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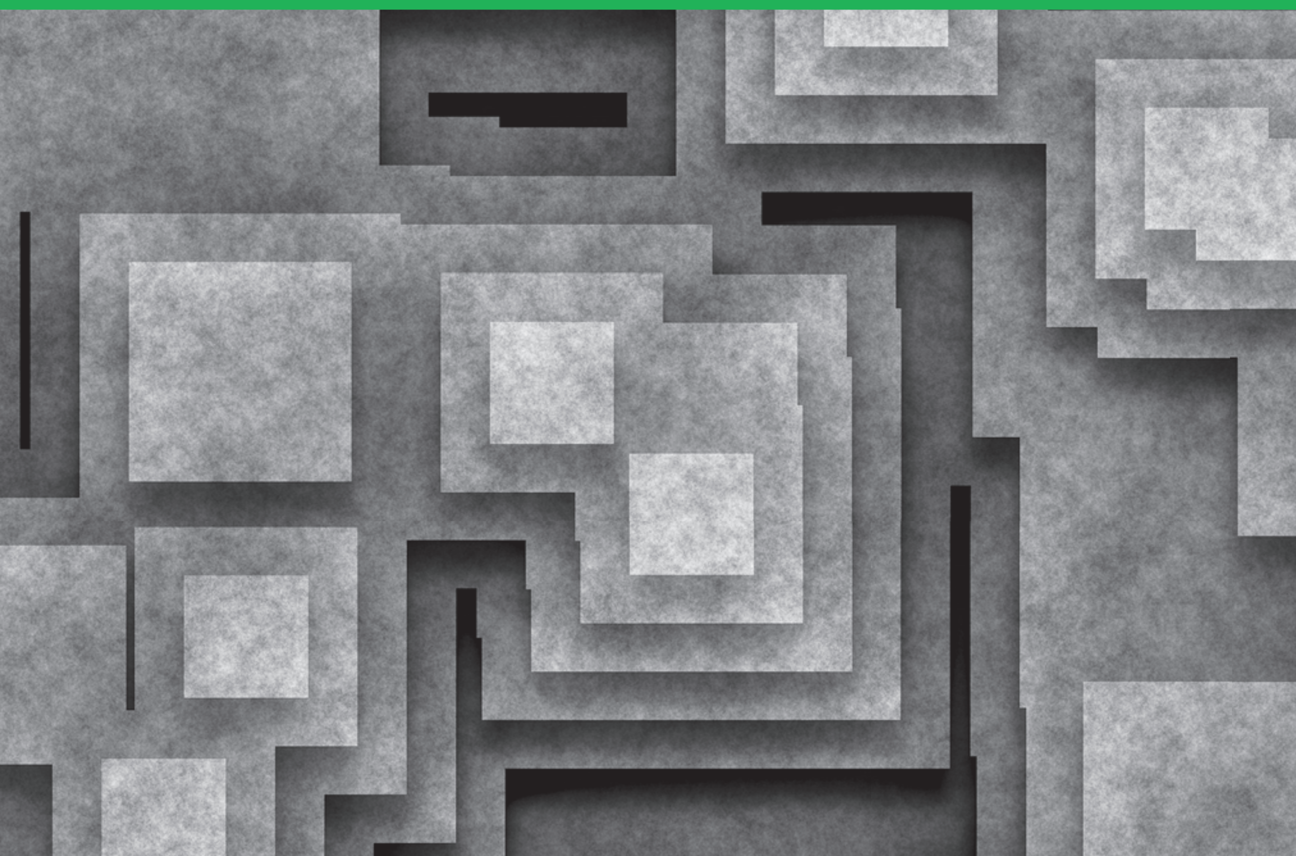

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Contents

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School Sector and Student Achievement in the Era of Standards Based Reforms

William Carbonaro[1] and Elizabeth Covay[1]

Abstract

The authors examine whether standards based accountability reforms of the past two decades have closed the achievement gap among public and private high school students. They analyzed data from the Education Longitudinal Study (ELS) to examine sector differences in high school achievement in the era of standards based reforms. The authors found that students in Catholic and private secular schools enjoy greater math gains from 10th to 12th grade than comparable public school students. However, they found that these advantages are largely concentrated among more advanced math skills. Moreover, private school students took more academic math courses than public school students, even after controlling for family background and prior achievement. These differences in course taking accounted for most of the public-private difference in achievement gains.

Keywords

Achievement, School Sector, Course Taking

Over 40 years ago, the ''Coleman Report'' (Coleman et al. 1966) launched a vigorous debate about the importance of schools for student learning. Coleman's unexpected findings indicated that few school attributes were related to student achievement (net of student characteristics) and that family background along with student attitudes were the most important predictors of student learning (Coleman et al. 1966). Many subsequent studies have provided evidence both for and against the importance of school characteristics for student outcomes (e.g., Greenwald, Hedges, and Laine 1996; Hanushek 1997; Konstantopoulos 2006). In the 1980s, Coleman was once again at the center of controversy regarding research on school effects when he reported that Catholic school students learned more in high school than comparable public school students (Coleman and Hoffer 1987; Coleman, Hoffer, and Kilgore 1982; Hoffer, Greeley, and Coleman 1985). Critics charged that estimates of sector effects were either plagued by unmeasured selectivity or were possibly too small to pay attention to (Alexander and Pallas 1985; Cain and Goldberger 1983; Jencks 1985). Subsequent research has raised questions about how pervasive sector differences in achievement are (Carbonaro 2003, 2006; Jepsen 2003; Lubienski and Lubienski 2006; Morgan 2001; Reardon, Cheadle, and Robinson 2009).

In this article, we will reexamine the debate over school effects viewed through the lens of school sector. There are two main justifications for revisiting sector effects on student learning. First, recent research on elementary school students has found that public school students are either outperforming or doing as well as private school students (Carbonaro 2003, 2006; Lubienski and Lubienski 2006; Reardon, Cheadle, and

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Robinson 2009). Since this research uses more recent data, it is important to analyze contemporaneous data from high school students to provide a more complete picture of sector differences in achievement for one time period. Second, institutional changes in the public and private sectors suggest that sector differences in high school achievement may have narrowed or perhaps even disappeared in recent years. In the 1990s, Catholic schools experienced declining enrollments and numerous school closures and consolidations (Youniss and Convey 2000). Consequently, the population of students in Catholic schools has become more selective (i.e., fewer minority and low SES students) since the 1990s (Cahalan et al. 2006). More importantly, standards based accountability reforms within the public sector may have increased the rigor of public school students' academic experiences and closed the public-private gap in learning opportunities and achievement in recent years.

Our findings indicate that Catholic school students are still more likely to take high-level math courses in the era of standards based reforms, net of student ability and background. Students in Catholic and private-secular schools also have slightly higher math gains from 10th to 12th grade. Most of these gains are concentrated among medium to advanced math skills. Finally, nearly all of the private sector advantages in achievement are explained by sector differences in course taking in high school.

Sector Differences in Student Achievement and Learning Opportunities

Research on school sector has focused on two main outcomes: (1) average achievement gains and (2) the relationship between ascribed characteristics (race/ethnicity and SES) and achievement. Initial studies of sector differences in student achievement examined the High School and Beyond (HS&B) data set, a longitudinal sample of 10th- and 12th-grade students in 1980 and 1982. One group of studies (Bryk, Lee, and Holland 1993; Coleman and Hoffer 1987; Hoffer et al. 1985) indicated that Catholic school students enjoyed greater achievement gains in high school than public school students. In addition, a ''common school effect'' was evident in Catholic schools: Race and socioeconomic status were less important for achievement in Catholic schools than they were in public schools. Other scholars analyzed the same data and concluded that sector differences in achievement gains were either due to omitted variable bias or too small to merit much consideration (Alexander and Pallas 1985; Willms 1985).[1]

The next round of sector studies focused on the National Education Longitudinal Study of 1988 (NELS:88), another nationally representative sample of high school students who were sampled in 8th, 10th, and 12th grades (1988, 1990, and 1992). Generally, the findings indicated that Catholic school students enjoyed greater learning gains than comparable public school students. Hoffer (1998) found a significant Catholic school advantage in 8th- to 12th-grade achievement gains for math, reading, and history. However, he did not find a common school effect. Morgan and Sørensen (1999) and Morgan (2001) analyzed 10th- to 12th-grade achievement gains in NELS:88 and found a Catholic school advantage over public school students. Gamoran (1996) compared the performance of Catholic, private, and public magnet schools in urban settings and found greater 8th- to 10th-grade math gains for Catholic school students. Finally, Altonji, Elder, and Taber (2005a, 2005b) found higher levels of Catholic school achievement in math and reading, but after correcting for selection bias, they found that Catholic school effects were no longer significant.[2]

