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THE EFFECT OF SCHOOL CHOICE ON PARTICIPANTS: EVIDENCE FROM RANDOMIZED LOTTERIES

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School choice has become an increasingly prominent strategy for enhancing academic achievement. To evaluate the impact on participants, we exploit randomized lotteries that determine high school admission in the Chicago Public Schools. Compared to those students who lose lotteries, students who win attend high schools that are better in a number of dimensions, including peer achievement and attainment levels. Nonetheless, we find little evidence that winning a lottery provides any systematic benefit across a wide variety of traditional academic measures. Lottery winners do, however, experience improvements on a subset of nontraditional outcome measures, such as self-reported disciplinary incidents and arrest rates.

KEYWORDS: School choice, randomized lottery, student outcomes.

1. INTRODUCTION

THE TYPICAL COUNTRY SPENDS 5 percent of gross domestic product on education (National Center for Education Statistics (2004)). Understanding how to improve the efficiency of resources devoted to education is a question of fundamental economic importance. Perhaps the most common approach to this problem has been to measure the impact of observable school inputs, such as spending per pupil, student–teacher ratios, and teacher credentials, on student outcomes. The literature to date has yielded mixed results with regard to the ability of policy makers to influence educational outcomes by altering the set of inputs to the educational process.[2]

Another approach that has been adopted by countries around the globe in recent years involves increasing the scope of schooling alternatives available to students—an approach long advocated by leading economists (Friedman (1955), Becker (1995), Hoxby (2002c)).[3] Creating a competitive and active

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[2]See Hanushek (1997) for an overview of this literature, and Aaronson, Barrow, and Sander (2002), Rockoff (2004), and Hanushek, Kain, O'Brien, and Rivkin (2005) for recent evidence on the impact of observable teacher characteristics on value added. There is a related and vast literature that seeks to estimate the impact of peer characteristics on individual educational outcomes with mixed findings (Hoxby (2000b), Sacerdote (2001), Zimmerman (2003), Graham (2004), Lefgren (2004)).

[3]The United Kingdom (Gorad (2001)), New Zealand (Fiske and Ladd (2000)), Colombia (Angrist, Bettinger, King, and Kremer (2002)), Chile (Hsieh and Urquiola (2003)), and even China (Tsang (2000)) are among the many countries that have instituted policies that enhance school choice.

marketplace has the potential to improve educational outcomes because schools improve in response to increased market pressure. To the extent that match quality between a school and a student is important, school choice programs may also yield benefits simply by increasing the set of schools over which a student is able to choose. For school choice to be an effective means of reform, however, it is necessary that students benefit from the opportunity to attend sought-after schools, and that these improvements are apparent to students and parents.

Unfortunately, estimating a causal relationship between access to sought-after schools and student outcomes has proven difficult. In the United States, observational studies of private schools (Coleman, Hoffer, and Kilgore (1982), Bryk, Lee, and Holland (1993)) and magnet schools (Blank (1983), Gamoran (1996)) find that students who attend these schools experience better educational outcomes, but these studies suffer from potentially important selection bias. Studies that use instrumental variables approaches to account for endogenous schooling choice find mixed effects, with some showing benefits (Evans and Schwab (1995)) and others showing little or no effect (Sander (1996), Neal (1997)).[4] More recently, there has been a series of studies that exploit randomized lotteries. The Milwaukee voucher program, which offers vouchers to a limited number of low-income students to attend one of three private nonsectarian schools in the district, is the most prominent of these. Analyses of this program obtain sharply conflicting estimates of its impact on achievement that depend on the assumptions made to deal with selective attrition of lottery losers from the sample (Witte, Sterr, and Thorne (1995), Green, Peterson, and Du (1997), Witte (1997), Rouse (1998)). Although, in theory, randomization provides an ideal context for evaluating the benefits of expanding students' choice sets, in the Milwaukee case less than half of the unsuccessful applicants returned to the public schools and those who did return were from less educated, lower income families (Witte (1997)).[5]

In this paper, we study one particular form of school choice known as *open enrollment*, a system in which public school students can apply to gain access to public magnet schools and programs outside of their neighborhood school, but within the same school district.[6] We are able to overcome many of the empirical

[4]Altonji, Elder, and Taber (2002) suggests that the instruments used in prior studies may not be valid.

[5]Evidence from other small-scale school choice experiments in the United States is similarly mixed. Peterson, Myers, and Howell (1998) and Howell and Peterson (2002) find that the opportunity to attend a private school modestly increases student achievement for low-achieving African American students in New York City, Dayton, and Washington, DC. A reanalysis of the New York City experiment by Krueger and Zhu (2003), however, suggests that even claims of modest benefits may be overstated. Prior studies that exploit lotteries to examine the benefit of attending magnet schools find mixed evidence of any long-term benefit (Crain, Heebner, and Si (1992), Crain and Thaler (1999), Kemple and Snipes (2000)).

[6]This form of choice is the most common form of choice available to students in urban areas (National Center for Education Statistics (1997)), and it is likely to become even more prevalent

difficulties that earlier studies confronted by using detailed administrative data from the Chicago Public Schools (CPS). Most importantly, we avoid the issue of nonrandom attendance at a choice school by using lottery data. Many CPS high schools use lotteries to allocate spots when they are oversubscribed, and we analyze 194 lotteries at 19 of these schools. Our use of lotteries as the source of identifying variation permits straightforward analysis based on comparisons of means. In principle and in practice, controlling for other characteristics will have little impact on any conclusions drawn, although we do so to increase the precision of our estimates. Sample selection in terms of which students choose to apply to a particular school will not bias our estimates, because among the applicants to a given school, those who win or lose the lottery will on average have the same characteristics.[7]

The CPS data we use offer a number of additional advantages beyond randomization. First, selective attrition is not an important concern in our sample because more than 90 percent of lottery participants enroll in CPS in ninth grade, the year after the lottery, and losing a lottery has only a minor impact on a student's propensity to stay. Moreover, there is little evidence that those who remain in the sample differ on observable dimensions from those who leave. Second, we have access to a far broader range of student outcomes than is typically available. In addition to standard achievement and attainment measures, we also have student survey responses that cover a wide range of issues, such as their degree of satisfaction with the school attended, how they are treated by teachers and peers, expectations about college attendance, and self-reported arrest data.[8] Little is known about how reforms affect these nontraditional measures of student outcomes, although this issue may be of considerable importance given the frequent inability of school-based interventions to induce large changes in standard educational measures like test scores (Hanushek (1997)). Third, CPS has been one of the most aggressive school districts in the country in implementing intradistrict school choice. Over half of high school students in CPS take advantage of the program by attending a school other than the one assigned, allowing us to examine the benefits of a systemic program rather than one where a small percentage of children participate. Finally, the type of school choice we analyze in this paper is particularly

under the recent federal education legislation *No Child Left Behind*. School districts that accept Title I funds must allow students at lagging schools to attend other schools in the district, giving preference to low-achieving and low-income students.

[7]One does still need to use care in interpreting the resulting parameter, which is an unbiased estimate of the impact of winning a lottery for the students who applied to the lottery, but may not generalize to other students.

[8]Few prior studies have examined the effects of specialized schools on nontraditional student outcomes. Two recent studies find opposite results for the impact of Catholic schools on drug use, sexual behavior, and criminal activity (Figlio and Ludwig (2000), Mocan, Scafidi, and Tekin (2002)). Using a unique telephone survey, Angrist, Bettinger, King, and Kremer (2002) find that being randomly assigned a private school voucher improves social as well as educational outcomes in the Colombian context.

relevant to the current federal accountability mandate insofar as our analysis focuses on public schools in a large, disadvantaged urban district.

Comparing lottery winners and losers, we find little evidence that winning a lottery provides any benefit on a wide variety of traditional achievement measures, including standardized test scores, graduation, attendance rates, course-taking patterns, and credit accumulation. These results are robust to a variety of sensitivity analyses and do not vary substantively across student subgroups. This finding is surprising because students who win contested lotteries would be expected to fare better because of access to better resources, better peers, or a program that better suits their learning needs for idiosyncratic reasons.

We explore a variety of potential explanations that underlie the lack of academic benefits. One possibility is that students who win lotteries end up attending similar schools to those who lose (i.e., the "treatment" is limited). This is not the case, however. Students who win lotteries to the most select programs do attend what appear to be substantially better high schools; e.g., schools with higher achievement levels (and gains), higher graduation rates, and lower poverty rates. Hence, our results appear to reinforce a large body of prior work that showed that measurable school inputs have little causal impact on student outcomes (Hanushek (1997)). A second explanation is that attending a choice school is a substitute for parental involvement. We find only weak support for this hypothesis. Another explanation is that students who win lotteries may have to travel much greater distances to school or experience less continuity in peers as they transition from elementary to high school, and these factors might interfere with academic success. The differential disruption and travel costs experienced by lottery winners appear to be quite small, however, and thus are unlikely to explain our results.[9]

One of the most interesting findings to emerge from this study is the fact that students who, ex ante, stand to gain the most in terms of peer quality by winning a lottery, in practice appear to realize the smallest benefits of choice. In fact, in many ways, these students appear to be hurt by winning a lottery, at least in terms of academic outcomes. For example, lottery winners have substantially lower class ranks throughout high school as a result of attending schools with higher achieving peers and are more likely to drop out. These findings are consistent with literature on the importance of mismatch (e.g., Light and Strayer (2000)) and of one's relative position (e.g., Kaufman and Rosenbaum (1992)) in educational settings.

The coexistence of intense competition for entry and little academic benefit to students who win the lotteries could indicate that parents are not well informed about the education production function and mistake higher school outputs for higher school value added. Alternatively, parents and children might apply to magnet schools for predominantly nonacademic reasons, in

[9]Furthermore, students should only be willing to pay these and any other disruption costs if adequately compensated.

which case systematic academic gains would not be expected. Using the unique set of survey data on student attitudes and behaviors, we examine the impact of winning a lottery on measures such as enjoyment of school, behavior of peers, student–teacher trust, expectations for the future, and self-reported disciplinary incidents. If parents and children choose schools for nonacademic reasons, one would expect positive effects on these nontraditional outcomes. We find some, though limited, support for this hypothesis: winners report fewer incidents of disciplinary action, fewer arrests, and lower incarceration rates, but are no more likely to report positive outcomes on other measures, such as liking school, trusting their teachers, and having high expectations for the future. These results are broadly consistent with the recent literature on the influence of peer effects on individual behavior. For instance, Kremer and Levy (2003) and Duncan, Boisjoly, Kremer, Levy, and Eccles (2005) find evidence that students randomly assigned to a roommate who drank in high school are more likely to drink in college, and Stinebrickner and Stinebrickner (2005) show that, for college students, one's roommate influences one's own study effort.

There are at least two important caveats to interpreting our results. First, we look at one particular form of school choice: open enrollment within the public schools. Other forms of school choice, such as vouchers, might yield substantially greater benefits. Second, we are only able to evaluate the partial equilibrium effects of school choice. In other words, the lotteries allow us to estimate how winning access to a particular school affects educational outcomes for a student, holding constant the existence of a school choice program. We are unable to determine how the introduction of school choice affects outcomes, because the introduction may have altered the composition of students in the public sector, the overall level of public school quality (Hoxby (2000a, 2005), Rothstein (2005)), and residential location patterns.[10]

The remainder of the paper is structured as follows. Section 2 provides background on open enrollment in CPS, the lotteries, and the administrative data. Section 3 describes our estimation strategy, focusing on how we utilize the lottery randomizations. Section 4 analyzes the impact of lottery outcomes on a variety of traditional and nontraditional outcome measures. Section 5 offers a brief conclusion.

