TECHNICAL REPORT:
HOW NEW YORK CITY CHARTER SCHOOLS:
AFFECT ACHIEVEMENT

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We analyze the achievement of 93 percent of the New York City charter school students who were enrolled in test-taking grades (grades 3 through 12) in 2000-01 through 2007-08. More than 94 percent of charter school applicants participate in admissions lotteries. The lotteries are crucial for remedying the self-selection problem because charter school applicants are substantially more likely to be black and poor than students in the traditional public schools. Using the lotteries to form an intention-to-treat variable, we instrument for actual enrollment and compute the charter schools' average treatment-on-the-treated effects on achievement. These are 0.09 standard deviations per year of treatment in math and 0.06 standard deviations per year of treatment in reading. These results are robust, as shown by specification tests for various issues: non-matching, attrition, retention-in-grade, returning to the traditional public schools, and so on. The results do not differ statistically significantly by the race/ethnicity of the student, the gender of the student, the number of years we observe the student, or the lotteried-in percentage of the school. We estimate associations (not causal relationships) between charter schools' policies and their effects on achievement. Policies with fairly consistent positive associations with achievement include a long school year; a greater number of minutes devoted to English during each school day; a small rewards/small penalties disciplinary policy; teacher pay based somewhat on performance or duties, as opposed to a traditional pay scale based strictly on seniority and credentials; and a mission statement that emphasizes academic performance, as opposed to other goals.

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* This is a technical report associated with the September 2009 overall, non-technical report from the New York City Charter Schools Evaluation Project, which is entitled "How New York City Charter Schools Affect Achievement". The non-technical report, which is appropriate for all readers except those mainly interested in statistical methodology, can be downloaded from http://www.nber.org/~schools/charterschoolseval.

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I. Introduction to the Analysis of New York City's Charter Schools

We show the causal effect of New York City's charter schools on the achievement of the students who enroll in them.[1] The evidence we provide is causal (free from selection biases) because we use the the charter schools' random admissions lotteries to generate treated and control groups of students who are the same, not just on their observable characteristics (such as race and poverty) but also on their unobservable ones (such as motivation and aptitude). Specifically, we use being lotteried-in (being offered a place at a charter school) as the intention-to-treat variable and use enrollment in a charter school as the treatment variable. This allows us to compute treatment-on-the-treated effects: the effect of attending a charter school as opposed to the regular public school that the child would otherwise attend. By design, charter schools are intended to enroll only students who are interested in applying to them. Therefore, treatment-on-the-treated effects are the key estimates we need to evaluate them for policy purposes.[2]

Using the lotteries to eliminate selection biases is crucial for New York City charter schools because students who apply to them are highly selected. Applicants are much more likely to be black and substantially more likely to be low income than non-applicants. Applicants are also likely differ on unobservable dimensions, such as motivation and aptitude. Most obviously, a family is unlikely to apply if its child is doing very well in the traditional public schools and "fits" there. Elsewhere (Hoxby and Murarka 2007), we have shown that--using the lottery-based estimates as the "gold standard"--alternative evaluation methods, such as pure value-added and matching methods, produce inaccurate estimate of the charter schools' effects.

We use rich, high-quality administrative data from the New York City Department of Education that allow us to explore a variety of empirical issues: non-matching, attrition, retention-in-grade, returning to the traditional public schools, and the specification of the estimating equation. In several cases, we show bounds on the impact these issues could create. We present tests showing the potential of each of these issues to affect our main results. The tests indicate that the main results are robust--that is, the point estimates differ within a narrow range but never differ by a statistically significant amount. We

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[1] This is the second technical paper based on a continuing study of the charter schools in the City. A non-technical report that covers the same topics as this article but that is aimed at educators and policy makers is available at http://www.nber.org/~schools/charterschoolseval. Its title is "How New York City Charter Schools Affect Achievement," and it is dated September 2009. The first technical report in this series (2007) is also available from www.nber.org.

[2] Given that no policy makers consider *forcing* students to attend charter schools to which they would not wish to apply, it is not clear what policy question could be answered with intention-to-treat effects, as opposed to treatment-on-the-treated effects.

attribute this robustness both to the lottery-based method, which is inherently robust to extraneous phenomena that affect students like the applicants, and to the fact that we do not see much evidence of the relevant phenomena (grade retention, missing data, differential attrition, and so on) in the New York City data.

Our estimates are representative of nearly the entire population of charter school applicants in New York City. This is because the vast majority (94 percent) of charter school students are admitted via lotteries held among applicants. Also, all charter schools in New York City hold lotteries when they are oversubscribed, and all charter schools in the city are routinely oversubscribed.[3] Our main estimates show the effect of the charter schools for the average charter school applicants. They thus mechanically give more weight to charter schools that have a higher ratio of applicants to places (lower "win rates"). However, we show that the estimated effects do not vary systematically with the win rate of a school. Put another way, our main estimates reflect the effect of the charter schools in general; they do not disproportionately reflect the effect of the more oversubscribed charter schools. (This is likely because oversubscription rates do not vary greatly among New York City charter schools.)

Because charter schools are autonomous, it is reasonable to estimate a treatment effect separately for each school. We do this towards the end of the paper. However, as described below, all charter schools face essentially the same constraints, governance structures, and incentives. These shared features, which economics suggests will affect their management and performance, are the reason why we first estimate the average effect of the charter schools--the equivalent of aggregating the individual schools' effects with weights corresponding to the number of students in each.

We find that the causal effect on math test scores in the third through eighth grades is a positive 0.09 standard score units per year of attendance in a charter school. The parallel causal effect on reading test scores is two-thirds as large: 0.06 standard score units per year of attendance in a charter school. In the ninth through twelfth grades, students in New York state takes Regents examinations. The estimates indicates that each year of charter high school attendance raises a student's Regents scores by 3 to 4 points, depending on the subject of the exam. Also, each year of charter high school attendance raises the probability that student graduates with a Regents diploma by 7 percentage points.

As already noted, there are some features that all charter schools share, and the average effects should be attributed to these features. However, charter schools do make independent policy choices on management, curriculum, personnel, discipline, and the structure of the school year and day. The

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[3] The only routine exception is the charter school that exclusively serves autistic students: it does not run lotteries and is not included in this study. There are a few other charter schools that are targeted to disabled students and drop-outs. They run lotteries for some of their places, and those lotteried places are included in this study.

variation in their choices is far greater than the variation within the traditional public school sector (not just in New York City but nearly everywhere in the U.S.). Thus, their varied choices give us the opportunity to explore the association between achievement and some important policies that are rarely studied because they vary so little in the traditional public school sector. Specifically, we use multiple regression to identify school policies and practices that are associated with a school's having a more positive estimated effect on achievement. We emphasize that these associations cannot be interpreted as causal because charter schools may adopt policies in response to factors that we do not observe. These unobserved factors may themselves affect achievement. In addition, schools tend to adopt "packages" of policies, causing a substantial multicollinearity problem. Thus, while we can say that certain policy packages are associated with more positive achievement effects, we can generally not give identify the independent effect of individual policies. For instance, schools with long school years very often also have long school days, and it is not possible to say whether the long years or the long days (or both) generate the correlations we see.

Our lottery-based empirical strategy not only produces credible average effects and school-level effects, it can also produce effects that differ by students' type (race, ethnicity, gender, and so on), by the grade at which the student enters charter school, by the number of years the students spends in charter school, and so on. We show a variety of tests for such heterogeneity of effects.

Finally, this paper provides some descriptive evidence on the students who apply to charter schools, the students who are offered places at charter schools (nearly always through lotteries), and the students who actually enroll in and attend charter schools. We describe students on the basis of race, ethnicity, gender, their classification for various school-based programs (such as free lunch and special education), and their pre-application test scores (available only for students who applied to fourth grade or a higher grade). The descriptive evidence allows us to conclude that the lotteries do indeed appear to be random. It also helps us answer the question of which students apply to charter schools. There is no right answer to this question because there is no type of student whom charter schools should or should not enroll. By design, they are schools that students are supposed to freely choose or freely ignore. Owing to the inherent limitations of the data, we will show that it is--unfortunately--not possible to compare the representative charter school applicant to non-applicants students on some dimensions. Nevertheless, we describe the limited and problematic evidence available.

While our estimation strategy produces estimates that are very credibly causal, there are limits to what we can learn from this study or any study that attempts to estimate a local average treatment effect of a school or group of schools. (That is, the limitation apply also to studies based on matching methods, most selection correction methods, or panel methods.) In particular, since we estimate effects that are

local to students and schools like those in New York City, our estimates can only safely be extrapolated to other students similar to New York City applicants and to other charter schools similar to New York City's. Fortunately, many charter school students in the U.S. are similar demographically to New York City's applicants and they attend urban schools that are arguably similar as well. Some charter schools belong to management organizations that run numerous schools, and their effects in New York City can probably be safely extrapolated to their other schools. Also, as we will show, New York City's charter schools have a fairly wide array of missions and models, so we need not worry that the city's schools are somehow unusual or narrow. We would, however, argue against the results being extrapolated to students from advantaged backgrounds, rural students, or charter schools that do not follow a model used by any charter schools in New York City.

Another limitation of this study (or any study that attempts to estimate the partial equilibrium effect of charter schools on their students) is that the traditional public schools may be affected by the presence of charter schools. For instance, if traditional public schools improve when faced with competition from charter schools, then lotteried-out students are likely to be better off than they would have been in the entire absence of charter schools. Or, the peer composition of traditional public schools may be affected by the charter schools' presence, and this may affect the lotteried-out students. There is unfortunately nothing we can do to produce a counterfactual that is entirely purged of the influence of charter schools, but we surmise that the charter schools' influence on the traditional public schools is still small in New York City simply because charter schools enroll only 1 percent of public school students in the city. The general equilibrium effects of charter schools on other schools are a worthy topic for another study (indeed, we have investigated them in other work), but we do not believe that New York City currently offers a propitious environment for such an investigation.[4]

II. Background on Charter Schools in New York City

A charter school is a public school that operates fairly autonomously within guidelines laid down by its state. Charter schools are generally free to manage day-to-day operations, hire teachers and let them go, choose salary schedules, and make curricular decisions. Charter schools must advertise their availability to all students who are eligible to attend the public schools, and they are not allowed to select

[4] See Hoxby (2003, 2004) and Bettinger (2005) for estimates of the general equilibrium effects of charter schools. Economists generally argue that charter schools need to be able to enroll a critical share of students in a school district before they produce notable general equilibrium effects on either management or peers (since districts can easily backfill with similar peers when charter schools draw students from certain schools). To the best of our knowledge, no one has thus far argued for a critical share as low as 1 percent, which is the charter schools' share of New York City public school students.

students. Specifically, if a charter school in New York receives more applicants than it has places, it must hold a random lottery among the applicants. Lotteries are specific to a school, grade, and year of intended entry--for instance, the lottery for the kindergarten class commencing in fall 2010 in charter school X.

When a charter school enrolls a student, the student essentially brings a "fee" with him that is tax-financed. In New York State, a formula determines this fee and it is usually between two-thirds and four-fifths of what would be spent on the student's education if he remained in the traditional public schools.[5] Charter schools that are moving into or renovating facilities may also get some funding from the state's Stimulus Fund. However, the key thing to remember about charter schools is that they cannot survive if they cannot attract students because they will not have the necessary funds. Thus, families automatically exercise some governance over charter schools when they "vote with their feet" by choosing whether to apply or whether to keep their child enrolled. In addition to this governance exercised by parents, charter schools must get initial approval for their start-up from an authorizer, who examines proposals and accepts some and rejects others on the basis of educational and fiscal soundness. Every few years (five in New York), a charter school must have its charter renewed by this same authorizer. Charter renewal is typically a period of scrutiny for the school. In response to this scrutiny, important policies may be altered, charter school leadership may be changed, and new performance criteria may be adopted. Between renewals, a charter school's leaders must answer to their board, which is typically composed of local leaders, people from community organizations, and experienced educators. Charter schools' boards can dismiss school leaders and hire new ones. They can also mandate curricular and other policy changes. Finally, charter schools--being public schools--participate fully in their state's and the federal government's accountability system. For instance, their students take all statewide tests. In New York City, it is not common for authorizers or boards to force charter schools into closure, but very substantial reconstitution of a school (involving leadership changes, other personnel changes, curriculum changes, and other policy changes) can be expected if a school fails to satisfy its board, its authorizer, state standards, or federal standards.

In New York State, charter schools are authorized by the Charter Schools Act of 1998.[6] In the first year of operation for charter schools, 1999-00, one charter school, Sisulu-Walker, educated students. By 2000-01, an additional nine schools were enrolling students. Four of the schools that opened that year (Wildcat Academy, Renaissance, KIPP Academy, and Beginning with Children) were conversions of

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[5] See Center for Education Reform (2007).

[6] The New York State Charter Schools Act of 1998 (as amended) is Article 56, Sections 2850 to 2857 of the New York State Consolidated Laws.

previously-existing public schools that had had unusual programs and autonomy.[7] Subsequently, five schools opened in 2001, two schools opened in 2002, five schools opened in 2003, nine schools opened in 2004, sixteen schools opened in 2005 (including one conversion school, Future Leaders Institute), twelve schools opened in 2006, 2 schools opened in 2007, 18 schools opened in 2008, and 22 schools opened in 2009. The variation in school openings by year is partly a function of the legislature's "cap" on the number of charter schools in the state. See Table 5 for a listing of New York City charter schools, their first year of operation, and the grades they serve.

A. Participation by New York City Charter Schools in this Study

This article is the second technical report from a multi-year study in which we hope to engage all New York City charter schools with an exception described below. When we refer to this "report," we mean this document. When we refer to the "study," we mean the ongoing study. Because there are new schools opening each year in New York, numerous schools that currently exist are not covered by this article even though they *are* participating in the study. However, this article does cover 93 percent of students who were in test-taking grades as of the 2007-08 school year, the most recent school year for the achievement data evaluated in this report.

In particular, this article analyzes achievement in charter schools that had opened in New York City as of the 2005-06 school year. All but a few are participating in the study. The NY Center for Autism Charter School is not included in the study because it serves a very special population that is not compatible with many elements of the study. The United Federation of Teachers Elementary Charter School has declined to participate in the study thus far. Because it has very few students in test-taking grades, its not being included in this report has no essentially no effect on the achievement results. One school, Readnet Bronx Charter School, closed during the 2005-06 school year. Unfortunately, we have not be able to retrieve information on its lotteries. However, the omission of Readnet Bronx is likely to have only small effects because the school had only two years of test-taking students: third and fourth graders in 2005-06 and third graders in 2004-05.

It is important to understand that New York City charter schools often open by serving only one or two grades, most often kindergarten and first grade. However, third grade is the first grade in which all New York students are tested. As a result, until a charter school has been in operation for a few years (four years if it opens with kindergarten only), its effects cannot be assessed and it does not contribute to the overall estimated effect of charter schools. This is why this article covers such a large share of charter

[7] They were part of the "New Visions" initiative started by New York City Schools Chancellor Rudy Crewe. When they converted, they brought with populations of students who applied and who were admitted partly on the basis of a lottery and partly on the basis of priorities decided by the New York City Department of Education.

school students who have been tested even though it does not cover newly opened charter schools.

The average effect of charter schools, which this report estimates, reflects the average student's experience. Thus charter schools that enroll more students generally have more effect on the overall results. Given the principles on which charter schools are based, this student-weighted approach is the right one. If successful charter schools expand and unsuccessful ones shrink, we should not attempt un-do these dynamics with statistics. The expansion and shrinkage is *part* of the charter school policy, which is intended to create an average student experience in which unsuccessful schools are forced to play a small role and successful schools are allowed to play a large role. Researchers sometimes worry, however, that schools with larger applicant pools relative to their number of places (lower win rates) have a greater influence on the results. They might therefore mask the results of schools with higher win rates. We examine this possibility in two ways. First, we estimate individual schools' effects. Second, we show that, at least in New York City, schools' effects do not vary systemically with their win rates.

B. Admissions to New York City Charter Schools

Because there are excess applicants for nearly every place in New York City's charter schools, 94 percent of students covered by this report were admitted via random lotteries, which are held at public events. The remaining students were admitted to a school that targets certain students (such as drop-outs), were admitted to schools before they converted to charter school status, or were admitted for a place for which there were not excess applicants (this is rare except in a school's start-up year). As shown in Table 1, 37,454 applicants who participated in lotteries are covered by this report, and 54 percent of them were lotteried-in. The remaining 46 percent were lotteried-out.

As mentioned previously, charter schools often open with only their lowest grade, the “intake” grade, and add a grade each subsequent year. This is known as "rolling up." For example, a charter high school may open with only ninth grade. By rolling up, the school serves all of the high school grades from nine to twelve by its fourth year of operation. Because kindergarten and first grade are both traditional intake grades, charter elementary schools in New York City often open with both kindergarten and first grade. By their fifth year of operation, they have rolled up to serving kindergarten through grade five. Rolling up is intended to give schools a manageable way to grow and to instill their school’s culture and standards into students.

Charter schools do not always roll up. Some open by admitting students into intake and non-intake grades alike. Schools that convert to charter school status in New York City typically do so with their full complement of grades. As a rule, however, once a school gets past its first year or two of operation, its admissions are dominated by its intake grades. Non-intake grades admit only a trickle of students to fill places that happen to open up when students depart. Thus, a charter elementary school

might run a kindergarten lottery to fill 50 places, a first grade lottery to fill 20 places, and second through fifth grade lotteries to fill a couple of places in each of those grades.[8]

Table 1 shows applicants to New York City charter schools by the grade to which they applied. The intake grades of kindergarten, one, five, and nine stand out. Almost one third of applicants applied to kindergarten, and just under one half of all applicants applied to kindergarten or grade one. 14 percent of applicants applied to grade five and 2.5 percent applied to grade nine. Apart from these intake grades, the percentage of applicants declines monotonically with the grade level. Table 1 actually *understates* the degree to which the intake grades dominate current and will dominate future admissions. This is because the table includes years in which numerous charter schools in New York opened, and start-up schools sometimes admit whole cohorts of students into non-intake grades.

C. The Neighborhoods where Charter Schools are Located within New York City

Currently, charter schools are operating in four of the five boroughs of New York City, and Staten Island will have one or more charter schools starting in 2010. See Figure 1, which maps the schools' locations. Charter schools marked with a star are covered by this report. Notice the concentration of charter schools in Harlem (Manhattan) and in the South Bronx.

When a charter school, especially one that serves elementary grades, locates in a neighborhood, it can expect to serve students who are disproportionately from that neighborhood. Thus, it is useful to know how the charter schools' neighborhoods compare to the rest of New York City. Table 2 shows census data for the average Census tract in which a charter school is located and for all the tracts in New York City. Charter schools locate in neighborhoods that have unusually low proportions of white and Asian residents (19.5 percent in charter neighborhoods versus 49.7 percent in New York City as a whole), and unusually high proportions of black and Hispanic residents (77.3 percent in charter neighborhoods versus 47.2 percent in New York City as a whole). Households in charter schools' census tracts have low average income ($37,639 versus $59,743) and a disproportionate number of households with very low incomes (43.7 percent are below $20,000 in charter neighborhoods versus 28.4 percent in New York City as a whole). The adults in charter school neighborhoods are disproportionately likely to have no high

[8] Owing to the peculiarities of New York City school facilities and the large number of special schools within the traditional public system, some charter schools have intake grades that would not be obvious based on the range of grades they serve. For instance, one might expect that Renaissance Charter School, which serves kindergarten through grade twelve, would do nearly all of its intake in kindergarten and grade one. In fact, the facilities it was granted allow it to serve only one class per grade through fourth grade and two classes per grade thereafter. Also, its students are fairly successful in gaining admissions to the International Baccalaureate school which begins with the seventh grade and some of the more sought-after high schools, such as the exam schools, which begin with the ninth grade. In short, the school has several intake or partial intake grades: kindergarten, first, fifth, seventh, and ninth.

school diploma or GED (41 percent versus 28 percent) and are disproportionately *un*likely to have a baccalaureate degree (15.2 percent versus 27.9 percent). A strikingly disproportionate share of children in charter school neighborhoods live with a single parents (57.0 percent in charter neighborhoods versus 39.2 percent in New York City as a whole).

In short, we expect charter schools to enroll students who are likely to be substantially more disadvantaged, in the terms of family background, than the traditional public schools in the city.

D. The Authorizers and Operating Agencies of New York City's Charter Schools

When a group of individuals decides to form a charter school, they write a proposal. They may submit this proposal to only one authorizer at a time. If the authorizer grants the school an initial charter, which is something between a contract and a prospectus, the school may open. Every five years, the authorizer reviews the school's performance and decides whether to renew the charter. If the charter is not renewed, the school closes. Authorizers have the right to scrutinize in detail charter schools' finances, student performance, personnel, and management decisions. Between renewals, they can influence schools' key decisions, especially regarding leadership and finances. Given these powers of scrutiny and enforcement, an authorizer is an important source of incentives, constraints, and governance for its schools. There are three organizations with the power to authorize charter schools in New York City: the trustees of the State University of New York, the Chancellor of the New York City Schools, and the New York State Board of Regents. Among the charter school students covered by this report, 53 percent were in schools authorized by the State University of New York, 39 percent were in schools authorized by the Chancellor, and 7 percent were in schools authorized by the Board of Regents. See Figure 2.

Each charter school has an operating agency. If, as is typical, the operating agency helped to write the charter school proposal, it is also called the founding agency. There are three types of operating agencies in New York City: non-profit Community Grown Organizations (CGOs), non-profit Charter Management Organizations (CMOs), and for-profit Education Management Organizations (EMOs). CMOs and EMOs are formal organizations that exist to manage charter schools, and they function somewhat like firms that have a strong brand and that establish fairly independent branches or franchises. CMOs and EMOs typically make overarching curricular and policy decisions, conduct back office activities, and provide something of a career ladder for teachers and administrators within their network of schools. Some larger management organizations in New York City are the KIPP Foundation (CMO), Achievement First (CMO), and Victory Schools (EMO), all of which operate multiple schools in the city. These management organizations also operate charter schools in urban areas other than New York City.

The CGO category is something of a catch-all and, thus, CGO schools are much more varied. They may be founded by a group of parents, a group of teachers, a community organization that provides

local social services, one or more philanthropists, or the teachers union. More often than not, the founding group combines people from a few of the groups listed above. Some CGOs operate multiple schools--for instance, Harlem Children's Zone and Harlem Village Academies. We classify the conversion charter schools as CGOs because they were started by groups like those listed above.

Figure 3 shows that 49 percent of the charter school students covered by this report attend schools whose agencies are CGOs, 29 percent attend schools whose agencies are CMOs, and 20 percent attend schools whose agencies are EMOs.

E. The Missions and Characteristics of New York City Charter Schools

Each charter school describes itself in a carefully crafted mission statement that sets out its vision, educational philosophy, and focus. The statements are prominent on the schools' materials for prospective parents, student, and staff, so it is fair to assume that they reflect a school's tendencies. While no mission statement can accurately be reduced to a few words, we have attempted to categorize them roughly by analyzing the statements. We categorize them as having: a child-centered or progressive philosophy (29 percent of students), a general or traditional educational mission (28 percent of students), a rigorous academic focus (25 percent), a mission to serve a targeted population of students (11 percent of students), or a mission to offer a specific curriculum (7 percent of students). Figure 4 shows the proportions of students and schools in each category.

There is a good deal of overlap in schools' missions, but a few key features prompt a school's assignment to a category. Child-centered or progressive schools typically seek to develop students' love of learning, respect for others, and creativity. Such schools' mission statements may also focus on helping students realize their potential and on building strong connections between students and their families and communities. Schools with a general or traditional educational mission typically seek to develop students' core skills and would like to see them meet or exceed New York State's academic standards. Schools with a rigorous academic focus have mission statements that almost exclusively mention academic goals such as excelling in school and graduating from college. Schools with a mission to serve a targeted population of students include those that focus on low-income students, special needs students, likely drop-outs, male students, and female students. The remaining schools use a special focus, such as science or the arts, to structure their whole curriculum.