Discrepant Findings across Levels of Schooling: Sector Effects in Elementary School

More recent research on sector differences in achievement has examined data from elementary schools. Jepsen (2003) examined data from the ''Prospects'' study of Title I programs and found no sector differences in reading and math gains for first- and fourth-grade students (one year later). Unfortunately, the sample of Catholic schools from Jepsen's study was small and not generalizable to the Catholic sector.[3] Carbonaro (2003, 2006) analyzed the Early Childhood Longitudinal Study (ECLS-K; collected in 1998-99) and compared learning gains for kindergarteners and first graders in public and private schools. Students in public kindergartens gained more in reading, math, and general knowledge than comparable students in private-secular kindergarten, and students in public, Catholic, and religious non-Catholic schools had similar gains in kindergarten (Carbonaro 2006). Among first graders, the results were mixed: Private school students outgained public school students in reading, but public school students outperformed private school students in math and general knowledge (Carbonaro 2003). Consistent with Hoffer's (1998) findings, Carbonaro did not find a ''common school effect.'' Research on the third- and fifth-grade waves of ECLS-K suggests that public school students outperform Catholic school students in math and experience equivalent gains in reading (Reardon et al. 2009). Similarly, Lubienski and Lubienski (2006) analyzed fourth- and eighth-grade National Assessment of Educational Progress (NAEP) data from 2003 and found that public school students had higher math scores than private school students after controlling for sector differences in sociodemographic characteristics.

These recent studies on sector effects in elementary schools have raised some important questions regarding the generalizability of sector effects across levels of schooling (i.e., elementary, middle, secondary). Since the data on elementary and secondary school achievement were not collected during the same time period, it is unclear whether these discrepant findings across levels of schooling reflect differences in sector effects during students' schooling careers or whether they reflect a broader change in sector effects across time periods.[4] Our article will fill this gap in the literature on sector effects by examining high school data collected during the same time period as the recent studies of school sector and achievement in elementary school.

Explanations for Sector Differences in Achievement

Several explanations for sector difference in achievement have been offered, including higher levels of social capital among students, teachers, and parents (Coleman and Hoffer 1987); stronger school community (Bryk et al. 1993); and greater selectivity and chartering (Bidwell and Dreeben 2006) in Catholic schools. However, the explanation with the strongest empirical support focuses on sector differences in students' *academic experiences*. Research from both HS&B and NELS:88 indicates that Catholic high school students (on average) take a more academically rigorous curriculum than public high school students (Bryk et al. 1993; Coleman and Hoffer 1987; Gamoran 1996; Hoffer et al. 1985; Lee et al. 1998). In particular, Bryk et al. (1993) found that Catholic schools placed more students in the academic track and fewer in the vocational academic track than public schools. In addition, Catholic school students took greater numbers of academic courses, even after controlling for student's background characteristics and prior achievement (Lee et al. 1998).

Whereas sector differences in high school learning opportunities consistently favored Catholic school students, studies of elementary school students provided a more mixed picture. Carbonaro (2006) found similar levels of curricular coverage in public and private kindergartens, but public kindergartens spent more time per week on reading and math instruction than private kindergartens. Lubienski, Lubienski, and Crane (2008) found that ''reform oriented'' math practices (which were positively related to math achievement) in fourth and eighth grade were more prevalent in public schools than private schools.

In the following section, we argue that institutional changes in the public sector justify a reexamination of sector differences in high school achievement with more recent data. More specifically, standards based accountability reforms may have equalized learning opportunities for public and private school students. In particular, we suspect that standards based reforms of the 1990s and early 2000s have exposed public school students to a more rigorous academic curriculum. New analyses with more recent data will provide a much more complete picture of how student outcomes vary by school sector.

Institutional Changes in the Public Sector: Standards Based Reforms

For public schools, the 1990s was a decade of reform dominated by heightened academic standards, numerous accountability reforms, and increased testing requirements (National Science Board 2004, 2006, 2008; Phillips and Flashman 2007). Several studies indicate that states and/or districts that implemented strong accountability systems in the 1990s enjoyed improved achievement levels for elementary and middle school students (Carnoy and

Loeb 2002; Hanushek and Raymond 2005; Jacob 2005). At the high school level, standards based reforms have had important consequences for students' course taking in math (National Science Board 2008). From 1987 to 2002, the number of states that required three or more math courses to graduate from high school increased from 9 to 25. During the same time period, the number of states requiring fewer than three math courses for high school graduation dropped from 29 to 16 (National Science Board 2006). State mandates regarding course taking had important effects on course offerings by high schools: From 1990 to 2000, the percentage of students attending high schools offering advanced math courses (e.g., pre-calculus, statistics, calculus) increased markedly (National Science Board 2006).[5] From 1990 to 2005, the number of students taking advanced math courses rose steadily in concert with the increased offerings in public high school (National Science Board 2008).

These changes have important implications for private-public differences in achievement because (1) course taking is a potent predictor of math achievement (Bozick and Ingels 2008; Lee, Croninger, and Smith 1997) and (2) differences in course taking largely explained the Catholic school advantage in high school achievement in prior studies of sectors effects (Bryk et al. 1993; Hoffer et al. 1985). As already noted, prior research suggests that Catholic school students are more likely to enroll in higher level math courses than public school students, net of prior achievement and family background (Lee et al. 1998). Bryk et al. (1993) argued that the Catholic school advantage in course taking was attributable to sector differences in school organization. The Catholic Church's core mission encouraged ''Catholic high schools [to] take a direct, active role in deciding what their students should learn and deliberately create an academic structure to advance this aim'' (Bryk et al.:124). In practice, Catholic schools shaped students' course taking patterns by: (a) offering fewer electives and (b) imposing graduation requirements that prevented students from opting out of academically advanced courses (Bryk et al. 1993). In contrast, public schools resembled ''shopping malls'' (Powell, Farrar, and Cohen 1985), where variety (a broad array of academic and nonacademic classes), choice (few curricular requirements), and neutrality (deference to student preferences) prevailed. In this academic environment, self-selection created highly unequal course taking patterns among public school students.

We argue that standards based reform initiatives in the 1990s have likely minimized sector differences in how students are allocated to courses. The greater availability of advanced courses along with increased course taking requirements at the state and district levels should have narrowed the public-private gap in math course taking. Thus, standards based reforms may have reduced sector differences in achievement by exposing public school students to a more rigorous mathematics curriculum in high school. An analysis of data collected *after* standards based reforms were implemented will allow us to examine this important issue.

Standards based reform efforts also motivate us to reexamine sector differences in achievement from a different perspective. Prior research on sector differences in achievement has focused exclusively on *average gains* made by students. However, as Rock and Pollack (2002) note, an equal gain by low and high achievers (e.g., five points) may not be equivalent because gains in the bottom half of the distribution may be easier to achieve than gains in the top half. By focusing solely on average gains and ignoring the kinds of skills students are learning (e.g., basic, intermediate, advanced), sector research has failed to examine whether sector gaps in achievement are equivalent across the full range of math skills that students learn in high school.

We suspect sector differences in achievement are smallest (likely insignificant) for basic and midlevel math skills because public schools focus more resources on teaching basic and midlevel skills to their students since these skills are specifically targeted in curricular standards and assessed on high stakes exams (Hyde et al. 2008).[6] Indeed, some evidence suggests that low achieving students experienced the greatest improvement in learning opportunities through increased course taking requirements under standards based reform efforts (e.g., Chaney, Burgdorf, and Atash 1997; Clune and White 1992). Standards based reforms have increased enrollments in advanced math courses, but these gains have been less dramatic than increased enrollments in lower level math courses (National Science Board 2006, 2008). Thus, we expect that private school students are still more likely to take advanced math courses. Consequently, since advanced math course work is a significant predictor of whether students master advanced math skills, we expect to find sector differences in achievement to be concentrated among more advanced math skills.