2. INSTITUTIONAL DETAIL AND DATA DESCRIPTION

The Chicago Public Schools have one of the most extensive school choice programs available.[11] Each student is guaranteed admission to an assigned

[10]It is worth noting that the existing voucher experiments may understate the true long-run impact of vouchers because they are small scale and temporary, and thus do not encourage investment on the part of the private sector.

[11]School choice was first instituted in Chicago in response to a 1980 desegregation consent decree with the federal government. The goal of the consent decree was to create schools whose racial

neighborhood school, but can also apply to any other CPS school. Indeed, more than half of all high school students in CPS in 2000 and 2001 elected to attend a school other than the school assigned.

To attend a school other than the assigned school, a student must submit an application in the spring of the preceding year. A student must reside within the school district, but does not need to be currently enrolled in CPS to submit an application, and there is no restriction placed on the number of applications an individual student can submit. In most cases, if the number of applicants exceeds the number of available positions, randomized lotteries are used to determine the allocation of spots. For a limited number of programs, typically the most selective, admission is based on criteria such as test scores, and lotteries are not used.

For programs that use lotteries, there are explicit rules that govern the way in which the lotteries are conducted. Because of desegregation goals and variation in the number of available slots at different grade levels, separate lotteries are conducted for each gender–race–grade combination. A particular school may also house multiple magnet programs, each of which conducts separate lotteries. As a consequence, one school can potentially have a large number of lotteries each year.[12]

Working with the CPS, we have obtained detailed administrative data on applications submitted in spring 2000 and spring 2001. The application data include the name, race, gender, date of birth, home address, current school, and grade of each applicant, as well as the program a student is applying to, whether that application was part of a lottery, and, if so, the lottery outcome. We focus on eighth grade students who are applying for ninth grade admission. This is the transition period from primary to secondary school in CPS and thus is the juncture at which school choice is most frequently exercised.[13]

We exclude the small fraction (7 percent) of eighth grade students who apply from outside CPS. Note that excluding these students does not affect the validity of the randomization because enrollment status at the time of application is a predetermined variable. These students are no more or less likely to be represented among winners than among losers of any given lottery. However, excluding these students greatly reduces problems of selective attrition. Stu-

composition roughly matched the racial composition of the school system. Since that time, the size and scope of school choice has expanded dramatically.

[12]There is a further layer of complexity with regard to lotteries, namely that schools also reserve a share of available seats and conduct special lotteries for siblings of current students ("sibling lotteries") and for students who live nearby ("proximity lotteries"). Because such lotteries are rarely oversubscribed, they do not provide useful variation for our empirical work.

[13]The only other grade within CPS for which substantial numbers of school assignments are allocated by lottery is kindergarten. Test score data for the 2000 and 2001 cohort of kindergarten applicants will become available once these students age into tested grades.

dents who apply from outside the district's public schools are much less likely to enroll in CPS the following year, particularly when they lose the lottery.[14]

For our sample of eighth grade applicants who attend public schools in the district, the application data also provide their CPS identification number. Using this number, we link each application to a student's school records. This provides not only information on demographics and prior academic performance, but also information on whether the student enrolled in the CPS the following year and, if so, all of the student's future outcomes. In addition, for a subset of students we have responses to an extensive survey administered in eighth or ninth grade (see Appendix A for a detailed description of the variables and data sources used in this study). Our data have the shortcoming that we do not observe outcomes, other than reason for leaving, for students who do not attend CPS in subsequent years.

After eliminating applications to schools that do not use lotteries to assign slots (a handful of very selective test-based schools), special education schools, and schools with incomplete lottery outcome data, we are left with a baseline sample of 19 schools and 194 lotteries.[15] Our baseline sample contains 19,520 applications submitted by 14,434 students. The students in our sample constitute approximately one-fourth of all eighth graders in CPS during this 2-year period. Overall, these lotteries are quite competitive, with only 15 percent of applicants winning in the average lottery. Because a student can apply to multiple lotteries, roughly 20 percent of the students in the sample win at least one lottery.

Table I presents information about the 19 schools represented in the data set. Schools are ranked according to the eighth grade test score performance of students enrolling in ninth grade, which is presented in column 1 of the table. These schools range from the top 10 percent among the 70 regular high schools in CPS along this test score dimension (Von Steuben and Chicago Agricultural) all the way down to the very bottom (Orr is the second lowest scoring high school in CPS). Columns 2–4 report alternative indicators of school quality: a school's "value added" in reading test scores,[16] how competitive the lotteries are (a smaller percentage of lottery entrants selected indicates a greater imbalance between demand and supply), and the fraction of lottery winners who actually choose to enroll in the school when given the opportunity. There

[14]Applicants for ninth grade slots from eighth graders not enrolled in CPS during eighth grade are 35 percent more likely to enroll in the CPS if they win a contested high school lottery than if they lose. This provides evidence that the availability of school choice serves to attract students to the public sector.

[15]Appendix A describes the construction of our sample in greater detail.

[16]Value added is computed as the mean residual by high school across three cohorts from a student-level regression of ninth grade reading percentile score on flexible controls for eighth grade reading score, student demographic characteristics, and fixed effects for the middle school a student attended in eighth grade. See Appendix B (posted on the supplementary material website (Cullen, Jacob, and Levitt (2006a))) for more detail.

TABLE I

CHICAGO PUBLIC HIGH SCHOOLS REPRESENTED IN THE ANALYSIS[a]

High School Name	Mean Peer Achievement (1)	Mean Value Added (2)	Fraction of Applicants Accepted (3)	Fraction of Accepted Applicants Enrolling (4)	Number of Analysis Lotteries (5)	Number of Participants in Analysis Lotteries (6)
Von Steuben Metro	0.622[b]	0.008[b]	0.069[b]	0.586[b]	15	5,888
Chicago Agricultural Science	0.611[b]	−0.009	0.127[b]	0.663[b]	9	627
Curie Metro	0.528[b]	−0.004	0.121[b]	0.632[b]	56	898
Hyde Park Academy	0.511[b]	−0.001	0.104[b]	0.399[b]	5	1,243
Kennedy	0.500[b]	0.003[b]	0.433	0.242	7	817
George Washington	0.492	−0.014	0.684	0.251	5	355
Lake View	0.488	0.045[b]	0.540	0.185	9	144
Taft	0.486	−0.031	0.195	0.237	16	1,881
Bogan Technical	0.470	−0.007	0.174	0.364	12	3,289
Amundsen	0.439	−0.011	0.052[b]	0.593[b]	6	522
Senn Metro Academy	0.393	−0.021	0.327	0.175	11	831
Juarez Community Academy	0.376	−0.013	0.227	0.123	5	241
Roosevelt	0.371	−0.020	0.200	0.259	16	860
Hirsch Metro	0.353	0.006[b]	0.569	0.342	2	240
Corliss	0.352	0.026[b]	0.463	0.280	2	365
Wells	0.362	−0.009	0.619	0.261	7	654
Robeson	0.312	−0.007	0.303	0.116	2	131
Harper	0.310	−0.006	0.180	0.169	7	366
Orr Community Academy	0.305	−0.029	0.372	0.136	2	168

[a]The summary statistics reported in column 1 are based on all ninth graders enrolled in these high schools in fall 2000 and fall 2001. Mean peer achievement is the mean composite eighth grade math and reading percentile scores for entering students, where a value of 0.5 indicates that the student is performing at national norms. Value added in column 2 is calculated by extracting the mean residual by high school campus from a student-level regression of ninth grade reading percentile score on flexible controls for eighth grade reading score, student demographic characteristics, and eighth grade campus fixed effects for the 1999–2001 cohorts (see Appendix B, posted on the supplementary material website (Cullen, Jacob, and Levitt (2006a)), for more detail). The statistics reported in columns 3 and 4 are averages across all 2000 and 2001 applications, regardless of whether an individual application is involved in a nondegenerate lottery. Columns 5 and 6 describe the nondegenerate lotteries and applications included in the empirical analysis.

[b]The high school is in the top (or bottom for column 3) quartile of analysis schools on this measure.

TABLE II

COMPARISON OF LOTTERY PARTICIPANTS TO EIGHTH GRADE NONAPPLICANTS[a]

Student Characteristic	Lottery Participants (1)	Non-Applicants (2)	Difference (1) − (2)	Standard Error of the Difference
White	0.119	0.113	0.006	0.003
Black	0.460	0.526	−0.066	0.005
Hispanic	0.370	0.338	0.032	0.005
Male	0.423	0.563	−0.139	0.005
8th grade math percentile score	0.526	0.389	0.137	0.003
8th grade reading percentile score	0.485	0.368	0.117	0.002
Free lunch eligible	0.725	0.757	−0.032	0.004
Receiving special education	0.116	0.256	−0.140	0.004
Ever received bilingual education	0.432	0.358	0.074	0.005
Living with a biological parent	0.800	0.786	0.013	0.004
Tract poverty rate	0.218	0.250	−0.031	0.001
Tract fraction high school graduates	0.646	0.638	0.009	0.001

[a]The unit of observation is the student. There are 14,434 students who participate in at least one of the lotteries included in our analysis. Mean characteristics for lottery participants are shown in column 1. There are 34,570 eighth graders enrolled in CPS in spring 2000 and spring 2001 that we do not observe submitting an application to a choice school. Mean characteristics for these students are shown in column 2.

is substantial variation across schools along all of these dimensions.[17] Schools with high mean achievement tend to be popular with students, as measured by either the competitiveness of the lotteries or the take-up rates of lottery winners (the correlation between columns 1 and 3 is −0.34, and between columns 1 and 4 is 0.71). Notably, the schools that we identify as high value added are *not* the most popular schools (the correlation between our value added measure and the acceptance and take-up rates is 0.27 and 0.09, respectively). In terms of the number of lottery participants, the high-achieving schools (particularly Von Steuben) are heavily overrepresented.[18]

Analysis of the raw data at the student level in Table II clearly demonstrates the important differences between the pool of applicants entering our lotteries (column 1) and other eighth grade students in CPS (column 2) along a variety of dimensions. Students who enter lotteries are less likely to be Black or male, have substantially higher test scores, and are less likely to be poor (as proxied by free-lunch eligibility and census tract poverty rates). Given the substantial

[17]Other natural dimensions of school quality include financial resources and teacher quality. In the CPS, funding is allocated largely by formula, whereby schools with larger populations of poor, special education, and language minority students receive compensatory funding, making it difficult to interpret higher levels of expenditures as a signal of quality. Some information on teacher characteristics by school is available, but we were unable to find a measure that both varied across schools and had an unambiguous association with the quality of instruction.

[18]Von Steuben has received national media attention and was included in two recent lists of America's best public high schools (Toch (1999), Matthews (2003)).

differences in observable characteristics, one might also be concerned that lottery applicants are systematically different on unobservable dimensions (for example, motivation level, parental involvement, etc.). It is precisely for this reason that lottery-induced randomization is likely to be important for drawing conclusions about the causal impact of attending a choice school on the students in our sample.

