

**The Effects of Catholic Schools on Mathematics Achievement
in Twelfth Grade: School District Variations***

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Abstract

Using the propensity score matching method and regression models with data from the Education Longitudinal Study of 2002, this study found a significant Catholic school effect on the mathematics achievement of 12th graders who were least likely to attend a Catholic school. These students tended to come from low socioeconomic backgrounds. A significant Catholic school effect was also found for students studying in districts that allowed private education through public funding, regardless of their likelihood to attend a Catholic school. Among students least likely to attend Catholic school, only those who were eligible for public aid for private schooling received academic benefits from Catholic schooling. The results from school districts have implications for policies concerning Catholic schools.

Keywords: School choice, Catholic school, mathematics achievement, school district, secondary education, propensity score matching

Since the 1970s, the number of Catholic schools and the proportion of Catholic school students has declined. Nearly seven percent of Catholic schools have closed in the last few years (Meyer, 2007). In the 2007-2008 school year, Catholic school enrollment was 2.27 million, which is less than half of the enrollment in 1960 (McDonald & Schultz, 2008). However, the proportion of ethnic minority students in Catholic schools has increased, from 11% in 1970, to 19% in 1980, and 29% in 2009. Today, the minority composition in Catholic schools is about 13% Hispanic, 7% Blacks, and 5% Asians (McDonald & Schultz, 2011). This demographic shift may be a result of the expansion of the school choice program in many states (Goodman, 2009). School choice in the form of voucher or scholarship tax credit programs for private education rose by about 90% over the last five years (Goodman, 2009). Many minority students who previously lacked the means to attend Catholic schools are now able to afford them. Such demographic changes may have important implications upon the effects of Catholic schools. The objective of this study is to reassess the Catholic school effect on secondary school student achievement using newer, nationally-representative data.

Research into the Catholic school effect on student academic outcomes in secondary schooling has found mixed results. A number of earlier studies show positive effects of Catholic schools on academic achievement, especially for low-income or minority students (e.g. Bryk et al. 1993); Coleman et al., 1982; Hoffer et al., 1985). However, critics of these studies argue that the earlier studies failed to correct for selection bias (Murnane, Willett, & Olsen, 1985; Witte, 1992). Recently, drawing on the merit of counterfactual inference for survey data, Morgan (2001) used a matching method to estimate the effect of Catholic schooling on student achievement. His 1990 data showed that 10th grade students who were not usually enrolled in Catholic schools, and who were also more likely to be low-income minority students, benefitted from Catholic

school attendance. It is unclear, however, if such results of the effects of Catholic high schooling continue to exist in more recent years.

One of the most controversial issues in education is the use of public monies to support private schooling through vouchers, scholarships, or tax credit programs. However, few studies have directly evaluated the relationship between these school choice programs and the Catholic school effects on nationally-representative data. Public funds are extra resources for Catholic schools, which may help improve student achievement. However, school choice programs target students of low socioeconomic status (SES), and low SES predicts poor academic achievement. Thus, it is unclear if public aid for private schooling would strengthen or attenuate the Catholic school effect.

This study investigated how the Catholic school effects are associated with school districts that allow public funds for private schooling. Considering that school districts are important administrative units that govern the distribution of educational resources and decision making, surprisingly no prior study examines school district variations in the Catholic school effects, nor do we know the patterns of students' movements across district boundaries to attend schools of their choices. The recent debate surrounding the proposal of converting four Catholic schools into charter schools in Brooklyn and Queens in New York is a case in point (Hernandez, 2009). This study aims to estimate Catholic school effects within school districts and compare these effects across districts with different policy environments. Including the school district as an analytic unit is useful for informing educational policies.

Explanations for the Catholic School Effect

The early literature on Catholic schools showed that the achievement gap by family SES was smaller in Catholic schools than it was in public schools (Coleman, Hoffer & Kilgore, 1982;

Greeley, 1982; Hoffer, Greeley & Coleman, 1985). The early explanations of the more equitable Catholic school effect on achievement focused on the social relationships among parental networks within the Catholic school community (Coleman & Hoffer, 1987). The overlapping spheres between the Catholic school and the church create “social capital” among adults – the human relationships that facilitate the achievement of desirable goals (Coleman, 1988). Parents tend to know their children’s friends and their friends’ parents, as well as their children’s teachers and school administrators. The social closure is especially tight in Catholic schools where there are often distinctive common themes and enforced norms within the schools that are not typically found in public comprehensive schools (Hill, Foster & Gendler, 1990). Through sharing norms/themes along with a strong academic focus, social capital reinforced by social closure bolsters students’ efforts and improves students’ academic performance (Coleman & Hoffer, 1987).

From the fieldwork of seven Catholic secondary schools and national data, Bryk and colleagues (1993) suggest another form of social capital that they term “voluntary community.” Unlike public schools, the external influence in Catholic schools is relatively low. The autonomy enjoyed in Catholic schools may motivate teachers to become more efficient knowledge providers. Teachers are thus more committed to raising students’ academic achievement. In addition, members of the Catholic school faculty are more willing to help students and work with parents, albeit reciprocity is also expected. This form of social capital based on mutual trust facilitates students’ academic learning.

Another major explanation for the Catholic school effect on students’ achievement is the restricted academic organization in Catholic schools, which governs students’ course-taking patterns (Bryk et al., 1993). Catholic schools determine what academic courses students have to

take, while students of public schools have a wider choice of courses and schedules. The curricula of Catholic secondary schools is relatively homogeneous and the core course is basically college preparatory. In practice, the average level of mathematics courses taken by all students is higher in Catholic than in public schools, partially explaining the Catholic school effect on achievements (Gamoran, 1996; Morgan & Sørensen, 1999).

By contrast, in public schools, less advantaged students are more likely to enroll in nonacademic courses (Lucas, 1999). Without family support, disadvantaged students are likely to benefit most from attending schools in which there is a strong academic commonality for everyone. The highly differentiated academic structure in comprehensive public high schools tends to amplify initial social differences among students and thus leads to a less equitable distribution of achievement (Lee & Bryk, 1989).

Mixed Results in Previous Literature

The early research that found significant positive Catholic school effects (Coleman & Hoffer, 1987) was criticized for failing to control for selection bias (Goldberger & Cain, 1982; Murnane et al., 1985). Whether Catholic-school advantage is attributable to the schools themselves or to the type of students attending Catholic schools has long been the key issue in the study of the Catholic school effect (Willms, 1985). Researchers have adopted several methods to address this problem of selection bias.

Sander and Krautmann (1995) applied the Heckman (1979) two-stage procedure on the 1980 High School and Beyond data. They found that the dropout rate for high school sophomores is lower than it is for sophomore students attending Catholic schools. However, Catholic school students do not get more years of education than their public school counterparts. Adam Gamoran (1996) also used the Heckman procedure to analyze the 1988 National

Educational Longitudinal Study (NELS), but he did not find the Catholic school effect on math test scores. These results on educational attainment and achievement suggest that the previously found benefits of Catholic schools come mainly from parental selection: parents of Catholic school students are more likely to devote time and other resources to their children's education. These children who are sent to Catholic schools are therefore more motivated to perform well in school.