Research Questions

Fortunately, newly collected data on American high schools from the Education Longitudinal Study (ELS) allow us to provide a more complete picture of sector differences in high school achievement. Data from HS&B and NELS:88 provided information on sector differences in achievement from 1980 through 1992, a period that largely preceded major standards based accountability reforms in the public sector. The ELS data were collected (in 2002 and 2004) *after* standards based reforms efforts were implemented. An analysis of sector effects in ELS will complement prior research and provide insights regarding whether standards based reform reduced or eliminated the sector gap in achievement. In addition, the ELS data are contemporaneous with sector studies of achievement in elementary school. Thus, it is possible to establish whether discrepancies in sector studies of elementary and high school students reflect a real change in sector effects across time periods (i.e., the 1980s vs. 2000s) or instead, a difference in sector effects across levels of schooling.

We will explore the following four research questions in our study:

Research Question 1: Are there sector differences in achievement gains among recent high school students in the era of standards based reform?
Research Question 2: Do public and private schools differ in the types of math skills (e.g., low, medium, and advanced) they instill in students?
Research Question 3: Do course taking patterns in high school differ for public and private school students, net of background characteristics?
Research Question 4: Do any observed differences in course taking account for sector differences in student achievement?

By exploring these questions with more recent data, we will gain a much more complete understanding of how school sector is related to both students' learning opportunities and achievement outcomes.

DATA

We analyze data from the Education Longitudinal Study, a nationally representative sample of 10th graders in 2002 who were resurveyed again during their senior year in 2004. The base year survey in 2002 includes questionnaires distributed to students, parents, math teachers, English teachers, administrators, and librarians. In 2004, both students and school administrators were surveyed again. ELS provides a rich source of information on students' family background, future educational ambitions, academic experiences, and academic achievement. In addition, there is much information about students' teachers and their schools. The longitudinal data allow us to examine students over time and to control for the relationships between prior experiences and current academic achievement outcomes. Basic descriptive statistics on all variables included in our analyses are included in Table 1.

We analyzed data from the restricted version of ELS in order to get additional information about high schools that was unavailable in the public use data (see the following). Our analytical sample includes all students who were in school in 2004. Dropouts who did not return to school (approximately 1,000 students) were dropped from our sample because they did not have 12th-grade test scores.[7] We know that dropouts are likely to have less achievement growth from 10th to 12th grade and public school students are less likely to graduate than private school students (Altonji et al. 2005a, 2005b). Consequently, differential attrition across sectors will likely underestimate sector differences in achievement growth. We performed a supplementary analysis to address this issue. Using a two-stage model to correct for sample selection bias (see Berk 1983), we first specified a model predicting dropout and then used the inverse Mills ratio to control for selection in our substantive regression. Overall, we found that our results were very similar to our original analyses after making this adjustment to our models. Ultimately, we decided to present our original models that exclude dropouts because they are more parsimonious and rely on fewer untestable assumptions.

Table 1. Means and Standard Deviations for the Variables in the Analyses

Variable	Public (*N* = 10,290) Unweighted	Catholic (*N* = 1,880) Unweighted	Private, Other Religious (*N* = 700) Unweighted	Private, Secular (*N* = 570) Unweighted	Total (*N* = 13,440) Unweighted	Weighted	Minimum	Maximum
Catholic school					0.140	0.048	0	1
Private, other religious					0.052	0.019	0	1
Private, secular					0.042	0.016	0	1
Student background								
Female	0.510	0.481	0.504	0.504	0.505	0.502	0	1
Socioeconomic status	−0.044	0.459	0.521	0.722	0.088	0.041	−2.12	1.81
	(0.716)	(0.621)	(0.635)	(0.634)	(0.737)	(0.717)		
Disability	0.189	0.134	0.161	0.127	0.177	0.194	0	1
Family resource scale	3.845	4.412	4.261	4.443	3.971	3.939	0	5.204
	(1.110)	(0.787)	(0.958)	(0.866)	(1.078)	(1.086)		
Number of siblings	2.335	1.998	2.130	1.809	2.255	2.280	0	6
	(1.546)	(1.334)	(1.360)	(1.343)	(1.508)	(1.512)		
Other race	0.054	0.040	0.061	0.051	0.053	0.049	0	1
Asian	0.120	0.039	0.044	0.083	0.103	0.044	0	1
Black	0.144	0.080	0.040	0.064	0.126	0.136	0	1
Hispanic	0.150	0.126	0.046	0.064	0.138	0.150	0	1
Nonintact family	0.412	0.254	0.229	0.299	0.375	0.401	0	1
English-native language	0.811	0.925	0.879	0.901	0.834	0.868	0	1
Student expects at least college	0.741	0.893	0.862	0.858	0.773	0.753	0	1
Parent wants at least college	0.872	0.970	0.939	0.967	0.893	0.879	0	1
Achievement								
Item response theory (IRT) gain score	4.802	6.572	6.197	7.093	5.219	4.919	−39.460	46.690
	(6.457)	(6.027)	(6.746)	(6.570)	(6.464)	(6.347)		
10th-grade math IRT	42.956	48.706	49.430	51.978	44.478	43.575	13.740	82.030
	(13.918)	(12.079)	(12.900)	(12.766)	(13.864)	(13.876)		
12th-grade math IRT	47.758	55.278	55.627	59.071	49.697	48.494	15.200	82.540
	(15.120)	(12.972)	(13.810)	(12.972)	(15.113)	(15.037)		
10th-grade reading IRT	29.482	34.812	34.336	35.435	30.731	30.265	10.20	49.09
	(9.589)	(8.060)	(8.316)	(8.722)	(9.563)	(9.600)		

(continued)

Table 1. Continued

Variable	Public (N = 10,290) Unweighted	Catholic (N = 1,880) Unweighted	Private, Other Religious (N = 700) Unweighted	Private, Secular (N = 570) Unweighted	Total (N = 13,440) Unweighted	Weighted	Minimum	Maximum
Highest math course taken								
Algebra I	0.066	0.008	0.023	0.019	0.053	0.063	0	1
Geometry	0.138	0.050	0.079	0.035	0.118	0.133	0	1
Algebra II	0.300	0.258	0.279	0.216	0.289	0.300	0	1
Trigonometry	0.119	0.197	0.160	0.118	0.132	0.123	0	1
Pre-calculus	0.171	0.267	0.255	0.249	0.192	0.181	0	1
Calculus	0.152	0.215	0.193	0.351	0.171	0.146	0	1
Additional academic variables								
College preparatory track	0.517	0.781	0.702	0.811	0.576	0.534	0	1
Vocational track	0.110	0.024	0.033	0.035	0.091	0.100	0	1
No math course in 12th grade	0.379	0.208	0.284	0.169	0.341	0.374	0	1
Amount of math needed to graduate	5.853 (0.625)	6.047 (0.541)	6.032 (0.788)	6.095 (0.459)	5.900 (0.624)	5.860 (0.624)	4	7

Note: Standard deviations are in parentheses.

Student Achievement Measures

Math achievement is the academic achievement outcome of interest in this study. ELS collected test score data for 10th-grade math and reading and 12th-grade math. The test scores we use are criterion referenced and were derived using item response theory (IRT). For our analyses, we use gain scores computed from the difference between a student's math IRT score in 10th and 12th grades. Gain scores permit us to look beyond differences in prior student achievement and examine variables that may be associated with a student's rate of achievement growth between the sophomore and senior year of high school.

We also decided to use a second measure of academic achievement in our analyses. In addition to IRT scores, ELS also provides measures of students' proficiency in math. These proficiency scores indicate the likelihood that a given student has mastered a given level of math skills. ELS devised five skill levels: (1) simple arithmetical operations on whole numbers; (2) simple operations with decimals, fractions, powers, and roots; (3) simple problem solving, requiring the understanding of low level mathematical concepts; (4) understanding of intermediate concepts and/or multistep solutions to word problems; and (5) complex multistep word problems and/or advanced mathematical material. For both 10th and 12th grades, students' test scores were translated into a probability that they were proficient at each level.

Proficiency scores offer information that goes beyond average achievement growth and focuses on *specific math skills* that students are learning. By examining proficiency scores, we can investigate whether sector effects are concentrated at certain skill levels or whether they are uniformly distributed across low, medium, and high skill levels. Together, these complementary measures of achievement growth and proficiency levels offer a more complete picture of student learning across school sector than prior research.