3. EMPIRICAL STRATEGY

In theory, lottery-induced randomization provides a simple solution to the problem of endogenous sorting of students. Because lottery outcomes are randomly assigned, winners and losers of a particular lottery will be identical, on average, in terms of unobservable as well as observable characteristics. Consequently, a simple difference of observed student outcomes between students who win and lose the lottery provides a consistent estimate of the impact of winning the lottery.

In the presence of J independently conducted lotteries, we could, in principle, generate J different estimates δ_j that capture the marginal impact of being allowed admission to the school represented by lottery j,

$$\delta_j = E[Y_i|Win_{ij} = 1; Apply_{ij} = 1] - E[Y_i|Win_{ij} = 0; Apply_{ij} = 1], \quad (1)$$

where Y is some outcome measure for student i, Win_{ij} is a binary variable that indicates whether the student won lottery j, and $Apply_{ij}$ is a binary variable equal to 1 if the student applied to the lottery and 0 otherwise. Then δ_j indicates whether winners are systematically higher or lower on the characteristic Y than losers in the same lottery.

Although δ_j is clearly an unbiased estimate of the impact of winning this lottery, it is important to consider its interpretation. Students may apply to and win other lotteries (10 percent of losers in our sample win another lottery), and not all winners choose to attend the lottery school. If the treatment is defined as attending the lottery school, then as long as the lottery is truly randomized and there is no selective attrition, δ_j provides an unbiased estimate of the intention-to-treat (ITT) effect on students who choose to apply, even if we are missing information about other schools to which a student may have applied or been accepted. If the treatment is instead defined as having the option to attend the lottery school, δ_j no longer corresponds to an ITT effect and becomes a parameter of direct interest: It measures the impact of having this school in the choice set for students who expressed an interest.

It is also legitimate to estimate separate treatment effects for subgroups of students, as long as the sample is split according to characteristics that are predetermined at the time of application. For example, the impact of winning for students in lottery j with a specific value for a characteristic z would be

$$(2)\qquad \delta_{jk} = E[Y_i|Win_{ij} = 1; Apply_{ij} = 1, z_i = k] - E[Y_i|Win_{ij} = 0; Apply_{ij} = 1, z_i = k].$$

In practice, the standard errors for particular lotteries and subgroups within lotteries in our data are too large to make such estimates informative. Therefore, we instead report results from ordinary least squares regressions (or Probit models when the dependent variable is binary) of the form

$$(3)\qquad Y_i = \delta(Win\_Lottery_{ia}) + \Gamma(Lottery_a) + e_{ia},$$

where the subscripts i and a index students and applications, respectively. The phrase $Win\_Lottery_{ia}$ denotes a binary variable that indicates whether application a for student i was a lottery winner. The term $Lottery_a$ is a vector of fixed effects that indicates the lottery to which the observation refers and e is a stochastic error term. In this specification, the δ coefficient is a weighted average of the δ_j's for the various lotteries, with the weight for lottery j equal to $(N_jP_j(1-P_j))/(\sum_j N_jP_j(1-P_j))$, where N_j is the number of students entered in lottery j and P_j is the proportion of students entered in lottery j who win the lottery. Holding the likelihood of winning constant, weights are proportional to the number of students in the lottery. The closer a lottery is to having half the applicants win, the more weight it receives.

In all specifications, we include covariates such as student demographics, prior achievement, and neighborhood characteristics. Our conclusions are not sensitive to the inclusion of these covariates.[19] Because the same student is included in the regression more than once if he or she submits multiple applications (we have roughly 1.3 applications per student), we report standard errors that are robust to clustering at the student level. When we examine high school outcomes, we report standard errors that are robust to clustering at the school level.[20]

3.1. *Establishing the Validity of the Randomization and Testing for Attrition Bias*

If the lotteries were conducted properly, then one would predict that the winners and losers of a given lottery would be, on average, perfectly balanced on all predetermined characteristics. Even if the lotteries are valid randomizations, however, selective attrition may bias our findings because we observe subsequent student outcomes only if the student enrolls in CPS. In Table III,

[19] In large samples, the estimates will be the same with and without this conditioning, as long as there is no selective attrition from the original sample.

[20] Because each student attends only one school, allowing for arbitrary correlation at the school level addresses any within-student correlation as well.

TABLE III

TESTING THE VALIDITY OF THE LOTTERIES[a]

	Lottery Losers	All Lottery Participants		Participants Enrolled in 9th Grade the Following Fall	
Dependent Variable	Mean of Dep. Var. (1)	Effect of Winning (2)	Std. Error (3)	Effect of Winning (4)	Std. Error (5)
Student's characteristics at time of application					
8th grade math percentile score	0.520	−0.000	0.005	−0.002	0.006
8th grade reading percentile score	0.479	−0.003	0.005	−0.004	0.005
Age	13.951	0.006	0.011	0.007	0.012
Free-lunch eligible	0.734	0.005	0.010	0.003	0.011
Reduced-price lunch eligible	0.106	0.000	0.007	0.000	0.008
Receiving special education	0.112	0.010	0.008	0.009	0.008
Ever received bilingual education	0.418	−0.006	0.008	−0.005	0.009
Living with a biological parent	0.800	−0.002	0.010	−0.004	0.010
Attends assigned 8th grade school	0.615	0.005	0.011	0.015	0.012
Number of applications submitted	3.397	0.002	0.048	0.003	0.051
School and neighborhood characteristics at time of application					
Mean achievement level in school	0.428	0.003	0.003	0.005	0.003
Fraction transferring into school	0.331	−0.005	0.007	−0.009	0.007
Tract fraction Black	0.423	0.003	0.005	0.002	0.005
Tract fraction Hispanic	0.319	−0.004	0.005	−0.005	0.005
Tract poverty rate	0.222	0.001	0.003	0.000	0.003
Tract fraction high school graduates	0.647	0.001	0.003	0.002	0.003
Tract fraction homeowners	0.419	0.005	0.005	0.007	0.005
Tract fraction not in the labor force	0.412	0.002	0.002	0.002	0.002
Tract crime index	{0.637}	0.012	0.012	0.010	0.013
Tract fraction in private high schools	0.144	0.002	0.003	0.002	0.003

Continues

we test for the validity of the lotteries and the presence of selective attrition by estimating (3) for a series of demographic and achievement variables that are predetermined at the time of the lottery. The predetermined variables include student, school, and neighborhood characteristics at the time an application is made, and survey responses given in eighth grade prior to application. Although the other measures are available for all students, the survey responses are available only for the subset of the 2001 cohort who attended an eighth grade school at which the survey was administered and who completed the survey. Column 1 presents the mean for each measure among the control group of lottery losers.[21] Columns 2 and 3 present the coefficient and standard error on

[21]For some survey measures that are scaled in arbitrary units, the standard deviation across students is more informative than the mean of the variable. In such cases, which are noted in the table, we report the standard deviation rather than the mean in column 1.

TABLE III—*Continued*

Dependent Variable	Lottery Losers Mean of Dep. Var. (1)	All Lottery Participants: Effect of Winning (2)	All Lottery Participants: Std. Error (3)	Participants Enrolled in 9th Grade the Following Fall: Effect of Winning (4)	Participants Enrolled in 9th Grade the Following Fall: Std. Error (5)
8th grade survey measures (2001 cohort)					
Responded to survey	0.676	0.003	0.015	0.009	0.016
Social resources in community[b]	{1.642}	0.021	0.065	−0.006	0.067
Student's liking for school[b]	{2.046}	0.057	0.081	0.048	0.084
Parents' support for learning[b]	{1.537}	0.024	0.058	0.011	0.060
Degree of parental supervision[b]	{2.206}	0.190**	0.085	0.157*	0.090
Home educational resources[b]	{1.815}	0.044	0.071	0.048	0.073
Regularly participates in school clubs	0.479	0.023	0.020	0.024	0.021
Born in United States	0.858	0.005	0.016	0.004	0.017
Speaks a language other than English	0.549	−0.008	0.015	−0.000	0.016
Attends religious services weekly	0.417	0.016	0.020	0.011	0.021
Reports getting into trouble at school	0.682	0.007	0.018	0.004	0.019
Lives with both parents	0.465	−0.010	0.018	−0.022	0.018
Mother completed some college	0.573	0.000	0.022	−0.006	0.023
Status in the fall following application					
Enrolled in CPS in 9th grade in the fall	0.895	0.020**	0.007	NA	NA
Leaves for private h.s. in the fall	0.031	−0.008**	0.004	NA	NA

[a] Column 1 reports the mean (or standard deviation { } for index measures) among lottery losers for the dependent variable indicated in the row heading. The remaining columns report results from separate regressions of the dependent variables on an indicator for being selected in a lottery and a full set of lottery fixed effects. Except for the binary variables, the models are estimated by ordinary least squares and the coefficient on the indicator for being selected is reported. The models with binary dependent variables are estimated using a Probit specification and we report the mean marginal effect of being selected. Eicker–White robust standard errors clustered by student are reported in columns 3 and 5. The results shown in columns 2 and 3 are based on the full sample of 19,520 applications involved in the 194 nondegenerate lotteries. The results shown in columns 4 and 5 are based on the subset of applications from students who enroll in ninth grade in CPS the following fall. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

[b] Composite measure created by the Consortium on Chicago School Research.

an indicator variable that reflects whether the student won the lottery.[22] The full sample of students is used in these columns, providing a test of the validity of the initial lottery. Columns 4 and 5 are identical to columns 2 and 3, except that the sample is limited to students who actually enroll in CPS in ninth grade. These latter columns thus reflect the degree to which, even after attrition occurs, the lottery winners and losers that we observe in our sample are matched on observable characteristics.

As the final two rows of Table III demonstrate, enrollment rates among lottery losers are high (89.5 percent), and winning a lottery increases the like-

[22] For the binary dependent variables, we report the mean marginal effect of being selected and its standard error (calculated using the delta method).

lihood of enrolling by only 2.0 percentage points. Thus, the degree of initial differential attrition is quite low. In both the full sample *and* in the subsample of students who actually enroll in CPS in ninth grade, lottery winners and losers are similar on a wide range of observable characteristics. The magnitudes of the implied differences are universally substantively small and we observe only one statistically significant difference in each sample—the degree of parental supervision is higher among lottery winners in both cases.[23] The validity of the initial lottery is not surprising given that the outcomes were computer-generated and the output was write-protected to prevent tampering. More impressive is the fact that there is no evidence of selective attrition.[24]

4. THE IMPACT OF WINNING A LOTTERY ON STUDENT OUTCOMES

To estimate the effect of winning a lottery on student outcomes, we estimate (3) for a wide range of outcome variables on the left-hand side of the regression. The specifications include an extensive set of student and neighborhood covariates (all predetermined and listed in the table notes) to increase the precision of our estimates. We present results for the average impact of winning a lottery across all participants and schools, as we did in testing the validity of the lotteries and the relationship between lottery outcomes and attrition. We also explore possible heterogeneous treatment effects across a variety of school and student characteristics.