Another method researchers use to correct for selection bias is the instrumental variable (IV) approach. This method requires the identification of an exogenous variable that affects the selection into Catholic schools but is not correlated with student outcomes. Evans and Schwab (1995) used Catholic affiliation as an instrumental variable and showed a favorable Catholic school effect on high school graduation. In addition to Catholic affiliation, Neal (1997) added two other instruments: the Catholic school availability and the proportion of Catholics in the county. Based on the 1979 National Longitudinal Survey of Youth, he found positive effects of Catholic high schools to be greater for ethnic minority students than for Whites in inner cities. However, there was no Catholic school effect in suburban areas. The relatively large Catholic school effect on urban minorities is probably a result of the poor quality of the public schools serving urban minorities. Public schools in suburban areas are likely to be as competitive as Catholic schools.

These studies using the IV method consistently conclude that Catholic schools appear to do better. However, the validity of using the suggested instrumental variables for Catholic study is questionable. For example, Murnane and colleagues (1985) argued that Catholic affiliation is not an exogenous variable in the achievement/attainment equation. It is hard to find a good instrumental variable that is consistently efficient for Catholic school selection across datasets.

More recently, the propensity score matching method has emerged in social science research, including the sociology of education, as a popular causal method because it has properties of an experiment – the gold standard in educational research. Using this method, Morgan (2001) estimated matched Catholic and public high school students on a set of observed variables that predict the propensity of Catholic school attendance. Catholic and public school students with similar propensity scores stand as counterfactuals to each other. His results indicated that students who are least likely to attend Catholic schools gain more from Catholic school attendance. Because low-income students have a lesser opportunity to attend private schools than do high-income students, the implication is that low-income students are more able to benefit academically from attending Catholic schools.

A limitation of the propensity score method is its inability to control for unobserved heterogeneity. Attempts have been made to control for selection based on unobservables, such as the AET method proposed by Altonji, Elder and Taber (2005a, 2005b). However, the AET method requires strong assumptions about the relationship between observables and unobservables. It also requires a large amount of information about students before they entered high school. The data requirement is not likely to be practical for most high school datasets. Given available data and fewer assumptions, the propensity score method is currently more feasible than other causal methods in estimating the Catholic school effect in secondary school.

Apart from estimating an average Catholic school effect, Neal (1997) and Altonji and colleagues (2005a, 2005b) also find heterogeneity of the Catholic school effect by geographical locations: the favorable Catholic school effect tends to be more marked for ethnic minority students in inner-city schools than for Whites and suburban students. According to these authors, the heterogeneity effect might be attributed to differences in student composition and school

quality by location. Suburban students are more likely to come from middle or high SES families who are more involved in children's schooling, regardless of the types of schools these students attend. Also, equipped with better funding from property taxes, suburban public schools are likely to be similar in quality to Catholic schools. This is not the case for public schools in urban areas, especially in inner cities, where low-income families are less involved and where educational funds from local taxation are meager. At the same time, urban public schools have many more low income and minority students to educate than do urban Catholic schools. Catholic schools are likely to provide a better education for poor inner-city children.

The Relevance of School Districts to Catholic Schools

As long as local taxes form the basis of educational funds, differences of school quality among geographical locations are closely associated with differences among school districts. Understanding the association between Catholic schools and school districts is important for policies. Catholic schools are accredited by independent and/or state agencies and are supported through tuition payments and fund raising. They enjoy a high degree of autonomy, although they do connect to the government by receiving scholarships and vouchers granted to poor students. The public aid for private schooling is especially available when public schools in the inner city perform poorly in achievements. Federally-funded programs, such as Title I, provide counseling, reading, math, and English as a foreign (or second) language (EFL/ESL) to help low-performing students under the poverty line in private schools

(see <http://www2.ed.gov/policy/elsec/leg/esea02/pg1.html>).

In 2005-2006, compared with 56% of public schools, about 37% of Catholic schools reported participating in Title I (Stullich et al., 2007). The Title I bill authorizes the local school district to provide services to students in non-public schools who demonstrate need. Furthermore,

the No Child Left Behind (NCLB) Act requires school districts to evenly distribute their Title I funds among eligible, poor students in both public and private schools that choose to participate. The funds to private schools are paid through support services for private schools.

School districts could manage funds for Catholic schools two ways – federal funds for disadvantaged students (e.g. Title I and scholarships) and voucher programs. As long as Catholic schools contain low-income, minority, and other disadvantaged students, public funds are channeled to them through school districts.

Thus far we do not know to what extent Catholic schools would affect students' learning within districts, if public school students were given the Catholic school choice. School choice is a policy-driven issue and the school district is an important administrative and policy unit. Families that choose schools for their children usually consider first the schools available within their school districts. An analysis of the Catholic school effect at the school district level would be appropriate and crucial. If a positive Catholic school effect within the district is found, it would be important information for public schools within the same school district, which can borrow good practices from Catholic schools. Additionally, analyzing the within-district effect provides research evidence to the recent controversial issue about converting Catholic schools into charter schools in urban school districts.

There are about seven Catholic schools in Washington D. C. that were closed because of declining enrollment and rising operating costs; these were converted to charter schools in 2009 (Hernandez, 2009). At the same time, in New York, the mayor proposed a conversion plan to turn four Catholic schools into charter schools in Brooklyn and Queens. The latter is still being debated and has not been mandated. A positive within-district Catholic school effect may favor such a policy, and vice versa.

This study presented an update of the Catholic school effects using newer data. Four overarching questions guide our research: (1) Is there any effect from Catholic schools for those who attend Catholic schools? (2) Is there heterogeneity of the Catholic school effect? (3) What is the effect of Catholic schools within school districts? (4) Do the Catholic school effects vary across school districts with or without public funding for private schooling?

Finally, to aid the current debate about transforming Catholic schools to charter schools within districts, this study presented results on the patterns of student mobility across district boundaries for Catholic schooling.

Data

This study used several sources of data. First, student-level and school-level data were obtained from the Educational Longitudinal Study of 2002 (ELS). ELS is a nationally representative sample of over 15,000 students in approximately 750 high schools. This study was based on data from the base year and the first follow-up collected in the spring of 2002 for 10th grade and the spring of 2004 for 12th grade, respectively. The first follow-up weight (f1qwt) was included to adjust for the design effect because of the complex and stratified sampling design. See Ingels et al. (2005) for a detail discussion of the sampling strategy and research design.

Second, to supplement school-level data from ELS, we also extracted school variables from the Common Core of Data (CCD) and Private School Survey (PSS). The CCD provided information about public schools, while the corresponding private school variables were from PSS. School district characteristics, such as the percent of White and Black students in a district and the district identifier, are extracted from CCD for school districts that contain public schools with 10th-12th grades. PSS does not provide information about Catholic (or other private) schools' districts. We had to use the School District Demographics System (SDDS) map data to locate

Catholic schools within school district boundaries in order to extract district information for Catholic schools. All district variables were merged into the ELS sample. Finally, neighborhood characteristics (e.g., neighborhood segregation) came from the 2000 Census. They were then merged with the ELS students by students' residential zip codes.