Course Taking Measures

Finally, we examined math course taking at the end of high school as an outcome as well as a predictor of achievement. We used the student reported highest math course taken for at least a half of year by the spring of 12th grade.[8] We create a categorical outcome variable that has four categories: less than trigonometry, trigonometry, pre-calculus, and calculus.

School Sector Variables

In our study, we compare achievement outcomes for students in four different sectors: public, Catholic, private-secular, and private-other religious (information only available in the restricted data). Additional information about particular types of schools (e.g., public comprehensive, public magnet, full-time vocational, public school of choice, charter, Catholic parish, Catholic diocesan, etc.) is also available in the ELS restricted data. However, no additional information about private-secular and private-other religious schools is available.[9] We recognize that the private-secular and private-other religious sectors both contain a diverse variety of school types. While this heterogeneity makes it somewhat difficult to generalize about schools within these sectors, we believe that all private schools share a common institutional environment that separates them from public schools (Bidwell and Dreeben 2006; Chubb and Moe 1990). In addition, we argue that it is important to include non-Catholic private schools to help make sense of the Catholic school coefficients. In particular, inclusion of other types of private schools in the analyses provides an opportunity to examine whether sector differences are only found in the Catholic sector (as prior research suggests) but not elsewhere in the private sector.

Background Control Variables

Numerous background variables were included as control variables in the analyses. We control for student ability by adding measures of 10th-grade math and reading IRT scores to our model. Basic demographic variables included sex, race (white [non-Hispanic], black, Asian, Hispanic, and ''other'' [American Indian, Alaska native, and multiracial]), a composite measure of family socioeconomic status, number of siblings, native English speaker, learning or physical disability (as reported by either a parent or teacher), and family composition (living with two biological parents vs. not). We also created and included a family resource scale. It included student reports to the following items: whether or not the family has a daily newspaper, a computer, access to the Internet, a DVD player, an electric dishwasher, a clothes dryer, more than 50 books, a fax machine, receives a regular magazine, and whether the student has his or her own room.

The scale has an alpha of .686 and is weighted using the respective factor loadings as weights. Finally, we included dummy variables to indicate the parents' college aspirations for the student and the students' own expectations regarding how far they will go in school. Both parents' aspirations and students' expectations were measured at the end of 10th grade.

METHOD

Selection bias is a major concern when studying sector differences in student achievement. Numerous critics have charged that sector differences in achievement reflect little more than omitted variable bias (e.g., Alexander and Pallas 1985). Thus, the challenge is to compare achievement levels among public and private school students who are otherwise comparable in all other respects related to achievement. We agree that omitted variable bias is a major concern in estimating sector differences in achievement. In the results section of the article, we will present ordinary least squares (OLS) models that employ numerous controls to reduce this problem. We also checked how robust our results are to omitted variable bias by running a sensitivity analysis and also using propensity score modeling. A summary of the findings of these supplementary analyses are presented in the results section, and more information about each one is presented in an appendix at the end of this article.

Missing Data

To deal with missing data due to item nonresponse, we used multiple imputation techniques to generate five data sets with five different sets of imputed values.[10] Multiple imputation allows us to retain cases with incomplete information in the sample (unlike listwise deletion) while also accounting for uncertainty inherent in imputing missing values. Each of the five imputed data sets contains 13,450[11] cases for analyses. Subroutine commands in the Stata software package allowed us to average the coefficients and standard errors from analyses across the five data sets.[12]

Correction for Design Effects

Since ELS sampled schools and then sampled students within schools, it is important to adjust for clustering when calculating the standards errors for our regression coefficients. In our analyses, we used the *cluster* option in Stata, which gives robust standard errors, also known as Huber/White standard errors or ''sandwich'' estimates. The *cluster* option downwardly adjusts for the inflated standard errors that result from the violation of the independent errors assumption (due to the clustering of students within schools).

RESULTS

Sector Differences in Achievement Gains

Our first set of analyses examines whether significant sector differences in achievement gains are still present in the era of standards based reform. In Table 1, we see that (as expected) the average 10th-grade math and reading achievement levels for private school students are roughly one half a standard deviation above the mean for public school students. More importantly, we also see that private school students enjoyed greater achievement *gains* in math from 10th to 12th grade than public school students, ranging from an additional 2.3 questions for private-secular schools to 1.4 for private-other religious schools. We can also interpret sector differences using the average public school gain (4.8) as a benchmark: The private sector math gains are 47.7 percent (private-secular), 36.8 percent (Catholic), and 29.0 percent (private-other religious) larger than the average public school achievement gain. These estimates of public-Catholic school differences are much smaller than those reported by Hoffer et al. (1985) in their analysis of HS&B (85 percent) and more similar to those reported in Morgan's (2001) analysis of NELS:88 (25 percent).

The first set of multivariate analyses (see Table 2) examines whether the sector differences in math gains observed in Table 1 remain significant after controlling for differences in students' ability and background characteristics. Model 1 is a baseline model that shows the unadjusted differences in the achievement gains across school sector. Model 2 adds the 10th-grade test scores in reading and math to the regression as proxies for student ability. Controlling for student ability does little to reduce the private school advantages in math gains (with the exception of a 17 percent reduction in the Catholic coefficient).

The next model (model 3) estimates achievement gains, net of student background characteristics.

Table 2. Sector Differences in Math Gains Adjusted for Prior Test Scores, Background, and Course Taking

	Model 1 (Unadjusted)	Model 2 (+ Ability)	Model 3 (+ Background)	Model 4 (+ Course Taking)
Sector				
Catholic	1.770***	1.467***	1.118***	0.590**
	(0.187)	(0.192)	(0.198)	(0.201)
Private-other religious	1.395**	1.263**	0.958*	0.771
	(0.477)	(0.472)	(0.447)	(0.436)
Private-secular	2.291***	2.255***	1.796***	1.154*
	(0.417)	(0.452)	(0.456)	(0.492)
Course taking				
Algebra I				0.392
				(0.305)
Geometry				0.948**
				(0.296)
Algebra II				2.211***
				(0.303)
Trigonometry				3.446***
				(0.349)
Pre-calculus				4.988***
				(0.356)
Calculus				6.153***
				(0.405)
R^2	.0140	.0505	.0911	.1575

Note: $N = 13{,}440$. Standard errors are in parentheses. Model 2 includes controls for 10th-grade math and reading item response theory (IRT) scores. Model 3 adds controls for gender, socioeconomic status, disability status, family resource scale, number of siblings, race, family structure, native English speaker, student educational expectations, and parental educational aspirations (along with controls from model 2). Model 4 adds student reported highest math course taken, no math taken during 12th grade, track, and years of math needed to graduate (along with controls from model 3).
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Sector differences in achievement growth decrease by roughly one fourth after controlling for background characteristics, but private school students in private-secular and Catholic schools still enjoy a statistically significant advantage in achievement gains over public school students. (The private-other religious coefficient is marginally statistically significant.) Although private-secular school students outscored Catholic school students by .7, this difference is not statistically significant. Overall, prior achievement and family background explain roughly 40 percent of the public-Catholic gap and one fifth of the public-private (secular) gap in math achievement gains from 10th to 12th grade. Thus, our results are consistent with prior research from the 1980s regarding sector differences in achievement gains: public school students learn less math than comparable private schools students during the last two years of high school. Judging the size of sector effects has been controversial in past research (see Jencks 1985). If we use the average public school gain in math achievement (4.8) as a benchmark, Catholic and private-secular school students are outgaining public school students by 23 percent and 37 percent (respectively). These sector differences are substantially smaller than the findings reported from HS&B (85 percent).