There are many reasons to expect that charter schools will choose different policies and practices. They are independent and fairly autonomous. Their operating agencies have a variety of histories and priorities. All are young schools and more likely to experiment with new policies than are established schools. At the same time, there are reasons to think that New York City's charter schools will share certain policies. They commonly serve disadvantaged students; they are all under pressure to attract

parents and to satisfy a small number of authorizers; they may imitate one another consciously by deliberating adopting another school's policy that seems to be working; they may also imitate one another unconsciously (as when teachers who have worked at one school are hired by another and bring their knowledge with them).

Table 3, which shows the share of the charter schools with each of a number of characteristics, demonstrates that the schools vary a lot but that there are also distinguishable patterns among them. Knowing the schools' characteristics is useful for two reasons. First, one can learn which policy innovations seem promising to the leaders of urban schools who have the power to select their policies. Second, different charter schools have different effects on achievement. Later in this report, we attempt to see which characteristics are associated with more positive effects on achievement.

About 89 percent of charter school students attend schools that require uniforms or a strict dress code, and about 92 percent attend schools that voluntarily administer standardized exams (such as Terra Nova, the Iowa Test of Basic Skills, or the Stanford 9) for diagnosis purposes--that is, to track progress and identify students in need of different instruction. (All charter schools also administer the standardized exams required by the state of New York.) 82 percent of charter school students in middle or high school grades experience the advisory system. In an advisory system, a teacher or pair of teachers is assigned to a group of students for an entire school year. Teachers meet frequently (often daily) with their students and are responsible for tracking their progress and preventing them from "falling through the cracks." Because students in elementary grades are assigned to one teacher for most of the school day, advisory systems would be duplicative and are therefore not used by elementary schools.

The average charter school student has a school year of 192 days. In contrast, students in traditional public schools in New York City have 180 day school years, shorter by 2.4 weeks. (A 180 day school year is typical in the U.S.) About 20 percent of charter school students experience very long school years of 200 days or more. The average charter school student experiences a school day that is 8 hours long. This is about 90 minutes more per day than the traditional public schools offer. The average charter school student learns English language arts (reading) for 112 minutes per day, whereas 90 minutes is the length of the literacy block mandated for elementary school grades in New York City. 50 percent of charter school students learn math for ninety or more minutes per day, whereas regular public elementary schools in New York City are required to have between 60 and 75 minutes of math instruction daily, depending on the grade. 57 percent of charter school students attend a school that offers Saturday School (sometimes mandatory, sometimes optional), and the vast majority (80 percent) attend a school that has an after-school program.

There are no dominant math or English language arts curricula in the New York City charter

schools although substantial minorities of students experience Saxon Math (39 percent), Everyday Math (30 percent), SRA reading (15 percent), or Open Court reading (25 percent). 28 percent of students experience a curriculum developed by their own charter school or its operating agency. (The appendix contains a short description of each curriculum in fairly wide use.) 66 percent of charter school students learn via a direct instruction teaching style in at least their math class. Direct instruction is a method of teaching that emphasizes the explicit introduction of skills through lectures, scripted exercises, or demonstrations. It is often contrasted with methods in which a student learns by doing. These other methods are variously known as exploratory learning, discovery learning, or inquiry-based learning.

The average class size experienced by charter school students is 23. We are wary of comparing this number to class size in New York City's traditional public schools, as reported in the Department of Education's annual report. Our caution is due to the fact that the charter schools' class sizes are based on schools' self-reports and the traditional public school class sizes are based the actual student register on a particular day of the school year. These different measurement methods (self-reports and registers) tend to produce quite different reports of class size, for the same actual experience. With these caveats, however, we note that the average class size reported for New York City elementary schools is 22.

At least 22 percent of charter school students experience a "small rewards/small punishments" disciplinary strategy. This strategy is based on the idea that rewarding small courtesies and penalizing small infractions is important. Such discipline is usually carried out in the classroom and sometimes employs an explicit system of points. This is in contrast to disciplinary strategies that focus more on preventing or punishing large infractions and that are carried out mainly by administrators above the classroom level. A school may call its disciplinary policy by a variety of names but we classified it as "small rewards/small punishments" if it clearly fit the description given above. Since we erred on the side of not classifying a school if its strategy was hard to characterize, we believe that the 22 percent number understates the share of charter schools with small rewards/small punishments.

52 percent of charter schools students attend a school where parents are asked to sign a contract. These contracts are not legally enforceable, but they may influence parents' beliefs about what the school expects of them. A typical parent contract specifies expectations about attendance, on-time arrival at school, homework, and similar issues.

For about 60 percent of charter school teachers, some of their pay is based on their performance and duties they undertake. The standard pay scale experienced by teachers in the traditional public schools is largely based on seniority and credentials, such as whether a teacher has a master's degree. The standard scale does allow pay to depend a little on duties but it does not allow pay to depend on performance, such as whether a teacher raises her students' achievement. Although a small minority of

New York City charter schools do have unionized teachers, this phenomenon is not as interesting as it seems at first glance. The vast majority of the unionized charter school teachers are in the conversion charter schools, all of which converted with unionization in place. Since all the conversion schools were experimental and fairly autonomous before they converted, it is not clear that they have ever had typical unionized environments.[9]

Many of the policies just described tend to appear in "packages." For example, it is very common for schools with a long school year also to have a long school day. Appendix Table 1 shows the correlations among policies: many of the correlations are quite high. Thus, we expect to face a substantial multicollinearity problem when we examine the association between charter schools' policies and their effects on achievement. We are not able confidently to associate achievement effects with *individual* policies. In addition, policies that nearly all charter schools share will end up affecting their average effect on achievement, just as do the incentives, constraints, and governance structures that they all share.

F. Charter School Histories and Grade Compositions

In an evaluation of this nature, it is not possible to describe the history of each charter school in the New York City. Table 4, however, does show the number of schools offering each grade in each year since 1999-00. Table 5 lists the individual charter schools, the year in which each opened, the grades it currently offers, and the grades it intends eventually to offer.

A key thing to note in Tables 4 and 5 is the enormous variation in charter schools' grade composition (not just current composition, but also intended composition). While many schools start in kindergarten, this entry grade is combined with exit grades of 5, 6, 7, 8, 9, 10, and 12. Charter schools exhibit a variety of intended compositions focusing on middle school grades: 5 through 9, 6 through 9, 5 through 8, and so on. We see charter schools that commence with a middle school grade and end with a high school grade: 5 through 12, 6 through 11, and 6 through 12. Finally, there are charter schools that focus on the high school grades of 9 through 12.

The implication of the history and grade composition shown in Tables 4 and 5 is that there is *no* simple dynamic to charter school attendance. It is not possible to estimate, say, the effect of attending a charter elementary school as a binary treatment. Students enter in various grades and exit in various

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[9] In addition, the conversion charter schools are somewhat different from the other charter schools because they have been operating longer--in some cases, much longer. Also, some of their older students were admitted prior to lotteries being used. Thus, if we were to see that the conversion schools have different effects on achievement, we would not know whether to attribute the difference to unionization or the other dimensions on which the conversion schools systematically differ.

grades, and our measure of treatment must record not only whether a student attended charter school but for how long and in which grades.

III. Data

Most of the data used in the study are derived from the administrative database of New York City's Department of Education (the "New York City Basic Educational Data System"). This database includes all students who attend New York City's traditional public schools *and* all students who attend New York City's charter schools.

The procedure for our data assembly is as follows. Each spring, charter schools put their applications (typically a single page) in lotteries and hold these lotteries at public events. We gather the data from these lotteries and send them to the New York City Department of Education. A typical applicant's data includes his name, birth date, parents' or guardians' names, address, telephone number, and the grade to which he is applying. Additional data that are sent if available include the student's current school, his social security number, and his identification number in the New York City Department of Education ("OSIS number"). The data are matched to the Department's database by a contractor using the maximum amount of information possible.[10] Once an applicant had been matched to his record in the database, information is extracted on his characteristics; enrollment; attendance; test scores, and certification for and participation in various programs such as free and reduced-price lunch, special education, and English language services. This information is gathered both from the years prior to his applying to a charter school and from the years after his applying. When the information had been gathered, it is sent to us with an encrypted student identification number (and without other identifying information).

A. Match Rates

When this study commenced, we advised schools on the variables that we would like to see on their applications because they would be useful for matching. We obtained application data starting in

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[10] For students who did not match on the basis of a unique identification number, such as a Social Security or OSIS number, match keys were used as follows: (i) last name, first name, date of birth with various versions of the names (abbreviations, alternative spellings, and so on); (ii) last name, first name, and various likely permutations of the date of birth (most often the month and day reversed since Americans are fairly unique in putting the month before the day); (iii) last name, first name, prior school, and prior grade with various likely adjustments to prior grade; (iv) name, date of birth, and prior grade; (v) telephone number and alternative telephone number. Once these match keys had been run, an applicant might be matched to multiple possible records. All of the likely matches were checked by hand, bringing to bear all available variables simultaneously. Knowledge of common abbreviations, spelling mistakes, and similar issues was also applied in the hand check. For instance, two possible matches might be differentiated based on the student's home address or his parents' names.

spring 2005, and we requested not only the 2005 lottery data but also all previous years' data. Because schools had not been aware that these earlier years' application data would later be useful, not all schools had archived it or had requested all of the elements that would prove helpful in matching on their applications. Therefore, our application data from 2005 forwards are essentially complete and contain the key information for matching.[11] Previous years' application data are less ideal on both dimensions.

We *should* not achieve a match rate of 100 percent because applicants who were not attending a New York City public school at the time they applied and who did not subsequently attend one should not have matched to a record in the database. Such applicants include children applying for kindergarten who subsequently attend a private school, enroll in a public school outside the district, or engage in home schooling. Such applicants also include children who were attending a private school, another district's schools, or home schooling when they applied and who continued to attend such a school. Note that students can apply to a New York City charter school from outside the district so long as they reside in the district at the time they actually commence attending the school. To determine what match rate we ought to achieve, we computed the percentages of applicants who reported, at the time they applied, attending a private school (14 percent), engaging in home school (less than 1 percent), and living in another district (less than 1 percent). Unfortunately, the first computation does not help with students who are applying to kindergarten, the single most common grade for applicants. Moreover, there are a large number of private kindergartens in New York that are not connected to a full array of elementary grades, and we are concerned that students who apply to a first grade from a private kindergarten might not be able to continue in private school. Thus, we also use the Integrated Public Use Microdata Samples from the 2000 Census to compute the percentage of New York City students who attend private school: 10.6 percent. To make this computation, we re-weighted the students in the Census data so that they had the gender, race, ethnicity, and poverty composition of the applicant pool.[12]

In short, although we hope to match all applicants who have a record in the Department's database to their records, we believe that we should be able to match only about 90 percent of students, plus or minus a few percent. There is some variation among charter schools in their ideal match rates because some schools attract more applicants from private schools and so on.

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[11] We have already collected the application data through the 2009 lotteries, and the completeness and quality of the data has increased with each lottery year.

[12] Specifically, using the combined 5 percent and 1 percent samples from the 2000 Integrated Public Use Microdata (Ruggles, 2007), we computed the probability of attending a private school for each gender-by-race or ethnicity-by-free or reduced-price lunch cell. We then associated those probabilities with each applicant based on the applicant's cell. The resulting average probability among the applicants is what we report in the text.

The match rate for spring 2005 applications was 90.8 percent. Recall that this is the first year for which we had complete, high quality application data. The match rates for spring 2004 and spring 2003 were 88.4 and 88.7 percent, respectively. For full details on the match rate, see Table 6, which also shows that an extremely high percentage of students who have ever attended a New York City charter school are included in the study. Over all the years available, the percentage is 97 percent.

Table 7 compares applicants who were and were not successfully matched to the New York City Department of Education's database. They do not differ on most characteristics that we can observe--this is not merely a statement about the statistical significance but also about the very small magnitudes of the differences. They are equally likely to be female, white, Hispanic, and non-native English speakers. 64.1 percent of matched students are black and 65 percent of unmatched students are black. This difference is actually statistically significant at the 95 percent level because we have so many observations. However, it is a trivial difference.

The only interesting difference between matched and unmatched student is that 54.1 percent of matched students are lotteried-in whereas only 48.6 percent of unmatched students are lotteried-in. This makes sense. An applicant from a private school, home school, or another district who is lotteried-in is likely to attend a charter school and will thereafter appear in the district's database. If such a student is lotteried-out, he has some probability of remaining in his current school, thereby never appearing in the database. This means that a small number of lotteried-out students are "missing" in the sense that they would have appeared had they been lotteried-in. Our best estimate is that 402 lotteried-out students (2 percent of all lotteried-out students) are missing. We base this estimate on a simple calculation. Consider:

total lotteried-out students = matched lotteried-out students +
unmatched lotteried-out students who would have been unmatched even if they had been lotteried-in +
unmatched lotteried-out students who would have been matched had they been lotteried-in

total lotteried-in students = matched lotteried-in students + unmatched lotteried-in students

If we assume that the non-match rate among lotteried-out students, *had they been lotteried-in*, would have been equal to the non-match rate among lotteried-in students, then we can back out the number of missing lotteried-out students:

unmatched lotteried-out students who would have been matched had they been lotteried-in = total lotteried-out students - matched lotteried-out students - [(matched lotteried-in students/total lotteried-in students) · total lotteried-out students]

Later, we use our estimated number of missing lotteried-out students to bound the effect they could have on our results.

B. Attrition

A student attrits from the study if his family moves out of the district, he begins attending private school, or he begins home schooling.[13] Students who move back and forth between charter schools and traditional public schools do not, however, attrit. We do not count a student as an attritor if he graduates from high school.

Apart from considerations of statistical power, attrition is not a problem for studies of this kind if it is random. Attrition is only a problem when it is substantial, systematically related to students' characteristics, and systematically related to whether a student is lotteried-in or lotteried-out: "differential attrition." For instance, if low achieving applicants and high achieving lotteried-in applicants stayed in the data but high achieving lotteried-out applicants attrited with a 10 percent probability, the lotteried-out group would systematically lose a portion of its high achievers while lotteried-in group would keep its high achievers.

Fortunately, the attrition in this study is not differential. This is shown later in this report. Results corrected for attrition using inverse probability weighting (Wooldridge 2007) are also shown. Because attrition is not differential, they do not differ from the uncorrected estimates.

C. Substantial Problems in the Recording of Special Education and English Language Learner Status and Minor Problems in the Recording of Other Classification Variables

There are problems in the recording of special education and English Language Learner status in the database we use in this report. The problems can lead to very substantial underestimates of disability and the need for English language learning in charter schools.

Consider special education first. According to our understanding, which is based on communications with the New York City Department of Education and the New York City Center for

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[13] Because of errors in the database, a student might also attrit in practical terms when he does not actually leave the public school sector in New York City. This can happen if he moves to a new school within the district and his information is entered differently so that his old and new records do not match up.

Charter School Excellence, there are three main problems that occur.[14] A school that refers a student for special education must work with the Committee on Special Education to get him formally identified, and some charter schools have experienced significant delays getting this done. The charter schools have little control over the timing because the Committee on Special Education is the responsibility of the host district--in this case, New York City. Students can sit in the referral queue for extended periods, and so long as they are there, they are not recorded as having special needs. Second, even when a student has been formally identified, a subsystem of the New York City database known as CAPS must be updated to reflect the student's designation. Traditional public schools have direct access to CAPS, but most charter schools can get entries updated only by working through the Committee on Special Education or through a third party contractor. Not only can there be delays and problems in the updating of a student's designation, but the system must also be updated to show that a student has moved into a charter school. Apparently, this second update is sometimes overlooked, with the result that student's special education status is not attributed to the charter school. Third, although there is a "flag" for special education in the main part of the database system known as ATS, charter schools not required to fill in this flag in ATS. (Because many charter schools use another student information system as their primary system, charter schools are only required to enter students' enrollment and other basic information in ATS.) In contrast, ATS *is* the primary student information for traditional public schools, which are required to fill in not only students' basic information but also flags like the special education flag. When a charter school leaves the special education flag blank, the system appears to produce the answer that no students are in special education when, in reality, the system simply contains no information on the matter. In other words, missing data appear to be "zeros" (students' non-participation in special education).

In short, there are three important problems with the recording of charter school students' need for special education, and all three problems cause under-reporting. When we compare the percentage of special education students in charter schools that we compute from the data extracted from the District's database to the official state count (8.90 percent), the official count is more than three times our count. This is a such a large discrepancy that, at present, we cannot use the database numbers to make comparisons between students *in* charter schools and students in traditional public schools. However, we do show statistics based on the pre-lottery designations of students who apply to charter schools while they are in the traditional public schools. As we shall see, pre-lottery designations have their own problems but they are much less severe because all of the recording is done through the traditional public

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[14] For help in understanding these problems, we are particularly grateful to Jennifer Bell-Ellwanger, Office of Assessment and Accountability, New York City Department of Education and to Arthur Sadoff, Special Education Consultant to the New York City Center on Charter School Excellence.

school system.

The recording of a student's status as an English Language Learner status is also problematic for charter schools. There is a "flag" for English Language Learners in the ATS part of the database system, but--like the flag for special education--charter schools are not required to fill it in and many leave it blank for all students. The system then appears to produce the answer that no students are English Language Learners when, in reality, the system simply contains no information on the matter. This problem is exacerbated by the fact that charter schools receive only a fraction of the compensation for English Language Learners that traditional public schools receive. This gives them little incentive to fill in the flag. When we compare the percentage of English Language Learners in charter schools recorded in the database to the official state count (2.80 percent), the official count is more than twice the database count. This also is such a large discrepancy that the database numbers cannot be used to make comparisons between students *in* charter schools and students in traditional public schools. We do show statistics based on pre-lottery designations, but these have their own problems (see below).

Some of the same problems (recording delays, ATS flags not filled in) exist for the recording of students who have been certified for the National School Lunch Program. Charter schools' numbers are understated as a result, especially for new entrants. We estimate the magnitude of the understatement to be about 8 percentage points. Finally, charter schools report that they find it hard to correct the database when it shows a student's race and ethnicity as being different than what the school knows the student's self-identification to be.[15] The latter problem appears mainly to affect students whose parents check multiple boxes for race and ethnicity.[16]

D. New York State Tests

All students in the traditional public schools and charter schools take the New York State examinations in English language arts and math in all of grades three through eight. They take science examinations in grades four and eight, and they take social studies examinations in grades five and eight. New York students also take (and may retake) the New York State Regents Examinations in several subjects. The Regents Examinations are offered in January, June and August, and a student need not take tests on a specific schedule. However, to earn a regular high school diploma (a "Regents Diploma"), a

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[15] The source is authors' conversations with charter school leaders regarding differences between race and ethnicity as parents wrote it on applications and race and ethnicity as shown in the Department's database.

[16] The rule for the standard federal classification is that Hispanic ethnicity "trumps" race so that the categories are black non-Hispanic, white non-Hispanic, Asian and Pacific Islander, Native American, Hispanic, and unknown or none of the above. School staff report, however, that it appears to them that the rule is not always applied so that a parent, say, who checks the black and Hispanic boxes may have his child classified as black.

student must pass exams in Living Environment (biology), Mathematics, Global History, Comprehensive English, and U.S. History. It is recommended that students take Living Environment in grade nine, Math A in grade ten, Global History in grade ten, Comprehensive English in grade eleven, and United States History in grade eleven. There are no differences in how scores get recorded for charter and traditional public school students.

The tests in grades three through eight are given scale scores and there is an official mapping between the scale scores and New York State's four performance levels. See Appendix Figures 1 through 4 for the 2007-08 mapping in each subject. Throughout our analysis, we use standard or Z scores--that is, scale scores that have been first demeaned and then divided by the standard deviation. We use the means and standard deviations for all New York City students in the relevant year and subject. Purely to provide context, we translate some results back into scale scores or "performance levels." When we do this, we use the 2007-08 translations. A great deal of information about New York State's tests is available from the Office of State Assessment.[17]

E. Differences between the Truth and Proxies for Poverty, Disability, and the Lack of proficiency in English

Researchers who rely on administrative data, as we do, do not directly measure poverty, disability, or the lack of proficiency in English. Instead, we use proxies such as certification for the National School Lunch Program , participation in special education, and classification as an English Language Learner. Here a problem arises (in addition to the already described recording problems) because the proxies are measures of *treatment*, not measures of a child's needs. If we use data on these proxies from a student's current school, the comparison between charter school applicants and other public school students is unreliable. The unreliability stems from differences in the ways charter schools and traditional public schools certify students for free and reduced-price lunch and treat students who have learning problems or a lack of proficiency in English.

For example, consider free and reduced-price lunch eligibility. In order to certify a child for the program, a school must get his parents to must document their household's income and composition (adults, dependent children, other dependents, and so on). Certifying parents is a sufficiently challenging task that federal studies regularly find that some schools certify students who are not really eligible and

[17] The website of the Office of State Assessment in the New York State Education Department includes examination scoring information, score conversion charts, manuals and technical reports on the tests, test samplers, and tests that have been released. See http://www.emsc.nysed.gov/osa/ (accessed June 2007).

that other schools fail to certify students who are really eligible.[18] Schools vary in how they describe program eligibility and documentation requirements, whether they use direct certification, and whether they encourage parents whose applications are rejected or whose certification is terminated to reapply.[19] The matter is complicated by the fact that schools can provide a schoolwide lunch program if they certify a sufficient share of their students. Thus, the same administrator who is aggressive about certifying students when he is at a school that is just shy of the threshold for a schoolwide program may be unaggressive when he is at a school that has already passed the threshold. Charter schools are, for the purpose of federal programs, independent Local Education Agencies that conduct their own processes of certifying students and may choose not to offer a federal lunch program at all. Numerous small school districts in the United States do not participate in the federal program owing to the fact that the paperwork involved is considerable but the subsidy is small for small districts because it is on a strictly per-pupil basis.

Problems arise with special education and English Language Learner classification because for every student who is profoundly disabled or profoundly incapable in English, there are many students whose classification is close to the margin in the sense that, properly implemented, either a mainstream or a specialized experience could suit the student's needs well. A small school, including a charter school, may be more likely to offer a marginal student a student a mainstream classroom experience--thereby not classifying him--than would a large school that already has extensive programming for disabled and English Language Learner students. In fact, Cullen and Rivkin (2003) report that some families apply to charter schools in a deliberate attempt to move their marginally classified child into a mainstream experience.

In short, we expect charter schools and traditional public schools faced with identical students to display variation in the proxies for poverty, disability, and the lack of proficiency in English. We can partially address the resulting problem (and the already described recording problem) by focusing on the value of a student's proxies at the time he applied rather than at the current time. For students who were in the traditional public schools at the time they applied, this procedure improves the reliability of comparisons owing to the fact that the same Local Education Agency is classifying all the students. In particular, this procedure should greatly improve the reliability of a comparison between two applicants

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[18] See, for instance, Burghardt and Hulsey (2004) and United States Department of Agriculture (2003).

[19] Most large school districts currently use direct certification for students whose parents claim to be participants in a means-tested program such as Temporary Aid for Needy Families. Such parents are asked to bring recent documents relating to their program participation and these are checked against state social insurance records.

who are in the same lottery and who previously attended similar traditional public schools. Unfortunately, time-of-application comparisons are not informative for more than about two-thirds of charter school applicants because they have no classification history when they apply. The vast majority of the students without a history are applicants to kindergarten or first grade (who together make up almost 50 percent of all applicants; see Table 1) but there are also applicants from private schools, home schooling, and schools outside the district.