Sample attrition between 10th and 12th grade affected our analytic sample. About 13% of the students exited between survey waves. Among them, about 5% were Catholic students but 88% were public students. Dropping attrited cases would create sample selection bias. Thus we used the multiple imputation technique (Little, 1987; Schafer, 1997) to impute missing values. Multiple imputation bears a close resemblance to the EM algorithm (Rubin 1977) and other computational methods for calculating maximum-likelihood estimates based on observed data. It estimates missing values from other observed non-missing data. The observed variables used to impute missing values include student-level information, family background, and parent and school characteristics. In this study, we used the STATA software to create five imputed datasets and then combined them for each statistical analysis.

Because Catholic schools are rarely found in rural areas, our sample was restricted to students attending urban and suburban schools. After imputation and subsequent deletion of private non-Catholic schools, the full sample had about 9,240 students. In a separate analysis of the Catholic school effect within school districts, the sample was further restricted to students in districts that have both Catholic and public schools. This “district sample” includes approximately 7,470 students.

Subsequent deletion of students from the two samples was due to propensity score matching (discussed below). Two “matched samples” were created. One is the *main matched*

sample that had about 5,430 students. The other is the *district match sample* that had about 1,620 students.

Variables

The dependent variable is 12th-grade standardized math score, which is calibrated via the item response theory (IRT). The 10th grade math standardized score is used as a control. Mathematics is a subject more related to school instruction than other academic learning (Borman & D'Agostino, 1996; Murnane, 1975), and previous research has shown that students who scored higher on mathematics tests were more likely to attend competitive four-year colleges (Hoffer, 1995). It is worth noting that the ELS contains students' reading achievement as well, but it is only available in the base year and not in the follow-up study. Our cross-sectional analysis of reading achievement produced results consistent with the results of math achievement. For simplicity of presentation, we only report our findings on math achievement here.

The major independent variable is *Catholic school attendance*, which is a dummy variable identifying whether a student enrolls in a Catholic school. Students' prior academic performance is measured by 12th graders' *10th-grade mathematics scores*. Controlling for prior score is important because it stabilizes the variation of the dependent variable that is associated with prior schooling and it helps eliminate selection bias.

A number of demographic and family background variables are used to predict students' school attendance in Catholic or public schools as a result of parental school choices. These variables include *age* (in years) in grade 12; *gender* (male=1, female=0); *race/ethnicity* (a series of dummy variables that identify a student's race/ethnicity as White, Black, Hispanic, Asian, or other race); whether student is an *immigrant* (1=yes, 0=not); whether English is the student's

native language (1=yes, 0=no); *family composition* (dummy variables that categorize whether the student is from a two-parent, single-parent, step-parent, or no-parent household; reference group: two-parent); *number of siblings* (continual variable from 0-6, and 6= 6 or more); *working mother* (dummy variables that capture whether a student’s mother is currently a full-time, part-time employer, or not working; reference group: full-time); *socioeconomic status* (SES) (a continual composite measure of parents’ highest education and occupation status); and *Catholic church affiliation* (1=Catholic; 0=non-Catholic).

Previous studies found neighborhood segregation to be associated with students’ propensity of opting out of assigned public schools (Lauen, 2007). In this study, *neighborhood segregation* is measured by a diversity index called “entropy” (Reardon & Firebaugh, 2002) using zipcodes of ELS students’ residences. The entropy ranges from 0 to 1, representing the least segregated to the most segregated neighborhoods¹. Other neighborhood variables include the *level of neighborhood crime* reported by parents (dummy variables for low, moderate, and high levels; reference: low), *neighborhood poverty rate* (the ratio of population below poverty over those above poverty by zip codes).

Most explanations for parental school selection have focused on demand-side factors measured by students’ socioeconomic status and other social background variables. However, the number of nearby schools available for parental choice is potentially an important factor, although extracting such information is non-trivial. To our knowledge, no previous studies have

¹ The zipcode-wide entropy index H is defined as:

$$H = \sum_{i=1}^n \left[\frac{t_i(E - E_i)}{ET} \right], \text{ where } t_i \text{ is the population of the census-block group } i, E \text{ and } E_i \text{ are the diversity score of zipcode and census-block group } i, \text{ respectively.}$$

$$E_i = \sum_{r=1}^r (p_{ri}) \ln[1/p_{ri}], \text{ where } p_{ri} \text{ is the proportion of racial/ethnic group } r \text{ for block group } i.$$

T denotes the zipcode population, and n is the number of block groups within a zipcode. Each zipcode covers multiple block groups.

examined the school supply factor for a national sample of students. The Geographic Information System (GIS) technique has opened up a new opportunity for the measure of school supply. It allows the creation of the variable, the *number of public schools available*. First, GIS was used to calculate the distance between the centroids of the zipcodes of students' residences and the schools these students attended. Six miles is the average home-to-school distance. We then constructed a six-mile radius from each centroid and counted the number of other schools within that area.

Another use of GIS in this study was to identify two kinds of school districts: the "receiving districts," which is the district where the student's school was located; and the "sending district," which is the district where the student's residence was located. Together they helped create the variable, *cross school district*, that identifies whether a student crossed a district boundary to attend a school away from his/her home school district.

The policy variable, *public aid for private schooling*, identifies whether a student lived in 2000 in a state or county that allowed for public aid to support private schools. The information for this variable came from two sources: the 2002 State Regulation of Private School (see <http://www.ed.gov/pubs/RegPrivSchl/index.html> & Goodman, 2009). According to these sources, Florida, Maine, Milwaukee (WI), Cleveland (OH), and Vermont had voucher programs. Iowa, Minnesota, Pennsylvania, Illinois, Florida, and Arizona instituted tax credits for private schooling. And Pennsylvania enacted a scholarship tax credit for private school students in 2001.

School selection could be constrained by the spatial distribution of schools surrounding residences. Therefore, some spatial characteristics are taken into account to predict students' attendance in Catholic or public schools. These are *urban school* (suburban school is the

comparison group) and four dummy variables representing the geographical *region*: northeast, north central, and west (reference is south).

School district characteristics are useful for examining the differentials between district crossers' sending and receiving districts. These variables include *the percent of receiving free/reduced-price lunch*, *the percent of students who are in LEP (Limited English Proficiency) programs*, *the percent district dropout rate*, *the percent of White students*, and *the percent of Black students*.

Methods

To investigate the effect of Catholic schools on student achievement, this study used the quasi-experimental method of propensity score matching (Rosenbaum & Rubin, 1983). In the language of experiments, students attending Catholic schools are in the “treatment” group – the group of students given the Catholic education treatment. Their counterfactuals or the “control” group is the students in public schools. The goal of the propensity score analysis is to match students in the treatment group with students in the control group.