[23]To determine how many statistically significant differences would be expected due purely to chance, we need to account for correlation across the background characteristics within students. We employ a simulation-based test, whereby we repeatedly randomly assign students (within lotteries) to winning or losing at the same rates as in the actual lotteries and reestimate (3). In 1,000 trials, the marginal effect of winning was found to be statistically significant for exactly one background variable 30.8 percent of the time at the 5 percent level and 26.1 percent of the time at the 10 percent level, so our finding is far from extreme. Whereas the results in Table III could mask systematic differences between winners and losers in opposing directions across lotteries, we have conducted more careful Monte Carlo tests based on lottery-specific comparisons of the absolute value of the difference between winners and losers on each background measure relative to the simulated distribution of this difference under random assignment (based on 1,000 trials). We cannot reject that the across-lottery distribution of the number of background measures for which the difference is in the tail (the top 5 percent or 10 percent of the simulated distribution) is consistent with random assignment.

[24]It is nonetheless possible that, conditional on enrollment, winners and losers may have different propensities to have valid outcome data in subsequent years. For example, lottery losers might become discouraged and either drop out of school or fail to show up to take the standardized achievement exams at greater rates than lottery winners. To examine outcome attrition, we estimate models similar to those shown in Table III and find no evidence of systematic selection in the presence of missing data. We also conduct a series of sensitivity analyses and selection corrections, which further confirm that our results are unlikely to be heavily influenced by attrition (see Appendix C, posted on the supplementary material website (Cullen, Jacob, and Levitt (2006b)), for more detail and the relevant regression results).

The first set of outcomes we examine includes the characteristics of the high school the student attends. These results tell us the extent to which winning a lottery affects the student's school environment. They also provide a means to translate the ITT estimates for student outcomes that we present later into estimates of treatment on the treated, which in our case are more accurately described as local average treatment effects (LATEs).[25] The results are presented in Table IV. Each cell of the table corresponds to a separate regression. The dependent variable of the regression differs by row. Columns reflect different subsets of lotteries. The first column uses all lotteries. The second through fourth columns include only the subset of lotteries from the five schools in our sample that are highest on each of our three proxies for school quality (high-achieving peers, high value added, and high popularity).[26] In each cell of the table, we report the marginal effect of winning a lottery (from ordinary least squares regressions for continuous outcomes and from Probit models for binary outcomes), a robust standard error in parentheses, and the control group mean in square brackets.[27]

The results of Table IV demonstrate that lottery outcomes have a substantial impact on the type and characteristics of high schools students attend within CPS. In the top panel, the dependent variables are a series of indicator variables for the type of school attended. The first column of the top row, for instance, shows that winning any lottery increases the probability that a student attends the school for which the lottery is held by 28.0 percentage points. Note that some students who lose the lottery nonetheless are sometimes able to enroll in the school, although the rates are low (between 6.9 and 8.2 percent depending on the type of school). That is because there are sometimes multiple programs offered within a given school, some of which may not be

[25]The lottery randomization potentially creates four groups: always-takers (who attend the lottery school whether they win or lose the lottery), never-takers (who do not attend whether they win or lose), compliers (who attend if they win, and do not attend if they lose), and defiers (who do not attend the lottery school if they win but do if they lose). Consider a regression specification that relates student outcomes to an indicator for attending the lottery school and uses winning the lottery as an instrument for this endogenous choice variable. Assuming there are no defiers, the LATE parameter identified by this instrumental variables strategy is the mean impact of attending the lottery school for compliers. If there are also no always-takers, the LATE parameter is the treatment-on-the-treated parameter. See Heckman, Tobias, and Vytlacil (2003) for a more thorough discussion.

[26]The top five schools on each proxy are indicated in the relevant column in Table I. In terms of high-achieving peers and value added, our top five schools fall into the top quartile of schools in the CPS overall on these measures. The top five schools are the same for (low) percentage of students who win lotteries and (high) take-up rates among lottery winners, so we report the results only once under the title "high popularity school."

[27]For the binary dependent variables, we estimate the marginal effect by calculating the derivative for each observation at its value of the covariates and then take the average across these derivatives.

TABLE IV

THE IMPACT OF WINNING A LOTTERY ON THE CHARACTERISTICS OF SCHOOL ATTENDED—BY LOTTERY SCHOOL TYPE[a]

Dependent Variable	The Effect of Winning a Lottery to Any School (1)	High-Achieving School (2)	High Value Added School (3)	High Popularity School (4)
Type of high school attended				
School for which lottery applies	0.280**	0.338**	0.242**	0.381**
	(0.012)	(0.022)	(0.023)	(0.024)
	[0.069]	[0.082]	[0.072]	[0.082]
Any school other than the student's attendance area school	0.095**	0.131**	0.116**	0.140**
	(0.009)	(0.014)	(0.016)	(0.016)
	[0.759]	[0.763]	[0.739]	[0.759]
School in top quartile in terms of peer achievement	0.063**	0.283**	0.174**	0.297**
	(0.011)	(0.019)	(0.020)	(0.022)
	[0.350]	[0.431]	[0.422]	[0.407]
School in top quartile in terms of value added	0.022**	0.099**	0.233**	0.046**
	(0.011)	(0.019)	(0.020)	(0.022)
	[0.391]	[0.452]	[0.501]	[0.455]
Nonlottery selective admissions school	−0.014**	−0.021	−0.030*	−0.035**
	(0.007)	(0.015)	(0.017)	(0.017)
	[0.125]	[0.187]	[0.222]	[0.187]
Nonlottery career academy	−0.049**	−0.072**	−0.007	−0.085**
	(0.008)	(0.011)	(0.012)	(0.011)
	[0.159]	[0.126]	[0.087]	[0.128]
High school characteristic				
Fraction of 9th graders at or above norms on high school exams	0.025**	0.057**	0.045**	0.058**
	(0.004)	(0.007)	(0.008)	(0.008)
	[0.349]	[0.408]	[0.434]	[0.407]
Mean combined 8th grade math and reading percentile scores of 9th graders	0.019**	0.043**	0.025**	0.049**
	(0.003)	(0.005)	(0.005)	(0.005)
	[0.482]	[0.517]	[0.528]	[0.514]
Mean combined 8th grade scores of 9th graders in the student's English class	0.009**	0.020**	0.014**	0.021**
	(0.003)	(0.005)	(0.005)	(0.006)
	[0.475]	[0.523]	[0.535]	[0.514]
Value added measure	0.001*	0.003**	0.005**	0.002**
	(0.000)	(0.001)	(0.001)	(0.001)
	[0.003]	[0.006]	[0.008]	[0.006]
Fraction Black or Hispanic in 9th grade school	−0.037**	−0.055**	−0.048**	−0.053**
	(0.003)	(0.006)	(0.006)	(0.006)
	[0.811]	[0.762]	[0.715]	[0.756]
Fraction Black or Hispanic in 9th grade English class	−0.031**	−0.055**	−0.047**	−0.053**
	(0.004)	(0.007)	(0.007)	(0.008)
	[0.818]	[0.764]	[0.715]	[0.757]
Fraction of students receiving free lunch	−0.021**	−0.044**	−0.027**	−0.056**
	(0.003)	(0.006)	(0.007)	(0.007)
	[0.786]	[0.747]	[0.736]	[0.744]

Continues

TABLE IV—*Continued*

Dependent Variable	Any School (1)	High-Achieving School (2)	High Value Added School (3)	High Popularity School (4)
	The Effect of Winning a Lottery to			
Graduation rate	0.018**	0.033**	0.023**	0.043**
	(0.003)	(0.004)	(0.004)	(0.005)
	[0.689]	[0.714]	[0.715]	[0.709]
Index of crime level in the neighborhood of the school	−0.194**	−0.268**	−0.151**	−0.287**
	(0.023)	(0.042)	(0.047)	(0.051)
	{1.052}	{1.189}	{1.272}	{1.201}
ln(median household income) in the neighborhood of the school	0.053**	0.010	0.016	−0.010
	(0.010)	(0.017)	(0.018)	(0.019)
	[10.45]	[10.48]	[10.52]	[10.48]
Disruption/continuity measures				
Distance from the student's home to his/her 9th grade school	−0.491**	0.521**	0.364**	0.469**
	(0.056)	(0.097)	(0.095)	(0.110)
	[2.521]	[2.652]	[2.503]	[2.611]
Fraction of 8th grade peers attending the student's 9th grade school	−0.039**	−0.058**	−0.054**	−0.060**
	(0.004)	(0.006)	(0.007)	(0.006)
	[0.167]	[0.168]	[0.174]	[0.169]
Fraction of 9th grade peers from the student's 8th grade school	−0.008**	−0.013**	−0.011**	−0.014**
	(0.002)	(0.002)	(0.002)	(0.002)
	[0.042]	[0.038]	[0.039]	[0.039]
Fraction of students in 9th grade school who differ in terms of race/ethnicity	0.051**	0.038**	0.018*	0.042**
	(0.006)	(0.009)	(0.09)	(0.011)
	[0.391]	[0.432]	[0.489]	[0.435]
Student's own race/ethnicity is the predominant race/ethnicity in 9th grade school	−0.042**	0.001	−0.002	−0.018
	(0.011)	(0.019)	(0.023)	(0.022)
	[0.684]	[0.653]	[0.603]	[0.644]
Fraction of students in 9th grade English class who differ in terms of race/ethnicity	0.050**	0.040**	0.019*	0.051**
	(0.006)	(0.010)	(0.010)	(0.012)
	[0.361]	[0.402]	[0.455]	[0.407]
Student's own race/ethnicity is the predominant race/ethnicity in 9th grade English class	−0.057**	−0.053**	−0.048**	−0.086**
	(0.012)	(0.020)	(0.024)	(0.023)
	[0.705]	[0.672]	[0.624]	[0.664]

[a]Each cell reports results from a separate regression. All regressions include a set of lottery fixed effects as well as student characteristics (Black, Hispanic, male, eighth grade math percentile score, eighth grade reading percentile score, age, free-lunch eligible, receiving special education in eighth grade, ever received bilingual education up to and including eighth grade, living with a biological parent in eighth grade, attending assigned eighth grade school) and neighborhood (census tract) characteristics (fraction Black, fraction Hispanic, poverty rate, fraction high school graduates, fraction homeowners, fraction not in the labor force, crime index, fraction of high school students attending private schools). Except for the binary variables, the models are estimated by ordinary least squares and the coefficient on the indicator for being selected is reported. The models with binary dependent variables are estimated using a Probit specification, and we report the mean marginal effect. Eicker–White robust standard errors clustered by student are shown in parentheses. Control group means (for applications from students not selected in the lottery) are shown in square brackets; standard deviations are shown in braces for index measures instead. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

oversubscribed.[28] Winning a lottery to a high popularity school or one with high-achieving peers has an even larger impact on enrollment in that school (38.1 and 33.8 percentage points, respectively), but winning a lottery to a high valued added school has a slightly lower impact on enrollment (24.2 percentage points). The fact that take-up rates, while substantial, are far from complete is central to understanding the appropriate interpretation of the results presented later in the paper. Winning a lottery has a smaller effect on whether a student attends any school other than the assigned school (the second row of the table) because students may win multiple lotteries or apply to schools that do not use lotteries. Nonetheless, winning a lottery is associated with a greater likelihood of attending any top quartile school as measured either by peer achievement or value added.[29]

The middle panel of Table IV explores the impact that winning a lottery has on the characteristics of the school that a student attends (regardless of whether the student actually chooses to go to the school at which he or she wins the lottery). On average, students who win lotteries attend schools with a lower fraction of minority students and peers who score higher on standardized tests, have lower rates of poverty as measured by free-lunch eligibility, and have higher graduation rates.[30] This is particularly true of students who win lotteries to schools that are high quality on the dimensions we measure. For instance, winning a lottery to a high popularity school raises the share of peers who test at or above national norms by 5.8 percentage points (off of a baseline of 40.7 percent), reduces the fraction of free-lunch-eligible peers by 5.6 percentage points (from a baseline of 74.4 percent), and raises the graduation rate of peers by 4.3 percentage points (relative to a baseline of 70.9 percent). Since there are multiple programs within many high schools, a more accurate peer measure may be those students with whom a child attends class. Because we do not have information on program enrollment, we examine the peers in each student's ninth grade English class. We find that lottery winners attend class with peers who have significantly higher test scores than lottery losers, although the magnitude of the peer differences is half as great as for the school-based peer measure, indicating that some lottery winners may be in lower tracked classes within their school. The schools attended by lottery winners are also in higher income and lower crime neighborhoods. Thus, on a wide range of dimensions that might be expected to reflect school quality,

[28]Unfortunately, we only know the school in which a student is enrolled, not the particular program within the school. Another channel through which lottery losers could gain access to the school is through the discretion that principals have to admit a small number of students outside of the lottery process.