Although ''common school effects'' are not the main focus of our article, we will briefly report our findings on this issue. We added interactions between race/ethnicity, SES, and school sector to our regression in model 3 (Table 2) testing for these common school effects in ELS. None of these interaction terms were statistically significant (results not shown). Overall, the findings indicate that race-ethnicity and social class have

Table 3. Checks for Selection Bias in the Relationship between School Sector and Math Gains

Method		Statistic	Catholic	Private, Secular	Private, Other Religious
Ordinary least squares	Coefficient (Table 2, model 3)		1.118*** (0.198)	1.796*** (0.456)	0.958* (0.447)
Sensitivity analysis	Robustness to percentage bias*		0.651	0.502	0.083
Propensity score matching	Average treatment effects	Unmatched	1.77***	2.29***	1.39***
		Matched	1.04***	1.47***	1.22**
	Gamma		1.2 (0.05, 2.14)	1.15 (0.04, 2.66)	1.15 (0.145, 2.52)

Note: Numbers in parentheses for the OLS coefficients are standard errors. Numbers in the parentheses under the Gamma statistics are upper and low bound estimates for each Gamma.
*$p < .05$. **$p < .01$. ***$p < .001$.

the same relationship with achievement in public and private schools.[13]

Analyses Examining the Sensitivity of Our Results to Selection Bias

Numerous critics have charged that OLS regression does not adequately address the problem of omitted variable bias when estimating sector differences in achievement, while others believe it is adequate (for a useful summary, see Jencks 1985). In this section, we present the results of two supplementary analyses that examine whether our results are robust to alternative approaches to dealing with this problem. We will present the main findings of our checks, but have included the relevant details for our analyses in an appendix for interested readers.

First, we ran a sensitivity analysis proposed by Frank (2000) on our OLS results. Frank's sensitivity analysis produces a numerical estimate of how robust our coefficients are to possible systematic bias from omitted variables. We used the coefficients from model 3 to estimate the robustness indices. The results are displayed in Table 3.[14] For the Catholic school coefficient in the model, 65.1 percent of the coefficient would need to be attributed to omitted variable bias for the Catholic school effect to lose significance. Similarly, for the private-secular coefficient to lose significance, 50.2 percent of the sector difference would have to be attributable to systematic bias. It is important to note that the systematic bias in the sector coefficients in model 3 would be *above and beyond* variables that have already been controlled for in our model. Thus, any selection effects would have to work independently of prior achievement and background controls. Although Frank's sensitivity analysis quantifies how vulnerable a given estimate is to selection bias, the final judgment about the possible threat posed by unmeasured selectivity remains open to interpretation. We think that Frank's index suggests that the case for sector effect above and beyond unmeasured selection is quite plausible.

We also used propensity score matching, a recently popular approach for addressing several important limitations of OLS regression, to address concerns about selection bias in the OLS analyses (Rubin 1997). Several studies of school sector have utilized propensity score matching to account for possible selection bias (Carbonaro 2006; Hoffer et al. 1985; Morgan 2001), and in each case, propensity score analysis yielded conclusions similar to those from OLS analyses.

We created propensity scores for our data by replicating the models used by Morgan (2001) in his analysis of sector differences in NELS:88.[15] Overall, the propensity score models generated average treatment effects (see Table 3) consistent with our conclusions from the OLS models: Students who attend Catholic and private-secular schools outgained public school students in math from 10th to 12th grade.[16] Sensitivity analyses are commonly used in propensity score analyses to check whether treatment effects are robust to possible unobserved bias from omitted variables. We use a ''gamma'' statistic that estimates the robustness of average treatment effects to omitted variable bias (see Gangl 2004); the higher the gamma, the more insensitive the model is to hidden bias (Rosenbaum 2002). Table 3 displays the gammas for our treatment effects. The Catholic school effect has a gamma of 1.2, which indicates that for a null hypothesis of no effect to be acceptable, there would need to be an unmeasured variable that increases the odds of attending a Catholic school by 1.2, and it would need to be a strong predictor of the outcome variable. The private-secular treatment effect is slightly less robust with a gamma of 1.15. The gamma results somewhat reduce our confidence in our sector difference findings.

Overall, these supplementary analyses do not offer a definite conclusion regarding whether sector differences are due to unobserved selectivity. However, the findings, taken together, in Table 3 increase our confidence that sector differences in achievement are *not* solely due to unmeasured selection, given that any unobserved variables would have to have a robust relationship with school sector and achievement (net of our controls) to eliminate the sector effects in our models.

Sector Differences in Student Proficiency Levels

Our second research question focuses on whether sector differences in achievement vary depending on the specific math skills analyzed. Prior research on sector differences in achievement has focused exclusively on the size of students' gains without specifying the kinds of skills students are learning. Research on standards based reforms suggests that public schools may devote more resources to and generally might be more effective at teaching basic skills, while private schools might be more effective at teaching more advanced skills. To examine these issues, we will examine sector differences in how proficient students are at basic, medium, and advanced math skills. We argue that analyzing sector differences in student proficiencies at different skill levels complements a gain score analysis and provides a more detailed and complete picture of sector difference in student learning.

The National Center for Education Statistics (NCES) estimated each student's probability of being proficient at five distinct skill levels, ranked from lowest to highest. Column 1 of Table 4 presents sector differences in these probabilities at the end of 12th grade, without adjusting for any covariates. Overall, we see that by the end of high school, public and private school students differ most dramatically in medium level math skills (levels 2–4). Sector differences are also present at the highest level of math skills (level 5, complex word problems and advanced math material), but the differences are smaller, primarily because students in all four sectors have a low average probability of mastering these high level skills. At the lowest skill level (simple arithmetical operations on whole numbers), small but significant sector differences are present but the average probability of proficiency is very high in all four sectors.

Model 2 in Table 4 adjusts for 10th-grade proficiency scores and other background characteristics.[17] Overall, sector differences are greatly reduced in this fully adjusted model. There are no sector differences in level 1 skills (with the exception of a small Catholic advantage), and the differences at levels 2 and 3 are fairly small: Mostly, students have a 1.4 percent to 3.3 percent higher chance of being proficient at levels 2 and 3 in private school. Sector effects are largest in level 4 (understanding of intermediate concepts and multistep word problems): The chances of being proficient at level four are 4.3 percent higher in Catholic school and 5.7 percent higher in private-secular school when compared with the public sector. The chances of being proficient at level 5 are low in both the private and public sectors, although students in private-secular schools have 2.7 percent higher chance of being proficient in these high level math skills.

Overall, the analyses of students' proficiency in math indicate that private school gains in achievement are largest for more advanced math skills. We argue that this pattern may well be driven by standards based reforms in the public sector. Initiatives to increase the number of credits required for graduation along with the implementation of high school graduation exams may have directed more resources toward teaching basic math skills and minimized the gap with private schools for low level skills. Private schools, with a more advantaged population of students (both in terms of ability and background), may focus more heavily on developing higher level math skills, with an eye toward preparation for college math.

Table 4. Predicted Probabilities of Math Proficiency

	Model 1	Model 2	Model 3
	Unadjusted Model	Plus Background Characteristics	Plus Course Taking
Level 1: Simple arithmetical operations on whole numbers			
Public	.9582	.9651	.9654
Catholic	**.9910*****	**.9684****	.9670
Private-other religious	**.9874*****	.9676	.9662
Private-secular	**.9935*****	.9686	.9686
Level 2: Simple operations with decimals, fractions, powers, and roots			
Public	.7681	.8001	.8017
Catholic	**.9166*****	**.8142****	.8073
Private-other religious	**.9145*****	**.8189****	.8142
Private-secular	**.9482*****	**.8239***	**.8227***
Level 3: Simple problem solving, requiring understanding of low level mathematical concepts			
Public	.6004	.6453	.6485
Catholic	**.8080*****	**.6701****	.6570
Private-other religious	**.8048*****	**.6694****	.6629
Private-secular	**.8696*****	**.6779***	.6714
Level 4: Understanding of intermediate concepts and/or multistep solutions to word problems			
Public	.3294	.3679	.3714
Catholic	**.5164*****	**.4109*****	**.3976****
Private-other religious	**.5167*****	.3937	.3918
Private-secular	**.6217*****	**.4244****	**.4082***
Level 5: Complex multistep word problems and/or advanced mathematical material			
Public	.0383	.0459	.0462
Catholic	**.0594****	.0417	.0422
Private-other religious	**.0859****	.0618	.0655
Private-secular	**.1227****	.0732	.0621

Note: $N = 13{,}440$. Model 2 includes controls for 10th-grade proficiency, gender, socioeconomic status, disability status, family resource scale, number of siblings, race, family structure, native English speaker, student educational expectations, and parental educational aspirations. Model 3 adds student reported highest math course taken, no math taken during 12th grade, track, and years of math needed to graduate (along with controls from model 2). The predicted probabilities in bold indicate regression coefficients that are significantly ($p < .05$) different from public schools.
*$p < .05$. **$p < .01$. ***$p < .001$.