F. Miscellaneous Notes on Data

We observe students' October, March, and June records, the last being the official year end record. Thus, a student who transfers in the middle of the school year between schools will have each school assigned its portion of the year, at least approximately.[20] Also, variables such as the time elapsed since a student starting attended a charter school are recorded in partial years when appropriate.

Finally, to provide background information, we use data from published reports of the New York City Department of Education (various dates), published Summary File C of the 2000 Census of Population and Housing (2002), and the Integrated Public Use Microdata Samples from the same Census (Ruggles, 2007).

IV. The Students who Apply to New York City's Charter Schools

In this section, we describe charter school applicants and compare them to the subset who are lotteried-in, the subset who enroll in a charter school, and the entire population of students in New York City's traditional public schools. This section is intended to offer some evidence on how charter schools affect the composition of students in the traditional public schools. For instance, if there are peer effects within schools, we would want to know how peer composition changes in the traditional public schools. Unfortunately, we can offer only partial evidence of this type, owing to the data problems already discussed.

This section is *not* intended to formally test where the charter school lotteries are random. To do this, we must introduce some empirical methodology. We do this in the next section.

A. Comparisons of applicants to others on the basis of gender, race and ethnicity

The characteristics that are most fixed and most easily measurable are gender, race, and ethnicity.

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[20] We are attempting to get even more complete attendance records that will allow us to allocate partial years more precisely, but specification tests suggest that varying our approximations a reasonable amount does not make a difference to any results. The vast majority of students switch schools between school years, not within a school year.

Table 8 shows race, ethnicity, and gender variables for charter school applicants, lotteried-in applicants, students who enroll in charter schools, and all traditional New York City public school students.

The table shows that 63 percent of applicants are black, 64 percent of lotteried-in students are black, and 61 percent of charter school students are black. In contrast, only 34 percent of New York City's traditional public school students are black. Thus, the charter schools unambiguously reduce the share of traditional public school students who are black.

The charter schools unambiguously increase the share of traditional public school students who are white or Asian. The table shows that 4 percent of applicants are white, 4 percent of lotteried-in students are white, and 4 percent of charter school students are white. However, 15 percent of New York City's traditional public school students are white. Similarly, the table shows that 3 percent of applicants are Asian, 3 percent of lotteried-in students are Asian, and 4 percent of charter school students are Asian. However, 12 percent of New York City's traditional public school students are Asian.

Interpreting the numbers for Hispanic students in Table 8 is somewhat tricky. As has already been seen, the charter schools draw only tiny shares of their applicants from white and Asian families. The race/ethnicity shares must add up to 100 percent, and even if charter schools were to draw *no* white and Asian applicants, they would still have to draw a less than proportionate share of Hispanic applicants to accommodate their disproportionate draw of black applicants. That is, if a school disproportionately draws black applicants, it mechanically disproportionately does not draw Hispanic students, and *vice versa*. People often find this mechanical relationship confusing because they are accustomed to thinking about a school being more minority (that is, black and Hispanic) and less white. Such a situation is not possible for New York City's charter schools. The bottom line is that when we say that charter school applicants are disproportionately black, we are also saying they are disproportionately not Hispanic. These are no two separate statements but two ways of stating the same thing.

With these facts in mind, it is no surprise that 29 percent of applicants are Hispanic, 28 percent of lotteried-in students are Hispanic, 29 percent of charter school students are Hispanic, and 38 percent of New York City's traditional public school students are Hispanic.

One explanation of the disproportionate draw of charter schools among black students is that the authorizers have approved some schools that are named after a black person (Harriet Tubman, Sisulu Walker) or associated with an organization with long-established ties to the black community (Harlem Children's Zone). However, the disproportionate draw is much wider than these schools, suggesting that policies that are common among charter schools but uncommon among traditional public schools may appeal more to black families (less to Hispanic families). Alternatively, Hispanic families may like traditional public schools better or be more inclined to accept their traditional public school as the one

that authorities have assigned them.[21]

Table 8 shows that 50 percent of charter school applicants are female, 50 percent of lotteried-in students are female, 52 percent of charter school students are female, and 50 percent of New York City traditional public school students are female. Although the difference between 52 percent of charter school students and 50 percent of traditional public school students is statistically significant, it is too small a difference to be interesting.

B. Comparisons of applicants to others on the basis of prior test scores

Unfortunately, only 22 percent of charter school applicants have prior test scores at the time they apply. Moreover, applicants with prior test scores are not representative of applicants in general.

Table 9 shows that applicants with prior test scores differ statistically significantly on race, ethnicity, and gender from students without prior test scores. Moreover, the two groups differ dramatically on the grade to which they are applying. The average application grade is 5.65 for an applicant with a prior test score. It is just 1.89 for an applicant without a prior test score. This nearly four year difference in the application grade is a serious problem because it means that the typical student with prior test scores has considerable experience in the traditional public schools when he decides to apply to a charter school. It is likely that he does not fit well in the traditional public schools but we do not know in what way. He might be less motivated than his classmates, more motivated, on an unexpectedly bad growth trajectory, or on an unexpectedly good one. We can be fairly sure that these late grade applicants are not a random sample from their traditional public schools. In contrast, the applicants without prior test scores are so young that their parents have little information on which to decide that they do or do not fit well in the traditional public schools. Thus, it is reasonably likely that they are a more random draw from the population in the charter schools' neighborhoods. In short, it is impossible to extrapolate from the applicants with prior test scores in order to make reliable comparisons between the prior test scores of the average charter school applicant and the average New York City public school student.

For what little they are worth, Table 10 shows prior test scores for the non-representative 22 percent of applicants who have them. The scores are in standard score form so that each New York City average score is mechanically zero. (The mean score used for computing the standard score is the overall

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[21] In both the New York City traditional public schools and in charter schools located in areas with a significant Hispanic population, key materials (such as applications, school calendars, and brief school descriptions) are usually available in Spanish but many non-key materials (such as school newsletters and longer program descriptions) are not. We are thus inclined not to attribute the disproportionate draw of charter schools to language proficiency alone but to an interaction between language proficiency and an inclination to accept the default. That is, if a parent finds it equally challenging to learn in depth about his local traditional public school and his local charter school, he may be inclined to choose the default school.

New York City mean.) Among charter school applicants who have prior test scores, the average standard scores in math and English language arts are all less than zero--for those who apply, those who are lotteried-in, and those who enroll in charter schools.

C. Comparisons of applicants to others on the basis of proxies for poverty, disability, and lack of proficiency in English

We have already mentioned that the proxies for poverty, disability, and lack of proficiency in English are problematic because (i) they are measures of treatment, not circumstances, and charter and traditional public schools may treat marginal students differently; (ii) charter schools' information is recorded with substantial understatement; and (iii) the proxies are available at the time of application for only a share of applicants.

Unfortunately, the 33 to 44 percent applicants for whom time-of-application proxies are available are not representative of the applicant pool.[22] We can show this by comparing the intended grade of entry, gender, race, and ethnicity information of applicants who do and do not have time-of-application proxies available. Each of these indicators is statistically significantly different for the two groups and some of group differences are substantial in magnitude: the average grade of intended entry is 3.7 for students with time-of-application proxies but only 1.9 for students without them. About 32 percent of students with time-of-application proxies are Hispanic but only 23 percent of students without them are.

Nevertheless, Table 11 shows that, *at the time they apply*, 92 percent of charter school applicants are certified for free or reduced-price lunch. 91 percent of lotteried-in applicants and 91 percent of charter school students are so certified. In contrast, only 72 percent of New York City's traditional public school students are certified for free or reduced-price lunch. This certification difference of 19 percentage points is so large that it is implausible that charter school students are not actually poorer than the average New York City student. Correcting the multiple measurement problems could not plausibly make the positive 19 percentage points become a negative number.

Table 11 also shows that, *at the time they apply*, 11 percent of charter school applicants participate in special education. This number is the same for lotteried-in applicants and charter school students. 13 percent of students in New York City's traditional public schools participate in special education. These numbers are so similar that, if we were to correct for the multiple measurement problems, we might plausibly find that charter schools disproportionately drew disabled students, disproportionately failed to draw disabled students, or drew an exactly proportionate share of disabled

[22] The proxies for disability and lack of proficiency in English are available for 33 percent of applicants. The proxy for poverty is available for 44 percent of applicants.

students. All we can say for certain is that, in terms of disability, charter school applicants do not differ dramatically from students in the traditional public schools.

Table 11 shows that, *at the time they apply*, 4 percent of charter school applicants are classified as English Language Learners. This percentage is the same for lotteried-in students and charter school students. 14 percent of New York City students are English Language Learners. Because of the multiple measurement problems, we hesitate to interpret the difference between 4 percent and 14 percent. What we do find instructive, however, is the disproportionate appeal of charter schools to black students as opposed to Hispanic students. Since black students are more likely to be native English speakers than Hispanic students, it seems likely that charter schools draw a somewhat small share of English learners.

Finally, Table 11 shows that, *at the time they apply*, only 1 percent of charter school applicants have been retained in a grade. This percentage is identical for lotteried-in applicants and applicants who enroll in charter school. Keep in mind that most applicants are applying to kindergarten or first grade, so many have had little or no opportunity to be retained. Unlike the program participation variables, the retention rate *is* representative of charter school applicants.

V. Empirical Methodology for the Lottery-Based Analysis of Achievement

In previous sections, we described numerous problems that make it hard to compare charter applicants to other students in the traditional public schools. None of these problems affect the achievement analysis that we now describe because the achievement analysis is based entirely on applicants. The strategy uses instrumental variables based on lotteried-in status to generate a treatment-on-the-treated effect of attending charter schools.

A. The randomized lotteries

Unlike some randomized studies in which there is one lottery that determines treatment or control status, there are 725 lotteries in our data. This is because, each year, each school holds a lottery for each grade in which it has space but is oversubscribed. Assignment is random within a lottery but a student's decision to participate in a certain lottery is non-random. In order to make use of all the within-lottery randomness and none of the between-lottery non-randomness, we include lottery fixed effects in all regressions.

The logic of randomization is that, owing to the law of large numbers, the average lotteried-in and lotteried-out students should not only be comparable on observable characteristics but also on unobservable ones. We hypothesize that lotteries that are balanced on the basis of students' observable characteristics are also more likely to be balanced on the basis of their unobservable characteristics. For this reason, we test each lottery for balance on the observable covariates prior to including it in the

analysis. This is a conservative assumption in that we are relying solely on the *within*-lottery randomization and not the tendency of one unbalanced lottery to offset another *across* lotteries.[23] Although we believe that results based only the balanced lotteries are the most credible, we also show results based on all lotteries as a specification test.

To test for balance, we use Hotelling's T^2 test, which is the analog to the t-test when multiple variables are considered simultaneously. We use all available pre-determined student characteristics: gender, race, ethnicity, certification for free and reduced-lunch at the time of application, participation in special education at the time of application, classification as an English Language Learner at the time of application, and prior test scores. We use the classic fix of setting these variables equal to zero when they are missing and including an indicator for their being missing. Thus, we are also testing whether the lotteried-in and lotteried-out are balanced on having missing data.

Using Hotelling's T^2 test set at the 95 percent level, we find that 94 percent of students were in a lottery identified as balanced. This is about what we expect from random lotteries.[24]

B. Students with complex lottery participation

Some students participate in multiple lotteries. For instance, a student may apply to two charter schools for kindergarten. Alternatively, he may apply to a single charter school for kindergarten but then reapply for first grade when he is lotteried-out. For the purposes of estimation, such students are put in "complex lotteries" or "risk sets" that contain all other students who have exactly the same application pattern as they do. For instance, the student who applies to two charter schools for kindergarten is put in the same complex lottery as all other students who apply to the same two charter schools for kindergarten. This is because a student's lottery outcome is random conditional on being in his complex lottery group, but it is not random which complex lottery group a student is in. For instance, a student who applies to multiple charter schools may be more determined to gain admittance than students who apply only to a single charter school.

Hereafter, whenever we state that we control for a student's lottery, we are controlling for the complex lotteries. For instance, the tables that show the estimated effects on achievement all state that "complex lottery fixed effects" are included.

In New York, if a student applies to a charter school and has a sibling who is already enrolled

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[23] If each of our lotteries was an independent draw from the same population, we would rely equally on balanced and unbalanced lotteries. We are not confident making such an assumption, however.

[24] We exclude siblings from this statement because they are not actually lotteried-in in the lottery in which they appear to be present.

there, he is given a place in the grade to which he applies if there is space. That is, he is placed before the lottery is held. (This is standard treatment for siblings in many magnet, intra-district choice, and desegregation programs.) If a larger number of siblings applies than there are places, then a lottery is run among the siblings. This does not occur often. We treat a student who is admitted on the basis of his sibling's enrollment as having been lotteried-in with his sibling. That is, he counted as lotteried-in. If a student has a sibling and participates in an all-sibling lottery, then he is lotteried-in if he is lotteried-in in that lottery and he is lotteried-out otherwise. Such lotteries are complex lotteries since participation is conditioned on being a sibling.[25]

C. Measuring treatment and the intention-to-treat

As mentioned previously, students attend charter schools in highly varied grade sequences. Some attend kindergarten through fifth grade, others attend fifth grade through ninth grade, and so on. Thus, no binary treatment variable (experienced charter school or not) could plausibly measure all of these different treatments. In theory, we could separately estimate the effect of every grade sequence that we observe in the data. However, we do not have sufficient statistical power to do this. Moreover, it would be very difficult to interpret all these estimates without aggregating them in some manner, and aggregating them would bring us back to the question of how to measure treatment accurately and yet parsimoniously.

The most natural treatment variable is the length of time that a student attends a charter school. This is measured in school years. The parallel intention-to-treat variable is also natural: the length of time that has elapsed since the student could have been attending charter school owing to his being lotteried-in. This is also measured in school years. The advantage of these time-in-treatment measures is that they are intuitive and parsimonious. Also, they can easily be entered nonlinearly in a regression so that we can look for effects such as charter schools' initially having a positive effect which then plateaus. (The opposite--charter schools' initially having a negative effect which then turns positive--is also

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[25] Suppose that a family decides that it is interested in a charter school and puts their oldest child in a lottery. If he is lotteried-in, so in all likelihood are all of his younger siblings as long as they apply to the intake grade. Suppose that if he is lotteried-out, the family does not have the younger siblings apply when they reach the relevant age because the oldest child is already installed in a traditional public school and the family wants to keep the children together. This scenario does not pose a problem for the study.

Alternatively, suppose that even though their oldest child is lotteried-out, the family continues to enter younger siblings in lotteries when they reach the relevant age. *Also*, suppose that if a younger sibling gets lotteried-in, the older sibling(s) will then use sibling priority in the following year to enroll in the charter school if its non-intake grades have space. It is fortunate that this scenario very rarely occurs (less than 0.5 percent of applicants) because this scenario could be a problem for the study: it gives larger families "more bites at the apple". Then, if family size were correlated with outcomes, that correlation could be confounded with the charter school effect. Family size is generally found to be negatively correlated with student achievement so we would expect the problem to bias downward the estimated effect of charter schools on achievement.

plausible.) The disadvantage of the time-in-treatment measures is that they may miss some dimensions of treatment. For instance, if treatment is inherently different for a student who enrolls as a kindergartener than for students who enroll as second graders, the time-in-treatment variable would not pick this up.

To accommodate such concerns and yet still employ a parsimonious measure of treatment, we begin by using only the time-in-treatment variable and its intent-to-treat analog. However, we then test whether the effects that we estimate with these variables depends on variables such as grade of entry, the grade being attended, the level of the school being attended (elementary, middle, high school where such classifications are possible), and so on.

D. Compliance

We instrument for the treatment variable with the intention to treat variable to obtain a treatment on the treated effect. As is well known, the resulting estimates are local to the types of students who are compliers–that is, students who, when offered a place in a charter school, enroll. In some applications, having an estimator that is local to compliers is problematic because we would like to be able to think about the effect that treatment would have if it were extended to those who would be non-compliant. In the case of charter schools, however, an estimate that is local to compliers is exactly what we want. It is part of the charter school idea that only students who want to attend charter schools should attend them. What we want to be able to do is extrapolate the results to other students who, like the compliers, want to attend charter schools and have needs similar to those of the students who apply to New York City charter schools now.

In most randomized assignment studies, there are two types of non-compliance: students who decline the opportunity to enroll in a charter school even though they are offered a place ("decliners") and students who enroll in a charter school even though they are not offered a place ("defiers"). There are no defiers in our study. That is, in the data, we do not observe any student attending a charter school who was reported as having been lotteried-out of that charter school. We do observe decliners and it is precisely to account for them that we use instrumental variables to estimate the treatment on the treated effect. We show data below to investigate the question of how decliners compare to compliers and the lotteried-out.

D. The estimating equations

The specification that has been most validated for estimating the effect of a year of treatment is the following one (Kane and Staiger 2009):

$$A_{ijt}=\beta_1 time\text{-}in\text{-}treatment\text{-}this\text{-}year_{ijt}+\beta_2 A_{ij,t-1}+X_i\beta_3+I_j^{lottery}\beta_4+I_g^{grade}\beta_5+I_t^{school\ year}\beta_6+\varepsilon_{ijt}+\varepsilon_i \qquad (1)$$

where A_{ijt} is the year t achievement (standard score) of student i who participated in complex lottery j and

time-in-treatment-this-year$_{ijt}$ is his time spent in charter school in year *t* (equal to one if he spent the whole year in charter school, zero if he spent no time in charter school, one-half if he spent half the year in charter school, and so on). The vector $\boldsymbol{X_i}$ contains the set of pre-determined covariates that describe student *i*,[26] the vector $\boldsymbol{I_j}$ is an exhaustive set of complex lottery fixed effects (note the lack of another constant), $\boldsymbol{I_g^{grade}}$ is a set of grade fixed effects, $\boldsymbol{I_t^{school\ year}}$ is a set of school year fixed effects, ε_{ijt} is the observation level error term, and ε_i reminds us that there are robust standard errors clustered at the student level. Note that the grade-of-test and school year fixed effects are nearly superfluous because the test scores are standardized already using grade-by-year specific means and standard deviations.

This specification is desirable not only because it has been validated. It is also desirable because β_1 is easily interpreted: it is the effect of a year of charter school on a student's achievement. Moreover, this specification has been used often in studies of other treatments such as changes in class size, having a certain teacher, using a certain curriculum, and so on. Thus, we can compare β_1 to estimated effects of other treatments, in a perfectly straightforward way.

Of course, we cannot use specification in equation (1) for students who are in the third grade. They do not have a test score from the end of the prior grade. Moreover, their score at the end of third grade will reflect not only the treatment they received in the third grade but also whatever treatments they received in kindergarten through second grade. Therefore, we employ a simple "time elapsed" specification for them:

$$A_{ijt}=\gamma_1 time\text{-}in\text{-}treatment\text{-}this\text{-}and\text{-}prior\text{-}years_{ijt}+\boldsymbol{X_i}\gamma_2+\gamma\boldsymbol{I_j^{lottery}}\beta_3+\boldsymbol{I_g^{grade}}\gamma_4+\boldsymbol{I_t^{school\ year}}\gamma_5+\upsilon_{ijt}+\upsilon_i \quad (2)$$

where *time-in-treatment-this-and-prior-years*$_{ijt}$ is a student's time attending charter school in all grades from kindergarten through third. For instance, it would be equal to four for a student who attended a charter school from the beginning of his kindergarten year to the end of his third grade year. The coefficient γ_1 can be interpreted as the effect of a year of charter school on a student's achievement. This is the same interpretation as β_1, the key coefficient in equation (1).

This time elapsed specification (equation 2) is obviously closely related to the previous one (equation 1) because multiple one-year effects must add up to the effect of multiple grades of treatment. Indeed, we show this in our results by averaging (with appropriate grade-based weights) the effects we estimate by using equation (2) for grade three and by using equation (1) for grades four and higher.[27]

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[26] The list is given in the text in the discussion of the Hotelling T^2 test for balance.

[27] The average weights each estimate by the number of grade-year observations it represents.

These added-up effects are essentially identical to what we get if we simply use the time elapsed specification (equation 2) for *all* grades. We show this.

For equation (1), the first stage of the instrumental variables procedure is:

$$\begin{aligned} &time\text{-}in\text{-}treatment\text{-}this\text{-}year_{ijt} = \\ &\alpha_1 time\text{-}could\text{-}been\text{-}in\text{-}treatment\text{-}this\text{-}year\text{-}because\text{-}lotteried\text{-}in_{ijt} + \\ &\alpha_2 A_{ij,t-1} + X_i\alpha_3 + I_j^{lottery}\alpha_4 + I_g^{grade}\alpha_5 + I_t^{school\ year}\alpha_6 + \xi_{ijt} + \xi_i \end{aligned} \tag{3}$$

For the time elapsed specification (equation 2), the first stage of the instrumental variables procedure is:

$$\begin{aligned} &time\text{-}in\text{-}treatment\text{-}this\text{-}and\text{-}prior\text{-}years_{ijt} = \\ &\delta_1 time\text{-}could\text{-}been\text{-}in\text{-}treatment\text{-}this\text{-}and\text{-}prior\text{-}years\text{-}because\text{-}lotteried\text{-}in_{ijt} + \\ &X_i\delta_2 + I_j^{lottery}\delta_3 + I_g^{grade}\delta_4 + I_t^{school\ year}\delta_5 + \iota_{ijt} + \iota_i \end{aligned} \tag{4}$$

Although we have shown the treatment and intention-to-treat variables enter each equation above in a linear fashion, we can easily enter a polynomial based on them to allow for effects that are non-linear in the length of time a student has spent in charter school. For instance, a quadratic in the treatment variable would be good at picking up a plateauing of the effect of treatment as the length of treatment increases.

VI. The Lotteries and their Usefulness for Analysis of Achievement

A. The randomness of the lotteries

So far, we have not formally verified that the charter schools' lotteries are random. We do this here. We also show the differences (or lack of differences) between compliers and decliners. A statistically significant difference between compliers and decliners would not invalidate our lotteried-based empirical strategy but it would suggest that the estimates are local to the population of compliers, not to the population of decliners.

Table 12 lists several predetermined characteristics of applicants: race, ethnicity, gender, age at the time of application, certification for free or reduced-price lunch at the time of application, participation in special education at the time of application, classification as an English learner at the time of application, prior grade retention at the time of application, prior math scores, and prior language arts

scores. All of these variables should be the same for lotteried-in and lotteried-out applicants once we condition on complex lottery fixed effects. That is, lotteried-in and lotteried-out students in the same lottery should be equally likely to be black, but black students are not equally likely to participate in all schools' lotteries.

The left-hand panel of Table 12 shows tests for all lotteries we observe. The right-hand panel shows tests for the lotteries that are balanced.

We observe *no* statistically significant differences at the 95 percent level between the lotteried-in and lotteried-out. This is true both of the balanced lotteries and of all the lotteries. This suggests that the lotteries are indeed random.

We observe only a few statistically significant differences between compliers and decliners: compliers are slightly more likely to be female and slightly less likely to participate in special education or English Language Learners. However, all these differences, despite being statistically significant, are very small: 2 percent or less. Since differences between compliers and decliners are only useful for thinking about the population to which the estimates are local, it is hard to do much with such small differences. The type of students for whom we can extrapolate the effects remains essentially unchanged.

B. The availability of test score data on students who participated in lotteries

Do we have sufficient statistical power to estimate the effects of charter schools with reasonable precision? Table 13 shows that we have thousands of observations for each of the third through eighth grade math and language arts tests. There are at least one thousand students who took each Regents exam. It is unsurprising that these numbers of observations give us sufficient statistical power to estimate fairly precise effects of charter schools. However, it will turn out that we have insufficient observations for some individual charter schools to estimate effects of plausible size. Because science and social studies tests are administered only in certain grades, it will turn out that the number of observations is barely sufficient for those tests: effects of very plausible size are only statistically significant at the 85 percent level.