The matching procedure was done as follows. First, a logit model was applied to all students to compute the “propensity” (predicted probability) of attending Catholic school. Even Catholic school students received scores that represent their propensity to attend Catholic school. Covariates in the initial logit model included the 10th-grade math score, student demographics, and family background characteristics. Because school factors were measured *after* any school choice decisions were made, they were excluded from the logit model that essentially predicted the choice of Catholic school. Once students’ propensity scores are computed, the caliper method (Dehejia & Wahba, 2002; Morgan, 2001) is used to match each Catholic school student by propensity scores with at least one but no more than five public school students. A public school

student is selected only if his/her propensity score differs from a Catholic school student's propensity score by 0.01 or less. The matching is done with replacement. After all possible matches are obtained, the "trimming" takes place where students in public (or Catholic) schools who do not find one or more matched students in the Catholic (or public) sector are dropped from the dataset. The result is a matched sample in which each Catholic school student has at least one matched public school student.

To examine if the treatment and control groups are well matched, the matched sample of students is placed in hierarchical strata of propensity scores to check for "balance." This is done by performing t-tests to ensure that the average characteristics of the treatment and control groups are not significantly different from each other. The standard deviation of each variable must also be similar within each stratum in order to achieve balance. Because we use multiple imputation to handle missing values, this balancing procedure is performed in each of the five imputed datasets. When unbalanced data are found within certain strata, the strata can be divided into two to increase the likelihood of achieving balance within the new strata. Otherwise, the propensity scores are re-estimated by adding more covariates, interaction terms, and power terms, and the matching process is repeated until the control and treatment groups are balanced. We were able to add interaction terms between initial variables and race/ethnicity or SES in order to achieve balance with five strata. There are 60 independent variables¹ in the logistic regression that takes account of the design effects by estimating robust standard error and adjusting for cluster design with sampling weight.

The procedure followed after checking for data balance is the comparison of the achievement outcomes of the treatment and control groups to estimate the "average treatment effect for the treated" (ATT). Because the propensity score method compares the achievement

outcomes of Catholic and public school students who are otherwise very similar (have propensity scores that are close in value), researchers can estimate what the achievement of a Catholic school student would have had he/she not attended Catholic school. Such is the idea of a counterfactual. The difference between the treatment group and the counterfactual produces an estimate of the “causal effect” of the treatment, i.e., attending Catholic schools.

Once we have a balanced matched sample, we calculate the ATT of Catholic school attendance using the 12th grade math test score as the outcome. The ATT is first estimated by a comparison of group means without adjusting for any covariates. This is equivalent to estimating a simple regression,

$$Y_i = \alpha + \delta(C_i) + \varepsilon_i \quad \text{---- (1)}$$

where Y_i is the 12th grade test score for student i and C_i is Catholic school attendance.

Subsequent estimation of the ATT takes into account potential confounding factors using either the OLS (ordinary least square) model or a stratum fixed-effects model (Allison, 2005).

Specifically,

$$Y_i = \alpha + \delta(C_i) + \gamma(Test10_i) + b_1X_{1i} + \dots + b_qX_{qi} + \varepsilon_i \quad \text{---- (2)}, \text{ and}$$

$$Y_{is} = \alpha_s + \beta(C_{is}) + \gamma(Test10_i) + b_1X_{1i} + \dots + b_qX_{qi} + \kappa Z_i + \varepsilon_{is} \quad \text{--- (3)}.$$

The covariates include the 10th grade test score ($Test10$) and a host of students’ demographic characteristics, family background, and spatial characteristics, represented by X_n ($n=1, \dots, q$). Y_{is} is the test score of student i in stratum s , and Z is the dummy variable for each stratum. Both equations (2) and (3) estimate the net effects of Catholic school attendance, through direct control of other confounding factors, or comparison of group means among students with a smaller range of propensity scores. Equation (3) further compares students within the same

school district. The resulting estimates of the Catholic school effect would be subject to less “noise” because differences in school district characteristics, such as choice policies, that may have contributed to differences in performances between Catholic and public school students would be controlled.

This study examines the ATT in two different matched samples. As mentioned in the Data section, the main matched sample was constructed from the full sample, whereas the district matched sample was constructed using the sample of students attending schools in districts where both Catholic and public schools were found. The district matched sample was created by matching Catholic and public school students within the same school district. The district analysis involves comparing the Catholic school effects across school districts with different policy environments – whether or not the district offers public aids for private schooling.

The strata of propensity scores are not only useful for checking balance, but are also useful for detecting heterogeneity of the ATT. It allows researchers to investigate whether the ATT differs systematically for groups of students with different propensity scores. Students were classified by their propensity to attend Catholic schools.

In the district analysis, students were grouped by their exposure to policy intervention. This analysis revealed Catholic school effects among students who are eligible (or not) to exercise school choice.

Our last analysis investigated the extent to which students select Catholic schools outside of the public school district of their residence. This is a question that has not been addressed at the national level by previous research. With the help of GIS and the geographical correspondence 2000 Census file (<http://mcdc2.missouri.edu/websas/geocorr2k.html>) school districts were linked to students’ residential zipcodes. The sending school district was identified

by overlaying the student's residential zipcode with school district boundaries and then detecting the school district within which the student resided. To identify receiving districts, school district boundaries and the Catholic school location were overlaid in order to locate the school districts for the Catholic school. This entire procedure requires positioning on the map the students' residences, Catholic school locations, and school district boundaries.

Results

Descriptive Analysis of the Full Sample

Students attending Catholic and public schools are different in many ways, as shown in Table 1 for a number of demographic, family, spatial, and school district variables. Catholic school students significantly outperform their public school counterparts in both 10th - and 12th - grade mathematics tests. However, the superior achievement of Catholic school students cannot be attributed to the Catholic school education at face value, because students attending Catholic schools are highly selected in a range of demographic, socioeconomic, and spatial characteristics. Students in Catholic schools are less likely than are public school students to be Black and Hispanic. About 33% of public school students are immigrants, while only 20% of students are immigrants in Catholic schools. This is likely to be the reason why Catholic schools have a higher proportion of students who speak English as a native language than do public schools. About 25% of Catholic school students are from (non-White) minority groups, but the minority figure of 42% is much higher in public schools.

(Insert Table 1 about here)

Students in these two school sectors also differ in several major family characteristics. Families that send their children to Catholic schools have significantly higher socioeconomic status – parents are more educated and family income is higher. Public school students are

significantly more likely to live in stepparent, single parent, and no-parent families, while Catholic school students are significantly more likely to reside with two biological parents. Public school students have significantly greater numbers of siblings than do Catholic school students. Not only do Catholic school students have significantly more tangible resources than their public school peers, in terms of income, parental education, biological parents, and siblings to share resources, they also have significantly greater access to their mother's time. This is indicated by the fact that mothers in Catholic schools have a slightly higher but significant proportion of working part-time than those in public schools. Consistent with the difference in socioeconomic status, public school students are significantly more likely to live in neighborhoods with higher poverty tax rates.

