math. Close to 26 percent of admitted students scored in the top 2 percent of the ELA exam, which—until a recent law change—granted them priority admission to certain schools in the traditional high school matching process.

Girls were slightly overrepresented among applicants (50.7 percent, versus 49.1 percent of all eighth graders), but underrepresented among admissions and acceptances (45.6 percent and 42.3 percent, respectively). Compared with the baseline population, white and Asian students were overrepresented among applicants, offers, and matriculators. Asian students made up 14.2 percent of eighth graders, but 29.1 percent of applicants, 54.0 percent of offers, and 59.8 percent of matriculators. Black and Hispanic students made up a combined 71.6 percent of eighth graders, yet only 16.1 percent of specialized school offers. Applicants and admitted students were more economically advantaged and had fewer special educational needs than the population. Nonetheless, 32.6 percent of offers went to students eligible for free meals (compared with 58.6 percent of all eighth graders). As might be expected, only a small share of ELL and special education students took the SHSAT, and even fewer were offered a seat in a specialized school.

Table 2 also shows the high fraction of immigrant students in NYC public schools, and the specialized high schools in particular. Almost one in five (17–18 percent) at each stage of the admissions process were foreign-born. Chinese and other Far East Asian immigrants made up 2.3 percent of the baseline population, but 7.9 percent of

18. Private school students have been falling as a share of the baseline sample (from 10.7 percent in 2005 to 7.9 percent in 2013) and of specialized high school admissions offers (from 17.1 percent in 2005 to 13.2 percent in 2013).
19. These differences are consistent with those reported in the descriptive statistics of Dobbie and Fryer (2014) and Abdulkadiroğlu, Angrist, and Pathak (2014).

Table 2. Descriptive Statistics: Eighth-Grade Public School Students Applying to NYC High Schools

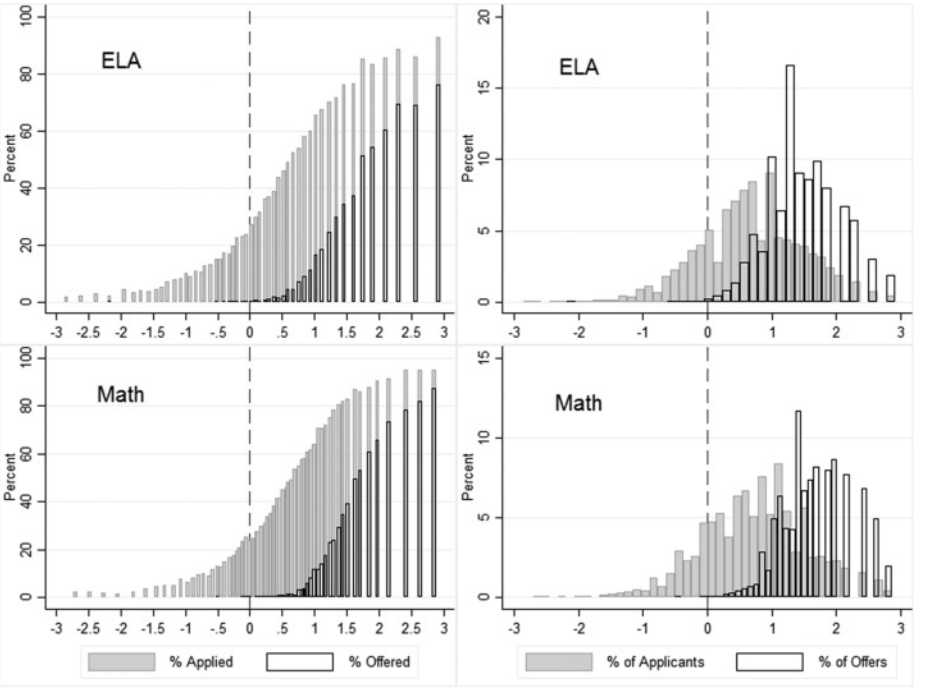
	Baseline	Applied to SPHS	Offered a SPHS	Offered a Big 3	Accepted SPHS Offer
Asian	14.2	29.1	54.0	59.3	59.8
White	13.5	18.0	29.1	26.7	24.4
Black	31.9	27.3	7.4	6.4	7.1
Hispanic	39.7	24.8	8.7	7.0	8.0
Female	49.1	50.7	45.6	45.1	42.3
Free-lunch eligible	58.6	48.0	32.6	33.8	35.5
Reduced-price lunch	7.1	9.6	10.5	10.8	11.2
ELL	11.9	3.6	0.4	0.3	0.4
Special education	16.1	4.3	1.2	1.1	1.2
Foreign born	17.9	17.3	16.9	17.4	18.3
Chinese spoken at home	5.3	12.4	28.1	32.2	32.3
English spoken at home	56.6	54.5	43.8	39.6	38.5
ELA *z*-score (8th grade)	0.012	0.660	1.545	1.579	1.521
Math *z*-score (8th grade)	0.012	0.741	1.666	1.722	1.697
Top 2% in ELA (7th grade)	2.9	7.7	25.8	26.9	24.5
Attendance (7th grade)	92.4	95.9	97.6	97.8	97.7
Borough of residence:					
Brooklyn	31.6	35.6	32.2	37.0	34.3
Manhattan	11.5	11.5	16.3	15.7	14.7
Queens	27.5	30.6	38.9	40.7	38.1
Staten Island	6.2	5.9	6.5	2.1	6.8
Bronx	23.1	16.5	6.1	4.6	6.2
Charter middle	1.2	2.1	0.9	0.7	0.8
No. of traditional choices	7.1	7.4	6.0	6.0	6.0
Travel time to closest Big 3	41.8	42.7	46.8	46.4	46.8
Travel time to offered SPHS	–	–	52.2	54.4	51.5
LaGuardia H.S. offer	1.1	2.7	6.8	6.9	3.6
SHSAT percentile	–	49.9	90.5	91.6	91.5
N	659,464	198,349	37,532	18,995	28,658