Table 13 also shows that 25 percent of the observations are generated by students whom we observe for 6 or more years *after* they participate in a lottery. (We often observe pre-lottery data as well.) 52 percent of the observations are generated by students whom we observe for 4 or 5 years after they participate in a lottery. The remaining 23 percent of the observations are from students whom we observe less than 4 year after their lottery. These percentages are useful later when we interpret our main findings.

VII. Lottery-based Analysis of Grade 3 through 8 Test Scores

A. The main achievement results for grade 3 through 8 in math and English

Table 14 presents the main test score results of this report. The first row shows the result of estimating the time elapsed specification for third graders. Note well that the effect shown in the first row is the *cumulative* effect of attending charter school up through third grade, since this is the first time students are tested. The second row shows the result of estimating the most validated specification (equation 1) for fourth through eighth grade. The final row of the table shows the results obtained by averaging the effects for all of grades kindergarten through eight.

The results in the first row of the table indicate that the cumulative effect of attending charter school through third grade is a 0.14 standard score increase in math and 0.13 standard score increase in language arts. This is of course relative to the lotteried-out students who were initially the same as the charter school students. The math result is statistically significant at the 95 percent level and the language arts result is statistically significant at the 90 percent level.

The results in the second row of the table indicate that a year in charter school between the fourth and eighth grades raises students' math performance by 0.12 standard score units and their language arts scores by 0.09 standard score units. These results are statistically significant at the 99 percent level. (The precision of the grade four through eight results is higher than the precision of the third grade results because there are five grades of test scores being analyzed rather than one.) Recall that a benefit of using the most validated specification (equation 1) is that we can compare the per-year effects of charter schools to the effects of other interventions. Relative to other interventions that have been rigorously analyzed--such as class size reduction, extended reading and math periods, and specific curricula--the per-year effects of charter schools are large. In fact, the per-year effect of charter schools is about the same magnitude as the effect of being assigned a teacher whose estimated value-added is two standard deviations above the mean.

The bottom row of Table 14 indicates that, over all of grades kindergarten through eight, charter schools raise students' math achievement by 0.09 standard score units and their language arts achievement by 0.06 standard score units. It is these average effects that we interpret in the figures below. We also use them as the basis for all of our specification tests. The main disadvantage of these estimates is that they cannot be easily compared to the estimated effects of alternative interventions.

Table 15 translates the results from Table 14 into scale score units. In other words, Table 15 does not contain truly new results, just a translation of the results into a new metric. Scale score points are often a more useful metric for policy makers because they are familiar with their state's proficiency threshold, which is set in scale score points. For instance, the proficiency threshold in New York State is

650 points on all grade three through eight tests. In grade three, the difference between "not meeting learning standards" (Performance Level 1) and "meeting learning standards" (Performance Level 3) is 26 points in math and 32 points in English. In grades four through eight, the difference between "not meeting learning standards" and "meeting learning standards" is about 31 points in math and 44 points in English.

Table 15 shows that our estimates imply that, by the third grade, the average charter school student is 5.8 points ahead of his lotteried-out counterpart in math and 5.3 points ahead in language arts. In grades four through eight, the average charter school student gains 5.0 more points each year in math and 3.6 more points each year in language arts than his lotteried-out counterpart. Keep in mind that these gains are in addition to whatever gains the lotteried-out students are making in the traditional public schools.

B. Interpreting the main results for grade 3 through 8 in math and English

Figures 5 and 6 are designed to aid in the interpretation of the results just discussed. In Figure 5, the horizontal axis registers a student's grade. The vertical axis registers the test score improvement that charter schools have caused as of each grade. The bottom blue line represents the achievement of lotteried-out students who attend the traditional public schools. It is normalized to zero so that growth in achievement among charter school students is shown *relative* to the lotteried-out students' achievement. (Later, we examine the gains that the lotteried-out students themselves are making. For now, it is convenient to think of them purely as a control group.)

The green line in Figure 5 shows the actual, raw data for lotteried-in students who attended charter schools throughout the third through eighth grades. By the end of third grade, the charter school students' scores are just about 5 points higher than those of their lotteried-out counterparts. By the end of the sixth grade, their scores are about 21 points higher than those of their lotteried-out counterparts. By the end of eighth grade, their scores are about 30 points higher than those of their lotteried-out counterparts.

The red line in Figure 5 is based on our estimated effects: 3.6 scale score units in math per year. It appears to be a smooth version of the actual data, but in fact the estimates are based on all the data, not just the data on students who are observed in charter schools in all of grades three through eight. This is an early indication that the per-year effect of attending charter school does *not* depend on whether a student attends only a few grades or several grades. We test this formally in a moment.

For now, what is important for interpretation is the cumulative effect of charter schools. The estimates indicate that, if a student receives nine year of treatment in charter schools (all of grades kindergarten through eight), he will be scoring about 30 points higher in math than he would have been

scoring if he had been lotteried-out and remained in the traditional public schools.

How much is 30 points? People often compare such gains to an "achievement gap" but, in practice, different people use different "gaps": the national difference between black and white students' test scores, the national difference between black or Hispanic and white or Asian students' test scores, the national difference between poor and non-poor students' test scores, and so on. Some reports use the district or state analogs of the aforementioned differences. Clearly, 30 points will be a different share of the achievement gap depending on which gap is selected.

We had three criteria for the gap we chose. First, we wanted a gap in the metric of the New York tests, for ease of interpretation. Second, we wanted a gap that represented the full difference between achievement of public school students who come from very disadvantaged backgrounds (as the charter school students do) and public school students who come from very advantaged backgrounds. Third, we wanted a gap that was concrete and salient. We therefore selected the achievement gap between the average student in a traditional public school in Harlem, the area with the highest concentration of charter schools, and the average student in Scarsdale, New York, a highly affluent and salient suburb of New York City. The average Scarsdale student routinely scores between 35 and 40 points higher than the average student in Harlem, so we will hereafter call 35 points the "Scarsdale-Harlem achievement gap." (The test score gap between Scarsdale and Harlem varies from grade to grade and year to year, so the 35 points is only approximate.

30 points is 86 percent of the Scarsdale-Harlem achievement gap. In other words, if we are willing to extrapolate our per-year results to a student's being treated for nine years in the average charter school, our results imply that such treatment would close 86 percent of the Scarsdale-Harlem achievement gap in math. Of course, this is merely interpretation of the results. We have not shown formally yet that such an extrapolation is warranted--except for the students whose actual data is shown in Figure 5. However, we will show in a moment that such extrapolation is supported by our current data.

Figure 6 is like Figure 5, except that it shows language arts instead of math. Again, the blue line represents the achievement of lotteried-out students, which has been normalized to zero. The green line shows the actual, raw data for lotteried-in students who attended charter schools throughout the third through eighth grades. By the end of third grade, the charter school students' scores are about 4 points higher than those of their lotteried-out counterparts. By the end of eighth grade, their scores are about 22 points higher than those of their lotteried-out counterparts. The red line is based on our estimated effects: 2.4 scale score units in reading per year or 23 scale score units cumulatively over all of grades kindergarten through eight. Again, the read line appears to be a smooth version of the actual data but is in fact based on all the data, not just the data on students who are observed in charter schools in all of grades

three through eight. This is another indication that the per-year effect of attending charter school does *not* depend on whether a student attends only a few grades or several grades.

23 points is 66 percent of the Scarsdale-Harlem achievement gap. In other words, if we are willing to extrapolate our per-year results to a student's being treated for nine years in the average charter school, our results imply that such treatment would close 66 percent of the Scarsdale-Harlem achievement gap in language arts.

C. Robustness of the main results

Table 16 shows a first set of robustness tests. It also shows evidence that the extrapolations shown in Figures 5 and 6 are supported by the data we currently have. (In Table 21, we present a variety of other robustness checks. They cover issues like non-matching, attrition, and retention in grade.) The first row of Table 16 is the same as the last row of Table 14. That is, it shows the average per year effect of attending charter schools for grades kindergarten through eight: 0.09 standard score units in math and 0.06 standard score units in language arts, per year.

The second row of Table 16 shows the results we obtain by using the time-elapsed specification (equation 2) for the data in all of grades kindergarten to eight. The math effect remains at 0.09 standard score units per year; the language arts effect ticks up just slightly from 0.06 standard score units to 0.07 standard score units. A Chow-type test shows that this minor difference in point estimates is not statistically significant. In other words, it is unimportant whether we use the specification given by equation (1) or the specification given by equation (2).[28]

To construct the third row of Table 16, we use data from *all* lotteries, not just the balanced ones. This has no effect on the point estimate for language arts, which remains at 0.06 standard score units per year. The point estimate for math ticks downward to 0.07 standard score units, but a Chow type test does not indicate that this change is statistically significant. Since the unbalanced lotteries are the ones in which the lotteried-in and lotteried-out are not similar on observable variables, it is not surprising that they change the point estimates somewhat. Indeed, an investigation of the unbalanced lotteries suggests that a few small lotteries in which the lotteried-out students had much high prior math scores than the lotteried-in are generating the change in the point estimate. The implausibility that the lotteried-in and lotteried-out are truly comparable in those lotteries is precisely why we test for balance.[29]

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[28] This is a complete specification test for Reardon's (2009) concerns about equation (1). He notes himself that his concerns are not valid if the time-elapsed specification produces the same results as averaging the results from equation (2) for third graders and equation (1) for other grades.

[29] Indeed, it is possible that outliers like the few lotteries mentioned are generated by peculiar circumstances or even errors in the database. Errors are unlikely to be due to New York State grading the

The fourth row of Table 16 adds a fully array of predetermined covariates to the estimation including not just race, ethnicity, gender, but also prior free-lunch certification, prior special education participation, prior English learner status, home language, and whether the student is a U.S. native. These covariates have essentially no effect on the estimates, which is what we expect because the lotteries balance these covariates already.

The remaining rows of Table 16 provide evidence that the main results can be fairly safely extrapolated as we did in the creation of Figures 5 and 6. We have already seen that the estimates correspond very closely to the raw data on students who attend charter schools for all of grades three through eight (at least six years). This correspondence suggests that the charter schools have similar effects on students who attend charter schools for longer and shorter periods. Nevertheless, we have not tested this formally. Specifically, we have not shown that the students who attend charter schools for longer periods are not special in some way--perhaps particularly susceptible to being positively affected by charter schools.

Therefore, what we show in Table 16 is separate estimates based on students who receive, based on our current data, 6 or more years of treatment, 4 to 5 years of treatment, and 1 to 3 years of treatment. 25 percent of students fall into the first group, 52 percent fall into the second group, and 23 percent fall into the last group. (Of course, some of the students whom we now observe for only 1 to 3 years will eventually become students with 6 or more years of treatment. In theory, we could produce separate estimates for students with each number of years of treatment--1, 2, 3, 4, and so on. However, we lack sufficient statistical power to make such estimates precise, especially once we split the data further, as we do.) Moreover, to test whether long-treatment students are somehow special, we examine whether they, if we had data on only their first 2 years post-lottery, would produce estimates like the students on whom we currently have 1 to 3 years of post-lottery data. We perform an analogous estimation for 4 to 5 years-of-treatment students using their first 2 years of post-lottery data. Finally, we investigate whether the first 5 years of post-lottery data on students with 6 or more years of treatment produce estimates like the students on whom we currently have 4 to 5 years of post-lottery data.. Because these regressions have smaller samples than we use for our main results, the estimates will not be as precise. Therefore, movements in the point estimates of even 0.04 standard score units are not statistically significantly from zero.

In fact, what Table 16 shows is that the point estimates do not vary greatly as we vary the sample

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tests incorrectly. Rather, they generally occur through errors in data entry, including data entry that results in the mixup of the records of students with nearly identical names or student identification numbers.

from students on whom we have six or more years of data to students on whom we have only one to three years of data. The point estimates for math are as low as 0.08 and as high as 0.10 standard score units per year. The point estimates for reading vary between 0.06 and 0.08. Moreover, there is no clear pattern to the point estimates. It is not the case that students with six or more years of treatment always have higher estimates, for instance. If they were intrinsically different, we would likely see a fairly consistent pattern. In short, the estimates shown in the bottom panel of Table 16 indicate that the annual effect of charter schools is fairly consistent across students with different current lengths of treatment. This suggests that students with long treatment experiences provide fairly reliable guidance on what we can expect for students whose treatment experience is currently short.

D. Do charter schools' effects differ with a student's race, ethnicity, gender, or incoming achievement?

Does the effect of New York City's charter schools depend on a student's race, ethnicity, gender, or incoming achivement? We can answer questions like this so long as we have a large enough number of observations in a subgroup to produce fairly precise estimates.

Recall that about two-thirds of charter school applicants are black, about one-third are Hispanic, and about half are female. It turns out that each of these subgroups is large enough for us to compute a separate estimate that is precise. We do not, however, have a sufficient number of Asian, white, or other race students to compute separate estimates for them. We can also divide students two subgroups based on incoming achievement: those whose incoming achievement was above median achievement and below median achievement (where the medians are defined among all charter school applicants with a prior achievement score). Recall, however, that only 22 percent of applicants *have* a prior achievement score, so the tests based on incoming achievement are not representative of all applicants.

Table 17 shows the results of the separate computations just described. The results for black and Hispanic students are the same as one another (and not statistically significantly than the results for charter school applicants of all races/ethnicities). The results for males and females have slightly different point estimates (most notably, the math effect is 0.10 for females and 0.08 for males) but they are not statistically significantly different at even the 0.85 level. The results for incoming below-median achievers and incoming above-median achievers are also not statistically significantly different from one another. Interestingly, the point estimates suggest that the charter schools may have a slightly greater effect on students who apply with a prior test score in hand,[30] but this difference too is not statistically significantly different from zero.

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[30] This would make sense if the students who have a prior test score available to them can more precisely assess how they will fare in charter schools versus the traditional public schools.

We also tested whether charter schools' effects depend on the grade to which a student applied. Previous work on Chicago (Hoxby and Rockoff 2004) suggests that students who apply to earlier grades experience larger, more precise effects. However, we found no such pattern among New York City applicants perhaps because the city's charter schools have a much wider array of grade compositions than do Chicago's charter schools.[31]

Summing, we find no evidence that the effects of New York City's charter schools differ by the student's type.

E. Robustness of the main results to attrition, non-matching, returnees to the traditional public schools, retention-in-grade, and variation in win rates among charter schools

The primary threat to the validity of a randomization-based study is differential attrition, which we define above. In addition, there are a variety of minor issues that can affect a randomization based study: failure to match lottery data to the New York City database, students returning to the traditional public schools when they need not do so, the retention of students in grade, and variation in win rates among charter schools. In this sub-section, we explore the robustness of the main results to all such issues.

Returning to the Traditional Public Schools

Because most charter schools in New York City do not cover all of the grades from kindergarten to twelve, charter school students do generally return to the traditional public schools if they enroll in a charter elementary school or charter middle school. So far, about 14 percent of charter school students analyzed in this report have returned to the traditional public schools. Their returning to the traditional public schools does not, of course, mean that they leave the study. We continue to observe their performance and, in future reports, we will analyze how they perform when they are back in the traditional public schools. Unfortunately, they are still too small in number for such an analysis.

A small share (8 percent) of students return to the traditional public schools even though the charter school they are attending does serve their grade. In Table 18, we use multiple regression to test whether these (voluntary) returnees differ from their fellow charter school students on any dimension: gender, race, ethnicity, free or reduced lunch participation (at the time of application), English learner

[31] We do not have sufficient statistical power to estimate fairly precise effects by individual grades of application, so we must group grades together. For Chicago, the students in each grade group entered in a fairly similar way because the charter schools had the same grade compositions. The same cannot be said for New York City. For instance, some students applying to fifth grade are applying to a school that begins with the fifth grade. Other students apply to fifth grade are applying to a school that is K-6 or even K-5.

services (at the time of application), or test scores in the charter school just prior to their return.[32] We also test whether the (voluntary) returnees have difference test score *gains* in the charter school just prior to their return. The motivation for these tests that some commentators are concerned that charter schools will find ways to push out students whose achievement or achievement gains are low or to push out students who are otherwise unattractive.

The estimates presented in Table 18 show no evidence that (voluntary) returnees to the traditional public schools are more likely to be female, Hispanic, other race, free or reduced-price lunch participants, or English learners. Also, compared to their fellow charter school students, they do not exhibit lower test scores or lower achievement gains prior to returning to the traditional public schools. Thus, we find no evidence that charter schools are pushing out students who are low achievers, for whom charter schools are not producing gains, or who are associated with traditionally disadvantaged groups. In contrast, Table 18 shows that we *do* find evidence that (voluntary) returnees to the traditional public schools are more likely to be white (2 percent more likely) or Asian (3 percent more likely). We speculate that the higher rate of voluntary return among white and Asian students may be due to the fact that charter schools, as noted above, enroll student bodies that are so black and Hispanic. A white or Asian student in a New York City charter school is likely to be the sole child of his race/ethnicity in his grade (or even a few grades, since charter schools are often small). Parents who find that their child is very isolated from his or her racial group may have a higher tendency to return their child to the traditional public schools.

Below, we show a bound on how our main estimates could be affected by the (voluntary) returnees. Specifically, we will treat them, for the purpose of estimation, as though they had never left the charter school in which they could have stayed. That is, we will give the charter school credit for their performance, good or bad, after they have returned to the traditional public schools. We will find that this makes no difference to the results, a finding that is no surprise given that Table 18 shows so little indication that returnees differ on important dimensions.

Students who leave the study

Students, both lotteried-in and lotteried-out, can leave the study for several reasons. Almost identical shares of lotteried-in and lotteried-out students covered by this report have left the study for any reason: 24.8 percent of lotteried-in students have done so; 24.9 percent of lotteried-out students have done so. See Table 19.

One reason students leave the study is that they graduate from high school. Since the charter

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[32] We did not have sufficient non-missing data on special education services at the time of application to test this variable.

school students are more likely to graduate (see Section VIII), it is not a surprise that 3 percent of charter school students have left the study by graduating while only 1.1 percent of lotteried-out students have left through this channel.

Table 19 shows a variety of other reasons that students have left the study and the percentage who have left for each reason. By far the most common reason is transferring to a school outside of New York City or to a private school inside the city. This accounts for 16.7 percent of charter school students and 22 percent of lotteried-out students. In addition, some students (1.4 percent of lotteried-in and 0.9 percent of lotteried-out) leave because their new address is unknown. Most of these students are likely to be transferring outside of New York City or to a private school. Very small fractions (always less than 2 percent) of lotteried-in and lotteried-out students leave for another reason such as being in a GED or similar program, voluntarily withdrawing due to absences or pregnancy, or being deceased or institutionalized.

Once one removes the students who leave the study because they graduate, it is clear that lotteried-in students are less likely to leave the study. Thus, there is no evidence that charter schools are pushing students out from New York City's public schools altogether. However, it might still be that charter schools are more likely to push a student out if he is low achieving than the traditional public schools are to push a student if he is low achieving. If this is so, we should find differential attrition: leaving the study has a stronger negative correlation with achievement among charter school students than it has among lotteried-out students. That is, we should find that being a low achiever makes a charter school student more likely to leave than being a low achiever makes a lotteried-out student likely to leave.

Table 20 shows tests for differential attrition based on multiple regression in which the dependent variable is a indicator for the student having attrited (for any reason other than graduation). The key coefficients are those the *interaction* between the lotteried-in indicator and the most recent test score. If these interaction terms are statistically significant, they indicate differential attrition. We find, regardless of whether we control for other student characteristics or not, that there is little to no evidence of differential attrition. The coefficient on the lotteried-in-times-math interaction is always very close to zero as a point estimate and is very far from being statistically significant (the p-value is greater than or equal to 0.65). The coefficient on the lotteried-in-times-English interaction is also close to zero and statistically insignificant at conventional levels. To the extent that we are willing to interpret the point estimate because it is significant at the 0.85 level, however, it has the *wrong* sign for the concern that commentators express about charter schools. That is, it suggests that any differential attrition from charter schools favors the traditional public schools because students who are higher achieving in English

are slightly more likely to attrit from the study if they are lotteried-in than if they are lotteried-out. That is, if anything, differential attrition causes us to underestimate the positive effect of charter schools on achievement. However, we feel no need to give a firm interpretation to the results because they are not statistically significant at conventional levels.

Below, we show how our main estimates are affected if we correct for attrition using inverse probability weighting. We find that this makes no difference to the results, a finding that is no surprise given the paucity of evidence for differential attrition in Table 20.

Grade retention

For grades kindergarten through eight, Table 21 shows that charter school students and lotteried-out students are retained in grade at almost identical rates of, respectively, 2.8 percent and 2.9 percent. Recall as well that lotteried-in and lotteried-out were equally unlikely to be retained in grade prior to applying to charter schools: the rate was only 1 percent (Tables 11 and 12). With such small shares of children being retained in either type of school, it is unlikely that the way we handle such students could affect our main results. Nevertheless, let us consider the handling.

When a student is retained in grade, he experiences an additional year of charter school treatment (or non-treatment) even though his grade remains the same as in the previous year. Our time-in-treatment and time-of-intention-to-treat variables increase by one year for students retained in grade, just as they do for students who are not retained. That is, our variables are measured in calendar years, not accumulated grades. Thus, given our estimation procedure, a school could not artificially improve its effects simply by retaining students (in the hope of making them appear to have been treated for a short periods than they were truly treated).

Having dismissed this possible source of trouble for estimation, one minor issue exists for retained students. Should their scale scores be converted into standard scores using the mean and standard deviation of scores for the grade in which they are being tested (for the second time)? Or, should their scale scores be converted into standard scores using the mean and standard of scores for the grade in which they would be tested had they not been retained? The latter conversion, which amounts to testing the student using the metric he would have faced if not retained, requires us to translate retained students' test scores into equivalent scores on tests for the higher grade. Such translation is known as vertical equivalence, and doing it for New York State tests is not easy because its test maker does not release vertical equivalence tables. Thus, for our main results, we convert retained students' scale scores into standard scores using the mean and standard deviation for the grade in which they are tested.

However, using all the test questions released by New York State, we produced our own vertical equivalence tables for the grade 3 through 8 test math and English tests. We used these tables, which are

admittedly cruder than what the test maker could probably produce, to convert the scores of the retained students. By doing this, we produce alternative estimates of the charter schools' effects. These are shown below. Because such a small share of students are retained in either charter or traditional public schools, it is not surprising that these alternative estimates are nearly identical to our main estimates.

Robustness checks for a variety of issues, including those mentioned above

Table 22 shows the robustness checks the issues mentioned above: (voluntary) returning to the traditional public schools, attrition, and retention-in-grade. The table also shows robustness checks for two issues mentioned earlier in the paper: "missing" lotteried-out students (students who would have been matched to the New York City database had they won the lottery; variation in win rates among charter schools.

The top row of the table shows our main results. The second row shows that these results are unaffected if we convert retained students scores using a vertical equivalence table and the relevant higher grade's mean and standard deviation. This is not surprising because very few students are retained and the conversion does not change the students' standard scores dramatically.

The third row shows that the results are affected very little if we assume that every "missing" lotteried-out student would have performed as well on tests as the top lotteried-out students whom we do observe. Since this is an extreme assumption meant to show the maximum effect that "missing" lotteried-out could possibly have, it is striking that the results are not meaningful different (let alone statistically significantly different).

The fourth row of Table 22 also shows a bound based on an extreme assumption: it holds charter schools accountable for the performance of each of their students who voluntarily returns to the traditional public schools. That is, to generate the estimates shown, we treat (voluntary) returnees as though they had remained in their charter school until its grades ended (thereby "returning" them only when they would have involuntarily had to return to the traditional public schools). The estimates for this bound are very similar to our main results. In fact, the point estimates are higher--something we could easily have predicted given that the voluntary returnees only differed in being slightly more likely to be white or Asian (slightly more likely to be advantaged).