The supply of schooling clearly favors families that send their children to Catholic schools. The average number of public schools surrounding residences within a six-mile radius is significantly higher for Catholic school students than for public school students. Compared to public school students, Catholic school students have about two more public schools from which to choose around their residences, but yet they are also significantly more likely (and more able) to attend school in another district not where they reside. About 46% of Catholic school students attend schools across districts, whereas only 15% of public school students choose to opt out of schools in their home districts. The high mobility of district crossing among Catholic school students, in the face of the greater supply of schools, likely indicates parents' strong motivation to seek quality schools for their children.

As is well known, Catholic and public schools are different for their student composition and school organization. Compared to Catholic schools, public schools are poorer and less academic, indicated by a significantly higher percent of students receiving free- or reduced-lunch

subsidy and greater percentage of vocational programs. The school districts where Catholic schools locate are richer and less diverse. However, these districts have a higher percentage of students in dropout and drug prevention programs. It is likely to be related to the Catholic school location. Catholic high schools mostly locate in inner cities and urban areas (McDonald & Schultz, 2011). Thus, for wealthier urban parents, they might serve as a substitute for poor or struggling low-quality public schools.

Creating Matched Samples

In an effort to isolate the Catholic school effect from self-selection, we matched Catholic and public school students by their propensity to attend Catholic school. A logit model predicting Catholic school participation (see Table A1 in Appendix) was used to calculate the propensity score for each student, regardless of their current school sector. Based on their propensity scores, students were stratified into five propensity-score strata. Sample reduction after trimming was about 41% for the main matched sample (from 9,240 to 5,430) and 78% for the district matched sample (from 7,470 to 1,650). In the district sample, there were about 450 schools and 380 school districts.

We checked for balance of the Catholic and public students on their demographic and family characteristics, and the supply of schooling (results not presented here). Most significant differences between Catholic and public school students presented previously in Table 1 disappeared. The only significant difference that remained, for all strata, was Catholic school affiliation for Catholic school students. To further check for balance, Table 2 presents the summary statistics of propensity score by five strata. The mean and standard deviation within each stratum is approximately the same for Catholic and public school students. This suggests that students in the same strata are alike in terms of the covariates controlled in the logit models

(student demographics, family background, school supply, and interaction terms). Students most likely to attend Catholic schools are placed in the highest stratum (5), while those least likely to attend Catholic schools are in the lowest stratum (1). Not surprisingly, more Catholic school students and fewer public school students were found in higher strata, and vice versa.

(Insert Table 2 about here)

Catholic School Effect on the Main Matched Sample

Table 3 presents various estimates of the Catholic school effect or the ATT. Models 1, 2, and 3 correspond to equations (1), (2), and (3) specified in the Method section. Without any control, Model 1 reports the main effect of Catholic schools on 12th graders' mathematic scores: it is significant at the .05 level ($t=5.304$) and is substantively large. The coefficient of 4.72 can be translated into an overall effect size of over one-quarter of a standard deviation ($15.23/4.72$).

(Insert Table 3 about here)

However, after controlling for confounding factors in Model 2, the coefficient size dropped about 74%, from 4.72 to 1.22. Thus, most of Catholic school students' superior achievement was not due to their Catholic school attendance, but to other factors, such as students' family background characteristics that are associated with Catholic school attendance. Similarly, accounting for propensity score strata also reduced the effect size substantially from 4.72 to 1.11, shown in Model 3. Judging from Models 2 and 3 together, Catholic school students do gain from their schools, and the effect size net of students' demographic, family, and spatial factors is about 12 or 14% of a standard deviation of the mathematics score.

Models 4-8 are within-stratum analyses that examined potential heterogeneity of the Catholic school effect for different strata. The lowest and the 4th stratum showed the Catholic school effect at the .05 significance level. The effect in the second lowest stratum was marginally

significant at the 0.10 level. When adjacent strata were grouped to create two categories of high (4th-5th quintiles or 3rd-5th quintiles) and low strata (1st-3rd quintiles or 1st-2nd quintiles, respectively), it was clear that the low strata consistently showed significant Catholic school effects but no significant effect was found within higher strata. Because students in lower strata had lower propensity scores, the result suggests that students who are less likely to attend Catholic schools benefit more from Catholic schooling than those with a higher likelihood of attending Catholic schools.

Catholic School Effect in the District Sample

Thus far, our Catholic-public school comparison has not taken school districts into account. A Catholic school student may be matched with some public school students in different school districts. To more effectively address policy issues regarding school choice, we examined if there is a Catholic school effect within school districts – an important policy unit. The analyses below created estimates of the Catholic school effect using the district matched sample in which all school districts had both Catholic and public schools. Model 1 in Table 4 shows that Catholic school students do not perform with significant differences from public school students in mathematics. The district fixed-effects model in Model 2 also suggests no significant average Catholic school effect within school district. The lack of ATT in the district matched sample clearly differs from the significant ATT found in the main matched sample, leading to an inconclusive result on the overall ATT.

(Insert Table 4 about here)

However, when the sample was divided into low and high propensity strata, in Models 3 and 4, the within-district Catholic school effect in the lower propensity strata (1st- 2nd quintiles) emerged. That is, in the same school districts, Catholic school students with low propensity

scores outperform their public school counterparts with similarly low propensity of Catholic school attendance. Again, the Catholic school effect was not found in the higher propensity strata (3th – 5th quintiles). These results resemble Models 11 and 12 in Table 3, showing that Catholic schooling benefits students with a low propensity of attending Catholic school but not students with a high propensity. Students with low propensity scores tend to come from low SES backgrounds.

Public aid for private schooling is typically implemented at the school district level. Table 4 presents two sets of district-fixed effects models to reveal if the Catholic school effect varies by public aid for private schooling. Model 5a shows a marginally significant ($p < .10$) Catholic school effect within school districts that offer public aid for private schooling. However, among students living in school districts without public aid for private schooling, Model 5b presents no significant within-district Catholic school effect.

The remaining question on the Catholic school effect is whether Catholic schooling benefits low SES students regardless of their school district policy in terms of public aids for private schooling. Models 6a and 6b were estimated on a sample that kept only students with low propensity scores (strata 1-2 combined), who tend to come from low SES homes. Model 6a reveals a statistically significant ($p < .05$) Catholic school effect for these students living in school districts where public aid was available. The mathematics scores gain was about 2.23 ($t = 1.993$). Model 6b shows that, for Catholic school students with lower propensity scores, Catholic schooling does not benefit them if they are *not* living in the district boundaries where public aid for Catholic schooling is available. In terms of the effect size, the score gains for those living within districts with public aid for Catholic schooling almost double ($2.230/1.036$) the gain for those who did not live in such districts. Taken together, the results from Models 6a and 6b

suggest that receiving public aid for Catholic schooling is important for low SES Catholic school students to achieve better outcomes on math tests.

Crossing School District Boundary to Attend Catholic School

Thus far we have shown a positive Catholic school effect on math achievement within school districts for high school students with low propensity to attend Catholic schools. However, this result does not imply that school districts will better serve low SES students by converting Catholic schools in the district into charter schools or providing district funds for attending Catholic schools, because some students attending Catholic school may not come from the same district. To our knowledge, no previous research has gauged the question of the pattern of Catholic school students' mobility across districts.