Notes: Authors' calculations using High School Admissions Process (HSAPS) and Specialized High School Admissions Test (SHSAT) data provided by the NYCDOE, 2004–05 through 2012–13. See the online appendix for a description of the baseline sample. Includes only students who applied from a NYC public school. The number of traditional choices refers to the number of schools ranked on the student's main high school admissions form (not the specialized high schools). ELA = English language arts; ELL: English language learner; SPHS = specialized high school.

matriculators. Rather remarkably, 28.1 percent of students admitted to a specialized high school spoke Chinese at home.[20]

Figure 1 provides a closer look at the eighth-grade math and ELA achievement of specialized high school applicants and admitted students in 2013 (both scores are normalized to mean zero, SD one, using all eighth-grade test takers). Panel A shows the percent of students at each *z*-score who applied or were admitted to a specialized high school, and panel B shows the resulting score distributions for applicants and admitted students. Application and admission rates increase sharply and nonlinearly with math and ELA scores. Notably, not all admitted students had exceptional scores on

20. Detailed statistics on country of origin and language spoken at home are provided in Appendix table A.3, available online.



Note: Includes eighth-grade public school students only. ELA = English language arts.

Figure 1. Percent Applying and Receiving Offers to Specialized High Schools by Eighth-Grade Test Scores, and Test Score Distributions of Applicants and Offers, 2013. a. Percent Applying and Receiving Offers [Above Lefthand Column]. b. Test Score Distribution of Applicants and Offers [Above Righthand Column].

eighth-grade tests, particularly in ELA. Also notable is the nontrivial fraction of high-achieving students that did not take the SHSAT at all (15–20 percent of students who scored more than 1 SD above average on state tests).

Compositional differences in applicants, admitted students, and matriculators reflect increasingly high-achieving populations and are not necessarily evidence of differences in the propensity to apply or be admitted to a specialized school for students with similar achievement. To identify factors associated with progression through the specialized school pipeline, we estimated the sequential logistic models described in section 4. The marginal effects from these models are shown in table 3.

Table 3 confirms that student performance on state ELA and math tests is strongly related to application and admission to the specialized schools, with math achievement more predictive than ELA. Conditional on achievement, however, we observe interesting group differences in the likelihood of application, admission, and matriculation to the specialized high schools. (All the ones described here are statistically significant at the 1 percent level or below.) For example, holding constant prior achievement, black students were more likely to apply (by 2.0 percentage points), and more likely to accept an offer when extended one (by 9.1 points). Hispanic students were also more likely to accept an offer (by 2.9 points) but less likely to apply (by 3.3 points). Similarly, low-income students were more likely to accept an offer (3.7 points) and less likely to apply (2.4 points). Asian students, in contrast, were substantially more likely to apply, at every

Table 3. Marginal Effects from Logistic Regression Models for Application, Admission, and Offer Acceptance, 2005–13