[29]Winning a lottery does, however, slightly reduce the likelihood a student will attend either of the sought after types of schools that do not use lotteries: selective admissions schools and career academies.

[30]Table VIII also reveals that lottery winners are much more likely to have ready access to computers. This suggests that winners are exposed to higher levels of school resources.

lottery winners go to better schools than students who enter but lose the same lottery.

Theory would predict that lottery winners would experience improved academic outcomes, not only because they are attending higher quality schools on average, but also because their choice set is increased. To the extent that there are idiosyncratic features of a student–school match, winning a lottery may improve student outcomes even without a change in our proxies for school quality. Table V, however, presents surprising results to the contrary. Each row of Table V corresponds to a different regression with a traditional measure of school performance on the left-hand side. The specifications estimated are otherwise identical to those in Table IV.[31] Overall, we find no compelling evidence that students who win lotteries perform better on the range of academic measures we examine.

Outcomes related to enrollment or exit status by the end of four years are shown in the top panel. Students in our sample, regardless of whether they remain in CPS over time, are assigned to one of the five mutually exclusive categories shown.[32] Four-year graduation rates from CPS are actually significantly lower for the lottery winners as a whole in column 1 (a 4.4 percentage point reduction off a baseline rate of 58.3 percent), although the estimates are statistically insignificant for lotteries within our high-quality choice schools. There are multiple reasons why a student does not graduate from CPS in four years, including dropping out, failing a grade, transferring to a private school in Chicago, or moving out of the city of Chicago. For the overall sample, the nongraduates are about evenly split between those who drop out of CPS and those who transfer out of the CPS system, but not to local private schools. The magnitude of the differences in dropout rates for lottery winners and losers is substantial (2.0 percentage points off of a baseline of 19.2 percent), but not statistically different from zero at standard levels of confidence, although the lower bound of the 95 percent confidence interval, which is −1.1 percent, implies that we can rule out even modest reductions in dropping out for lottery winners versus losers.[33] It is unclear why winning a lottery would be associated with an increased rate of transfer outside of the Chicago area. One possibility is that match quality was worse than expected; another explanation is that there is a fixed cost associated with moving a child away from the neighborhood school (e.g., learning how to use the public transit system) that can be applied to attending other schools.

[31] As in Table IV, all of the results we report are conditional on a student enrolling in CPS in the fall of ninth grade. As we document in Table III, there is little evidence of selective attrition for that enrollment decision.

[32] The 1.7 percent of students the CPS was unable to track is an omitted group.

[33] Dropout rates by eleventh grade (shown in the last panel of the table), if anything, also show a tendency to be higher among lottery winners, although these results are not statistically significant. The coefficient on eleventh grade dropout is estimated more precisely than the corresponding coefficient on twelfth grade dropout because we have data for both cohorts on the former measure, but only for one cohort on the latter.

TABLE V

THE IMPACT OF WINNING A LOTTERY ON TRADITIONAL MEASURES OF STUDENT OUTCOMES—BY LOTTERY SCHOOL TYPE[a]

	The Effect of Winning a Lottery to			
Dependent Variable	Any School (1)	High-Achieving School (2)	High Value Added School (3)	High Popularity School (4)
Outcomes at the end of 4 years				
Graduated[b]	−0.044**	−0.017	0.011	−0.046
	(0.018)	(0.034)	(0.051)	(0.044)
	[0.583]	[0.636]	[0.635]	[0.621]
Enrolled in the CPS[b]	0.000	−0.001	−0.025**	0.008
	(0.009)	(0.013)	(0.012)	(0.015)
	[0.084]	[0.071]	[0.071]	[0.073]
Dropped out[b]	0.020	0.013	−0.005	0.033
	(0.015)	(0.024)	(0.032)	(0.029)
	[0.192]	[0.155]	[0.152]	[0.164]
Transferred to a private school in the Chicago MSA[b]	0.004	−0.004	0.003	−0.005
	(0.005)	(0.006)	(0.009)	(0.007)
	[0.016]	[0.017]	[0.016]	[0.017]
Moved out of the district[b]	0.025**	0.010	0.023	0.014
	(0.010)	(0.021)	(0.027)	(0.028)
	[0.107]	[0.104]	[0.108]	[0.108]
9th grade outcomes				
Reading percentile score	−0.013**	−0.009	−0.010	−0.010
	(0.005)	(0.007)	(0.008)	(0.009)
	[0.415]	[0.469]	[0.487]	[0.456]
Algebra end-of-course exam score	−0.002	−0.009	−0.005	−0.008
	(0.007)	(0.010)	(0.012)	(0.012)
	[0.446]	[0.492]	[0.518]	[0.488]
English I end-of-course exam score	−0.001	0.000	0.013*	−0.002
	(0.004)	(0.005)	(0.006)	(0.005)
	[0.596]	[0.620]	[0.628]	[0.619]
Spring semester fraction of days absent	0.003	−0.001	−0.005	0.004
	(0.003)	(0.005)	(0.004)	(0.006)
	[0.101]	[0.087]	[0.083]	[0.090]
Spring semester credits earned	−0.029	0.020	0.036	−0.052
	(0.093)	(0.165)	(0.114)	(0.201)
	[27.68]	[27.83]	[27.87]	[27.84]
Class percentile rank (1=best)	−0.020*	−0.047*	−0.029	−0.069**
	(0.011)	(0.025)	(0.029)	(0.027)
	[0.577]	[0.593]	[0.591]	[0.584]

Continues

The other measures of academic success (e.g., test scores, absences, school credits, being retained, and class rank) are only observed if the student remains enrolled and, in the case of test scores, is present on the day the exam is

TABLE V—*Continued*

	The Effect of Winning a Lottery To			
Dependent Variable	Any School (1)	High-Achieving School (2)	High Value Added School (3)	High Popularity School (4)
10th grade outcomes				
Reading percentile score[b]	−0.010	−0.022**	−0.016	−0.027**
	(0.007)	(0.010)	(0.014)	(0.012)
	[0.467]	[0.523]	[0.543]	[0.509]
Geometry end-of-course exam score[b]	0.013	0.016	0.056**	0.001
	(0.009)	(0.018)	(0.021)	(0.021)
	[0.569]	[0.621]	[0.646]	[0.613]
English II end-of-course exam score[b]	0.002	−0.010	−0.009	−0.011
	(0.006)	(0.011)	(0.013)	(0.010)
	[0.517]	[0.548]	[0.556]	[0.543]
Spring semester fraction of days absent	0.006	−0.002	−0.003	0.003
	(0.005)	(0.006)	(0.007)	(0.007)
	[0.115]	[0.102]	[0.095]	[0.106]
Cumulative spring semester credits earned	−0.279	0.073	0.077	−0.042
	(0.237)	(0.305)	(0.199)	(0.369)
	[55.61]	[55.76]	[55.80]	[55.81]
Class percentile rank (1=best)	−0.025**	−0.045**	−0.017	−0.068**
	(0.011)	(0.020)	(0.025)	(0.020)
	[0.548]	[0.562]	[0.563]	[0.552]
11th grade outcomes				
Dropped out by spring	0.013	0.012	−0.012	0.016
	(0.009)	(0.015)	(0.009)	(0.013)
	[0.119]	[0.093]	[0.090]	[0.099]
Retained (enrolled in grade below 11th grade)	−0.001	−0.017	−0.004	0.015
	(0.013)	(0.027)	(0.031)	(0.032)
	[0.133]	[0.113]	[0.111]	[0.120]

[a] Each cell reports the results from a separate regression. All regressions include a set of lottery fixed effects as well as the student and neighborhood characteristics detailed in the notes to Table IV. Except for the binary variables, the models are estimated by ordinary least squares and the coefficient on the indicator for being selected is reported. The models with binary dependent variables are estimated using a Probit specification and we report the mean marginal effect of being selected. Eicker–White robust standard errors clustered by high school are shown in parentheses. Control group means (for applications from students not selected in the lottery) are shown in square brackets. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

[b] Sample limited to the 2000 cohort due to data availability.

administered. We have extensively explored whether selective attrition occurs *after* enrollment in ninth grade (see Appendix C, posted on the supplementary material website (Cullen, Jacob, and Levitt (2006b))), finding no evidence that biases are introduced. The middle panels of Table V report results for these outcomes. Our results suggest that there is no impact of winning a lottery on the frequency of absences or the number of credits obtained—the point estimates for specifications are nearly zero and the standard errors are reasonably tight, allowing us to rule out any moderate to large positive or negative effects (relative to the baseline). There is also no evidence that lottery winners perform systematically better on the various test measures that are available to us. For the full set of lotteries, the point estimate on winning a lottery is negative on four of the six test outcomes we observe in ninth and tenth grade. The only one of these that is statistically significant (percentile rank on the ninth grade reading exam) carries a negative sign, implying that lottery winners perform worse.

The results are no more encouraging when we limit the sample to high-quality schools: those with high mean achievement (column 2), high value added (column 3), or high popularity (column 4). For example, our point estimates indicate that winning a lottery to a high-achieving (highly popular) school increases the probability of dropping out by roughly 1.3 (3.3) percentage points, although these estimates are not significant at conventional levels. Similarly, the point estimates for the majority of the test score outcomes are negative, although few are statistically significant.[34] The most consistent difference we observe is that students who win lotteries have statistically significantly worse class ranks by 2–7 percentile points, likely reflecting the fact that their own academic performance is not greatly affected, but the pool of peers against whom they compete is stronger. Interestingly, the test score estimates for high value added schools are somewhat better than for either high-achieving or highly popular schools.[35] As we subsequently discuss in greater detail, this pattern of results, along with the fact that the popular schools are those with the highest level of achievement and not necessarily the highest value added, implies that parents and students may not be able to recognize effective schools.