Recall from Table 1 that about 46% of Catholic school students attended school districts different from their districts of residence. Table 5 presents characteristics of the sending and receiving school districts for Catholic school students who crossed districts. It shows that the sending and receiving school districts differed significantly on several characteristics. The receiving districts were significantly less affluent, in terms of the higher percent of free-reduced price lunch. The receiving district also had a significantly higher percent of students in limited English proficiency (LEP). Assuming that school districts with fewer students wanting free or reduced lunches and fewer students having difficulty in English are more desirable, then the result here suggests that students tend to leave their more desirable districts to attend Catholic schools in less desirable districts. The result is surprising and it begs the question of why students choose to travel to less attractive districts.

(Insert Table 5 here)

A further analysis on students' math test scores looked into this puzzle. This was done by assessing the mathematics achievement standing of the mobile students in the sending districts (where they resided and where they would have attended public school had they not crossed district boundaries) and the receiving districts (where they attended Catholic schools). The results of the comparisons are shown in Table 6. Mobile Catholic school students had about eight points higher mathematics score than the average public or Catholic school student in the sending districts (row 1 and 2). However, mobile Catholic school students only scored 5.6 points higher in the math test than the average public school student in the receiving districts (row 3). Compared to the average Catholic school student in the receiving district (row 4), these mobile students were only slightly ahead in the math test (about 3 points higher). Thus, although Catholic school students who crossed across district boundaries performed better than public school students in both the receiving and sending districts, but the differences were smaller for the former than the latter. These results taken together suggest that a school's superior academic performance draws not only students in the district where the Catholic school is located, but it also attracts students to move from school districts having more desirable characteristics. Apparently, these results suggest that academic achievement of the school may be a better predictor of parental choice than the socioeconomic or minority status of the school.

(Insert Table 6 about here)

Summary and Discussions

Using data from the Educational Longitudinal Study of 2002 and supplementary data from multiple sources, we conducted a nationwide investigation on Catholic school effects. The results suggest that, first, there appears to be an average unadjusted Catholic school effect on 12th-grade students' mathematics achievement currently attending Catholic schools. These

Catholic school students would have had lower mathematics achievement had they not attended Catholic school. However, this positive Catholic school effect does not hold when we take school district into account. Within districts and among students with similar propensity to attend Catholic school, Catholic schooling does not differentiate students' mathematics scores. In other words, the effect of Catholic schooling is not found when the matching of students is restricted to within districts. The within-district comparison is clearly a more stringent matching criterion than the overall comparison. Due to this within-district finding, we are unable to draw a definitive conclusion about the average Catholic school effect.

Second, there was significant heterogeneity of the Catholic school effect. Students who benefit academically from Catholic schooling were those least likely to attend Catholic schools, and also were likely to come from low SES backgrounds. This result is similar to a previous study using student data collected more than a decade ago (Morgan 2001)². When the school district is taken into account in the matching process, the effect remains significant for students with a low propensity of receiving Catholic education. These two results suggest that the average Catholic school effect remains positive, despite a reduction of the number of Catholic schools and the increase in their minority representation.

Given this empirical finding, a question arises whether policies that allow parents in low-income districts to use public monies for Catholic education may be beneficial to their children. This leads us to our third result. We found a significantly positive Catholic school effect on math achievement within the districts where public aid for private schooling is available³. Students who are least likely to attend Catholic school gain from Catholic education in districts without policies that allow them to purchase private education with public funds. In districts without these policies, similar students do not receive benefits from Catholic schooling. Since students

who are least likely to attend Catholic school tend to be low SES students, this result suggests that low SES students benefit from Catholic schooling only when they are eligible under some school choice policies.

In light of the gradual decrease in Catholic schools, a controversial proposal was made to transform Catholic schools that face closure to charter schools (Hernandez, 2009). In the last two years, some inner-city Catholic schools in Indianapolis, Washington D.C., and Brooklyn and Queens in New York are under the spotlight for their transformations into publicly funded charter schools (Hernandez, 2009; PR Newswire, 2011). Those Catholic schools are on the closure list because of decreasing enrolment and financial support from the Roman Catholic Church or other sponsors. However, they tend to provide a positive impact on the neighborhoods by providing quality education. Keeping these schools through public funds but retaining the schools' autonomy may be a good strategy to improve disadvantaged students' academic achievement in large urban school districts.

Although our result of a positive within-district Catholic school effect appears to support the policy of creating charter schools from Catholic schools, a caveat is in order. The positive effect was found from an analysis of students attending the same district, which includes those students whose residences were in other districts and who crossed district boundaries to attend Catholic school. Like all other public schools, charter schools primarily serve students from the local district. If the Catholic schools of these district-crossers become charter schools, some or all of the district-crossers may lose their places. Because the district-crossers were found to have math performance slightly higher than their Catholic school peers in the receiving districts, the exclusion of these district-crossers may erode the Catholic school effect within districts. On the other hand, some students in the receiving district who had left for Catholic schools in other

districts may return to take advantage of the new charter school. These district crossers would boost the new charter school's achievement. Further studies examining in detail the mobile Catholic school students should help the discussions of the policy of transforming Catholic schools into charter schools.

Footnote

1. Morgan (2001) suggested that variables that might be affected by Catholic school enrollment, such as educational expectation and school climate in 10th grade, should be considered exclusive of the propensity score prediction model. The ELS:2002 survey tracked samples from 10th grade when students were already enrolled in high schools. It is not clear the degree to which selected high schools might have affected parental involvement and social networks. Therefore, the matching process did not include parental involvement, parental network, school and district characteristics to predict propensity scores. Ideally, rather than using variables from 10th graders, it is better to use variables of student characteristics before they enter high school for matching. However, there is no such variable available from ELS:2002 data. Thus, this study assumes that the variables used for matching are able to predict those students' prior-high-school characteristic.
2. We also used the same analytical strategy to investigate the Catholic school effect on 10th graders' mathematics and reading achievements. The result in Table A2 shows consistent findings. However, the effect sizes on reading are larger than on mathematics. In addition, to accommodate the concern of over-control during the prediction of propensity scores, we removed the prior core (10th-grade mathematics) from our logit model. Again, Table A3 illustrates a similar storyline but the effect sizes across models are larger than those in Tables 3 and A2. Only Catholic students in the last two quintiles (4th and 5th) did not significantly outperform their public school peers on 12th-grade mathematics achievement.
3. The same findings are supported by another set of analyses on 10th - grade reading achievements using a within-district sample that did not include prior achievement scores. Results are available upon request.