	Applied to SPHS	Offered a SPHS	Accepted SPHS offer	Pseudo-offer
Asian	0.1713***	0.0506***	0.1762***	0.0516***
	(0.0021)	(0.0020)	(0.0069)	(0.0024)
Black	0.0203***	−0.0475***	0.0912***	−0.0564***
	(0.0019)	(0.0027)	(0.0118)	(0.0033)
Hispanic	−0.0332***	−0.0576***	0.0291**	−0.0584***
	(0.0017)	(0.0023)	(0.0104)	(0.0028)
Female	−0.0272***	−0.0687***	−0.0880***	−0.0704***
	(0.0010)	(0.0013)	(0.0050)	(0.0016)
Free-lunch eligible	−0.0242***	−0.0298***	0.0368***	−0.0349***
	(0.0011)	(0.0015)	(0.0059)	(0.0019)
Reduced-price lunch	0.0033	−0.0168***	0.0241**	−0.0199***
	(0.0019)	(0.0022)	(0.0081)	(0.0027)
ELL	−0.0780***	−0.0571***	−0.0276	−0.0697***
	(0.0023)	(0.0073)	(0.0450)	(0.0082)
Special education	−0.0528***	0.0188***	−0.0110	0.0219***
	(0.0019)	(0.0058)	(0.0206)	(0.0066)
Recent immigrant	0.0017	−0.0066***	0.0374***	−0.0086***
	(0.0014)	(0.0017)	(0.0065)	(0.0020)
Math *z*-score	0.1291***	0.1347***	0.0236***	0.1311***
	(0.0008)	(0.0010)	(0.0043)	(0.0012)
ELA *z*-score	0.0890***	0.1027***	−0.0143**	0.1075***
	(0.0008)	(0.0010)	(0.0039)	(0.0012)
Attendance rate	0.0068***	0.0002	−0.0007	0.0009***
	(0.0001)	(0.0002)	(0.0008)	(0.0003)
Age	−0.0338***	−0.0142***	−0.0278***	−0.0124***
	(0.0010)	(0.0018)	(0.0071)	(0.0022)
Travel time to SPHS	−0.0004***	<0.0000	−0.0006***	<0.0000
(minutes)	(<0.0001)	(0.0001)	(0.0001)	(0.0001)
Charter middle	0.0699***	−0.0266***	−0.1135**	−0.0341***
	(0.0048)	(0.0068)	(0.0319)	(0.0075)
N	606,925	194,338	30,579	134,630
Mean of dep. var.	0.320	0.190	0.729	0.194
Pseudo R^2	0.322	0.480	0.126	0.481
Log-likelihood	−258195.08	−49117.94	−15610.72	−34343.00

Notes: Logit coefficients reported in online Appendix table A.5. "Pseudo offers" are assigned to applicants based solely on their SHSAT score, ignoring their ranked preferences for specialized high schools (which could affect their likelihood of admission); this model is necessarily restricted to 2008–13, the only years in which we observe SHSAT scores. The ELA and math *z*-scores enter all logistic models as a cubic function. The average marginal effects reported for ELA and math are the average effect of a marginal change in the ELA or math score on the outcome, across all students, and thus reflect the quadratic and cubic terms. ELA = English language arts; ELL: English language learner; SPHS = specialized high school. Standard errors reported in parentheses.

**$p < 0.01$; ***$p < 0.001$.

level of achievement, and were more likely to accept an offer when extended one (by 17.1 and 17.6 percentage points, respectively).

There were large group differences in admissions offers for students with similar eighth-grade math and ELA achievement. Black and Hispanic students were significantly less likely to be admitted (by 4.8 and 5.8 percentage points, respectively) and free-lunch eligible students were an additional 3.0 points less likely to receive an admission offer. Asian students were 5.1 percentage points more likely to be admitted to a specialized high school conditional on their eighth-grade test scores. Each of these gaps is large on a baseline admissions rate of 19.0 percent.

The gender gap in specialized high school enrollment begins at application, and grows at the offer and matriculation stages. Holding constant middle school achievement, girls were 2.7 percentage points less likely to sit for the SHSAT, 6.9 percentage points less likely to be admitted to a specialized high school (6.1 percentage points for the Big 3; not shown) and 8.8 percentage points less likely to matriculate when admitted. These gaps are quite large. Indeed, conditional on prior test scores, the gender gap is larger than both the black–white and Hispanic–white gaps in admission to the specialized schools.

Several other predictors of application, admission, and matriculation are worth noting. First, students in charter middle schools were much more likely to apply to specialized high schools (by 7.0 points), but were less likely to be admitted or to matriculate conditional on applying. The latter may reflect their opportunity for continued enrollment in their charter school. Second, travel time to the nearest specialized high school had a weak but statistically significant negative association with application. Students who would be required to travel farther to their offered specialized high school were also less likely to accept. We estimate a 1 SD increase in the expected travel time to school (24.7 minutes) to be associated with a 1.5-point reduction in the likelihood of matriculation, a relatively small effect.[21] Third, students offered admissions to both a specialized high school and LaGuardia High School were much less likely to accept their specialized high school offer (by 29 percentage points; not shown in table 3). Fourth, students who scored in the top 2 percent on the seventh grade ELA exam—and thus were guaranteed admission to an "educational option" program if they ranked it first—were also less likely to matriculate to a specialized high school when offered (by 3.4 points; also not shown).

These findings, together with observed variation across neighborhoods in the propensity to apply and matriculate to the specialized high schools, suggest students' decisions are influenced by their outside options. In online Appendix table A.4, we report the most common destinations for the one in four students who did not accept their specialized high school offer. Of those who turned down an offer in 2013, 12 percent ended the process with no assignment (suggesting they enrolled in a private school or public school outside of NYC), 13 percent accepted an offer at LaGuardia High School, and roughly 52 percent opted to attend one of fifteen other highly regarded high schools in the city, most prominently Townsend Harris in Queens (15 percent), and Beacon (5.8 percent) and Bard Early College High Schools (5.6 percent) in Manhattan.