An important caveat on the foregoing discussion, however, is that because of large standard errors, we cannot always rule out the possibility of sizable benefits of winning a lottery, in spite of the predominately negative point estimates. For instance, when using the full sample, the upper bound of the 95 percent confidence interval is negative for one test, less than 1 percentile for two of the tests, between 1.0 and 1.5 percentiles for another two, and 3.1 percentiles for tenth grade geometry. An improvement of a few percentile points is not trivial in magnitude, particularly if the treatment is defined to be attending the lottery school rather than adding the lottery school to the student's choice set. As reported in Table IV, winning a lottery is associated with an increased likelihood of attending that school ranging from 24.2 to 38.1 percentage points, depend-

[34]Moreover, when we limit the sample to lotteries to schools with a math focus, lottery winners perform no better on math tests than lottery losers. Similarly, winning a lottery to a school with a reading focus does not improve reading test scores.

[35]Indeed, two of the six test score estimates for high value added schools are positive and significant at the 10 percent level or better.

ing on the set of lotteries examined.[36] Thus, the LATE estimate is 2.5 to 4 times larger than the ITT estimate, with the corresponding 95 percent confidence intervals increased in that proportion. Although the basic findings suggest little positive impact on these academic outcomes from winning the lottery, the imprecision of the estimates limits the certainty with which one can draw the same conclusion for the impact of attending the lottery school.

Even if there are no systematic aggregate benefits, it is possible that winning a lottery has a positive effect for some schools or for some subset of students.[37] Figure 1 reports the distribution of treatment effects at each of the schools in our sample for a subset of the most relevant outcomes.[38] For the most part, the individual school estimates are too imprecise to be informative. One school, for example, shows a statistically significant *increase* in dropout rates associated with winning a lottery; another shows a significant decrease in dropout rates, but the other estimates are not statistically different from zero. The results are comparable for the other outcomes. Moreover, there is no clear relationship between peer quality and the school effects. Finally, the correlations between the school-specific estimates of different outcomes (e.g., ninth grade reading and ninth grade algebra or dropout probability) are small and not significantly different from zero. Hence, it does not appear that the aggregate estimates are masking substantially positive or negative effects in specific schools.

We also explore the possibility of heterogeneous treatment effects along observable dimensions of the student population: race, gender, whether the student was below average in eighth grade test scores, and by the extent of the difference in peer quality at the lottery school relative to the student's next-best option.[39] Table VI, which follows the format of Table IV (but reports only a representative subset of the school characteristics), presents results on how lotteries impact the characteristics of the school attended.[40] Our baseline results for the full sample are reprinted in the first column. There are no notable patterns across race, gender, and prior academic achievement (columns 2–5).

[36]If one thinks of the relevant treatment not as attending the particular school that runs the lottery, but rather, any high-quality school, the impact of winning a lottery to a high-achieving school is almost unchanged, but the effect of winning any lottery is much smaller.

[37]For example, in a series of voucher experiments, Peterson, Myers, and Howell (1998) find that the opportunity to attend a private school increases student achievement for low-achieving African American students, but not others.

[38]For the test score measures, we have data on all 19 schools. Only 10 of the schools have survey data. Graduation data are only available for lotteries that involve the 2000 cohort in schools with sufficient variation in the outcome (which limits the sample to 13 schools).

[39]Peer quality is measured as the average combined eighth grade math and reading scores of ninth graders at the same high school. We proxy for peer quality at the student's next-best option using the average high school peer quality experienced by students who attended the same eighth grade campus, are in the same ability quintile (as measured by combined eighth grade reading and math scores), and who lost (or did not apply for) our lotteries. This strategy accounts for the fact that students may apply to a wide set of schools other than those we observe in our sample.

[40]Full results for all outcome measures in all subgroups are available on request from the authors.

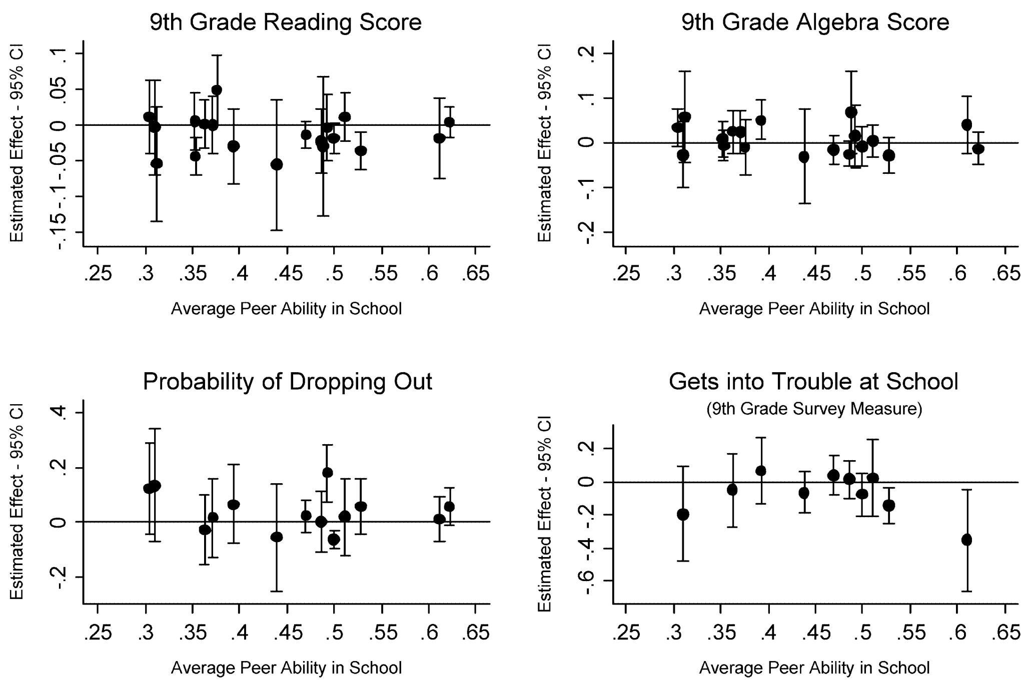

FIGURE 1.—The effects of winning a lottery by school. Each bar represents the effect for a separate school.

TABLE VI

THE IMPACT OF WINNING A LOTTERY ON THE CHARACTERISTICS OF THE SCHOOL ATTENDED—BY STUDENT TYPE[a]

Dependent Variable	All Students (1)	Black (2)	Hispanic (3)	Male (4)	Below Average 8th Grade Test Scores (5)	Potential Increase in Peer Quality: Bottom Quartile (6)	Potential Increase in Peer Quality: Top Quartile (7)
Type of high school attended							
School for which lottery applies	0.280**	0.292**	0.270**	0.279**	0.306**	0.182**	0.490**
	(0.012)	(0.017)	(0.021)	(0.018)	(0.017)	(0.021)	(0.038)
	[0.069]	[0.062]	[0.060]	[0.079]	[0.052]	[0.069]	[0.034]
High school characteristic							
Mean combined 8th grade math and reading percentile scores of 9th graders	0.019**	0.016**	0.024**	0.024**	0.023**	−0.024**	0.089**
	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)	(0.005)	(0.007)
	[0.482]	[0.458]	[0.477]	[0.485]	[0.415]	[0.579]	[0.417]
Mean combined 8th grade scores of 9th graders in the student's English class	0.009**	0.006	0.013**	0.010**	0.014**	−0.017**	0.043**
	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.006)	(0.008)
	[0.475]	[0.445]	[0.474]	[0.471]	[0.363]	[0.596]	[0.399]
Value added measure	0.001*	0.000	0.001	0.001	0.002**	−0.003**	0.007**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.003]	[−0.000]	[0.002]	[0.003]	[−0.006]	[0.016]	[−0.006]
Disruption/continuity measures							
Distance from the student's home to his/her 9th grade school	−0.491**	0.473**	0.658**	0.531**	0.544**	−0.025	0.943**
	(0.056)	(0.084)	(0.089)	(0.081)	(0.071)	(0.117)	(0.130)
	[2.521]	[2.813]	[2.107]	[2.463]	[2.092]	[3.154]	[1.981]
Fraction of 8th grade peers attending the student's 9th grade school	−0.039**	−0.030**	−0.057**	−0.039**	−0.044**	−0.010	−0.094**
	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)	(0.007)	(0.010)
	[0.167]	[0.140]	[0.197]	[0.173]	[0.188]	[0.134]	[0.204]

Continues

TABLE VI—*Continued*

Dependent Variable	All Students (1)	Black (2)	Hispanic (3)	Male (4)	Below Average 8th Grade Test Scores (5)	Potential Increase in Peer Quality: Bottom Quartile (6)	Potential Increase in Peer Quality: Top Quartile (7)
Fraction of students in 9th grade school who differ in terms of race/ethnicity	0.051**	0.062**	0.069**	0.051**	0.063**	0.003	0.100**
	(0.006)	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)	(0.017)
	[0.391]	[0.292]	[0.451]	[0.415]	[0.329]	[0.463]	[0.375]
Student's own race/ethnicity is the predominant race/ethnicity in 9th grade school	−0.042**	−0.037**	−0.103**	−0.037**	−0.057**	−0.001	−0.108**
	(0.011)	(0.013)	(0.021)	(0.017)	(0.015)	(0.019)	(0.034)
	[0.684]	[0.730]	[0.652]	[0.660]	[0.739]	[0.608]	[0.700]
Fraction of students in 9th grade English class who differ in terms of race/ethnicity	0.050**	0.057**	0.078**	0.046*	0.064**	−0.001	0.107**
	(0.006)	(0.009)	(0.011)	(0.010)	(0.009)	(0.011)	(0.018)
	[0.361]	[0.273]	[0.411]	[0.383]	[0.300]	[0.429]	[0.347]
Student's own race/ethnicity is the predominant race/ethnicity in 9th grade English class	−0.057**	−0.053**	−0.120**	−0.041**	−0.068**	0.006	−0.159**
	(0.012)	(0.014)	(0.022)	(0.018)	(0.016)	(0.022)	(0.035)
	[0.705]	[0.742]	[0.713]	[0.686]	[0.758]	[0.603]	[0.719]

[a]See notes to Table IV. For columns 6 and 7, the potential increase in peer quality (mean combined eighth grade math and reading percentile scores of ninth graders) is calculated as peer quality at the lottery school less peer quality at a student's inside option. We measure peer quality at a student's inside option using the average peer quality enjoyed by students who attended the same eighth grade campus and placed within the same eighth grade test score quintile. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

There are, however, sizable differences across students in the top and bottom quartile of the gap in peer quality at the lottery school versus the next-best option. Students who stand to gain the least in terms of peer quality (column 6) are much less likely than those who would gain the most (column 7) to actually attend the lottery school when victorious (marginal effects of 0.182 and 0.490, respectively). Indeed, the middle panel of Table VI shows that for the students with the least to gain, peer quality is actually lower, on average, at the lottery school. In stark contrast, among lottery winners with the most to gain, average combined eighth grade scores among students at the high school attended jump almost 9 percentile points and value added is substantially higher.[41]

Table VII reports the impact of winning a lottery on student outcomes for the various subsamples of the student population. Focusing on dropout rates, we see that winning a lottery appears to increase the likelihood of dropping out for Blacks (not statistically significant) and below average students (marginally significant). Remarkably, the group of lottery winners that fares the very worst in terms of educational attainment is the subset of students who gain the most in terms of peer quality. Students who win lotteries to schools with substantially higher peer quality than their next-best option are 10.7 percentage points (highly significant) *more likely* to drop out by 12th grade than comparable lottery losers. The difference for those who apply to schools with little potential benefit in terms of peer quality is considerably smaller (1.3 percentage points) and not statistically significant. Even if we take into account the larger first stage effects for the high-benefit group, the magnitude of the negative effect for the high-benefit group translated into a LATE is substantially larger than that of the low-benefit group. Thus, the group that a priori would be expected to benefit the most from access to high-quality schools actually shows the worst response to winning a lottery.[42]

The remainder of Table VII examines other academic outcomes such as test scores and class rank for the various subsets of students. Although the results are quite mixed, there is no evidence that any subgroup derives any substantial academic benefit from winning a lottery to a choice school. If we focus again on the distinction between low- and high-benefit groups, it is apparent that students who won lotteries to schools with higher achieving peers (compared to the students' next-best options) underperformed relative to their peers from

[41]The potential peer improvement from winning a lottery is a function of both the school to which the student applied as well as the school the student would have most likely attended if he or she did not win the lottery. In practice, students in column 7 are relatively low-achieving students (based on eighth grade test scores) who apply to high-achieving lottery schools. Conversely, students in column 6 tend to be moderate- or high-achieving students who apply to low- to moderate-achieving lottery schools.