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Table 1. Descriptive Statistics before Matching

Variables	<u>Overall</u> Mean	<u>Catholic</u> Mean	<u>Public</u> Mean	C-P Difference
<i>12th-grade math score</i>	49.18	55.31	47.75	**
<i>Catholic school attendance</i>	0.06	-	-	-
<i>Previous academic performance</i>				
10th-grade math score	43.97	48.70	42.87	**
<i>Demographics & family background</i>				
Age	18.35	18.31	18.36	**
Male	0.50	0.52	0.49	
Female	0.50	0.47	0.50	
White	0.58	0.75	0.58	**
Asian	0.04	0.03	0.04	
Black	0.15	0.07	0.16	**
Hispanic	0.16	0.12	0.17	**
Other race	0.05	0.03	0.06	
Immigrant	0.24	0.20	0.33	**
English as native language	0.81	0.92	0.78	**
Two parents	0.60	0.76	0.58	**
Step parent	0.14	0.08	0.15	**
Single parent	0.21	0.15	0.22	**
No parent	0.04	0.02	0.04	**
Number of siblings	2.30	2.00	2.37	**

Table 1. (continued)

	<u>Overall</u>	<u>Catholic</u>	<u>Public</u>	<u>C-P</u>
Variables	Mean	Mean	Mean	Difference
Mother does not work	0.24	0.20	0.24	
Mother works part time	0.19	0.22	0.18	**
Mother works full time	0.58	0.58	0.53	+
Socioeconomic status	0.04	0.46	-0.03	**
Catholic church affiliation	0.41	0.80	0.33	**
Neighborhood segregation	0.57	0.60	0.56	
Neighborhood crime: low	0.73	0.78	0.73	
Neighborhood crime: moderate	0.09	0.09	0.09	
Neighborhood crime: high	0.02	0.01	0.02	
Neighborhood poverty rate	12.27	9.77	12.85	**
# public schools within 6 miles	8.09	10.12	7.62	**
Cross school district	0.24	0.46	0.15	**
With Public aid for Catholic schooling	0.21	0.28	0.19	
<i>Spatial characteristics</i>				
Urban	0.38	0.59	0.33	**
Suburban	0.58	0.46	0.58	**
Northeast	0.20	0.27	0.18	**
Midwest	0.25	0.35	0.23	**
West	0.22	0.13	0.24	+
South	0.31	0.24	0.32	**

School district characteristics

Table 1. (continued)

	<u>Overall</u>	<u>Catholic</u>	<u>Public</u>	<u>C-P</u>
Variables	Mean	Mean	Mean	Difference
% receive free-reduced lunch	26.32	18.40	28.17	**
% in LEP	25.10	59.31	17.42	**
% dropout	6.89	5.82	7.14	*
% White	61.69	59.29	62.23	+
% Black	18.62	23.80	17.45	*
Number of observations	9,240	1,750	7,490	

** p<0.01, * p<0.05, + p<0.1

Note:

1. The sample is weighted with first follow-up weight (*flqwt*) and takes into account sampling design that students are nested within schools.
2. Calculations based on five imputed datasets.
3. According to the regulation of the use of NCES restricted data, all information related to sample size has to be rounded to 10 digits.

Table 2. Summary Statistics of Propensity Scores by Stratum

	<u>Catholic</u>			<u>Public</u>		
	Mean	SD	N	Mean	SD	N
<u>Main Matched Sample</u>						
Stratum1	0.025	0.015	330	0.021	0.014	2130
Stratum2	0.090	0.023	380	0.086	0.023	950
Stratum3	0.185	0.031	340	0.181	0.031	410
Stratum4	0.332	0.053	340	0.314	0.051	200
Stratum5	0.532	0.081	270	0.511	0.080	80
<u>District Matched Sample</u>						
Stratum1	0.017	0.010	70	0.010	0.010	750
Stratum2	0.063	0.017	100	0.058	0.016	170
Stratum3	0.138	0.028	100	0.132	0.028	70
Stratum4	0.262	0.044	120	0.233	0.037	40
Stratum5	0.520	0.114	220	0.485	0.132	10

Note: The number of observations is the average of five imputed data. In the main matched sample, there are 5,430 students, including 1,660 Catholic school students and 3,770 public school students. In the district matched sample, there are 1,650 students, including 610 Catholic school students and 1,040 public school students. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Table 3. Catholic School Effect on 12th-Grade Mathematics Achievement

Models	Catholic			
	school effect	SE	t-stat	N
1: Main effect (without covariates)	4.720	0.890	5.304	5,430
2: Full model: (1)+ (10 th -grade score, demographics, background, spatial)	1.222	0.515	2.372	5,430
3: Strata fixed effect	1.113	0.528	2.109	5,430
4: Stratum 1: 1 st quintile (lowest)	1.312	0.632	2.074	2,460
5: Stratum 2: 2 nd quintile	1.335	0.708	1.886	1,330
6: Stratum 3: 3 rd quintile	0.564	0.796	0.709	750
7: Stratum 4: 4 th quintile	1.940	0.943	2.057	540
8: Stratum 5: 5 th quintile (highest)	-0.017	0.958	-0.017	350
9: 1 st – 3 rd quintiles, combined	1.259	0.622	2.025	4,540
10: 4 th – 5 th quintiles, combined	0.974	0.669	1.456	890
11: 1 st – 2 nd quintiles, combined	1.282	0.547	2.344	3,790
12: 3 rd – 5 th quintiles, combined	1.181	0.675	1.75	1,640

Note: Statistics are based on the averages of five imputed data. The matched sample includes about 5,430 students. About 1,660 are Catholic school students and 3,770 are public school students. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Design effect is controlled by taking into account school clusters and the probability weight of the first follow-up data.

Table 4. Catholic School Effect on 12th-Grade Mathematics Achievement within School Districts

	Catholic school effect	SE	t-stat	N
1: Full model	0.818	0.551	1.485	1,620
2: School district fixed effect	1.024	0.641	1.597	1,570
3: 1 st – 2 nd quintiles (low propensity)	1.449	0.664	2.181	1,190
4: 3 rd – 5 th quintiles (high propensity)	-0.376	1.681	-0.223	380
5a: With public aid for Catholic schooling	2.074	1.114	1.862	400
5b: Without public aid for Catholic schooling	0.445	0.793	0.561	1,180
6a: Strata 1-2, with aid	2.230	1.119	1.993	270
6b: Strata 1-2, without aid	1.036	0.771	1.344	920

Note: Statistics are based on the averages of five imputed data. The matched sample includes about 1,620 students. About 570 are Catholic school students and 1,060 are public school students. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Design effect is controlled by taking into account school clusters and the probability weight of the first follow-up data.

Table 5. The Characteristics of the Sending and Receiving School Districts Among Catholic School Students Who Cross School District Boundaries

Variables	Sending	Receiving	Difference
Percent dropout	5.73	5.91	+
% Free-reduced price lunch	18.52	34.80	**
% Black students	14.54	31.30	**
% White students	65.61	47.04	**
% Limited English Proficiency	11.10	14.42	**

Note: Statistics calculated from five imputed datasets. The first follow-up student weight was applied.