Group differences in offers of admission could to some degree be an artifact of applicants' ranking of the specialized high schools. For example, if girls or free-lunch eligible students are less likely to rank schools with lower cut scores (ranking Stuyvesant, say, but not Brooklyn Tech or Brooklyn Latin) they will receive fewer offers of admission even with comparable scores. To examine this possibility, we used the SHSAT data to

21. It is likely that much of the effect of proximity on the application and matriculation decisions is absorbed by the residential neighborhood controls. Thus, the travel time coefficient likely understates the importance of proximity to these decisions. As a robustness check for our travel time result, we substituted travel time from students' homes to their offered school in 2013 (the only year for which we had these data). Indeed, the coefficient on travel time is larger when using this measure—we estimate a 1 SD increase in travel time to be associated with a 4.9-point reduction in the likelihood of matriculation. This is a larger effect but still small relative to the 73 percent acceptance rate.

Table 4. Gaps in SHSAT Performance Conditional on Eighth Grade Achievement, 2008–13

	SHSAT (1)	SHSAT: Math (2)	SHSAT: Verbal (3)	SHSAT (high ach) (4)
Asian	10.704***	10.258***	0.445	17.283***
	(0.445)	(0.263)	(0.275)	(0.713)
Black	−20.518***	−11.898***	−8.620***	−28.225***
	(0.471)	(0.278)	(0.291)	(0.947)
Hispanic	−19.684***	−11.145***	−8.540***	−26.855***
	(0.474)	(0.280)	(0.293)	(0.902)
Female	−20.329***	−12.577***	−7.752***	−22.605***
	(0.290)	(0.171)	(0.179)	(0.547)
Free-lunch eligible	−11.416***	−4.428***	−6.989***	−14.067***
	(0.328)	(0.194)	(0.203)	(0.618)
Reduced-price lunch	−8.553***	−3.005***	−5.548***	−9.541***
	(0.535)	(0.316)	(0.331)	(0.961)
ELL	−27.862***	−7.609***	−20.253***	−26.404***
	(0.858)	(0.508)	(0.531)	(2.527)
Cubic in state math score	YES	YES	YES	YES
Cubic in state ELA score	YES	YES	YES	YES
N	137,388	137,388	137,388	44,560
Mean SHSAT	397.3	199.7	197.6	476.2
SHSAT SD	90.9	49.2	50.2	74.3
R^2	0.663	0.598	0.575	0.425

Notes: SHSAT scores are in their original scale score units. The mean and standard deviation remain roughly constant over this period, at 400 and 90, respectively. The only student controls not shown in the table are age and enrollment in a universal free meals school (a proxy for low-income students not already identified by the free and reduced-price lunch variables). ELL: English language learner. Standard errors reported in parentheses.

***$p < 0.001$.

directly estimate gaps in exam performance unexplained by achievement on state tests. For the regressions shown in table 4, we again controlled for a cubic in state ELA and math scores while estimating differences in SHSAT scores by gender, race/ethnicity, free/reduced price meal eligibility, and ELL status.[22] The main result in column 1 shows sizable gaps in exam performance between groups, with black and Hispanic students scoring roughly 20 points (0.22 SD) below white students, Asian students scoring 10 points (0.12 SD) higher, and free-lunch eligible students 11 points (0.13 SD) below non-poor students. Somewhat remarkably, the gender gap on the SHSAT (20 points, or 0.22 SD) is approximately the same size as the black and Hispanic gaps after conditioning on prior achievement.

Columns 2 and 3 of table 4 split the SHSAT score into its math and verbal sections. For black, Hispanic, and female students the gap is larger on the math section (0.23–0.25 SD) than the verbal (0.15–0.17 SD). Asian students outperform in math (0.21 SD) but not verbal. On the verbal section, girls score 0.15 SD below boys with similar state test scores, a marked contrast from the raw 0.33 SD gap in favor of girls on the state test. Column 4 restricts the sample to high-performers, those scoring more than 1 SD

22. SHSAT scores are in their original scale score units rather than *z*-scores. The mean score and standard deviation remained roughly constant over time, at 400 and 90, respectively.

above the average on the state math and ELA tests, a more relevant range for successful applicants. Among this population, group differences in SHSAT scores are even larger.

Taken together, the racial/ethnic, gender, and income gaps in specialized high school admissions do not appear to be artifacts of preference rankings, but reflective of real differences in SHSAT performance. As an alternative way of looking at this question, we removed all potential effects of preference rankings by awarding "pseudo-offers" to the highest-scoring k students each year, where k is equal to the number of actual seats awarded. In this scenario, no student fails to receive an offer because of her specific ranking of specialized high schools. As seen in the rightmost column of table 3, the gaps in offer rates are comparable or larger.