The fifth row presents the estimates we obtain if we use inverse probability weighting (Wooldridge 2007) to correct for attrition. Such weighting makes virtually no difference to the results, something that we expected once we saw the lack of evidence of differential attrition.

Finally, the last three rows of Table 22 show estimates that do not address estimation issues but instead address *interpretation*. Recall that some commentators worry that lottery-based estimates of charter school effects disproportionately reflect the performance of schools with low win rates (high

number of applicants to places) and thus may be estimates that are local to more successful charter schools. Of course, such a concern would not invalidate the estimates but it is would make it hard to extrapolate them to charter schools in general. We would expect such a concern to be practical, as opposed to merely theoretical, if charter schools that raised student achievement more had lower win rates. Whether this occurs is not at all obvious: parents do not know which charter schools raise student achievement more (since they do not have access to the data we use in this study and they would be misled by published studies based on value-added or matching methods). Moreover, parents may decide not to apply to charter schools that are reputed to have low win rates, thus keeping win rates fairly even among charter schools.

In any case, we address the concern empirically. Figure 7 shows that New York City's charter school lotteries have win rates than are distributed with more concentration around the mean and median than is the normal distribution. The vast majority of lotteries have win rates between 0.35 and 0.65. The remaining lotteries, with more extreme win rates, tend to be lotteries for first-year charter schools and lotteries for non-entry grades.[33]

We find no systematic pattern in the results if we estimate them separately for lotteries with low win rates (less than 40 percent of applicants lotteried-in), medium win rates (40 to 60 percent of applicants lotteried-in), and high win rates (60 percent or more of applicants lotteried-in). To be precise, the estimates shown in the last three rows of Table 22 do not differ statistically significantly with the win rate. Moreover, the pattern of point estimates does not suggest that lotteries with lower win rates produce higher estimates: we obtain the highest estimates of charter schools' effects when we rely only on the lotteries with *high* win rates.

Summing up, Table 22 shows no evidence that our main results are vulnerable to issues such as attrition, retention-in-grade, non-matching, or returning to the traditional public schools. Our main results also are representative of New York City charter schools in general, not just charter schools with low win rates.

F. Charter schools' effects on science and social studies achievement

Table 23 shows the causal effects of charter schools on students' achievement in science and social studies in grades 3 through 8. The estimating equation and structure of the table is exactly parallel to that of Table 14, which shows math and English results.

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[33] It is not unusual for first year start-up schools to have high win rates, especially if they get their charter late in the school year and are unable to start their application process until after the regular application season is over. A small share of charter schools have actually opened their application process in the summer (June or July for school commencing in August) and they are naturally less likely to be oversubscribed in their initial year, as a result.

We find charter school effects on science and social studies that are apparently large in magnitude (based on the point estimates) but that are too imprecise to be statistically significant at conventional levels of 0.90 or above. Some of the estimates are, however, statistically significant at the 0.85 level, so they are at least suggestive of what we will find when we obtain more years of data. The imprecision of the science and social studies effects is due to the fact that students take tests in these subjects in only 2 grades (grades 4 and 8 in science, grades 5 and 9 in social studies). This is contrast to the 6 grades of testing in math and English. We have only about one quarter as many observations for science and social studies as we have for math and English.

By the fourth grade, which is the first time students are tested in science, the average charter school student's standard science score is 0.17 units ahead of his lotteried-out counterpart's (statistically significant at only the 0.85 level). In grades five through eight, the average charter school student gains 0.23 more units each year in science than his lotteried-out counterpart (statistically significant at only the 0.86 level). In the fifth grade, which is the first time students are tested in social studies, the average charter school student's social studies standard score is almost exactly the same as that of his lotteried-out counterpart. However, in grades six through eight, the average charter school student gains 0.17 more units each year in social studies than his lotteried-out counterpart (statistically significant at only the 0.85 level). Of course, the gains in science and social studies that have just been described are relative to whatever gains the students would have made if they had been lotteried-out and remained in the traditional public schools.

G. The performance of the lotteried-out students

All of the achievement effects discussed so far have been relative to the performance of the lotteried-out students. Before leaving this section, it is useful to examine their achievement briefly. Figures 8 and 9 show this analysis.

Historically, American students who are as disadvantaged as New York City's charter school applicants have fallen further and further behind the average student as they age. This pattern has somewhat changed recently as districts have enacted reforms, but this is the backdrop against which we must judge New York City's lotteried-out students.

New York State exams are scored so that a score of 650 means that a student has just reached his grade's proficiency threshold. That is, if a student scores 650 in every grade, he is making regular progress--just keeping at the proficiency threshold, in fact. This is a bit odd since it is natural to think to think that a student who earns the same score every year is not making any progress. In fact, he is making about a grade's worth of progress every year.

Figure 8 shows the math progress of students who entered lotteries for kindergarten through

grade three, were lotteried-out, and who subsequently attended the regular public schools for all of grades three through eight. Their scores are shown by the light green line. The minimum score to be proficient in each grade (650) is shown by the dark green line. The approximate level at which the average Scarsdale student scores is indicated by the red arrow.

The lotteried-out students score right at the proficiency threshold in grade three. They score higher than it in grade four, a bit below it in grade five, somewhat above it in grade six, and just a bit above it in grades seven and eight.

Figure 9 similarly charts the English Language Arts progress of students who entered lotteries for kindergarten through grade three, were lotteried-out, and who subsequently attended the regular public schools for all of grades three through eight. Again, their scores are shown by the light blue line, the minimum proficient score is the dark blue line, and the average Scarsdale student score is indicated by the red arrow.

The lotteried-out students score about 11 points below the proficiency threshold grade three. They score just at the threshold in grade four, and they score somewhat above the threshold in grades five and six. However, in grades seven and eight, they are scoring just on the threshold again.

In short, Figures 8 and 9 show that the lotteried-out students start out on or somewhat below proficiency threshold and make enough progress to end up a little above or on the proficiency threshold. They are not falling further behind other students, as we might expect. On the other hand, they are not closing the achievement gap by much: their achievement starts out quite far below that of the average Scarsdale student and the gap stays quite wide.

VIII. Lottery-based Analysis of High School Achievement and Graduation

In this section, we show the effects of New York City's charter schools that serve the high school grades of 9 through 12. In these grades, students are supposed to take at least 5 Regents Examinations (Mathematics A, Comprehensive English, Living Environment, Global History, and U.S. History) in order to earn a Regents Diploma.[34] Our analysis is parallel to that in the previous section. In particular, we use estimating equation (2) with a control for the relevant prior test score (grade 8 test score) whenever it is available. That is, we compare charter school students to lotteried-out students who scored similarly in the eighth grade.

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[34] The Regents Diploma is standard high school diploma of the state of New York. Various alternative diplomas exist. They are mainly for students with disabilities or other special circumstances.

A. Effects of charter high schools on Regents Examination scores

Table 24 shows the main results. Compared to lotteried-out students, charter school students have Mathematics A standard scores that rise by 0.19 units more per year spent in charter school. Similarly, compared to lotteried-out students, charter school students have Comprehensive English standard scores that rise by 0.18 units more per year spent in charter school. Charter schools raise students' Living Environment standard scores by 0.25 units per year spent in charter school. They raise students' Global History standard scores by 0.13 units per year spent in charter school. Finally, compared to lotteried-out students, charter school students have U.S. History standard scores that rise by 0.14 units more per year spent in charter school. All of these estimated effects are statistically significant with p-values of 0.02 or less.

Table 25 translates the effects into scale scores. That is, they are not new results but translations that are useful for those who want to know whether charter schools make students more likely to pass Regents Examinations. On each Regents Examination, a student must have 65 scale score points to pass and must have 85 scale score points to pass with distinction. The average applicant to a New York City charter high school has eighth grade test scores that suggest he will be close to the passing grade of 65 points if he continues in the traditional public schools. Thus, if charter schools raise students' scores by only a modest number of points, they can substantially raise the probability that students pass the exams.

Compared to lotteried-out students, charter school students have Mathematics A and Comprehensive English scores that rise by 3.0 points more per year spent in charter school. Thus, if a student took his Mathematics A and Comprehensive English exams at the end of eleventh grade, having entered a charter school in ninth grade, he could expect to score 9 points higher than he would have had he been lotteried-out. Also, charter schools raise students' Living Environment scores by 3.7 points per year, raise students' Global History scores by 2.3 points per year, and raise students' U.S. History scores by 2.5 points per year spent in charter school.

B. Effects of charter high schools on graduation

Having seen that charter schools improve students' performance on Regents Examinations, it is not surprising that they also increase the probability that students graduate with a Regents diploma of by age 20. This is shown in Table 26, which uses the same estimating equation the previous tables: equation (2) with a control for eighth grade test scores. Unfortunately, because we have only a limited number of observations on students who have reached the age of 20, the estimated effect is statistically significant with only 85 percent confidence. For what it is worth, however, the point estimate suggests that, compared to lotteried-out students, charter school students are 7 percent more likely to graduate with a Regents Diploma for every year they spend in charter school in grades 9 through 12. This means that a

student who was lotteried-in as a tenth grader and stayed in charter school through grade 12 would have a 21 percent higher probability of earning a Regents Diploma than a student who was lotteried-out as a tenth grader and stayed in traditional public schools thereafter. Of course, since the estimated effect is very imprecise, we do not place much reliance on this magnitude.

IX. Variation in Lottery-based Estimates of Effects Among Charter Schools and the Associations between these Effects and Schools' Policies

New York City's charter schools vary in their authorizers, school leaders, mission statements, policies, and curricula. New York City's charter schools also vary in their histories: some have been in operation for a considerable time (especially the schools that converted to charter status); some have been open only a few years. In short, there are many reasons to expect that New York City's charter schools' effects on achievement might differ.

On the other hand, there are also reasons to expect their effects on achievement to be somewhat similar. All of the charter schools are under pressure from parents (voting with their feet), trustees, authorizers, the state accountability system, and the federal accountability. They have the same degree of management autonomy and about the same access to resources (although some convert the access into tangible resources more fully). The charter schools also enroll fairly similar students (nearly all economically disadvantaged and black or Hispanic). The schools are close enough to learn from one another either informally (for instance, by hiring staff who have worked at other charter schools) or formally (by consciously adopting a policy that seems to be working well for another school).

A. The estimated effects of individual charter schools

We are able to estimate school-specific effects on the grade three through eight tests for all of the 43 charter schools covered by this report that have students enrolled in these grades. However, because the schools are of different ages and sizes, the precision of the individual schools' effects varies and three individual schools have estimated effects that are so noisy that it is not worthwhile comparing them to other schools' estimated effects except in a statistical setting where we can formally account for precision. (We do this below.) Visual inspection of all the other schools' estimated effects is useful. We view an individual charter school's estimated effect as too noisy to contribute to the visual inspection if is not only statistically insignificant but if also its standard error is such that an effect of 0.1 standard deviations would be statistically insignificant at the 85 percent level.[35]

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[35] We are *not* saying that the effect of attending a charter school is a reasonably precisely estimated zero for the remaining 36 percent of students. We are saying that our visual inspection of point estimates--a form of analysis that does not make it easy to consider precision--is helpful only with point estimates that are reasonably

Figure 10 shows the distribution of estimated effects of New York City's charter schools on math in grades three through eight. We created the figure by estimating an effect on math for each school separately. Then we plotted the distribution of the schools' effects, taking care that schools were represented according to the number of students they enroll. Thus, the distribution of effects is representative of the charter school students of New York City. We smoothed the distribution slightly so that readers could not pick out the effects of individual charter schools.

Just for comparison, we also show a normal distribution with a mean effect of zero and the standard deviation we estimate for schools that serve lotteried-out students. That is, the normal distribution roughly represents the experience of the lotteried-out students who (by construction) experience a zero average effect but whose schools' achievement effects nonetheless vary.

The distribution of estimated math effects of New York City's charter schools (the shaded area) is shifted to the right relative to the normal distribution. This indicates that the average effect of attending a charter school is positive--something we already know. In addition, we see that the vast majority oof charter school students attend a school that has a positive effect on math. To be precise, about 10 percent of charter school students attend a school that is estimated to have a positive effect on math that is greater than 0.2 standard deviations. About 59 percent of charter school students attend a school that is estimated to have a positive effect on math that is between 0.1 and 0.2 standard deviations. About 17 percent of charter school students attend a school that is estimated to have a positive effect on math between 0 and 0.1 standard deviations. Finally, the remaining 14 percent of students attend a school that is estimated to have an effect on math that is negative. (Percentages do not add up to 100 because of rounding.)

Figure 11 is constructed like the previous figure, except that it shows English. The distribution of estimated English effects of New York City's charter schools (the shaded area) shows that the vast majority of charter school students attend a school that is having a positive effect on English. Specifically, about 31 percent of charter school students attend a school that is estimated to have a positive effect on English that is greater than 0.2 standard deviations. About 45 percent of charter school students attend a school that is estimated to have a positive effect on English that is between 0.1 and 0.2 standard deviations. About 16 percent of charter school students attend a school that is estimated to have a positive effect on English between 0 and 0.1 standard deviations. Finally, the remaining 8 percent of students attend a school that is estimated to have an effect on English that is negative. (Percentages do not add up to 100 because of rounding.)

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precise. We include all charter schools in the statistical analysis below where we can explicitly account for precision. Of course, we also include all applicants' achievement in the estimates of the average charter school effects (0.09 standard deviations in math, 0.06 standard deviations in reading) described above.

Keep in mind that all of above statements about the percent of charter school students experiencing a certain effect are relative to the *average* experience of a lotteried-out student. Some charter school students would have experienced a positive effect and some would have experienced a negative effect anyway, if they had attended traditional public schools.

B. The associations between individual charter schools' effects and their characteristics

It is natural to ask whether charter schools' estimated effects are systemically associated with certain policies. We have limited ability to answer this question for a few reasons. First, we cannot determine how charter schools' characteristics *causally* change their effects on achievement. We can only describe associations between schools' characteristics and their achievement effects. The distinction between association and causation is important in practice. For instance, suppose that charismatic school leaders were a key cause of positive achievement effects, and suppose that charismatic leaders just happened to like long school years. We cannot measure charisma, but we can measure the length of the school year. Therefore, we might find an association between a long school year and positive achievement effects even if the charisma, and not the long school year, caused higher achievement. A school that lengthened its school year would be disappointed in the results, not realizing that what it had really needed to do was to hire a charismatic leader.

A second problem is that there is little variation in some charter school characteristics even though (a) the schools are not mandated to maintain the same policy and (b) the policy would be very unusual for traditional public school. For instance, nearly all New York City charter schools have school uniforms or strict dress codes. All the schools that serve middle and high school grades have student advisory systems. Almost no charter schools are unionized (and the few that are, in our data, are all conversion schools). We cannot investigate the association between individual schools' effects and any characteristic that hardly varies among the charter schools.

A third problem is multicollinearity. Charter schools tend to adopt loose packages of policies. For instance, schools that adopt a long school year very often also adopt a long school day. Appendix Table 1 shows the correlation matrix. If one policy in a package is measured well (in the sense that its variation accurately represents variation in the package) and other policies in the package are measured poorly, an association may load on the well-measured policy even it is not essential to the package.

Finally, for this report, we have estimated effects for only 43 charter schools. This limitation will be relieved in future reports, as recently started charter schools effects become estimable.

Despite the four limitations just mentioned, we use multiple regression to investigate whether certain school characteristics are associated with a school's having a more positive effect on achievement. To account for heteroskedasticity, we give weight to a school's estimated effect commensurate with the

precision of the estimate. We use both the estimated reading and math effects (86 observations), include subject fixed effects, and estimate robust standard errors clustered at the school level to account for the non-independence of each school's two estimated effects.

Table 27 shows the results of this regression analysis. Because the multicollinearity problem is substantial, the left-hand column of results shows the estimates of *univariate* regressions: the schools' individual effects regressed on school characteristics one at a time. The univariate results should, at a minimum, suggest which characteristics have any possibility of significant association with achievement. In the right hand column, we show estimates from a multivariate regression in which we included all the characteristics that were statistically significantly different from zero in a univariate regression. The multivariate regression suffers from multicollinearity but should nevertheless identify the characteristics are the most salient markers of schools with positive achievement effects. (The fact that they are the most salient does not imply that they are most important causally.)

The univariate estimates indicate that several characteristics are statistically significantly associated with a stronger positive effect on achievement: a long school year; a long school day; a greater number of minutes devoted to English during each school day; a direct instruction style of teaching; use of the Core Knowledge program; use of internal evaluations (tests) for diagnostic purposes; a greater number of internal evaluations per school year; a small rewards/small penalties disciplinary policy; teacher pay based on performance or duties, as opposed to a traditional pay scale based strictly on seniority and credentials; and a mission statement that emphasizes academic performance. The univariate results reveal only one school characteristic that has a negative association with a charter school's effect on achievement: having at least one seat reserved for a parent on the school's board. It seems unlikely that the negative association comes from the parent seat per se; it seems more likely that the parent seat is a marker for something more general about a school's management or governance.

Several coefficients from the univariate regressions are worth noting because many commentators anticipate that they will have strong associations with achievement and they do not. In particular, the number of years that a charter school has been operating does not have a statistically significant correlation. There is no statistically significant association between a school's operating agency type (CMO, EMO, CGO) and its achievement effects. Also, average class size does not have a statistically significant correlation.

The multivariate regression confirms some but not all of the associations revealed by the univariate regressions. In particular, we find a few characteristics that are statistically significantly associated with a stronger positive effect on achievement: associated with charter schools' having more positive effects on students' achievement: a long school year; a greater number of minutes devoted to

English during each school day; a small rewards/small penalties disciplinary policy; teacher pay based somewhat on performance or duties, as opposed to a traditional pay scale based strictly on seniority and credentials; and a mission statement that emphasizes academic performance, as opposed to other goals. Some school characteristics whose coefficients flip sign between the univariate and multivariate regressions are clearly plagued by multicollinearly, making their coefficients very difficult to interpret. In particular, the long school day has a negative coefficient in the multivariate regression, almost certainly because it is so often packaged with the long school year. Similarly, the number of minutes of math each day has a negative coefficient, almost certainly because it is so often correlated with the number of minutes of English each day.

Summing up, we must interpret with considerable caution all of the associations with achievement that we estimate. The estimates are suggestive but they also exhibit all four of the limitations that we described at the outset of this section. In particular, the associations we estimate are not causal, and we have little ability to identify the independent effect of a policy (as opposed to the effect of a package of policies). With all these caveats, it seems safe only to say that policy makers might wish to study, using rigorous methods, the effect of policy packages that arise disproportionately in charter schools that have strong positive achievement effects. For instance, by assigning it to a randomly selected subset of schools, a policy maker could rigorously test the package that consists of a long school year/long school day/large number of minutes on math and English. Policy makers might also wish to rigorously test policies that all or nearly all charter schools share, since such policies contribute to the average positive causal effect of charter schools on student achievement. Such policies would include charter school style governance (fee-based budgets, parents' voting with their feet, trustees, authorizers), autonomous management (hiring, teacher assignment, curricular choice), school uniforms or strict dress codes, routine diagnostic testing, and a lack of unionization.

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Figure 1
Map of NYC Charter Schools