[42]These findings cannot be explained by higher rates of initial attrition. Winners and losers in this sample enroll in CPS in ninth grade at rates of 92.7 and 90.5 percent, respectively, and the difference is not statistically significant.

TABLE VII

THE IMPACT OF WINNING A LOTTERY ON TRADITIONAL MEASURES OF STUDENT OUTCOMES—BY STUDENT TYPE[a]

						Potential Increase in Peer Quality	
Dependent Variable	All Students (1)	Black (2)	Hispanic (3)	Male (4)	Below Average 8th Grade Test Scores (5)	Bottom Quartile (6)	Top Quartile (7)
Outcomes at the end of 4 years							
Graduated[b]	−0.044**	−0.100**	0.003	−0.061**	−0.069**	−0.079**	−0.142**
	(0.018)	(0.020)	(0.025)	(0.024)	(0.025)	(0.036)	(0.058)
	[0.583]	[0.550]	[0.594]	[0.528]	[0.486]	[0.675]	[0.534]
Enrolled in the CPS[b]	0.000	0.005	−0.005	0.017	−0.018	0.005	0.012
	(0.009)	(0.017)	(0.013)	(0.018)	(0.017)	(0.014)	(0.027)
	[0.084]	[0.096]	[0.086]	[0.107]	[0.104]	[0.067]	[0.082]
Dropped out[b]	0.020	0.039	0.027	0.015	0.039*	0.013	0.107**
	(0.015)	(0.024)	(0.025)	(0.023)	(0.023)	(0.022)	(0.051)
	[0.192]	[0.233]	[0.162]	[0.208]	[0.253]	[0.150]	[0.227]
Transferred to a private school in the Chicago MSA[b]	0.004	0.014	−0.003	0.002	0.015	0.000	0.081**
	(0.005)	(0.011)	(0.008)	(0.010)	(0.012)	(0.017)	(0.036)
	[0.016]	[0.019]	[0.014]	[0.020]	[0.021]	[0.008]	[0.018]
Moved out of the district[b]	0.025**	0.041**	−0.001	0.029**	0.043**	0.050**	0.023
	(0.010)	(0.014)	(0.017)	(0.014)	(0.019)	(0.019)	(0.041)
	[0.107]	[0.086]	[0.122]	[0.115]	[0.122]	[0.078]	[0.125]
9th grade outcomes							
Reading percentile score	−0.013**	−0.012*	−0.016**	−0.007	−0.003	−0.031**	−0.013
	(0.005)	(0.006)	(0.008)	(0.007)	(0.006)	(0.009)	(0.011)
	[0.415]	[0.370]	[0.422]	[0.420]	[0.267]	[0.563]	[0.327]
Algebra end-of-course exam score	−0.002	−0.006	0.006	−0.008	0.005	−0.014	0.012
	(0.007)	(0.008)	(0.011)	(0.009)	(0.008)	(0.011)	(0.013)
	[0.446]	[0.398]	[0.452]	[0.459]	[0.347]	[0.548]	[0.401]

Continues

TABLE VII—*Continued*

						Potential Increase in Peer Quality	
Dependent Variable	All Students (1)	Black (2)	Hispanic (3)	Male (4)	Below Average 8th Grade Test Scores (5)	Bottom Quartile (6)	Top Quartile (7)
English I end-of-course exam score	−0.001	−0.002	0.001	0.001	−0.002	−0.002	−0.002
	(0.004)	(0.004)	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)
	[0.596]	[0.569]	[0.605]	[0.580]	[0.522]	[0.665]	[0.542]
Spring semester fraction of days absent	0.003	0.008*	−0.008	0.004	0.009**	0.001	0.008
	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
	[0.101]	[0.117]	[0.089]	[0.099]	[0.123]	[0.082]	[0.110]
Spring semester credits earned	−0.029	−0.089	0.144	0.069	−0.231*	−0.048	−0.317
	(0.093)	(0.141)	(0.129)	(0.108)	(0.142)	(0.130)	(0.282)
	[27.68]	[27.57]	[27.71]	[27.70]	[27.31]	[27.98]	[27.53]
Class percentile rank (1=best)	−0.020*	−0.032**	−0.000	−0.024**	−0.036**	0.007	−0.109**
	(0.011)	(0.012)	(0.012)	(0.012)	(0.014)	(0.011)	(0.036)
	[0.577]	[0.555]	[0.590]	[0.519]	[0.540]	[0.574]	[0.587]
			10th grade outcomes				
Reading percentile score[b]	−0.010	−0.016	−0.005	0.002	0.008	−0.021**	−0.032
	(0.007)	(0.013)	(0.010)	(0.009)	(0.009)	(0.010)	(0.020)
	[0.467]	[0.418]	[0.471]	[0.457]	[0.312]	[0.638]	[0.368]
Geometry end-of-course exam score[b]	0.013	−0.002	0.026**	0.014	0.024**	−0.026*	0.051
	(0.009)	(0.011)	(0.013)	(0.009)	(0.012)	(0.013)	(0.034)
	[0.569]	[0.510]	[0.573]	[0.587]	[0.448]	[0.691]	[0.501]
English II end-of-course exam score[b]	0.002	0.004	0.003	0.001	0.010	−0.007	−0.013
	(0.006)	(0.005)	(0.010)	(0.008)	(0.008)	(0.011)	(0.010)
	[0.517]	[0.491]	[0.518]	[0.498]	[0.438]	[0.597]	[0.465]

Continues

TABLE VII—*Continued*

Dependent Variable	All Students (1)	Black (2)	Hispanic (3)	Male (4)	Below Average 8th Grade Test Scores (5)	Potential Increase in Peer Quality: Bottom Quartile (6)	Potential Increase in Peer Quality: Top Quartile (7)
Spring semester fraction of days absent	0.006	0.008	0.003	0.012	0.013*	0.009	0.026**
	(0.005)	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)	(0.009)
	[0.115]	[0.140]	[0.096]	[0.110]	[0.141]	[0.093]	[0.124]
Cumulative spring semester credits earned	−0.279	−0.359	−0.086	−0.196	−0.558**	−0.237	−0.472
	(0.237)	(0.292)	(0.334)	(0.289)	(0.265)	(0.191)	(0.389)
	[55.61]	[55.56]	[55.50]	[55.58]	[55.16]	[56.04]	[55.40]
Class percentile rank (1=best)	−0.025**	−0.034**	−0.014	−0.032**	−0.048**	0.006	−0.110**
	(0.011)	(0.014)	(0.013)	(0.015)	(0.013)	(0.015)	(0.022)
	[0.548]	[0.525]	[0.555]	[0.483]	[0.500]	[0.556]	[0.546]
11th grade outcomes							
Dropped out by spring	0.013	0.029**	−0.003	0.023	0.028**	0.016	0.009
	(0.009)	(0.012)	(0.015)	(0.015)	(0.012)	(0.016)	(0.024)
	[0.119]	[0.131]	[0.112]	[0.129]	[0.160]	[0.092]	[0.137]
Retained (enrolled in grade below 11th grade)	−0.001	−0.003	0.006	0.017	−0.004	−0.015	0.017
	(0.013)	(0.017)	(0.020)	(0.017)	(0.019)	(0.015)	(0.028)
	[0.133]	[0.155]	[0.126]	[0.164]	[0.188]	[0.101]	[0.160]

[a]See notes to Table V. For columns 6 and 7, the potential increase in peer quality (mean combined eighth grade math and reading percentile scores of ninth graders) is calculated as peer quality at the lottery school less peer quality at a student's inside option. We measure peer quality at a student's inside option using the average peer quality enjoyed by students who attended the same eighth grade campus and placed within the same eighth grade test score quintile. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

[b]Sample limited to the 2000 cohort due to data availability.

the outset. Students who win lotteries in this group were ranked nearly 11 percentile points lower in class rank by the spring of ninth grade relative to lottery losers. This translates to a LATE effect of −22 percentile points off of a baseline of 59 percent.

Given the absence of systematic academic benefits to students who attend lottery schools, why is it that competition for entry is so intense? One possible explanation for why lottery winners perform no better, on average, than lottery losers is that other factors may mitigate any achievement benefits they receive from the school. For instance, as we see in the bottom panel of Table IV, lottery winners travel a greater distance to attend school than losers, although it is only about an extra one-half mile.[43] Lottery winners also experience less continuity in school peers when they transition to high school. The fraction of ninth grade peers from a student's eighth grade school, for example, is significantly lower among lottery winners compared with lottery losers, particularly among students who apply to high-achieving schools (see Table IV). However, the magnitude of this effect is quite modest; e.g., students who apply to but lose a lottery to a high-achieving school attend a ninth grade school where roughly 17 percent of their peers also attended their eighth grade school, whereas lottery winners have about 11 percent from their eighth grade school. Similarly, lottery winners are more likely to attend high school with students of a different race or ethnicity and less likely to be in the majority racial or ethnic group. Again, however, these effects are relatively small. Hence, it seems highly unlikely that the additional disruption experienced by lottery winners could explain the negative effects we observe.[44]

It is also possible that school quality and parental involvement may be substitutes in the education production function. For example, parents whose children win lotteries to select magnet schools or programs may feel less need to carefully monitor their children's academic progress or assist their children with their schoolwork. Although such behaviors are generally difficult to measure, the survey administered to one cohort in our sample when these students were in the ninth grade affords some insight. Students were asked a series of questions that capture both parental support of student learning and the level of parental supervision of their school and nonschool activities.

The top panel of Table VIII provides mixed evidence as to whether parental inputs substitute for school quality. The structure of the table is identical to the preceding tables, except that the dependent variables are taken from student

[43]Of course, parents and students should factor this time cost into their application and attendance decisions.

[44]There is a large literature that attempts to assess the impact of school mobility on student outcomes. Using estimates from a recent study by Hanushek, Kain, and Rivkin (2004) that includes student fixed effects so as to overcome selection concerns, we calculate that the additional change in peers experienced by lottery winners in our sample could explain only a tiny fraction of the negative ninth grade effects we find in some specifications.