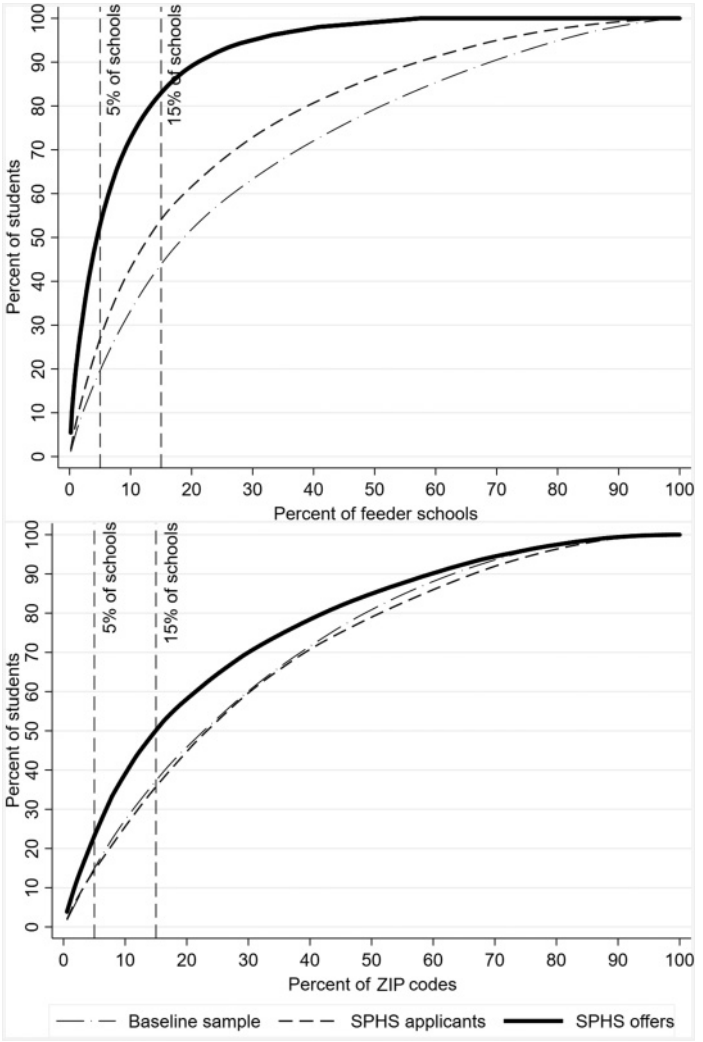
In the next section, we take a closer look at the public middle schools from which students apply.

6. MIDDLE SCHOOLS AND SPECIALIZED HIGH SCHOOL ADMISSIONS

A chief concern of the *Secret Apartheid* reports of the 1990s (ACORN 1996, 1997) was that students admitted to specialized high schools were disproportionately drawn from a small number of the city's middle schools. For the most part this remains true, a reflection of the uneven distribution of high-achieving students across NYC middle schools. For figure 2, we use our baseline population to produce a Lorenz-type curve showing the distribution of applicants and admitted students across public feeder schools. The curve plots the cumulative percent of students in a group (e.g., applicants, on the y axis) that come from a given x percent of feeders (on the x axis), after sorting schools in descending order by their number of students in that group. If schools were identical in size, a diagonal (45-degree) line would indicate a perfectly even distribution of students across schools. Because feeder schools vary in size, the baseline Lorenz curve serves as the benchmark for an even distribution, rather than the diagonal.[23]

The topmost curves in figure 2 show the distribution of students admitted to specialized high schools in 2013. In the top panel we see 53 percent of admitted students applied from only 5 percent of the city's middle schools.[24] By comparison, the largest 5 percent of middle schools enrolled about 20 percent of eighth graders. Eighty-three percent of admitted students originated from only 15 percent of middle schools, and nearly half of all middle schools sent few if any students to the exam schools. The distribution of *applicants* (those taking the SHSAT) is closer to the baseline distribution—5 percent of middle schools comprise about 27 percent of applicants, and 15 percent of feeders account for 53 percent of applications.[25]

23. In other words, if specialized high school applicants and admitted students were distributed across middle schools in the same way as the baseline population, their curves would look the same as the baseline. In addition to enrollment differences across feeder schools, differences in the propensity to move to the private sector for high school will affect the shape of the baseline Lorenz curve. (Students who intend to move to private schools and do not begin the public high school admission process are not included in our baseline sample.)
24. In 2013, 45 percent of all specialized high school offers to public school students went to students in only 20 middle schools (out of a total of 536 feeder schools in the baseline sample).
25. Though not shown here, we looked for changes over time in the concentration of applicants and admitted students between 2005 and 2013; the Lorenz curves in these years were nearly identical. If anything, the distribution of admitted students was more concentrated in 2013 than in earlier years.



Notes: Excludes special education, home school, and alternative feeder schools. Includes a total of 536 feeder schools and 178 ZIP codes with at least one student in the baseline sample in 2013. SPHS = specialized high school.