Figure 2
Charter School Authorizers

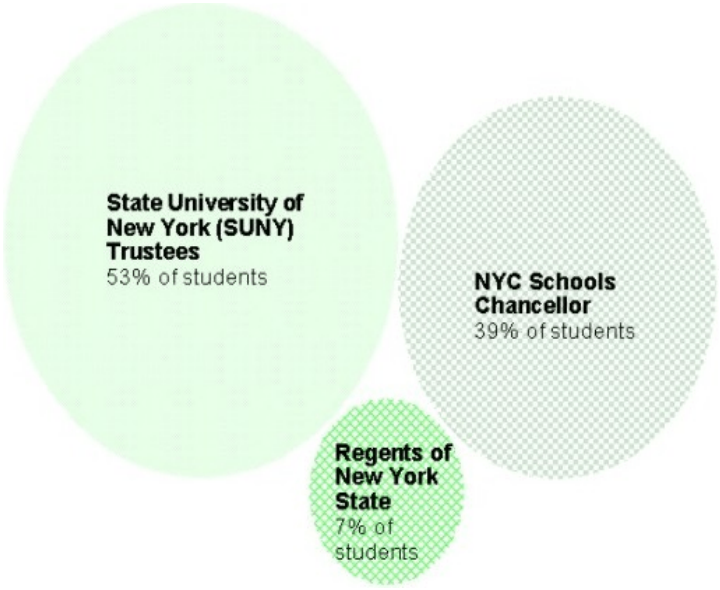


Figure 3
Charter School Operating Agencies

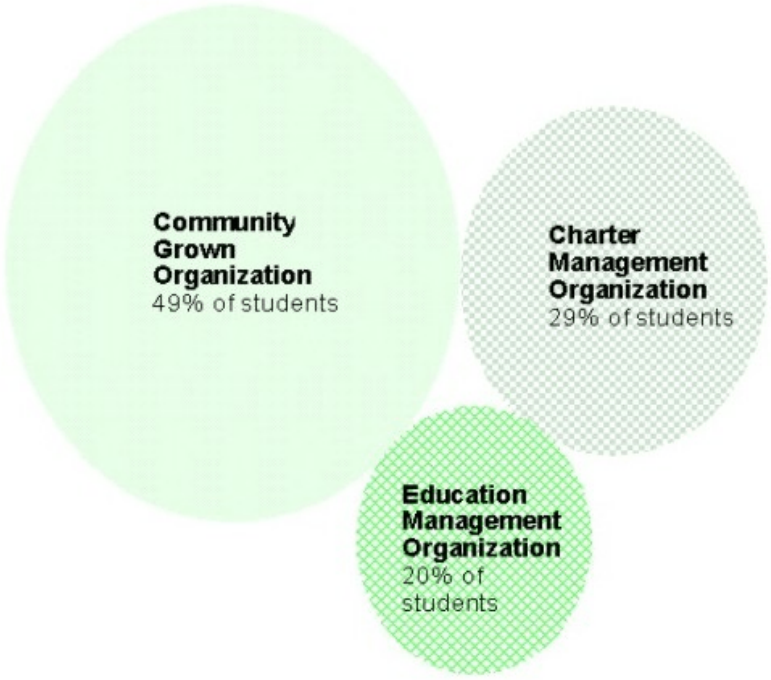


Figure 4
Charter School Missions

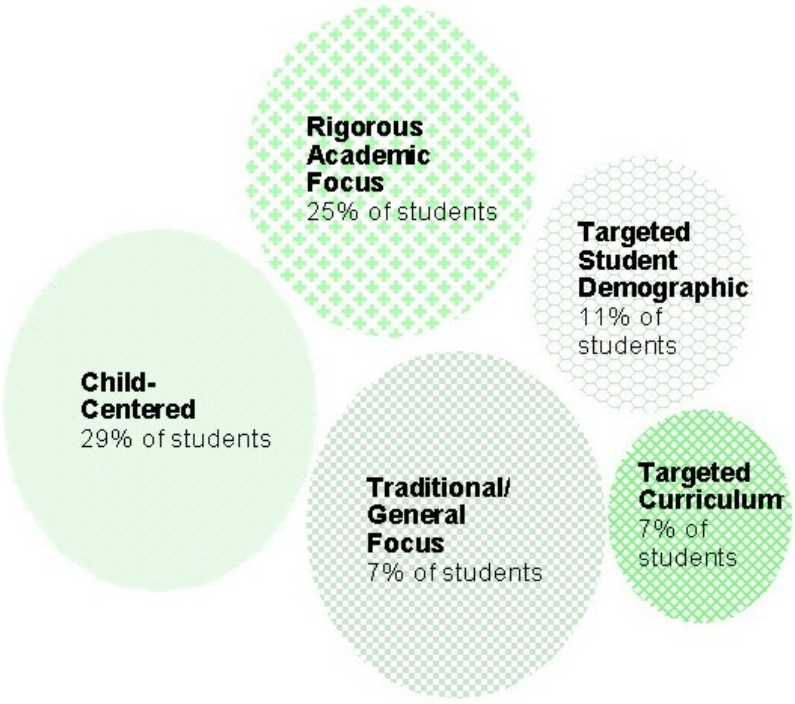


Figure 5

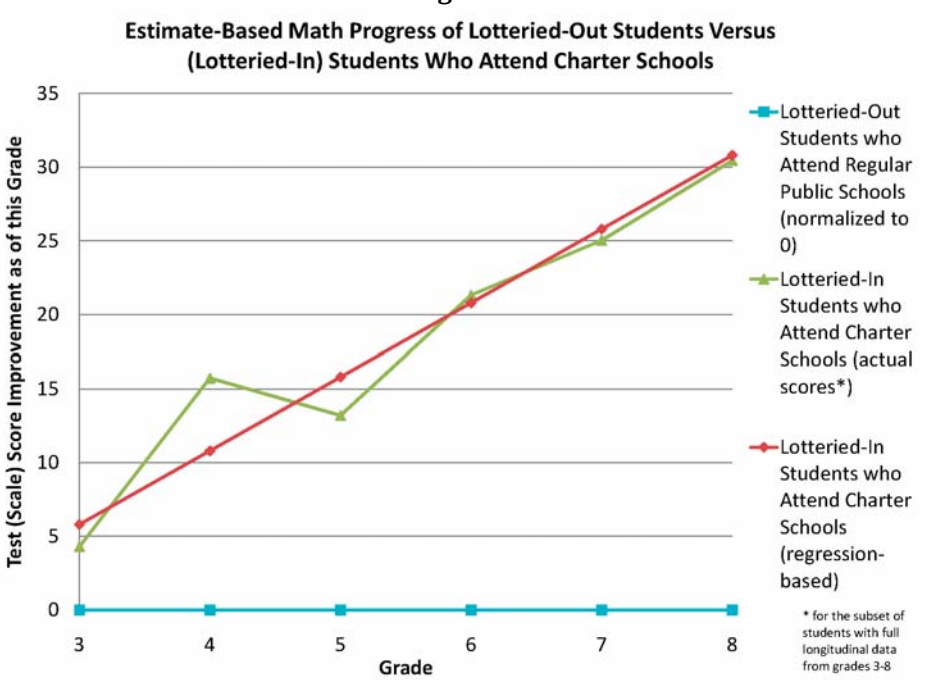


Figure 6

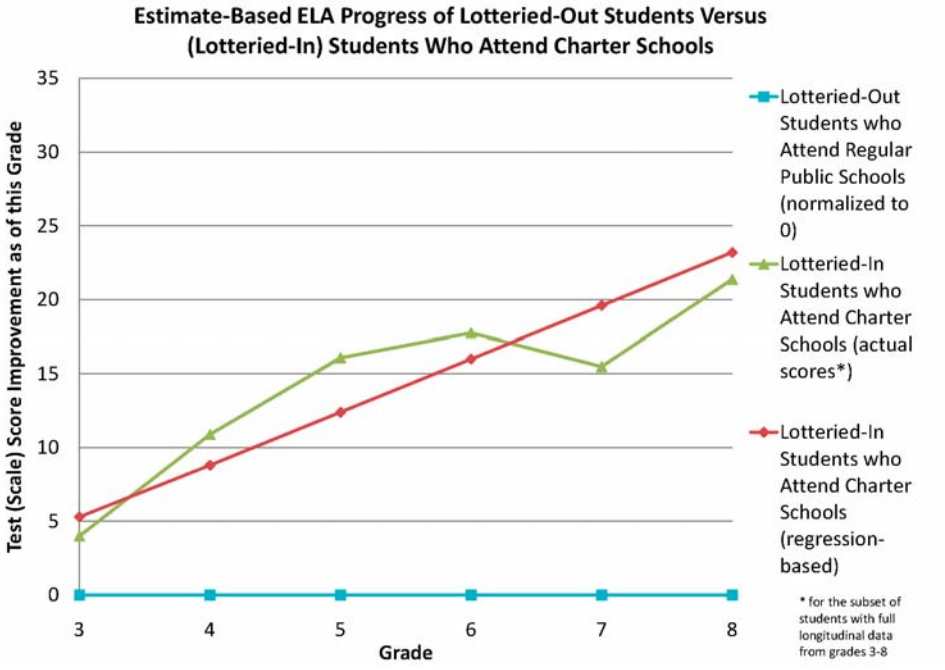
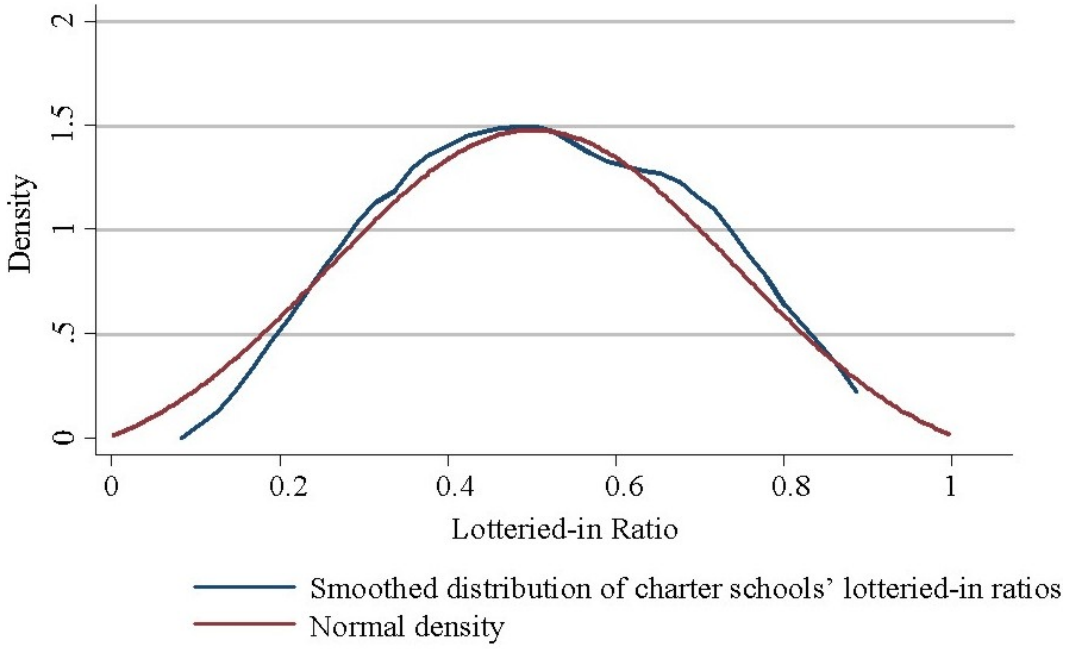


Figure 7
Distribution of Charter Schools' Lotteried-In Ratios
(lotteried-in ratio = lotteried-in applicants/total applicants)



kernel = epanechnikov, bandwidth = 0.1040

Figure 8

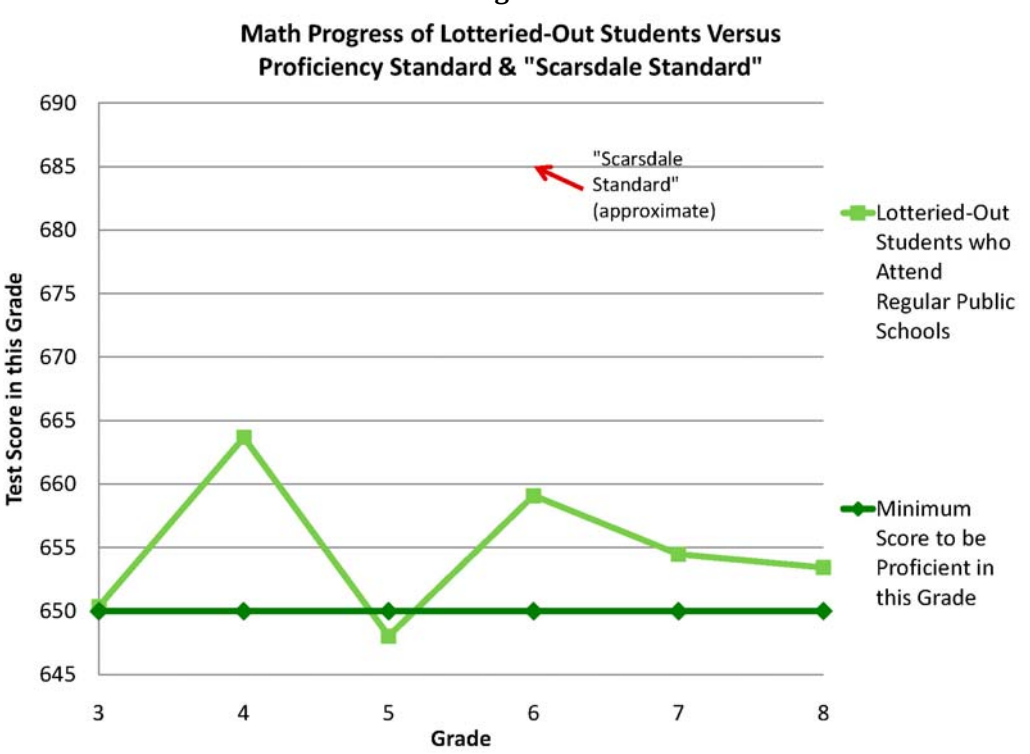


Figure 9

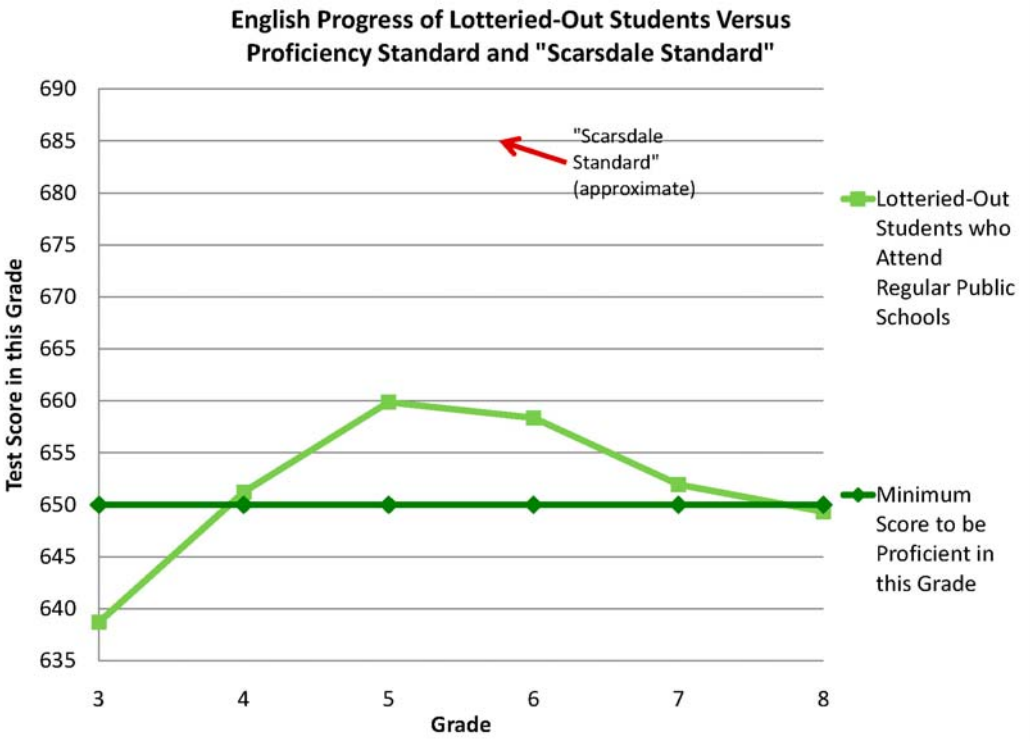


Figure 10

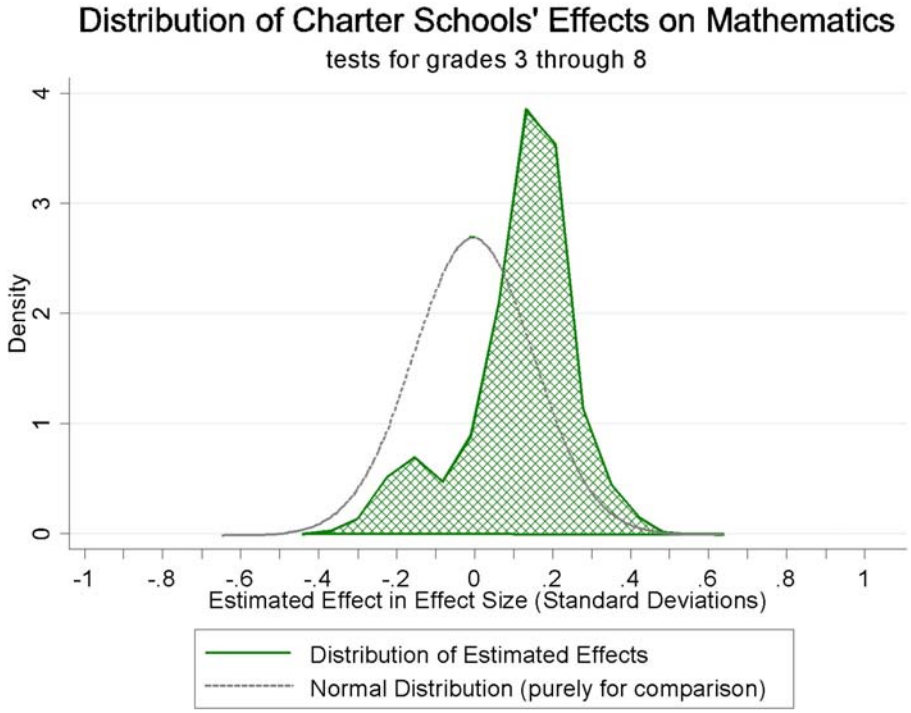


Figure 11

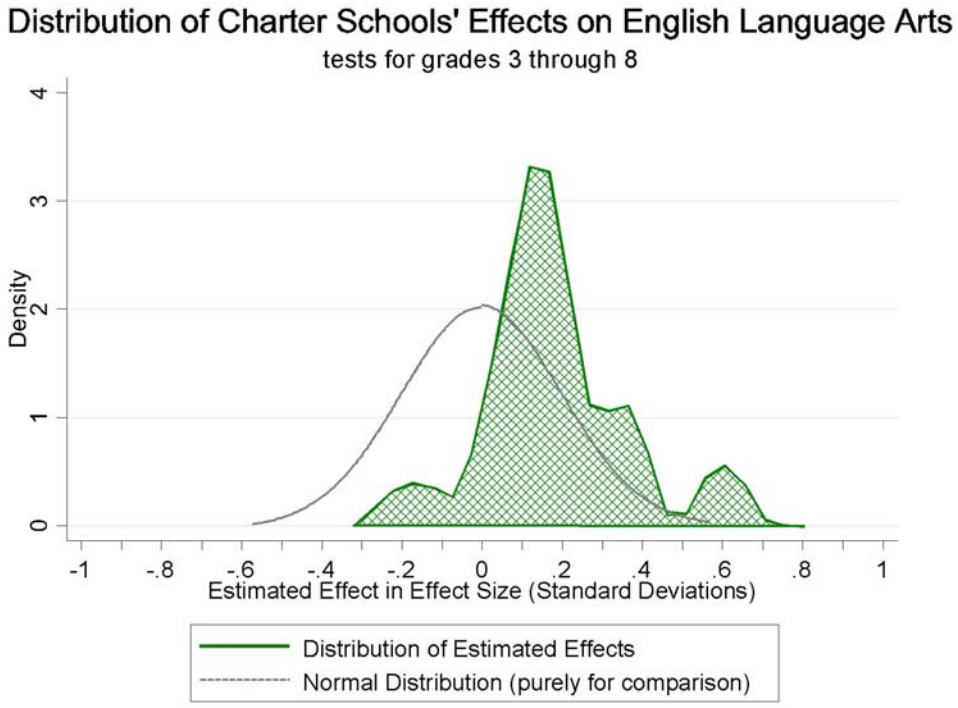


Table 1
Charter School Applicants

Total number of applicants (see note)	37,454
percent lotteried-in	54%
percent lotteried-out	46%
	Grade accounts for this percentage of all applicants
Kindergarten	31.6%
Grade 1	16.5%
Grade 2	9.7%
Grade 3	7.6%
Grade 4	5.4%
Grade 5	13.9%
Grade 6	6.9%
Grade 7	2.4%
Grade 8	1.0%
Grade 9	2.5%
Grade 10	1.8%
Grade 11	0.4%
Grade 12	0.2%

Note: Table includes the New York City charter schools and lotteries covered by this report. The lotteries covered are 1999-00 through 2005-06. Also, see text. The share of post-lottery observations (as opposed to students) in each grade is: kindergarten 8%, first grade 12%, second grade 14%, third grade 12%, fourth grade 10%, fifth grade 10%, sixth grade 9%, seventh grade 8%, eighth grade 5%, ninth grade 4%, tenth grade 3%, eleventh grade 2%, twelfth grade 2%.
Sources: Authors' calculations based on application data provided by the charter schools.

Table 2
Charter School Neighborhoods Compared to New York City as a Whole

Neighborhood Characteristic	*Neighborhoods of the charter schools covered by this report*	*New York City as a Whole*
% White (non-Hispanic)	14.3%	38.7%
% Black (non-Hispanic)	39.6%	22.4%
% Hispanic	37.7%	24.8%
% Asian	5.2%	11.0%
% Other races/ethnicities	3.3%	2.1%
Average household income	$37,639	$59,743
% households with income less than $20,000	43.7%	28.4%
% of adults who have no high school diploma or GED	41.0%	28.0%
% of adults with bachelor's degree or higher	15.2%	27.9%
% of families with children are single parent families	57.0%	39.2%

Source: Authors' calculations based on Geolytics 2008 estimates of U.S. Census of Population and Housing data. For the purposes of this table, a charter school's "neighborhood" is its Census tract (year 2000 definition).

Table 3
Policies and Characteristics of New York City Charter Schools

	average for NYC charter school students	*average for NYC charter schools*
Years that school has been operating by end of 2007-08 school year	6	6
Operated by a Charter Management Organization (CMO)	29%	30%
Operated by an Education Management Organization (EMO)	21%	16%
Operated by a Community Grown Organization (CGO)	49%	54%
Number of days in the school year	192	197
Number of hours in the school day	8	8
Saturday school (mandatory for all or certain students)	57%	58%
Optional after-school program available	80%	79%
Number of minutes of English language arts per day	112	115
Long mathematics period (90 minutes or more)	50%	47%
Saxon math curriculum	39%	35%
Scott Foresman math curriculum	8%	10%
Everyday Math curriculum	30%	28%
SRA reading curriculum	15%	14%
Scott Foresman reading curriculum	10%	10%
Open Court reading curriculum	25%	23%
Core Knowledge curriculum	17%	16%
School's/operating agency's own math & language arts curriculum	28%	32%
Direct instruction style of teaching	66%	65%
Class size	23	24
Internal evaluations regularly administered	92%	93%
Number of internal evaluations per year	2	2
Student-faculty advisory (middle and high schools)	82%	83%
School uniforms or strict dress code	89%	88%
Small rewards/small punishments disciplinary philosophy	22%	23%
Parent contract	52%	51%
Seat on the Board of Trustees reserved for a parent	58%	56%
Teacher pay based on performance/duties (not just seniority and credentials)	59%	56%
Number of school leaders	2	2

Notes: Table describes the schools covered by this report. Schools' characteristics are weighted by their 2007-08 enrollment, so the table represents the experience of New York City charter school students. More detailed descriptions of these policies may be found in the text.
Source: Authors' calculations based on descriptions provided by the charter schools. Preliminary descriptions were based on charter schools' published materials. These were confirmed, amplified, and corrected by charter school personnel through direct communication.

Table 4
Number and Grades of Charter Schools

school year	# of schools open and covered by this report	Number of schools offering grade...												
		K	1	2	3	4	5	6	7	8	9	10	11	12
1999-00	1	1	1	1	1	0	1	1	1	1	0	0	0	0
2000-01	10	6	7	4	3	2	4	4	2	2	2	2	2	2
2001-02	15	10	12	10	6	4	5	5	5	3	2	2	2	2
2002-03	17	12	13	14	12	7	7	5	5	6	2	2	2	2
2003-04	22	16	17	15	16	13	11	6	5	6	3	2	2	2
2004-05	31	23	24	20	15	16	17	12	7	6	4	3	2	2
2005-06	43	33	35	26	22	17	26	18	11	9	4	4	3	2
2006-07	43	32	34	34	25	21	27	23	16	12	5	4	4	3
2007-08	43	32	34	34	32	25	31	23	20	16	6	5	4	4

Notes: The table shows the grades offered by the New York City charter schools that are covered by this report (more are participating in this study and will be covered by future reports). Highlighted areas mark years in which students take New York State tests for which we have data.