Sector Effects on Course Taking Patterns

Our third research question focuses on sector differences in course taking. One main justification for reexamining sector effects in achievement is that standards based reforms in public schools may have dampened differences in learning opportunities for students in public and private schools. As a result of increased curricular standardization, accountability measures, and testing in public schools, we suspect that students' academic experiences in high school are less likely to differ across school sector. In the next set of analyses, we focus on a critically important source of variation in students' learning opportunities in high school: mathematics course taking.

Table 5 presents the students' highest math course by school sector. Despite standards based reforms of the 1990s, public school students are much more likely than private school students to have a low level math course as their highest course

Table 5. Unconditional and Conditional Probabilities of Highest Course Taken in High School

Unconditional Probabilities		Less than Algebra I	Algebra I	Geometry	Algebra II	Trigonometry	Pre-calculus	Calculus
Public	Percentage	5.44	6.58	13.91	30.26	11.84	16.84	15.12
	Cumulative	5.44	12.02	25.93	56.19	68.03	84.88	100.00
Catholic	Percentage	0.59	0.76	4.96	26.05	19.74	26.43	21.47
	Cumulative	0.59	1.35	6.31	32.36	52.10	78.53	100.00
Private-other religious	Percentage	1.16	2.32	7.97	28.26	16.09	24.93	19.28
	Cumulative	1.16	3.48	11.45	39.71	55.80	80.72	100.00
Private-secular	Percentage	1.08	1.97	3.58	21.86	11.83	24.55	35.13
	Cumulative	1.08	3.05	6.63	28.49	40.32	64.87	100.00
Conditional Probabilities					Less than Trigonometry	Trigonometry	Pre-calculus	Calculus
Public	Percentage				56.49	14.89	18.25	10.37
	Cumulative				56.49	71.38	89.63	100.00
Catholic	Percentage				42.14	21.61	23.73	12.53
	Cumulative				42.14	63.75	87.48	100.01
Private-other religious	Percentage				52.58	17.47	20.92	9.03
	Cumulative				52.58	70.05	90.97	100.00
Private-secular	Percentage				44.62	14.48	23.18	17.72
	Cumulative				44.62	59.10	82.28	100.00

Note: The conditional predicted probabilities were generated from the multinomial logistic regression presented in Table 6.

by the end of high school: More than 10 percent of public school students go no further than algebra I, and one quarter stop after geometry. Public school students are two to four times more likely to stop at these low level courses than private school students. The public and private school distributions converge somewhat at algebra II: Algebra II is the highest course taken for between 20 percent and 30 percent of students in all four sectors. However, the cumulative percentages indicate that less than half of public school students are taking advanced math courses, compared to 60 percent to 70 percent of private school students who take an advanced math course.

Clearly, standards based reforms have not erased the public-private school gap in course taking. However, the main question of interest is whether *otherwise similar* students take different courses in public and private schools. Higher enrollments in advanced math courses in private school may simply reflect their more advantaged (and academically ambitious) population. Alternatively, it is possible that attributes of school organization (see Lee et al. 1998) may lead less academically skilled students with lower educational ambitions to be enrolled in higher level math classes. Indeed, numerous studies of curricular differentiation suggest that the available seats in tracks and courses are partly independent of student characteristics, such as student ability (Garet and DeLany 1988; Hallinan 1992; McFarland 2006).

To examine sector differences in course taking that remained after controlling for student background and ability, we ran multinomial logistic regression models that predicted a student's highest math course taken in high school. The results are displayed in Table 6. In our model, we made comparisons across four categories: less than trigonometry, trigonometry, pre-calculus, and calculus. An inspection of the ELS data indicated that these courses do not align into a rigid, hierarchical course taking sequence.[18] Consequently, we examined contrasts between both ''adjacent'' and ''nonadjacent'' classes in our models.

After adjusting for students' background characteristics and 10th-grade achievement in our model, we find that Catholic school students are more likely to take more advanced math courses than comparable public school students. Interestingly, the ''less than trigonometry'' cut point is especially important. Catholic school students are more likely to make the modest jump from less than trigonometry to trigonometry; however, they are also more likely to make the more substantial leaps from less than trigonometry to pre-calculus and calculus. However, Catholic school students enjoy no significant advantages among the adjacent (or near adjacent) categories (e.g., trigonometry vs. pre-calculus, pre-calculus vs. calculus). Similarly, the only significant difference in course taking for private-secular school students is for the less than trigonometry versus calculus pairing, although that coefficient is only marginally significant (p value = .024).

At the bottom of Table 5, we present the conditional probabilities of taking a given course produced by our multinomial regression results in Table 6. Overall, our findings suggest that despite increased curricular standards and course taking requirements in the public sector, public school students are exposed to a less advanced curriculum than comparable students in Catholic and private-secular schools. While our results do not tell us whether this difference is due to self-selection into courses or sector differences in school organization, they suggest that students with similar math ability in Catholic school have a greater opportunity to learn advanced math skills than their public school counterparts. As we will see in the next section, the sector differences in course taking have important implications for students' math gains by the end of high school.

Course Taking and Achievement Differences across School Sector

Our analyses thus far indicate that standards based reforms have not eliminated sector differences in course taking or math achievement. Our last research question focuses on whether course taking differences explain sector differences in achievement gains and advanced math skills.

First, we examined how course taking affects math gains from 10th to 12th grade. In model 4 in Table 2, we added indicators of students' highest math course taken at the end of 12th grade to the regression. Not surprisingly, students who take more advanced courses enjoy much larger gains in achievement from 10th to 12th grade. Accounting for course taking patterns reduces the sector effects in model 3 substantially. The Catholic school advantage observed in model 3 is reduced by 47 percent and is substantively small—about a one-half point gain spread over a two-year interval. The advantage for private-secular school students

Table 6. Multinomial Logistic Regressions Predicting Highest Math Course Taken

	Less than Trigonometry versus Trigonometry	Less than Trigonometry versus Pre-calculus	Less than Trigonometry versus Calculus	Trigonometry versus Pre-calculus	Trigonometry versus Calculus	Pre-calculus versus Calculus
Catholic	.666***	.555***	.481**	−.111	−.185	−.074
	(.148)	(.135)	(.148)	(.143)	(.150)	(.127)
Private-other religious	.231	.208	−.068	−.023	−.300	−.277
	(.272)	(.257)	(.293)	(.224)	(.259)	(.206)
Private-secular	.210	.474	.771*	.264	.561	.297
	(.266)	(.261)	(.341)	(.334)	(.355)	(.237)

Note: $N = 13{,}220$. Pseudo $R^2 = .1852$. Numbers in parentheses are standard errors. Coefficients are unstandardized. The model includes prior achievement, gender, socioeconomic status, disability status, family resource scale, number of siblings, race, family structure, native English speaker, student educational expectations, and parental educational aspirations.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

drops by a third (from 1.8 points to 1.2 points), and the significance level is now at the .05 level. In short, much of the sector differences in achievement gains are explained by sector differences in course taking.

We also examined whether sector differences in course taking explained sector differences in students' proficiency levels. In model 3 of Table 4, we added our course taking variables as predictors of student's proficiency at each skill level. Generally, trigonometry is the most powerful predictors of lower level math skills (levels 1 and 2), while more advanced courses (e.g., pre-calculus and calculus) are stronger predictors of more advanced math skills (levels 3–5; results not shown). Since Catholic and private-secular school students are more likely to take higher level math courses (net of ability and background), course taking differences may explain why private school students enjoy an advantage in advanced math skills. This is confirmed in model 3: Very few sector differences in math skills remain after controlling for course taking. Almost all of the sector differences at levels 2 and 3 become statistically insignificant in model 3. For level 4, the sector differences shrink in magnitude, and the Catholic and private-secular coefficients remain statistically significant. In short, the private school advantage in advanced math skills is largely explained by sector differences in advanced math course taking by the end of high school.

DISCUSSION

The main goal of this study was to examine sector differences in high school course taking and achievement in an era of standards based reform. The findings suggest both similarities and differences with prior research on high schools. In this section, we will describe how our findings fit with prior research on school sector and suggest some implications for educational policy and future research.