Figure 2. Feeder School and ZIP Code Representation Among Specialized High School Applicants and Admitted Students, 2013.

The bottom panel in figure 2 repeats this analysis for residential ZIP codes, to see whether the concentration observed in figure 1 is an artifact of residential sorting by ability. Here the distribution of applicants and admitted students is less concentrated. This is partly due to the smaller number of ZIP codes than feeders. That said, sorting by academic ability across middle schools appears more pervasive in NYC than sorting by ability across residential neighborhoods.

A closer look at specialized high school admits by feeder school reveals a large majority of admitted students were already attending highly selective middle school programs. Among offers to students in the top 30 sending schools (which account for 56 percent of offers), 58 percent attended citywide or district gifted and talented programs that require a test for admission, and another 31 percent attended middle schools that

screen applicants based on test scores or other criteria. Only 13 percent were from unscreened programs (all in Queens).

As a more formal test for middle school effects, we use random effects linear probability models (LPMs) to quantify the between-school variation in outcomes not explained by student-level predictors.[26] In some cases, these middle school "effects" were sizable. For instance, we find a 1 SD difference in feeder effects is associated with a 9-percentage point difference in the propensity to apply to the specialized high schools, implying that similar students attending different schools have meaningful differences in application rates. On the admissions margin, a 1 SD difference in feeder school effects is associated with a 2.2-point difference in admission rates, or a 1.2-point difference in admission to the Big 3. These are fairly large differences given the overall offer rate of 19 percent. They appear to be driven by earlier cohorts, however, as this estimate is closer to zero in more recent years. For SHSAT scores, a 1 SD difference in feeder effects is associated with an 8.7 point (a 0.095 SD) higher SHSAT score.[27] We find the SD of feeder school effects on matriculation to be near zero.

In sum, there do appear to be middle school effects on the pathway to specialized high school admissions, particularly on the application margin. Middle school effects on admissions are also meaningful in size. Although we cannot rule out the possibility that these effects are due to sorting on student characteristics not accounted for by the models, they suggest that opportunities may exist to identify schools where application and admission to the specialized high schools lag behind (or surpass) others with similar populations.

7. SIMULATING THE EFFECTS OF ALTERNATIVE ADMISSIONS CRITERIA

Critics of the SHSAT as the sole factor in admission have argued that more holistic criteria—like those used in some other highly selective U.S. high schools—would increase access to and diversity in the city's specialized high schools (Finn and Hockett 2012; Treschan et al. 2013). We simulated how the composition of students in the specialized high schools would change, if at all, under alternative admissions policies. We focused this analysis on the 2009 applications cycle, the one year for which we have data on course grades, which are often proposed as potential admissions criteria.

We considered seven alternative admissions policies, described in table 5. All use some index of state test scores, course grades, and attendance to award offers. Rule 6 further forces proportional representation by borough,[28] and Rule 7 (a "Top 10%" rule) gives priority to students whose average test scores and math and English course grades are among the top 10 percent in their middle school. For each simulation, we fix the number of public school students admitted to the actual value in 2009 (4,324). Only

26. Coefficients from the LPM versions of our table 3 models are provided in the online appendix. In LPM models with fixed school effects, we can reject the null hypothesis that the fixed effects are jointly zero for each outcome (application, admission, admission to a "big 3," matriculation). We use a random effects model to quantify between-school variation, since fixed effects would overstate this variation (due to small samples for some middle schools).
27. These models control for eighth-grade ELA and math scores which are also potentially affected by middle school quality. As an alternative, we controlled for students fifth grade (pre-middle school) scores, which reduced the size of the feeder school effects somewhat, to 7.6 points for a 1 SD increase.
28. This is similar to a proposal made to the City Council in 2014 (see Shepard 2014).

Table 5. Simulated Admissions Rules

Rule 1	Applicants are ranked by the average of their seventh-grade math and ELA *z*-scores, and admitted in order, beginning with the highest average, until all seats are filled. (Seventh-grade scores are the most recent available at the time of application.)
Rule 2	Applicants are ranked by the average of their seventh-grade math and ELA *z*-scores, and their seventh-grade math and English grades (also *z*-scores), and admitted in order, beginning with the highest average, until all seats are filled.
Rule 3	The same as Rule 2, except that course grades are *weighted*, with honors/ accelerated classes weighted by a factor of 1.25 prior to standardization. Students are admitted in order, beginning with the highest average, until all seats are filled.
Rule 4	Applicants are ranked by the average of their seventh-grade math and ELA *z*-scores, and their seventh-grade math, English, social studies, and science grades (also *z*-scores), and admitted in order, beginning with the highest average, until all seats are filled. As in Rule 3, honors courses are given additional weight.
Rule 5	The same as Rule 3, but the student's *z*-score for seventh-grade attendance is also included in the average. Students are admitted in order, beginning with the highest average, until all seats are filled.
Rule 6	The same as Rule 3, but *proportional representation* by borough is enforced (Brooklyn 31.8%, Manhattan 11.3%, Queens 27.6%, Staten Island 6.1%, and Bronx 23.3%, mirroring the distribution of applicants). Within-borough students are admitted in order, beginning with the highest average, until all seats are filled.
Rule 7	"Top 10%" Rule: all students in the top 10% of their feeder school by the measure in Rule 3 are eligible for admission. If the number of eligible applicants exceeds the number of available seats, eligible (top 10%) students are admitted in order, beginning with the highest average, until all seats are filled.