Table 5
New York City Charter Schools, in order of when they opened

School Name	*Year Opened*	*Grades Offered as of 2008-09*	*Grades the School Plans to Offer*
Sisulu-Walker CS	1999	K-5	K-5
Amber CS	2000	K-6	K-6
Bronx Preparatory CS	2000	5-12	5-12
Brooklyn CS	2000	K-5	K-5
Community Partnership CS	2000	K-5	K-5
Harbor Sciences and Arts CS	2000	1-8	1-8
John V. Lindsay Wildcat Academy CS	2000	9-12	9-12
Kipp Academy CS	2000	5-8	5-9
Merrick Academy CS	2000	K-6	K-6
Renaissance CS, The	2000	K-12	K-12
Beginning with Children CS	2001	K-8	K-8
Carl C. Icahn CS	2001	K-8	K-8
Family Life Academy CS	2001	K-5	K-5
Harlem Day CS	2001	K-5	K-5
Harriet Tubman CS	2001	K-8	K-8
Explore CS	2002	K-8	K-8
Our World Neighborhood Charter	2002	K-8	K-8
Bronx CS for Better Learning	2003	K-5	K-5
Bronx CS for the Arts	2003	K-6	K-6
Brooklyn Excelsior CS	2003	K-8	K-8
Harlem Village Academy CS	2003	5-10	5-12
KIPP S.T.A.R. College Preparatory CS	2003	5-8	5-9
Bronx CS for Children	2004	K-5	K-5
Bronx CS for Excellence	2004	K-5	K-5
Bronx Lighthouse CS, The	2004	K-6	K-12
Excellence CS of Bedford Stuyvesant	2004	K-5	K-8
Grand Concourse CS of New York	2004	K-5	K-5
Opportunity CS, The	2004	6-11	6-11
Peninsula Preparatory Academy CS	2004	K-5	K-5
Williamsburg Charter High School	2004	9-12	9-12
Achievement First Crown Heights CS	2005	K-3, 5-7	K-9
Achievement First East New York CS	2005	K-3	K-7
Future Leaders Institute CS	2005	K-8	K-8
Girls Preparatory CS of New York (Lower E Side)	2005	K-4	K-5
Harlem Children's Zone/ Promise Academy CS	2005	K-5, 8-9	K-10
Harlem Children's Zone/ Promise Academy II	2005	K-4	K-5
Harlem Link CS	2005	K-4	K-5
Harlem Village Academy Leadership CS	2005	5-8	5-9

Table 5, continued

New York City Charter Schools, in order of when they opened

School Name	*Year Opened*	*Grades Offered as of 2008-09*	*Grades the School Plans to Offer*
Harlem Village Academy Leadership CS	2005	5-8	5-9
Hellenic Classical CS	2005	K-7	K-7
Kipp AMP (Always Mentally Prepared) CS	2005	5-8	5-9
Kipp Infinity CS	2005	5-8	5-9
Manhattan CS	2005	K-4	K-5
South Bronx CS for Int'l Culture & the Arts	2005	K-4	K-5
UFT CS	2005	K-4	K-12
Williamsburg Collegiate CS	2005	5-8	5-9
Achievement First Bushwick CS	2006	K-6	K-8
Achievement First Endeavor CS	2006	5-7	5-8
Community Roots CS	2006	K-3	K-5
Democracy Prep CS	2006	6-8	6-9
East New York Preparatory CS	2006	K-3	K-8
Harlem Success Academy 1 CS	2006	K-3	K-4
Hyde Leadership CS	2006	K-2, 6-8	K-12
International Leadership CS	2006	9-11	9-12
Leadership Prep CS	2006	K-3	K-4
New Heights Academy CS	2006	6-7, 9-11	5-12
Ross Global Academy CS	2006	K-3, 6-8	K-12
South Bronx Classical CS	2006	K-3	K-5
Carl C. Icahn Bronx North CS II	2007	K, 2-3	K-5
Kings Collegiate CS	2007	5-6	5-8
Achievement First Brownsville CS	2008	K-1	K-7
Bedford Stuyvesant Collegiate CS	2008	5	5-12
Bronx Academy of Promise CS	2008	K-2	K-8
Bronx Community CS	2008	K-1	K-8
Bronx Global Learning Institute for Girls CS	2008	K-1	K-5
Brooklyn Ascend CS	2008	K-2	K-12
Carl C. Icahn South Bronx CS III	2008	K, 1	K-5
DREAM CS	2008	K-1	K-8
Green Dot NY CS	2008	9	9-12
Harlem Success Academy 2 CS	2008	K-1	K-5
Harlem Success Academy 3 CS	2008	K-1	K-5
Harlem Success Academy 4 CS	2008	K-1	K-5
La Cima CS	2008	K-1	K-5
Mott Haven Academy CS	2008	K-1	K-8

Table 5, continued
New York City Charter Schools, in order of when they opened

School Name	*Year Opened*	*Grades Offered as of 2008-09*	*Grades the School Plans to Offer*
NYC Charter High School for Architecture, Engineering, & Construction Industries	2008	9	9-12
PAVE Academy CS	2008	K-1	K-5
St. HOPE Leadership Academy CS	2008	5-7	6-12
VOICE CS of New York	2008	K-1	K-8
Academic Leadership CS	2009		K-5
Believe Northside CS	2009		9-12
Believe Southside CS	2009		9-12
Brooklyn Prospect CS	2009		6-12
Brooklyn Scholars CS	2009		K-8
Brownsville Ascend CS	2009		K-6
Brownsville Collegiate CS	2009		5-9
Carl C. Icahn CS IV	2009		K-6
Coney Island Prep CS	2009		5-12
Crown Heights Collegiate CS	2009		5-8
Equality CS	2009		6-11
Equity Project CS, The	2009		5-8
Ethical Community CS	2009		K-12
Excellence CS for Girls	2009		K-8
Explore II CS	2009		K-8
Fahari Academy CS	2009		5-12
Girls Preparatory CS of East Harlem/Bronx	2009		K-4
Growing Up Green CS	2009		K-5
Hebrew Language Academy CS	2009		K-5
John W. Lavelle Preparatory CS	2009		6-12
Leadership Prep. East New York/Brownsville CS	2009		K-8
Summit Academy CS	2009		6-12
Achievement First North Crown Heights CS	2010		not yet known
East New York Collegiate CS	2010		not yet known
Leadership Preparatory Brownsville CS	2010		not yet known
Leadership Preparatory Flatbush CS	2010		not yet known

Sources: Authors' calculations based on information provided by the charter schools, the New York State Board of Regents, the New York City Basic Educational Data System, and the New York City Center for Charter School Excellence.

Table 6
Matching of Charter Schools Applicants to their Records in the New York City Department of Education (DOE) Database, By Year of Intended Entry into Charter School

	Students who applied in order to enter a charter school in...					
	2005-06	2004-05	2003-04	2002-03	2001-02	2000-01
Number of recorded applicants to charter schools in study	14,301	9,610	5,523	2,957	3,238	1,613
% Matched to DOE data	90.8%	88.4%	88.7%	82.8%	79.2%	88.0%
Number of recorded applicants to charter schools who participated in lotteries	13,400	9,044	5,278	2,776	2,613	936
% Matched to DOE data	91.1%	88.9%	88.1%	81.7%	74.2%	79.3%

Notes: A "recorded applicant" is a student whose application to a charter school was given to the study for matching into the New York City Basic Educational Data System. Not all students who applied to charter schools are recorded applicants because some charter schools did not keep records of their applicants from years prior to the commencement of the study.

Table 7
Comparison of Matched and Unmatched Charter Schools Applicants

	Students who were...	
	matched	unmatched
Lotteried-in	54.1%	48.6%*
Previous school was daycare or preschool	8.8%	9.1%
Previous school was homeschooling	0.3%	0.2%
Previous school was a private school	13.3%	14.4%
Previous school was an NYC public school	70.1%	68.7%
Previous school was a public school outside NYC	0.3%	1%
Age at the time of application	5.93	6.05
Female	49.0%	49.8%
White, non-Hispanic	4.2%	4.0%
Black, non-Hispanic	64.1%	65.0%*
Hispanic	27.6%	27.1%
Non-native English speaking family (among applications that collected this information)	17.2%	18.8%

Notes: An asterisk indicates that the statistic in question differs by a statistically significant amount at the 95% confidence level in a two-sided t-test.
Source: Authors' calculations based on New York City Basic Educational Data System and charter schools' lottery data.

Table 8
The Race, Ethnicity, and Gender of Charter School Applicants and Students in the Traditional Public Schools

	All applicants to charter schools	*Applicants who were lotteried-in*	*Applicants who enrolled in charter schools*	*New York City's traditional public schools*
% black non-Hispanic	63	64	61	34
% white non-Hispanic	4	4	4	15
% Hispanic	29	28	29	38
% Asian	3	3	4	12
% other race	<1	<1	<1	<1
% female	50	50	52	50

Note: The table includes data for all years of applicants covered by this report: 2000-01 to 2005-06. There are no statistically significant differences between the statistics reported for all applicants to charter schools and the statistics reported for applicants who were lotteried-in. Only % female is statistically significantly different at the 95% confidence level for the lotteried-in applicants and the applicants who enrolled in charter schools. All of the racial statistics are statistically significantly different at the 95% confidence level for New York City's traditional public schools and any of the groups shown in the other three columns: all applicants to charter schools, applicants who were lotteried-in, applicants who enrolled in charter schools.
Source: Authors' calculations based on the New York City Basic Educational Data System and application data.

Table 9
Prior Test Scores Availability by Charter School Applicants' Characteristics

	Applicants for whom prior test scores...	
	are available	are not available
average grade of intended entry (kindergarten=0)	5.65	1.89*
% female	50.72	48.70*
% black non-Hispanic	55.50	66.06*
% white non-Hispanic	3.47	4.25*
% Hispanic	36.98	24.25*
% Asian	3.13	2.59*
% other race or ethnicity	0.57	0.56

Notes: An asterisk indicates that the difference between this number and the parallel number for applicants whose prior test scores are available is statistically significant different from zero at the 95 percent level.
Source: Authors' calculations based on New York City Basic Educational Data System and charter schools' lottery data.

Table 10
Prior Test Scores of Charter School Applicants and Students in the Traditional Public Schools

	All applicants to charter schools	*Applicants who were lotteried-in*	*Applicants who enrolled in charter schools*	*New York City's traditional public schools*
Math standard score	-0.002	-0.014	-0.012	0
English language arts standard score	-0.007	-0.006	-0.007	0

Notes: None of the standard scores shown in three applicant-based columns of the table is statistically significantly different from any of the other standard scores shown in these columns. The data are for all years of applicants covered by this report: 2000-01 to 2005-06. Because about 80 percent of charter school applicants have not taken a prior test when they apply, the above table is not representative of New York City charter school applicants. See also previous table for evidence on the non-representativeness of the data on applicants. The data are accurate for the subset of applicants who do have a prior test score.
Source: Authors' calculations based on the New York City Basic Educational Data System and application data.

Table 11
Prior Program Participation and Grade Retention of Charter School Applicants and Students in the Traditional Public Schools

	All applicants to charter	*Applicants who were lotteried-in*	*Applicants who enrolled in charter*	*New York City's traditional public schools*
% who participated in the Free or Reduced-Price lunch program (at the time they applied if applicants)	92	91	91	72
% who participated in special education (at the time they applied if applicants)	11	11	11	13
% who used services for English Learners (at the time they applied if applicants)	4	4	4	14
% who had ever been retained in grade	1	1	1	n/a

Note: For the columns dealing with charter school applicants, the participation information is recorded at the time the applicant applied to a charter school. The data are reweighted so that the charter school applicants have the same grade composition as students in the traditional public schools. The table includes data for all years of applicants covered by this report: 2000-01 to 2005-06.
Source: Authors' calculations based on the New York City Basic Educational Data System and application data.

Table 12
Pre-Lottery Characteristics of the Compliers, Decliners, and the Lotteried-out, Relative to the Lotteried-in

	All Lotteries			Balanced Lotteries only		
	Compliers are this much above/ below average lotteried-in applicant	Decliners are this much above/ below average lotteried-in applicant	Lotteried-out are this much above/ below lotteried-In	Compliers are this much above/ below average *balanced* lotteried-in applicant	Decliners are this much above/ below average *balanced* lotteried-in applicant	*Balanced* lotteried-out are this much above/below *balanced* lotteried-In
% female	1.06[a]	-0.44[b]	-0.75	1.65[a]	-0.80[b]	-0.99
% black non-hispanic	0.00	-0.18	0.04	0.39	-0.17	-0.24
% white non-hispanic	-0.20	0.18	0.11	-0.24	0.17	0.13
% hispanic	-0.04	0.51	-0.10	-0.25	0.05	0.17
% asian	0.16	-0.44	-0.01	0.07	0.01	-0.06
% other	-0.06	0.11	0.02	-0.09	0.13	0.03
age at the time of application	-0.02	-0.05	0.04	-0.01	-0.03	0.02
% certificated for free or reduced-price lunch	0.01	-0.25	0.06	0.16	0.02	-0.11
% participate in special education	-0.58[a]	0.87[a,b]	0.31	-0.82[a]	0.96[a,b]	0.32
% classified as english language learners	-0.20	0.37[b]	0.09	-0.31	0.56[b]	0.06
% ever retained in grade	0.00	0.00	-0.51	0.00	0.00	-0.50
math standard score	0.0181	0.0189	-0.0214	0.0357	-0.0097	-0.0222
reading standard score	0.0115	0.0369	-0.0200	0.0296	0.0114	-0.0228

Notes: The table shows the pre-lottery characteristics of students who are lotteried, who are lotteried-in and enroll in a charter school (compliers), who are lotteried and do not enroll in a charter school (decliners), and who are lotteried-out. Lottery fixed effects are removed before the differences shown in the table are computed. The following number of observations are in the columns, left to right: 20501, 15497, 5004, 18945, 11037, 7812, 3225, 10384. Source: Authors' calculations based on the New York City Basic Educational Data System and application data.

[a] Difference is statistically significantly difference from zero at the 95 percent level.

[b] Difference between decliners and compliers is statistically significantly difference from zero at the 95 percent level.

Table 13
Number of Students Available for Assessing the Achievement Effects of New York City's Charter Schools

	Charter school applicants who took this test
Grade 3 math/English tests	14903
Grade 4 math/English tests	12917
Grade 5 math/English tests	13290
Grade 6 math/English tests	12192
Grade 7 math/English tests	10068
Grade 8 math/English tests	7190
Math A Regents exam	2250
Comprehensive English Regents exam	1521
Living Environment Regents exam	2590
Global History Regents exam	1950
U.S. History Regents exam	1557
	Percent of applicants ever tested who were...
observed for 1 to 3 years post-lottery	23%
observed 4-5 years post-lottery	52%
observed 6+ years post-lottery	25%

Notes: The table shows the number of students who took each test between 2000-01 and 2007-08 and who participated in admissions lotteries held by New York City charter schools. If a student took a test before applying to a charter school, that observation is not counted in the table.
Source: Authors' calculations based on New York City Basic Educational Data System and charter schools' lottery data.

Table 14
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Math and English Language Arts Scores in Grades 3 through 8
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools, shown in standard score units	
	effect on Math	effect on English
Extra gain up though Grade 3 (cumulative)	0.14 [pvalue= 0.04)	0.13 [pvalue= 0.07)
Extra gain *each year* in Grades 4 through 8	0.12 [pvalue<0.01)	0.09 [pvalue<0.01)
Average extra gain per year spent in charter school	0.09 [pvalue<0.01)	0.06 [pvalue<0.01)
treatment on the treated results	yes	yes
results based on balanced lotteries	yes	yes
school year fixed effects	yes	yes
complex lottery fixed effects (see text)	yes	yes

Notes: The table shows the effect of attending New York City's charter schools. The results are based on all balanced lotteries. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year, students' grade at the time they take the test, and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 15
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Math and English Test Scores for Grades 3 through 8
(shown in scale score points)

	Estimated Effect of Attending New York City's Charter Schools, shown in scale score points	
	effect on Math	effect on English
Extra gain up though Grade 3 (cumulative)	5.8 [pvalue<0.01)	5.3 [pvalue<0.01)
Extra gain *each year* in Grades 4 through 8	5.0 [pvalue<0.01)	3.6 [pvalue<0.01)
Average extra gain per year spent in charter school	3.6 [pvalue<0.01)	2.4 [pvalue<0.01)
treatment on the treated results	yes	yes
results based on balanced lotteries	yes	yes
grade of test fixed effects	yes	yes
school year fixed effects	yes	yes
complex lottery fixed effects (see text)	yes	yes

For notes, see the text that follows the previous table. The estimation is exactly the same as that shown in the previous table. The results are simply translated into scale score points.

Table 16
Robustness Tests--Part 1
for Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Math and English Language Arts Scores in Grades 3 through 8
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools Per Year Spent in Charter School, shown in standard score units	
	effect on Math	effect on English
average effect from preferred specification	0.09 [pvalue < 0.01]	0.06 [pvalue < 0.01]
pure time-elapsed specification	0.09 [pvalue < 0.01]	0.07 [pvalue < 0.01]
all lotteries including unbalanced ones	0.07 [pvalue < 0.01]	0.06 [pvalue < 0.01]
add all predetermined covariates	0.08 [pvalue < 0.01]	0.06 [pvalue < 0.01]
using only students with 6+ years of charter school by spring 2008	0.10 [pvalue < 0.01]	0.08 [pvalue < 0.01]
using only students with 4-5 years of charter school by spring 2008	0.10 [pvalue < 0.01]	0.07 [pvalue < 0.01]
using first 5 years of data on students with 6+ years of charter school by spring 2008	0.09 [pvalue < 0.01]	0.06 [pvalue < 0.01]
using only students with 1-3 years of charter school by spring 2008	0.09 [pvalue < 0.01]	0.06 [pvalue < 0.01]
using first 2 years of data on students with 4-5 years of charter school by spring 2008	0.08 [pvalue < 0.01]	0.06 [pvalue < 0.01]
using first 2 years of data on students with 6+ years of charter school by spring 2008	0.10 [pvalue < 0.01]	0.08 [pvalue < 0.01]

Notes: The table shows the effect of attending New York City's charter schools. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year, students' grade at the time they take the test, and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level. To estimate "treatment on the treated" estimates, an indicator for being lotteried-in is used as an instrument for attending the charter school.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 17
Tests for Heterogeneity of Effects by Race/Ethnicity, Gender, and Incoming Achivement
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Math and English Language Arts Scores in Grades 3 through 8
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools Per Year Spent in Charter School, shown in standard score units	
	effect on Math	effect on English
average effect for all students	0.09 [pvalue < 0.01]	0.06 [pvalue < 0.01]
black, non-Hispanic students only	0.09 [pvalue < 0.01]	0.07 [pvalue < 0.01]
Hispanic students only	0.09 [pvalue < 0.01]	0.07 [pvalue < 0.01]
female students only	0.10 [pvalue < 0.01]	0.06 [pvalue < 0.01]
male students only	0.08 [pvalue < 0.01]	0.07 [pvalue < 0.01]
incoming test score below the median	0.10 [pvalue < 0.01]	0.08 [pvalue < 0.01]
incoming test score above the median	0.11 [pvalue < 0.01]	0.08 [pvalue < 0.01]

Notes: The table shows the effect of attending New York City's charter schools. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year, students' grade at the time they take the test, and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level. To estimate "treatment on the treated" estimates, an indicator for being lotteried-in is used as an instrument for attending the charter school.
Tests: The estimated effects do not differ for black, non-Hispanic and Hispanic students at a confidence level of 90 percent or higher. There are insufficient Asian and white, non-Hispanic students to estimate separate effects for them. The estimated effects do not differ for female and male students at a confidence level of 90 percent of higher. The estimated effects do not differ for below-median and above-median incoming achievers at a confidence level of 90 percent of higher. Note that only 22 percent of charter school applicants *have* an incoming achievement score. This is why the estimates in the last two rows of the table differ from the estimates in the first row. That is, the estimates in the last two rows of the table are not representative of all applicants.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 18
Effect on the Probability that a Charter School Student Ever Returns to the Traditional Public Schools
(multivariate regressions)

Dependent variable: Indicator for student is a (voluntary) returnee to the traditional public schools		
Female	-0.004 [pvalue=0.22]	-0.004 [pvalue=0.20]
Hispanic	-0.002 [pvalue=0.71]	-0.002 [pvalue=0.69]
White, non-Hispanic	0.021 [pvalue=0.01]	0.021 [pvalue=0.01]
Asian	0.030 [pvalue=0.01]	0.030 [pvalue=0.01]
Other race	-0.002 [pvalue=0.60]	-0.002 [pvalue=0.60]
% who participated in the Free or Reduced-Price lunch program (at the time they applied)	0.002 [pvalue=0.70]	0.002 [pvalue=0.77]
% who used services for English Learners (at the time they applied)	-0.003 [pvalue=0.56]	-0.003 [pvalue=0.57]
Test score (math and reading combined) prior to return	0.002 [pvalue=0.61]	
Test score gain prior to return		0.002 [pvalue=0.56]
Complex lottery fixed effects (see text)	yes	yes

Notes: 7.9 percent of students who attend charter schools return at some point to the traditional public schools, where we are not counting as "returnees" those students who return only because their charter school does not serve the grade they will attend. The table shows estimates of the associations between charter school students' characteristics and their probability of returning to the traditional public schools. The results are from a linear probability multiple regression. The omitted category is black, non-Hispanic males. Complex lottery fixed effects are described in the text.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 19
Probability that Student has Left the Study, Overall and by Reason

	Lotteried-In	Lotteried-Out
Left the study for *any* reason	24.8%	24.9%
Left the study due to graduating from high school	3.0%	1.1%
Left the study due to:		
transferring to a school outside of NYC or to a private school	16.7%	22.0%
address unknown (could be a transfer or a withdrawal)	1.4%	0.9%
in a GED program or similar program	0.1%	0.1%
voluntarily withdrawn due to absence or pregnancy	1.7%	0.4%
all other reasons (deceased, in non-DOE institution, over age 21 etc.)	1.8%	0.4%

Sources: Student admit and discharge data from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 20
Effect on Probability that Student has Left the Study for Any Reason Other than Graduation
(multivariate regressions)

Dependent variable: Indicator for student having left the study (attrited) for any reason other than graduation		
Lotteried-in	-0.03 [pvalue<0.01]	-0.03 [pvalue=.15]
Most recent math test score	0.02 [pvalue=0.09]	0.02 [pvalue=0.10]
Most recent language arts test score	-0.02 [pvalue=0.02]	-0.02 [pvalue=0.03]
Female		-0.02 [pvalue=0.01]
Hispanic		0.03 [pvalue<0.01]
White, non-Hispanic		0.08 [pvalue<0.01]
Asian		0.01 [pvalue=0.63]
Other race		0.03 [pvalue<0.01]
% who participated in the Free or Reduced-Price lunch program (at time applied)		-0.04 [pvalue<0.01]
% who used services for English Learners (at time applied)		-0.02 [pvalue=0.12]
Lotteried-in *x* most recent test score in math	-0.003 [pvalue=0.80]	-0.01 [pvalue=0.65]
Lotteried-in *x* most recent test score in English language arts	0.02 [pvalue=0.13]	0.02 [pvalue=0.14]
Lotteried-in *x* female		0.01 [pvalue=0.40]
Lotteried-in *x* Hispanic		-0.01 [pvalue=0.24]
Lotteried-in *x* white, non-Hispanic		-0.03 [pvalue=0.21]
Lotteried-in *x* Asian		0.04 [pvalue=0.10]
Lotteried-in *x* other race		-0.01 [pvalue=0.35]
Lotteried-in *x* % who participated in the Free or Reduced-Price lunch program (at time applied)		0.01 [pvalue=0.62]
Lotteried-in *x* % who used services for English Learners (at time applied)		0.001 [pvalue=0.89]
Complex lottery fixed effects	yes	yes

Notes: Table shows estimates of the associations between students' characteristics and their probability of leaving the study for any reason other than graduating from high school. The results are from a linear probability multiple regression. The estimation includes a full set of complex lottery fixed effects.

Table 21
Grade Retention of Charter School and Lotteried-Out Students

	Charter School Students	Lotteried-Out
Percent retained in one of grades K through 8 *after* participating in a lottery	2.8%	2.9%
See tables 11 and 12 for pre-lottery retention rates		
Percent retained in one of grades 9 through 12 *after* participating in a lottery	4.4%	13.2%*

Notes: The asterisk indicates that the lotteried-out retention rate is statistically significantly higher than the charter school student retention rate in grades 9 through 12 at the 90% confidence level.
Sources: Student grade, enrollment, attendance, admit, and discharge data from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 22
Robustness Tests--Part 2
for Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Math and English Language Arts Scores in Grades 3 through 8
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools Per Year Spent in Charter School, shown in standard score units	
	effect on Math	effect on English
average effect from preferred specification	0.09 [p-value < 0.01]	0.06 [p-value < 0.01]
specification with alternative treatment of retained students (see text)	0.09 [p-value < 0.01]	0.06 [p-value < 0.01]
lower bound based on assumption that all "missing" lotteried-out, unmatched students would have been best performers (relative to their lotteried-in counterparts)	0.07 [p-value < 0.01]	0.05 [p-value < 0.01]
lower bound based on "keeping" students who voluntarily return to the traditional public schools in the charter school treatment, for the purpose of estimation	0.10 [p-value < 0.01]	0.07 [p-value < 0.01]
specification with inverse probability weighting to remedy attrition from the study	0.09 [p-value < 0.01]	0.07 [p-value < 0.01]
using only students from charter schools with ≤40% applicants lotteried-in	0.10 [p-value < 0.01]	0.07 [p-value < 0.01]
using only students from charter schools with >40% & ≤60% applicants lotteried-in	0.08 [p-value < 0.01]	0.05 [p-value < 0.01]
using only students from charter schools with >60% applicants lotteried-in	0.12 [p-value < 0.01]	0.09 [p-value < 0.01]

Notes: The table shows the effect of attending New York City's charter schools. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year, students' grade at the time they take the test, and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level. To estimate "treatment on the treated" estimates, an indicator for being lotteried-in is used as an instrument for attending the charter school.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 23
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Science and Social Studies in Grades 4 through 8
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools, shown in standard score units	
	effect on Science	effect on Social Studies
Extra gain up though Grade 4 (Science, cumulative) or Grade 5 (Social Studies, cumulative)	0.17 [pvalue = 0.15]	0.03 [pvalue=0.35]
Extra gain *each year* in Grades 5 through 8 (Science) or Grades 6 through 8 (Social Studies)	0.23 [pvalue = 0.14]	0.17 [pvalue = 0.15]

For notes, see the text that follows Table 14.