The Findings in the Context of Prior Research

Overall, several of our findings were consistent with prior research. First, Catholic school students experienced larger math gains from 10th through 12th grade than comparable public school students. This finding is consistent with research from both HS&B and NELS:88 (Bryk et al. 1993; Gamoran 1996; Hoffer 1998; Hoffer et al. 1985). Thus, changes in the Catholic and public sectors have not eliminated the Catholic advantage in high school achievement; it is now observable over a 20-year period beginning in the 1980s through the early 2000s. However, sector differences in ELS are substantially smaller than those found in analyses of HS&B. Regardless, a decade of standards based reform has not eliminated the gap in achievement growth among public and private high schools.

Second, despite standards based reforms in the public sector during the 1990s, private school students were still taking more advanced math courses than their public school counterparts. Perhaps more importantly, public school students were still less likely than private-secular and Catholic school students to enroll in advanced math courses *even after* controlling for family background characteristics and prior achievement. Thus, it appears that otherwise similar students are exposed to substantially different learning opportunities in public and private schools. Sector differences in course taking were substantively meaningful: Our findings show that private school students were more likely to go much further in the math curriculum than their public school counterparts. This is especially important given that math course taking in high school is an important predictor of college enrollment and completion (Adelman 1999).

Finally, consistent with prior research on school sector, most of the Catholic and private-secular school advantage in achievement was explained by differences in course taking among students. This finding is largely consistent with other studies that suggest that private school students benefit from exposure to a more rigorous academic curriculum than their counterparts in public school (Bryk et al. 1993; Hoffer et al. 1985).

Our analyses also produced some important differences with prior research on school sector and achievement. Unlike prior studies of school sector, we examined sector differences in both gain scores and specific math skills. We argued that simply focusing on gains scores provided an overly narrow view of sector differences in achievement. We hypothesized that since standards based reforms targeted students in the lower half of the achievement distribution, sector differences in math skills would be largest for more advanced skills. Our findings supported this hypothesis. We also found that sector differences in advanced course taking paid substantial dividends for students' higher level math skills. This is especially important to recognize since students with weak math skills are more likely to take remedial courses when in college, which increases their risk of leaving postsecondary education (Adelman 2004). However, it is important to note that very few students in public or private schools reached proficiency in the highest level of math skills. Thus, all schools, regardless of sector, need to provide additional resources to help students at the high end of the achievement distribution master the most challenging parts of the math curriculum.

Our findings also differ from prior studies on sector differences in elementary school that use contemporaneous data. As we noted earlier, our article, along with these other studies of elementary schools, provides the first complete portrait of sector differences in achievement across the entire K through 12 system for a single time period. In evaluating the importance of sector differences in achievement gains, Jencks (1985) argued that sector differences might be large and important if they were cumulative from K through 12. This does not appear to be the case: Achievement gains in math favor public school students in elementary and middle school (Carbonaro 2006; Lubienski and Lubienski 2006; Reardon et al. 2009), while our findings indicate that high school students learn slightly more in private schools than public schools. Thus, analyses of ECLS-K and ELS do not show sizable *cumulative* gains of attending a private school for 12 years. Indeed, it is quite possible that the public school advantage in elementary school and private school advantage in secondary school add up to *no significant sector differences* in achievement from K through 12.

Implications for Policy and Future Research

We believe our findings have some important implications for educational policy and future research on school sector. In terms of policy, public schools should redouble their efforts to enroll their students in higher level math courses if they want to match (or exceed) learning gains produced by private schools. While public school students have made impressive gains in math course taking in the past 15 years (National Science Board 2008), a substantial gap with private school students remains. Some of this gap reflects sector differences in student skills and future educational ambitions. However, it is important to note that private school students are more likely to take advanced math courses *even after controlling for these differences*. At the very least, public schools should work harder to ensure that ambitious, academically talented students make it past algebra II into higher level math courses by the end of high school. Doing so will likely reduce sector differences in both achievement and entry into the postsecondary pipeline.

Of course, past research suggests that course labels are only loosely coupled with curricular coverage and academic rigor. Research on ability grouping and tracking indicates that schools tend to tailor instruction and curriculum to the abilities of their students (Barr and Dreeben 1983; Rowan and Miracle 1983). In addition, teachers report higher levels of self-efficacy in their high track classes than they do in their low track classes (Raudenbush, Rowan, and Cheong 1992). Thus, many public schools may find it more difficult to deliver academic rigor in classrooms because they cannot be as academically selective as private schools. Future research on school sector should examine this issue more closely, and policy makers must address compositional issues when implementing reform.

Second, we believe that both public and private schools need to focus more energy and resources on teaching high level math skills to their students. The chances that students are proficient at level 5 math skills (complex operations and problem solving) are very low in both public and private schools. School personnel in both sectors need to raise the bar and offer greater challenges for their most academically talented students. Future studies could help by identifying which kinds of academic practices and experiences tend to promote the acquisition of high level math skills in high school.

This study also has some important implications for future research on school sector. While sector differences in achievement from K through 12 may be minimal, it is possible that school sector may be more consequential for other outcomes that have received less attention by sociologists, such as educational attainment (e.g., Evans and Schwab 1993; Neal 1997), civic engagement (Dill 2009), and religious practice and identity. Researchers must also look beyond Catholic-public school comparisons and broaden the research agenda to include comparisons with other types of private schools. Our empirical findings (along with other research by Carbonaro 2003, 2006) suggest that private-secular schools do at least as well as Catholic schools in terms of achievement and allocating learning opportunities to students. The inclusion of other types of private schools greatly increases the range of variation on key sector variables that might not otherwise be observable by focusing exclusively on Catholic schools. Bidwell and Dreeben (2006) offer numerous interesting dimensions for studying variation in school organization by school sector: market niches, external and internal hierarchies, chartering practices, organizational forms, and organizational control (to name a few). Heterogeneity within the private sector offers an opportunity to examine greater differences on these dimensions than public-Catholic comparisons allow.

Future research should also explore why the private school advantage in math learning is limited to high school students, with particular attention to differences in school organization across different levels of schooling. We believe the most likely explanation is that sector differences in learning opportunities are much smaller in elementary school (consistent with Carbonaro 2006 and Lubienski et al. 2008) than in high school. If future research further supports this explanation, Bryk et al.'s (1993) claim that the academic advantages of Catholic schooling can be traced back to the egalitarian ethos and communal organization of Catholic schools should be questioned. Why would these characteristics of Catholic schooling affect the organization of Catholic high schools but not Catholic elementary schools? This is a puzzle for which we have no answer.

To address this question, future research must focus on how school sector shapes school organization. While we found that private schools expose their students to a more academic curriculum that enhances achievement growth, we do not explain *why* private schools are organized in this way. School sector remains something of a ''black box'': Research on school sector indicates that private schools are organized differently than public schools, but it is less clear why this is the case. Prior research on Catholic schools focused on an ethos of caring that suffused the school and creates a climate of high expectations for all (see Bryk et al. 1993; Lee et al. 1998). Chubb and Moe (1990) offered a broader argument and analysis that examined bureaucratic and market governance of public and private schools. We hope that future studies in this area build on these theoretical frameworks and operationalize ''sector'' as an institutional environment that affects key attributes of school organization. By doing so, we hope that research can connect broader systemic forces with aspects of school organization that shape how students and teachers interact inside classrooms. Identifying these linkages will hopefully inspire new ideas and insights regarding how we can improve schools in ways that enhance educational outcomes for all students.

Appendix

Evaluating and Dealing with Selection Bias in Sector Effects

In this appendix, we present the details of our supplementary analyses designed to address the issue of selection bias in our findings. We recognize that each of these methods has important limitations (see Morgan and Winship 2007), and selection bias remains a possible explanation for part of our results. However, we argue that these supplementary analyses should increase our confidence that our coefficients reflect something more than selection bias.