Notes: In the event of ties at the threshold for admission, students at the threshold are offered seats at random. (In practice, ties only occur under Rule 1.) ELA = English language arts.

applicants—those who expressed an interest in attending a specialized school—were at risk for admission. We repeated this analysis using the full population, in essence removing the effect of differential application rates. The results were similar, and are available in the online appendix.

Table 6 summarizes the simulations, showing how the composition of students admitted to specialized high schools would differ under these alternative rules. The first column provides descriptive statistics for the students actually admitted in 2009, and the remaining columns show the change in student characteristics under the seven alternatives. Under all but the Top 10% simulation, the mean ELA and math score of admitted students would be at least as high as the mean for those actually admitted. This is partly by construction, because all the simulations make some use of math and ELA scores. Mean course grades and attendance rates under the alternatives are also as high as (or higher than) those observed among actual admitted students. Mean test performance on the SHSAT, however, would fall considerably, from 0.33 SD (Rules 1–2) to as much as 0.73 SD (Rule 7).

The simulated admissions rules do alter the gender and racial/ethnic mix of admitted students. When a combination of state test scores, grades, and attendance is used in place of the SHSAT, a significantly higher fraction of offers would be extended to girls (an increase of 9 to 13 points under Rules 1–6). In fact, the gender gap would shift dramatically in favor of girls with the use of grades and state tests. At the same time, the fraction of offers extended to Asian students would drop 4 to 13 points, and the fraction extended to whites would rise 2 to 4 points. (Asians and whites would remain overrepresented among offers, relative to baseline). The fraction of offers to black and Hispanic students would rise modestly in Rules 1–6 (0–4 and 3–11 points, respectively),

Table 6. Changes in Composition of Specialized High Schools Under Alternative Admissions Rules

	Actual Offers	Change from Actual Offers in 2009						
	in 2009	Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6	Rule 7
Asian	53.6	−8.8	−6.5	−6.5	−6.0	−4.3	−12.7	−15.9
White	29.2	+2.3	+3.3	+3.5	+3.1	+2.0	−1.7	−9.4
Black	7.7	+2.0	+0.1	−0.6	−1.3	−0.8	+3.5	+12.7
Hispanic	9.4	+4.2	+3.1	+3.5	+4.1	+2.9	+10.6	+12.4
Female	46.1	+9.3	+13.1	+11.3	+10.8	+11.5	+12.8	+14.1
Free-lunch eligible	30.6	−0.2	−0.1	+0.0	+0.7	+0.5	+4.5	+12.0
ELA *z*-score (grade 7)	1.421	+0.301	+0.176	+0.082	−0.057	+0.079	+0.057	−0.027
Math *z*-score (grade 7)	1.701	+0.232	+0.171	+0.048	−0.112	+0.050	−0.023	−0.123
Math grade (0–100)	93.1	+0.1	+2.0	+1.0	+0.5	+1.1	+0.4	+0.3
English grade (0–100)	91.3	+0.8	+2.8	+2.0	+1.7	+2.1	+1.2	+0.7
SHSAT score	533.8	−30.0	−31.0	−38.6	−48.0	−37.1	−46.7	−65.3
Attendance rate	97.7	−0.2	+0.0	−0.1	−0.2	+0.3	−0.2	−0.5
Received an offer in 2009	100	−37.9	−38.8	−43.8	−49.0	−42.9	−47.1	−57.7
Received a Big 3 offer in 2009	75.7	−26.6	−27.4	−31.4	−36.2	−30.6	−33.7	−43.3
No. of schools representing 50% of offers	23	+4	+1	−5	−7	−5	−1	+34
No. of schools representing 85% of offers	81	+13	+0	−26	−38	−26	+2	+96

Notes: Only students who applied for specialized high school admission (took the SHSAT) in 2009 are included in admissions simulations. See table 5 for descriptions of each admissions rule.

though they would remain significantly underrepresented. In fact, under Rules 2–5, the percent of offers extended to black students would decline from current levels.