TABLE VIII

THE EFFECT OF WINNING A LOTTERY ON NONTRADITIONAL OUTCOMES—BY SCHOOL TYPE[a]

	The Effect of Winning a Lottery to	
Dependent Variable	Any School (1)	High-Achieving School (2)
Parental support and supervision		
Parents regularly help with schoolwork	−0.022	−0.102**
	(0.021)	(0.038)
	[0.443]	[0.436]
Parents regularly discuss class- and school-related issues with student	0.022	0.106**
	(0.021)	(0.028)
	[0.734]	[0.758]
Degree of parental supervision (composite)	0.025	0.110
	(0.107)	(0.202)
	{2.24}	{2.25}
Other outcome measures		
Student's liking for school (composite)	−0.008	0.215
	(0.073)	(0.133)
	{1.84}	{1.69}
Degree of student–teacher trust (composite)	−0.017	0.018
	(0.053)	(0.091)
	{1.46}	{1.43}
Positive classroom behavior of peers (composite)	−0.070	0.079
	(0.072)	(0.100)
	{1.12}	{1.10}
Reports getting into trouble at school	−0.007	−0.087*
	(0.034)	(0.045)
	[0.636]	[0.583]
Arrested by police in past year	−0.021	−0.051**
	(0.015)	(0.022)
	[0.116]	[0.089]
Expects to graduate college	0.011	0.020
	(0.017)	(0.028)
	[0.823]	[0.867]
Reports the classrooms/hallways are safe	0.041*	0.032
	(0.022)	(0.044)
	[0.643]	[0.671]
Reports school has enough computers for students to use	0.058**	0.136**
	(0.029)	(0.031)
	[0.621]	[0.644]

[a]See notes to Table V. The sample is limited to students in the 2000 cohort and excludes students who applied to three schools (Von Steuben Metro, Roosevelt, and Lake View) that did not administer the survey. A double asterisk (**) denotes significant at the 5 percent level; a single asterisk (*) denotes significant at the 10 percent level.

survey responses to a wide range of questions. The sample is restricted to students in our 2000 cohort who applied to schools that administered the ninth grade survey.[45] We only report results for the full set of lottery schools and the schools with high-achieving peers; for other breakdowns of the data, the standard errors are too large for the results to be informative. The top three rows in the table show no evidence that parental inputs diminish for winners for the full set of lotteries. For those students who win access to high-achieving schools, parents are less likely to help with homework, but are more likely to discuss school-related issues. Although a benefit of school choice may be that parents of lottery winners trade less enjoyable for more enjoyable interactions with their children, it is not clear that home inputs are lowered in an absolute sense, so it is unlikely home efforts are completely undoing school efforts.

Finally, it is possible that parents and children seek alternative schooling environments for reasons other than academic performance. Parents might be interested in ensuring a safer or more nurturing environment for their children; students may be interested in attending particular schools for extracurricular activities or for a different peer group. Although many of these reasons may lead to improved life outcomes in the long run, they are less likely to influence traditional academic achievement measures in the short run. In this case, however, we would expect school choice to affect measures of school satisfaction, safety, or expectations for the future.

The remaining rows of Table VIII examine the effect of winning a lottery on a variety of nontraditional student outcome measures. The results present a somewhat more optimistic picture for open enrollment, particularly at high-achieving schools.[46] Students who win lotteries to high-achieving schools are statistically significantly less likely to report that they were subject to disciplinary action at school and also much more likely to report that their school has enough computers. Self-reported arrest rates are reduced by nearly 60 percent among students who win lotteries to high-achieving schools relative to students who lose such lotteries (3.8 percent versus 8.9 percent). The pattern of self-reported arrest rates is corroborated by administrative data on incarceration rates for students in our sample. We observe statistically significant reductions in the percentage of students behind bars when comparing lottery winners to losers: the greatest reductions are observed among the students whose peer quality stands to improve the most if they win. Although not statistically significant, the point estimates also imply improvements for students who win lotteries to high-achieving schools on all of the other measures we examine: how much students like school, the degree of student–teacher trust, classroom behavior of peers, expectations of college graduation, and safety of classrooms/hallways.

[45]Three schools (Von Steuben, Lake View, and Roosevelt) did not administer the survey.

[46]The more positive estimates found for the nontraditional outcomes are not simply a function of the different sample. We reestimated the results shown in Tables V and VII for this restricted "survey sample" and obtained comparable results.

The results for winning a lottery to any school are more mixed. These students report statistically significant improvements in the safety of classrooms/hallways and in having adequate numbers of computers. Relative to students who lose lotteries, they report higher (but not statistically significantly) expectations of graduating college and lower rates of getting into trouble and being arrested. On the other measures (liking school, student–teacher trust, classroom behavior of peers), however, the lottery winners report somewhat worse outcomes.

5. CONCLUSIONS

This paper uses lotteries to estimate the causal impact on student outcomes of gaining access to sought-after public schools. Although students often take advantage of winning a lottery by attending that school and, on average, the schools lottery winners attend are better on observable dimensions than the schools attended by lottery losers, we observe no systematic evidence of benefits to lottery winners (and even in some cases, significant declines) on traditional outcome measures such as graduation rates, test scores, and school attendance. This is true for a variety of subgroups of students, including those who one would a priori expect to benefit most from winning the lottery. Our results do not appear to be due to winners traveling greater distances to school or because of compensating behavior on the part of parents. We also find some evidence that winning a lottery is associated with positive outcomes on certain nonacademic measures, namely self-reported disciplinary problems and arrests.

Our results concerning the absence of a positive impact of public school choice and high-quality peers on traditional student outcomes stands in contrast to theoretical expectations, but is aligned with findings from other recent studies on the topic. In our earlier study (Cullen, Jacob, and Levitt (2005)) of the CPS open enrollment program, for example, we used distance from a student's residence to schools other than the assigned school as an instrument for attending a choice school and found no evidence that exercising choice is associated with increased educational attainment, with the exception of those students who chose career academies.

Because our research design can only measure improvements of lottery winners relative to those of lottery losers, our results do not provide any evidence as to whether increased competition induced by school choice confers benefits to all students, nor are our findings easily extrapolated to an evaluation of other forms of school choice such as vouchers. However, these results do provide some insights that may be relevant for school choice and school reform more generally. First, our results suggest that a student's relative position among his or her peers may be an important factor in determining academic success. This is consistent with prior studies in several disciplines (e.g., Light and Strayer (2000), Kaufman and Rosenbaum (1992)).

Second, the results here suggest that when deciding which schools to attend, students and parents may be concerned not only with traditional academic benefits, but also other factors related to safety or nonacademic amenities. This idea is consistent with several earlier studies that examine actual school choices made by families (Henig (1990), Glazerman (1997)) as well as recent housing mobility studies (Kling, Ludwig, and Katz (2005)). However, the fact that the most popular schools in our sample are universally those with the highest achievement *levels* (which does not correlate highly with our admittedly crude measure of value added) does suggest that parents and students do value higher achievement, but may not be able to identify those schools that can deliver.

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APPENDIX A: SAMPLE AND DATA SOURCES

CPS provided information on applications submitted in spring 2000 and 2001. The sample of applications provided to us for eighth grade applicants enrolled in the CPS at the time of application includes 59,962 applications to 45 choice high schools. Approximately one-third as many applications are submitted to the selective enrollment high schools that do not use lotteries in admissions, none of which is included in our analysis. Although the CPS has information on the applications submitted to 45 schools, it tracks lottery outcomes only for the 27 high schools for which the district manages the lottery process. There are a variety of idiosyncratic reasons why the CPS manages the lottery for some high schools, and these schools are not systematically different from the schools that manage their own.

There are a total of 26,805 applications from 17,582 students for which we have lottery outcomes. Of the 375 lotteries represented, 10 have no winners and 171 have no losers. Lotteries that are not oversubscribed will not have any losers. A lottery will not have any winners if parents mistakenly submitted an application to a school–program–grade that was not accepting any students in a given year (because of space constraints) or if changing enrollment numbers led schools to not accept new students, even though application brochures had indicated that the school would have open slots. Because we cannot estimate any treatment effects from these degenerate lotteries, we exclude them from our analysis. Restricting our attention to lotteries that have winners and losers, our analysis sample includes 19,520 applications from 14,434 students who participated in 194 lotteries at 19 different high schools.

Our school-level and student-level data come from a variety of sources as described in Table A.I.

TABLE A.I

DATA SOURCES AND VARIABLE CONSTRUCTION

Data	Source	Construction
Academic outcomes	CPS Board	Standardized test scores, grades, absences, credits, and course-taking outcomes are taken directly from student test and transcript files provided by the Board. Information on enrollment and exit status/reason is from administrative records provided by the Board. Various fields in these data allow us to determine the reason why a student has exited (is not enrolled in) the public school system, including moved out of the district, transferred to private school, graduated, and dropped out by reason (e.g., pregnancy, jailed). Ninth and tenth grade reading scores come from the Test of Academic Proficiency (TAP), a nationally normed standardized achievement exam published by Riverside, and are measured in terms of national percentile rank. The end-of-course exams (algebra, geometry, English I, English II) were developed specifically to coincide with the Chicago high school curriculum and consisted of multiple-choice as well as open-response items. We use only the multiple-choice items, which were graded electronically by a scanning machine. The test score is measured as a fraction of the items answered correctly. Absences are defined as the average number of days absent across courses for the spring semester of a given year. Total credits are defined as the sum of all credits earned in the spring semester of a given year (students receive credits if they do not fail the course, i.e., earn any grade above F).
Nontraditional outcomes	CCSR	The Consortium on Chicago School Research (CCSR) administered a survey to CPS students in grades 6–10 in spring 2001 that asked students a variety of questions about their teachers, schools, and peers as well as about their own attitudes and behaviors relating to school. This provides us with data from the spring of eighth grade for our 2001 cohort and from the spring of ninth grade for our 2000 cohort. Several of the survey outcomes we use are composite measures created by CCSR from student responses to a collection of individual items. Greater detail on the construction of these items is available from CCSR.

Continues

TABLE A.I—*Continued*

Data	Source	Construction
Student demographics	CPS Board	Student demographic variables (race, gender, age) come directly from student records provided by the Board. All of the demographics are based on status as of eighth grade. Special education status covers a variety of disabilities ranging from mild learning disabilities to severe physical handicaps. Eighth grade achievement scores come from the Iowa Test of Basic Skills, a nationally normed standardized achievement exam published by Riverside, and are measured in terms of the student's national percentile rank.
Neighborhood characteristics	2000 Census, CPS Board, & CCSR	Basic information on the student's census tract, such as median household income and percent below the poverty line, comes from the 2000 Census. Student census tract was determined on the basis of student address, which is contained in the CPS school records. The crime composite is an index created by factor analysis using official crime statistics for 1994 provided by CCSR. The index was created at the block group level. The variable used in this analysis is a tract-level average (for the student's tract in the spring of eighth grade), weighted by the total population in each block group.
Distance from home to school	CPS Board	Student and school census tracts were determined based on address information provided in CPS records. Distance from home to school was calculated as the distance from the centroid of home tract to the centroid of school tract.

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