Table 24
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Regents Examination Scores
(shown in standard score units)

	Estimated Effect of Attending New York City's Charter Schools				
	effect on Math A	effect on Comprehen-sive English	effect on Living Environment	effect on Global History	effect on U.S. History
Extra gain *each year* from Grade 9 through the date on which the Regents exam was taken	0.19 [pvalue=0.02]	0.18 [pvalue<0.01]	0.25 [pvalue<0.01]	0.13 [pvalue=0.01]	0.14 [pvalue=0.02]

Notes: The table shows the effect of attending New York City's charter schools on the five Regents examinations that are required for a Regents Diploma in New York State. The results are based on all balanced lotteries. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year, and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level. Students are recommended to take the examinations in a certain grade, but need not do so. The exam/grade combinations are as follows: Comprehensive English, grade 11; Math A, grade 10; Living Environment (biology), grade 9; Global History, grade 10; U.S. History, grade 11. A student needs 65 scale score points to pass a Regents Examination and needs 85 points to pass it with distinction.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 25
Lottery-Based Estimates of the Effect of Attending New York City's Charter Schools on Regents Examinations Scores
(shown in scale score points)

	effect on Math A	effect on Comprehen-sive English	effect on Living Environment	effect on Global History	effect on U.S. History
Extra gain *each year* from Grade 9 through the date on which the Regents exam was taken	3.0 [pvalue=0.02]	3.0 [pvalue<0.01]	3.7 [pvalue<0.01]	2.3 [pvalue=0.01]	2.5 [pvalue=0.02]

For notes, see the text that follows the previous table. The estimation is exactly the same as that shown in the previous table. The results are simply translated into scale score points.

Table 26
Lottery-Based Estimate of the Effect of Attending New York City's Charter Schools on Graduating with a Regents Diploma by the Age of 20

	Estimated Effect of Attending New York City's Charter Schools on Probability of Graduating with a Regents Diploma by Age 20
Extra gain in probability for *each year* spent in charter schools from Grade 9 through Grade 12	7% [pvalue = 0.15]

Notes: The table shows the effect of attending New York City's charter schools on the probability that a student graduates with a Regents diploma (Regents, Regents Honors, Regents Advanced) by the end of the school year in which he is 20 on or before December 31 of the school year. The results are treatment on the treated results--that is, the estimation takes account of which lotteried-in students do and do not actually attend charter schools. The results also account for students who attend school only part of the year and differences associated with the school year of the test. The estimation includes a full set of complex lottery fixed effects and year fixed effects. The standard errors are robust and clustered at the student level. To estimate "treatment on the treated" estimates, an indicator for being lotteried-in is used as an instrument for attending the charter school.
Sources: Student test scores and characteristics are from the New York City Basic Educational Data System (BEDS). Student applicant and lottery lists are from the charter school.

Table 27
Associations between Charter Schools' Characteristics and their Estimated Effects on Achievement

Characteristic	*An increase of a unit in this characteristic is associated with what change in the school's achievement effect*	
	univariate regression	*multivariate regression*
Years that school has been operating	0.004 [0.60]	
Community Grown Org (CGO) operating agency	-0.11 [0.52]	
Charter Management Org (CMO) oper. agency	-0.07 [0.66]	
Number of days in school year/10	0.05 [0.01]	0.15 [0.01]
Number of hours in school day	0.04 [0.09]	-0.17 [0.01]
Saturday school	-0.05 [0.30]	
Optional after-school program	-0.02 [0.85]	
Saxon math curriculum	0.08 [0.16]	
Scott Foresman math curriculum	-0.09 [0.44]	
Everyday Math curriculum	-0.09 [0.46]	
SRA reading curriculum	0.04 [0.71]	
Scott Foresman reading curriculum	-0.13 [0.36]	
Open Court reading curriculum	0.07 [0.23]	
Direct instruction style of teaching	0.06 [0.09]	-0.16 [0.03]
Curriculum is core knowledge	0.11 [0.08]	-0.26 [0.02]
Number of minutes of math per day/10	0.02 [0.21]	-0.03 [0.16]
Number of minutes of English per day/10	0.01 [0.07]	0.02 [0.07]
Average class size	0.01 [0.36]	
Internal evaluations administered	0.15 [0.09]	-0.24 [0.07]
Number of internal evaluations per year	0.06 [0.06]	-0.03 [0.64]
Small rewards/small punishment discipline	0.13 [0.02]	0.31 [0.05]
Parent contract	0.02 [0.78]	
Reserved seat(s) for parent on board	-0.18 [<0.01]	-0.24 [0.02]
Pay based on performance/duties (not merely on seniority & credentials)	0.16 [<0.01]	0.16 [0.07]
Mission statemt emphasizes academic performance	0.17 [<0.01]	0.32 [<0.01]
Number of school leaders	0.02 [0.54]	

Notes: Table shows estimates of the associations between schools' characteristics and their effects in math and English achievement. P-values for tests that the coefficient is equal to zero are shown in square brackets. The estimates are based on univariate and multivariate regressions. A few policies such as student advisories and uniforms cannot be tested because nearly all charter schools use them.

Appendix

A. Descriptions of curricula

Saxon Math
Using Saxon Math Courses 1, 2, and 3 each day, students work toward mastery in three ways: by reviewing, maintaining and building upon previously learned skills; through direct, explicit instruction of new content, mathematical thinking and vocabulary; and by applying, reinforcing and demonstrating cumulative learning.
Source: http://www.harcourtachieve.com (accessed June 2007).

Scott Foresman-Wesley Addison Mathematics
Scott Foresman-Addison Wesley Mathematics (Diamond Edition) is a research-based Pre-K-6 curriculum that focuses on developing students' conceptual understanding and skills through step-by-step instruction. The focus is on key ideas in mathematics, rich problem-solving lessons that build the reading and writing skills necessary for powerful problem solving, and differentiated instructional options to meet the needs of varied learners.
Source: http://www.scottforesman.com (accessed June 2007).

Everyday Mathematics
Everyday Mathematics is a research-based curriculum developed by the University of Chicago School Mathematics Project. Development of Everyday Mathematics began with a research phase. Based on their findings, the authors established several basic principles that have guided the development of Everyday Mathematics: Students acquire knowledge and skills, and develop an understanding of mathematics from their own experience; children begin school with more mathematical knowledge and intuition than previously believed; teachers, and their ability to provide excellent instruction, are the key factors in the success of any program.
Source: http://everydaymath.uchicago.edu/about.shtml (accessed June 2007).

SRA Reading Mastery Plus
Reading Mastery Plus gives students the skills and the clear, explicit instruction and guidance they need to master the fundamentals of reading. Oral language, phonemic awareness, and systematic phonics are the starting point. Vocabulary development, fluency, and comprehension are fundamental throughout. The program is set up so students are active participants. Group responses make learning highly efficient and enable teachers to provide instant feedback that confirms or corrects their responses. Less-structured activities and opportunities for independent work help students develop self-reliance. On-going assessment tools are used by the instructor to ensure that no student "falls though the cracks."
Source: www.sraonline.com (accessed June 2007).

Scott Foresman Reading Street
Scott Foresman Reading Street 2008 is an all-new reading program for Grades PreK-6. Reading Street is designed to help teachers build readers through motivating and engaging literature, scientifically research-based instruction, and a wealth of reliable teaching tools. The program takes the guesswork out of differentiating instruction with a strong emphasis on ongoing progress-monitoring and an explicit plan to help with managing small groups of students. In addition, Reading Street prioritizes skill instruction at each grade level, so teachers can be assured they will focus on the right skill, at the right time, and for every student.
Source: http://www.scottforesman.com (accessed June 2007).

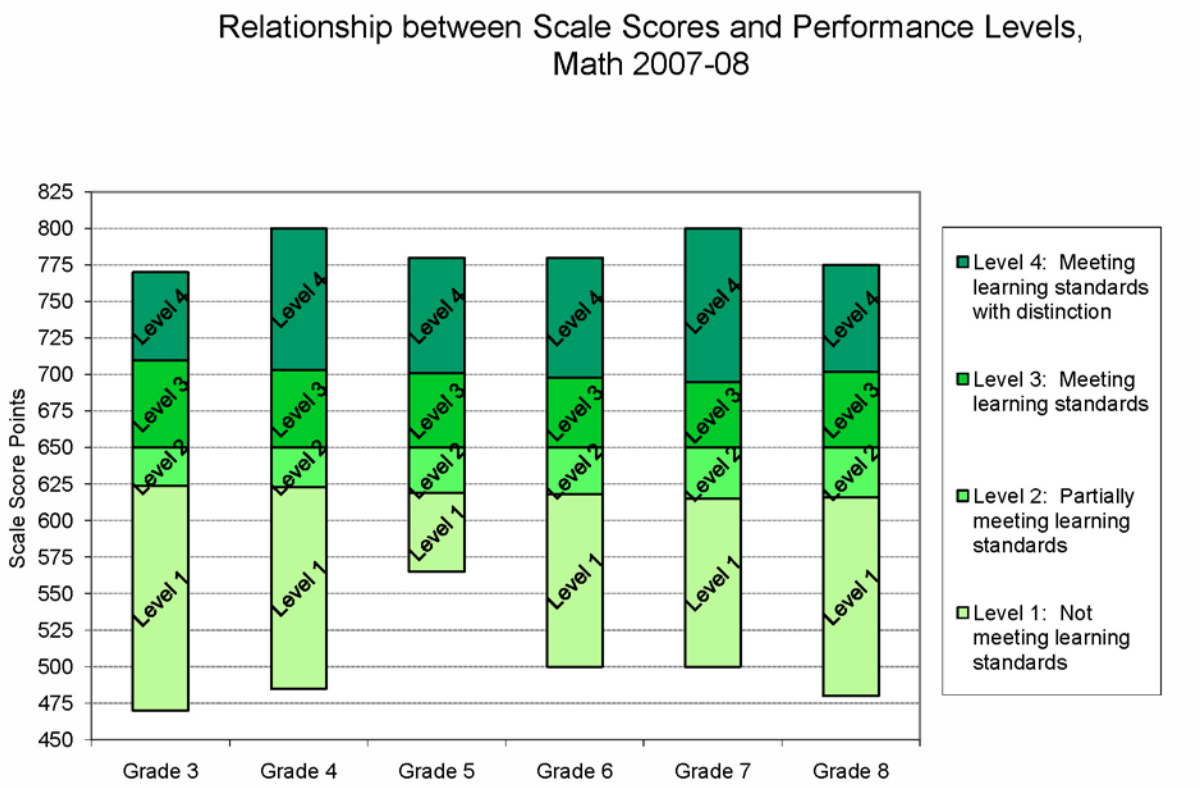
Open Court Reading

Open Court Reading is a complete elementary basal reading program for Grades K-6. It maintains strong instruction in the areas of decoding (learning how to read), comprehension (understanding what you read), inquiry and investigation (learning how to apply what you have read), and writing (how to communicate with others in print). Open Court Reading is designed such that no assumptions are made about students' prior knowledge. Each skill is systematically and explicitly taught in a logical progression to develop understanding and mastery.
Source: www.sraonline.com (accessed June 2007).

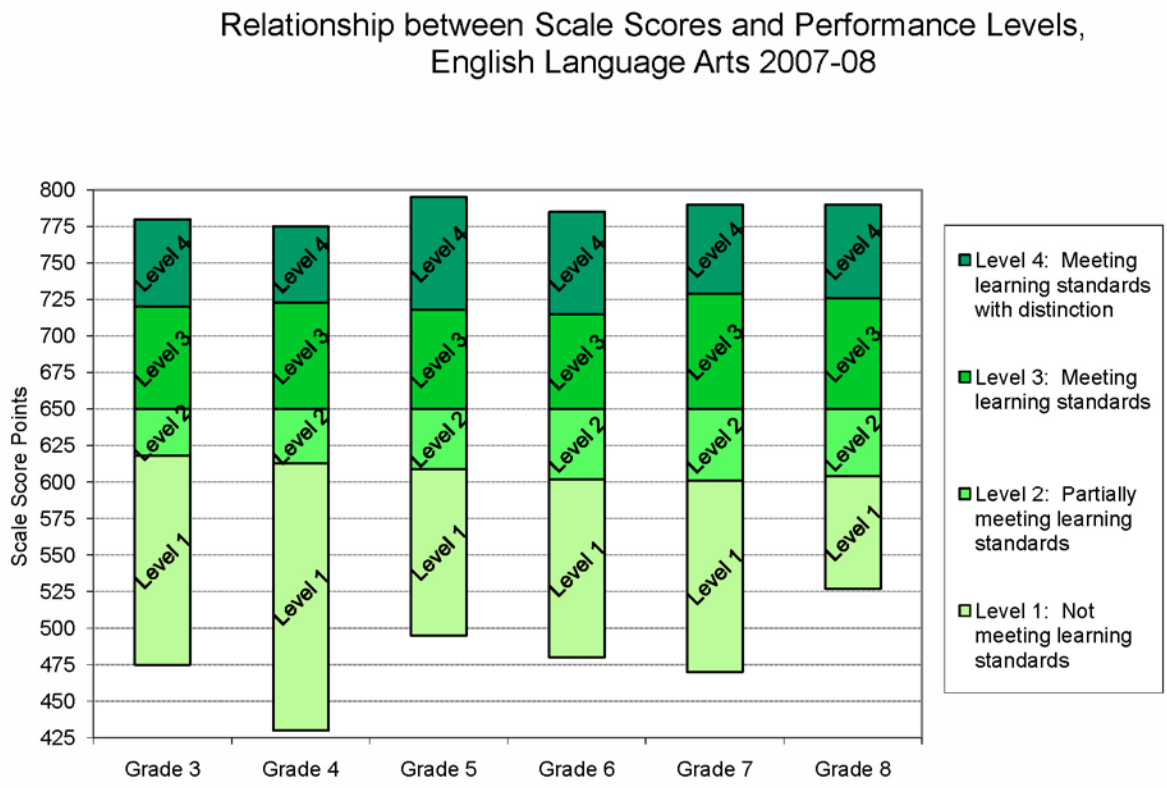
Core Knowledge Reading

Core Knowledge does not at present require any particular reading program. Schools are free to select from programs on the market. However, we recommend that schools choose a program that has strong phonics instruction, and we recommend that schools build oral language through frequent reading aloud on topics in the Core Knowledge Sequence. An ideal reading program will include good phonics instruction (followed by fluency work) combined with frequent reading aloud to expose children to new words and key subjects like the subjects listed in the Core Knowledge Sequence. Moreover, the reading aloud will include not only fictional stories but also generous amounts of nonfiction.
Source: www.coreknowledge.org (accessed June 2007).

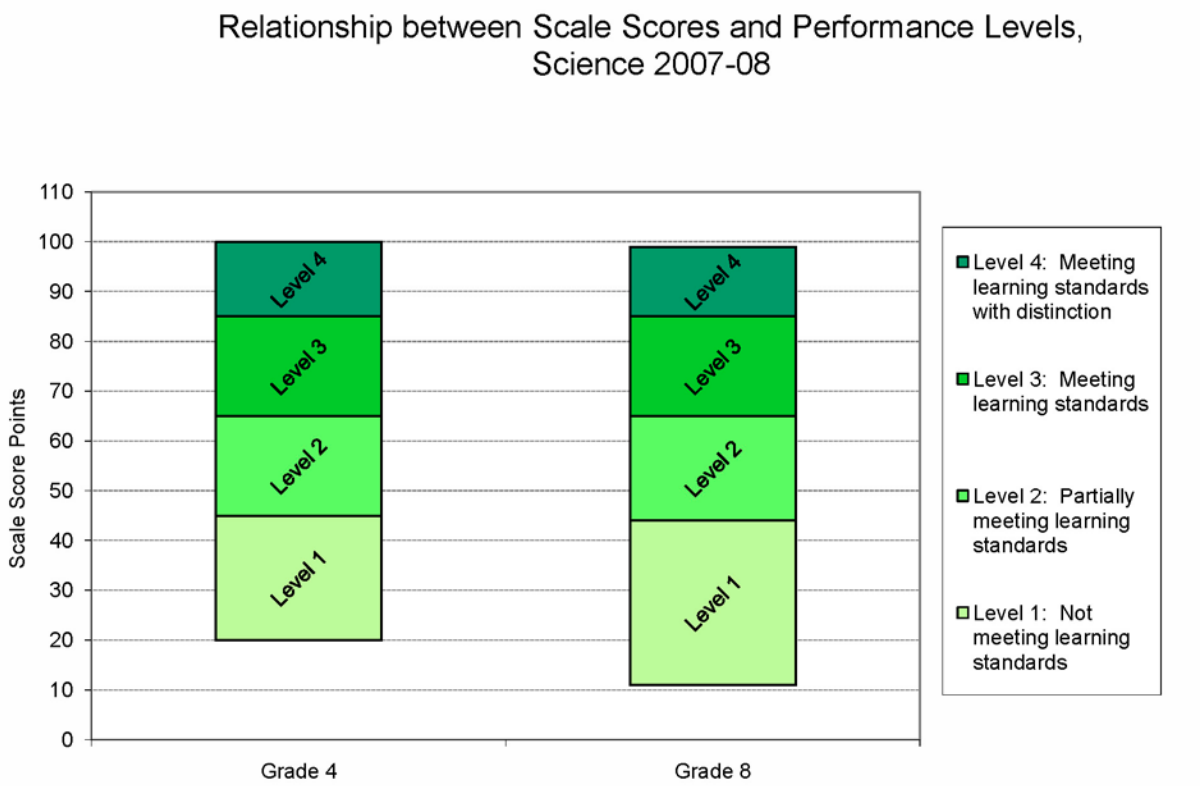
Appendix Figure 1



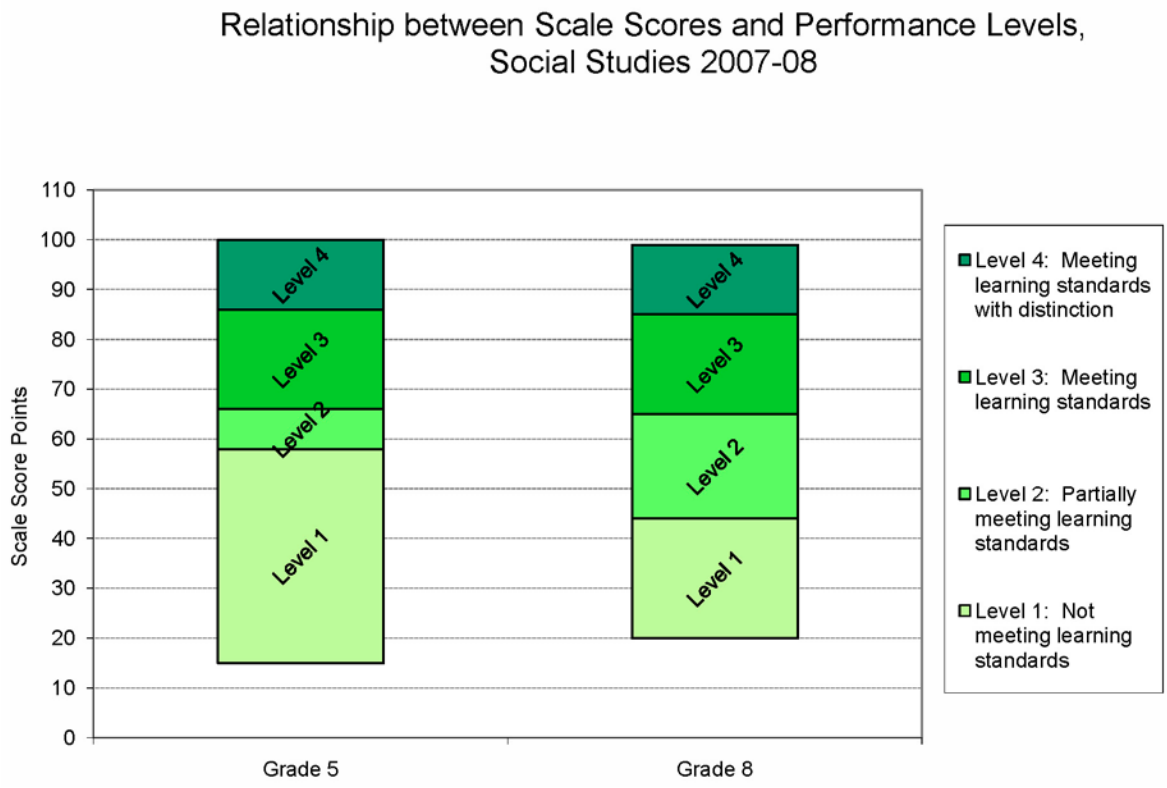
Appendix Figure 2



Appendix Figure 3



Appendix Figure 4



Appendix Table 1: **Correlations among Charter School Policies and Practices**

	# hrs schl day	# days schl yr	Saturday schl	opt after schl	Saxon math	ScottForeman math	Everyday math	SRA reading	ScottForeman	OpenCourt reading	Core Know.	own math/read curr	avg class size	internal evaluations	school uniforms	dress code	no broken windows	parent contract	parent on board	# schl leaders
number of hours in school day	1																			
number of days in school year	0.57	1																		
Saturday school	0.22	0.36	1																	
optional after-school	-0.4	-0.3	0.1	1																
Saxon math	0.13	0.14	0	0.1	1															
Scott Foresman math	0	-0.2	-0.3	0.16	-0.2	1														
Everyday math	0	0	0.23	0	-0.2	0.15	1													
SRA reading	0.14	0	0.18	0.27	0.16	0	-0.2	1												
Scott Foresman reading	0	0	0.1	0	-0.2	0.23	0.61	-0.2	1											
Open Court reading	0.31	0	0	0	0.36	0.14	0	0	-0.2	1										
Core Knowledge reading	0.29	0	-0.1	0	0.49	0.28	0	0.16	0.1	0.48	1									
own math/reading curriculum	0.65	0.55	0.25	-0.4	0	-0.2	-0.3	0.1	-0.3	0.13	0	1								
average class size	0.36	0.15	0.34	-0.2	0.24	0.1	0.1	-0.2	0.1	0.48	0.2	0.31	1							
internal evaluations	-0.2	0.1	0	0.1	0	0.1	-0.2	0.1	0.1	0.13	0.18	-0.1	0.11	1						
school uniforms	0.35	0.11	0	0.1	0.15	0.1	-0.2	0.14	0.15	0	0.3	0	0.17	0.26	1					
dress code	0	0.12	0	0.15	0	0	0	0	0.42	-0.2	0	-0.2	0.1	0.25	0.66	1				
No Broken Windows	0.57	0.37	0.47	-0.1	0.3	-0.1	-0.3	0.52	-0.2	0.25	0.3	0.57	0.33	0.12	0.2	0	1			
parent contract	0.3	0.2	0.22	0	0.38	-0.2	0	0	-0.2	0.21	0.18	0.1	0.13	0	0.23	0.1	0.28	1		
parent on board	-0.4	-0.3	0	0.12	-0.1	0.22	0.4	-0.4	0.4	-0.2	-0.2	-0.4	0	0	-0.2	-0.2	-0.5	-0.2	1	
number of school leaders	0	0.16	0	-0.1	0	-0.2	0	0.1	-0.1	-0.2	-0.2	0	-0.5	-0.1	0.1	0.1	0	0.2	0	1

Notes: The correlations shown provide answers to questions of the form, "If a school has policy of Saturday school, how likely is it all to have a policy of optional after-school programing. Note that some variables are continuous (numbers of hours in the school day and so on). Source: charter school descriptions.