Robustness Indicators

Frank (2000) proposes the creation of an indicator that quantifies how robust a given regression coefficient is to possible selection bias. The robustness of inference measure expresses robustness by estimating the magnitude of bias necessary to nullify the statistical significance of the variable of interest. To calculate the robustness to percent bias, the following information is required: the sample size, the *t*-value of x (where x is the variable of interest), the calculation of the two R^2 (y and covariates) and (x and covariates), and the total number of covariates in the model. Frank has made the calculations for the robustness of inference measure easy by creating a spreadsheet where the user enters the required information (for more information, see Ken Frank's Web site at https://www.msu.edu/~kenfrank/research.htm#causal). In general, there are four steps involved in estimating the robustness indicator. First, the correlation between the ''treatment'' and outcomes for all covariates is estimated. Second, a threshold for inference (based on the value of the correlation from step 1) that is statistically significant at .05 must be defined. The value estimated in step 2 is used in the calculation of the threshold for the impact of a confounding variable needed to invalidate the inference. Confounding variables with an impact over the threshold would lead to an invalid inference. However, if the impact is less than the threshold, the inference is robust to the confounding variable. Finally, adjustments are made for the number of included covariates in the model. If the confounding variable impact is less than the threshold, this sensitivity analysis allows the user to have more confidence in the ordinary least squares (OLS) results (DiPrete and Gangl 2004).

Propensity Score Matching

For our propensity score analyses, separate models were run to compare each private school sector with the public sector. To create our propensity scores, we used Stata's *psmatch2* command (Leuven and Sianesi 2003).[19] For each set of *p*-scores, we also used *pscore* (Becker and Ichino 2002) to ensure that the balancing assumptions were met. To estimate average treatment effects, we used several different matching strategies— kernel, nearest neighbor, and radius matching— and they provided similar results. In Table 3, we presented results from the default single nearest neighbor because we need a one-to-one match in calculating the ''r-bounds'' discussed in the following.

We also performed a sensitivity analysis with our results from the propensity score models. For each treatment effect in our propensity score models, we generated a ''gamma'' statistic, which indicates how robust the average treatment effects are to omitted variable bias (DiPrete and Gangl 2004). The *psmatch2* routine creates a new variable for the treated cases that is the ''matched'' outcome (Leuven and Sianesi 2003). The difference between the matched outcome and the actual outcome variable for the treated is used in the model to create ''Rosenbaum bounds'' (''r-bounds''; Gangl 2004). In other words, this sensitivity analysis uses the differences in outcomes from the treated and matched groups to test the bias of the average treatment effect. Rosenbaum bounds provide an estimate of the '''worst-case' scenario'' for the influence a confounding variable may have for the propensity score matching and average treatment effects (DiPrete and Gangl 2004:291).

Alternative Strategies for Correcting for Selection Bias

Another popular strategy for dealing with selection bias is the use of a two-stage selection (or instrumental variable) model. Prior research in this area has used either Catholic religion of the parent Evans and Schwab 1995) or proximity to a Catholic school (Neal 1997) as an instrument in these models. However, Altonji, Elder, and Taber (2005a) argued that Catholic religion is a poor instrumental variable because (in National Education Longitudinal Study of 1988 [NELS:88]) it is related to both 8th-grade control variables and 12th-grade outcomes. This was also

(continued)

Appendix. Continued

true of the Education Longitudinal Study (ELS) data: Overall, Catholics in Catholic schools were more advantaged (in terms of background characteristics) and had higher 12th-grade achievement levels than Catholics in public school. Altonji et al. proposed a new approach to dealing with selection bias in sector research. Possible bias on the unobservables is estimated by calculating the bias (related to being Catholic) on the observables in the model. This approach is similar to the one offered by Frank (2000). After correcting for the potential bias on the unobservables, Altonji et al. find that the Catholic school advantage in NELS:88 becomes small in magnitude and statistically insignificant.

Unfortunately, since ELS begins in 10th grade, we have very few variables that are causally prior to selection into Catholic school; we are essentially limited to measures of family background and ascriptive characteristics (race and gender). In addition, we do not have information about whether ELS students were in public or private schools in eighth grade—a key strategy that Altonji et al. (2005) used to adjust for selection bias. These limitations in the ELS data make it impossible to replicate their approach.

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NOTES

1. While there has been much work on sector differences in achievement, other researchers have examined attainment differences such as high school graduation, college enrollment, and graduation. Generally, these studies also find significant sector differences that favor Catholic schools (e.g., Evans and Schwab 1995; Neal 1997).
2. Altonji, Elder, and Taber (2005a, 2005b) challenge the validity of two commonly used instrumental variables in sector research: whether a family is Catholic and proximity from a Catholic school. They argue that both variables are inadequate because they are related to other predictors of achievement and the outcome. They devise a method of estimating bias on the unobservables from the bias on the observables and then use this to correct for selection bias. We discuss this method further in the appendix.
3. The ''Prospects'' study was designed to evaluate the efficacy of Title I programs in public and private schools. Consequently, the sample of Catholic schools ($n = 35$) was composed of students who largely matched the (less advantaged) public school population.
4. The exception is Jepsen (2003), who analyzed data collected in 1992 and 1993. While this makes the data set comparable with National Education Longitudinal Study of 1988 (NELS:88) in terms of time period, the sample of Catholic schools in the Prospects data was not representative of the Catholic sector (as noted previously).
5. For example, the percentage of schools offering precalculus/analysis rose from 75 percent (in 1990) to almost 90 percent in 2000. The percentage of schools offering statistics and probability doubled (from 24 percent in 1990 to 51 percent in 2000), and schools offering calculus rose from 79 percent to 93 percent in 2000.
6. Hyde et al. (2008) examined the ''depth of knowledge'' assessed on high stakes tests from several different several states. The assessments that they examined emphasized low level skills like ''recall'' and ''skill/concept'' mastery, but devoted very little attention to higher level skills such as ''strategic'' and ''extended'' thinking.
7. This group includes students who dropped out and did not return to school, students who dropped out and received an alternative degree, and students who were out of scope.
8. We used the student reports of highest math course taken as of 12th grade. We compared the student reports with the information about course taking from the transcript files and found that they were largely consistent. Student reports of course taking had less missing data than the transcript files, so we decided to use the student reports in our analyses.
9. Among many of the categories within each sector, there are relatively few schools available for analysis. Thus, further disaggregation of the sector categories is not viable.
10. We used the *ice* command in Stata to create the five imputed data sets. The same predictors were included to impute missing values for each variable in the data set. Further information about multiple imputation procedures is available upon request from the authors.

11. The sample sizes throughout the article are rounded to the nearest 10 in compliance with the National Center for Education Statistics (NCES) regulations for using restricted data.
12. Results from data that use multiple imputations for missing data do not yield estimates of the R^2 for the regression. Since readers will clearly be interested in the R^2 for each regression in our tables, we provide R^2 estimates from a standard regression analysis of one of the five imputed data sets in our tables.
13. Interestingly, although the coefficients are not significant for Catholic schools, the point estimates for the interaction terms suggest that socioeconomic status (SES) is more important for achievement and the black-white gap is bigger in Catholic schools. This is completely contrary to the findings from High School and Beyond (HS&B).
14. When conducting sensitivity analyses, a model without mediating variables should be used. Thus, we use model 3 from Table 2.
15. Probit regression was used to model selection into Catholic, private-religious, and private-secular. Separate propensity scores were generated for Catholic, private-religious, and private-secular schools. Predictors of enrollment in Catholic school include a combination of the following: parent is Catholic, student background characteristics (female, SES, race, number of siblings, family resource scale, family structure, disability), urban/rural/suburban dummies, regional dummies (East, Midwest, South), and numerous interactions. Predictors of enrollment in private-religious and private-secular schools were the same with two exceptions: (1) The parent is Catholic variable was not used, and (2) the list of interaction terms was similar but not identical to those included in the Catholic enrollment equation.
16. The unmatched results compare all cases in the treatment and control groups, while the ''matched'' estimates only include those that have matches based on our matching method. Not surprisingly, the estimates for the matched sample are more conservative than the unmatched; regardless, sector differences are still positive and significant.
17. Predicted probabilities were generated by plugging in the mean value for each variable in the regression using one of the imputed data sets.
18. For example, among students who took calculus, only 63.5 percent of students took both trigonometry and pre-calculus. Of calculus students, 23 percent went directly from trigonometry to calculus (skipping pre-calculus), and 13.6 percent entered calculus without taking either trigonometry or pre-calculus. Among students whose highest course is pre-calculus, roughly half skipped trigonometry.
19. This command allows the user to specify which variables should be included to estimate the likelihood of the student's attendance at a particular school sector. Similarly, *pscore* (Becker and Ichino 2002) will also run the probit regressions need to calculate the propensity score. In addition, *pscore* will alert the user if the balancing property has been satisfied.

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