Perhaps surprisingly, Rules 1–6 have little to no effect on the concentration of specialized high school offers in a minority of feeder schools (evident in figure 2). The bottom two rows of table 6 report the number of middle schools that constitute the first 50 and 85 percent of offers, after sorting schools in descending order by offer counts. Of Rules 1–6, only Rules 1–2 would reduce the concentration of offers (slightly). The others *increase* the clustering of offers into a smaller number of middle schools. Even Rule 6, which enforces borough proportionality, retains a high level of concentration. Rule 7 (Top 10%) has the most dramatic effect on the concentration and demographics of specialized high school offers. When giving admissions priority to applicants in the top 10 percent of each middle school, the racial/ethnic distribution would be closer to baseline, and a higher fraction of offers would be extended to low-income students. This assignment rule comes, however, at the cost of lower average achievement on state tests (and the SHSAT).

These simulations only approximate the potential effect of these rules on the composition of specialized high schools, for several reasons. First, they do not address the general equilibrium implications of a rule change. We took the applicant pool and its prior performance (e.g., test scores and grades) as given; it is likely both would change under a new regime. A new rule would likely affect the composition of students who apply, by incentivizing applicants to shift their emphasis away from SHSAT preparation and toward course grades and state tests. A rule with set-asides for top students in each school could also lead to mobility between schools, as was found under the

Top 10% plan in Texas (Cullen, Long, and Reback 2013). Second, our simulations omit private school students, who constitute a meaningful share of applicants but lack the performance measures used in these rules. (Many public school applicants also lack data on these measures, highlighting a potential barrier to implementation.) Third, our simulations do not consider qualitative admissions criteria often proposed, such as recommendations, essays, or interviews. Finally, they are uninformative about unmeasured qualities of students—such as higher-order thinking skills or the ability to succeed in a competitive admissions process—that the SHSAT is intended to measure. To the extent the SHSAT is capturing skills that existing performance measures do not, our simulations ignore an important dimension of selectivity. More evidence is needed on this question.

8. DISCUSSION

This paper provides a descriptive look at the pipeline from NYC public middle schools to matriculation at the city's elite specialized high schools. A remarkably high proportion of eighth graders aspire to attend one of these schools, but only a fraction is admitted. A comparison of mean characteristics confirms admitted students are a highly select population on multiple dimensions, including state test scores and course grades. They are a somewhat more economically advantaged group than the wider population, although nearly a third is eligible for free meals, and almost one in five was born outside of the United States.

The SHSAT does appear to be a barrier to diversity in the specialized schools. Among applicants with similar track records on state tests, black, Hispanic, and low-income students are significantly less likely to score high enough on the SHSAT to receive an offer of admission. Asian and white students, on the other hand, are substantially more likely to receive an offer. Girls score nearly a quarter of a standard deviation lower than boys on the SHSAT for the same level of prior achievement, and underperform on both the mathematics and verbal sections of the test. Simulated policies that offer admission using alternative measures, such as state test scores, grades, and attendance, suggest that many more girls, Hispanics, and whites would be admitted under these alternatives. They would not, however, appreciably increase the share of offers given to black or low-income students, nor reduce the high concentration of offers in a small number of middle schools.

Our findings offer several important insights. First, measures of academic performance beyond the SHSAT are strong predictors of admission to the specialized high schools. Admissions policies that rely on state test scores and course grades would admit many of the same students now admitted, and—although improving the representation of some groups (especially girls)—would not dramatically change the demographic composition of the specialized high schools. Behavioral responses to any new policy would likely limit its impact even further. Second, although measures such as test scores, grades, and attendance are strongly predictive of current admission, there are large group differences that remain unexplained. The difference may be higher-order skills that are not adequately captured in other achievement measures, or simply differences in test preparation. This remains an important open question for future research.

Finally, we identified several potential points of intervention to improve access to the specialized high schools. First, a nontrivial share of high-achieving students does not sit for the SHSAT at all. This may reflect a lack of interest, a lack of resources for test preparation, or a poor understanding of their odds of admission. We found a significant middle school effect on the propensity to apply for the specialized schools, suggesting schools may influence this behavior.[29] Second, girls and Hispanic and low-income students are less likely to apply for admission than their prior achievement would predict, and girls are much less likely to accept an offer when extended one. The latter may reflect preferences to some degree, but, given the prominent role specialized schools play in STEM education in NYC, a better understanding of this phenomenon is needed. Lastly, echoing the *Secret Apartheid* studies of the 1990s, we find that students admitted to the exam schools originate from a remarkably small number of the city's middle schools. Although middle schools matter, this result appears more than anything to reflect the highly uneven distribution of high-achieving students across schools.

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29. In March 2016, the Independent Democratic Conference of the New York State Senate recommended—and later approved—a $2.55 million increase in funding to NYC to improve the "pipeline" of admissions to the specialized high schools. (In doing so they relied heavily on evidence from this study; see Independent Democratic Conference 2016.) The legislation called for increasing the number of gifted and talented programs in low-income, high-minority middle schools, and providing more resources for SHSAT test preparation. In June 2016, the NYCDOE announced a $15 million plan to boost black and Hispanic enrollment in the specialized high schools, through test preparation and after-school programs (see Harris 2016).

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