The number of observations is approximately 240. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Table 6. Math Score Gains for Catholic School Students who Crossed School District Boundaries

Comparison Group	<u>Gain</u>	
	Mean	SD
1: (Individual score) – (Average score for public school students, send)	8.00	1.03
2: (Individual score) – (Average score for Catholic school students, send)	7.98	1.28
3: (Individual score) – (Average score for public school students, receive)	5.60	0.99
4: (Individual score) – (Average score for Catholic school students, receive)	2.98	0.67

Note: Statistics are calculated from the district matched sample. They are adjusted for the survey design effect and are based on five imputed datasets. The number of Catholic school students who crossed school district boundaries is about 240. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Appendix

Table A1. Logistic Regression on Catholic School Attendance

	Coef.	Robust SE	z	P> z
<i>Previous academic performance</i>				
10 th -grade math score	0.01	0.00	3.45	0.00
<i>Demographics & family background</i>				
Age	-0.11	0.08	-1.42	0.16
Male	0.16	0.08	2.10	0.04
Asian	0.71	0.70	1.02	0.31
Black	0.15	0.35	0.42	0.68
Hispanic	0.22	0.40	0.56	0.58
Other race	0.95	0.42	2.24	0.03
Immigrant	-0.25	0.17	-1.5	0.13
English as native language	0.93	0.16	5.78	0.00
Step parent	-0.50	0.13	-3.76	0.00
Single parent	-0.25	0.11	-2.26	0.02
No parent	-0.13	0.24	-0.55	0.59
Number of siblings	-0.03	0.04	-0.67	0.50
Mother does not work	0.44	0.12	3.73	0.00
Mother works part time	0.15	0.12	1.29	0.20
Socioeconomic status	0.51	0.12	4.09	0.00
Catholic church affiliation	2.41	0.11	21.59	0.00

Table A1. (continued)

	Coef.	Robust SE	z	P> z
Neighborhood segregation	-1.25	0.39	-3.12	0.01
Neighborhood crime: moderate	0.25	0.14	1.74	0.08
Neighborhood crime: high	0.60	0.29	2.04	0.04
Neighborhood poverty rate	2.45	1.64	1.49	0.14
# public schools within 6 miles	0.04	0.01	6.24	0.00
Cross school districts	1.76	0.09	19.12	0.00
Public aid available for Catholic schooling	0.03	0.09	0.30	0.76
<i>Spatial characteristics</i>				
Urban	0.84	0.26	3.17	0.02
Northeast	0.38	0.12	3.12	0.00
Midwest	0.08	0.12	0.73	0.47
West	-0.44	0.13	-3.29	0.00
<i>Interaction terms</i>				
Black * immigrant	0.46	0.34	1.35	0.18
Asian * immigrant	0.08	0.54	0.16	0.88
Hispanic * immigrant	0.17	0.27	0.64	0.52
Other race * immigrant	-0.07	0.43	-0.17	0.86
Black * SES	0.13	0.20	0.66	0.51
Asian * SES	0.26	0.22	1.17	0.24
Hispanic * SES	1.04	0.17	6.21	0.00
Other race * SES	-0.10	0.29	-0.32	0.75

Table A1. (continued)

	Coef.	Robust SE	z	P> z
Black * mother not work	-0.06	0.33	-0.20	0.84
Asian * mother not work	0.40	0.39	1.03	0.30
Hispanic * mother not work	-0.25	0.26	-0.97	0.33
Other race * mother not work	0.09	0.48	0.19	0.85
Black * mother works PT	0.67	0.35	1.89	0.06
Asian * mother works PT	-0.36	0.48	-0.74	0.46
Hispanic * mother works PT	-0.12	0.30	-0.39	0.70
Other race * mother works PT	-0.66	0.61	-1.08	0.28
Black * # siblings	-0.18	0.08	-2.18	0.03
Asian * # siblings	-0.34	0.15	-2.27	0.02
Hispanic * # siblings	-0.32	0.09	-3.61	0.00
Other race * # siblings	-0.24	0.13	-1.83	0.07
# siblings * SES	0.05	0.05	1.17	0.24
Black * Catholic Affiliation	-0.81	0.29	-2.79	0.01
Asian * Catholic Affiliation	-0.82	0.36	-2.28	0.02
Hispanic * Catholic Affiliation	-0.11	0.35	-0.3	0.77
Other race * Catholic Affiliation	-0.50	0.40	-1.23	0.22
Urban * neighborhood segregation	1.91	0.40	4.72	0.00
Black*urban*neighborhood segregation	0.51	0.58	0.88	0.38
Asian*urban*neighborhood segregation	0.80	0.67	1.19	0.24
Hispanic*urban*neighborhood				
Segregation	0.53	0.46	1.16	0.25
Other*urban * neighborhood segregation	0.28	0.64	0.44	0.66

Table A1. (continued)

	Coef.	Robust SE	z	P> z
Neighborhood segregation * poverty	-9.88	2.84	-3.48	0.00
Urban* # public schools in 6 miles	-0.01	0.01	-0.98	0.51

Note: The number of observations is 9,240. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Wald Chi2= 1396.05; prob> Chi2=0.0000; log pseudo likelihood=-1462.67; pseudo R2=0.305.

Table A2. Catholic School Effect on Mathematics and Reading Achievements for 10th -Grade Catholic School Students

	Catholic			
	school effect	StdE	t	N
<i>Mathematics</i>				
Main effect	4.308	0.868	4.962	5,190
Full model	1.685	0.792	2.129	5,190
Strata fixed effect	1.675	0.809	2.07	5,190
1 st – 2 nd quintiles (low)	2.256	0.872	2.586	3,720
1 st – 3 rd quintiles (low)	2.172	0.824	2.637	4,380
3 rd – 5 th quintiles (high)	1.132	0.944	1.199	1,470
4 th – 5 th quintiles (high)	0.577	1.159	0.498	810
<i>Reading</i>				
Main effect	4.234	0.728	5.813	6,180
Full model	3.516	1.370	2.567	6,180
Strata fixed effect	2.496	0.649	3.844	6,180
1 st – 2 nd quintiles	3.079	0.729	4.223	4,350
1 st – 3 rd quintiles	2.788	0.672	4.152	5210
3 rd – 5 th quintiles	2.087	0.767	2.722	1,830
4 th – 5 th quintiles	1.609	0.947	1.700	970

Note: Prior achievement scores were not available to obtain the matched sample for these analyses.

Models are adjusted for the survey design effect and are based on five imputed datasets. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.

Table A3. Catholic School Effect on Mathematics for 12th -Grade Catholic School Students (without Using 10th-Grade Math Score to Predict Propensity Score)

	Catholic			
	school effect	StdE	t	N
Main effect	5.285	0.936	5.645	4,860
Full model	2.618	0.846	3.093	4,860
Strata fixed effect	2.407	0.853	2.823	4,860
1 st – 2 nd quintiles (low)	3.038	0.919	3.308	3,380
1 st – 3 rd quintiles (low)	3.130	0.879	3.563	4,050
3 rd – 5 th quintiles (high)	2.128	0.990	2.149	1,480
4 th – 5 th quintiles (high)	1.202	1.147	1.048	810

Note: Prior achievement scores was not used to obtain the matched sample for these analyses. Models are adjusted for the survey design effect and are based on five imputed datasets. According to the rules and regulations for the use of NCES restricted datasets, the numbers of observations reported throughout the document are rounded by 10 digits.