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Does cream-skimming curdle the milk? A study of peer effects

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Abstract

The determinants of education quality remain a puzzle in much of the literature. In particular, no one has been able to isolate the effect of the quality of a student's peers on achievement. I identify this by considering the introduction of a magnet school into a school district. The magnet school selects high quality students from throughout the school district, generating plausibly exogenous variation in the quality of classmates remaining to those students in the regular schools. I find that the loss of high ability peers lowers the performance of low-scoring students remaining in regular schools.

JEL classification: I2; J0; H4

Keywords: Peer effects; Educational economics; Resource allocation

1. Introduction

The quality of a student's peers is generally thought to affect student achievement.[1] Efforts estimating this peer effect have met with mixed success. The main complication arises from Tiebout (1956) self-selection, the notion that parents sort according to the local public school, a local public good, that best fits their preferences. Unobservable family qualities are then correlated with their child's achievement as well as the quality of peers they choose for their child. Highly involved parents are more likely to spend time helping their child with his homework as well as choose better schools and peers for him. This may bias the coefficients on peer group characteristics in standard regression analyses.[2]

This paper estimates peer effects using the introduction of a magnet school into a school district as a plausibly exogenous source of variation in peer quality. The magnet school selects high ability students from throughout the school district into a science and technology-focused college preparatory program. The introduction of this cream-skimming generates exogenous variation in the quality of classmates remaining to those students in the regular schools, thus minimizing selection bias.

I use the percentage of students at each school scoring in each national quartile to compare students' test scores before and after the introduction of the magnet school.

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[1]Classic references finding evidence of positive peer effects are Henderson, Mieszkowski, and Sauvageau (1978) and Summers and Wolfe (1977). See also Glewwe (1997), Hallinan (1990), Sacerdote (2001), Slavin (1987) and others cited below.

[2]Evans, Oates, and Schwab (1992), Case and Katz (1991), and Manski (1993) provide some discussions of the problem of selection bias in estimating peer effects. The direction of the bias depends on how the omitted variables are correlated with peer quality and with student achievement.

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I first estimate peer effects using ordinary least squares (OLS). Because these estimates are likely to be biased, I then instrument for peer effects using school-specific policy dummies. I also present differences-indifferences estimates comparing the change in scores for schools differentially affected over time, controlling for the quality of the entering freshmen.

When their high ability peers leave, low-scoring students are affected negatively; high-scoring students are also affected negatively, but this effect is not statistically significant. After adjusting for the scores of the leavers, if an additional 1% of the high ability students leave a school, there is a one percentage point increase in the percentage of remaining students scoring in the bottom national quartile and a one-half of a percentage point decrease in the percentage of remaining students scoring in the top national quartile. Data limitations prevent the evaluation of the effect of the magnet school on the students enrolled in the magnet school. Thus, although the achievement of students remaining in the regular schools is adversely affected, this is potentially offset by gains to the magnet school students.

2. A model of test scores, leavers and peer effects

Student test scores are a function of their own characteristics, school quality, cohort quality and school-specific cohort quality. Test scores for individual i in school j in year t in eighth and 11th grades are X_{ijt}^{8} and X_{ijt}^{11}. Eighth grade test scores are a function of the school effect, s_j^8, the cohort effect, c_j^8, the school/cohort effect, $\underline{sc}_{ijt}^{8}$, and individual characteristics, ε_{ijt}^{8} :

$$X_{ijt}^{8} = f(s_j^8, c_j^8, \underline{sc}_{jt}^{8}) + \varepsilon_{ijt}^{8}, \tag{1}$$

ε_{ijt}^{8} is the innate ability of student i in school j at time t. The school effect is a fixed school quality allowing better schools (including better teachers, better facilities, and the like) to improve student scores more. The cohort effect is a time-specific, county-wide effect that captures systematic variations such as the weather (snow days, for example), the difficulty of the exam given in a particular year, changes in county policy, and the like. The school/cohort effect reflects school-specific shocks to achievement in a given year such as a class of better students.

Similarly, 11th grade test scores are a function of the school effect, s_j^{11}, the cohort effect, c_t^{11}, the school/cohort effect, $\underline{sc}_{jt}^{11}$, and the individual characteristics, ε_{ijt}^{11}. They are also a function of the percentage of students from each school/cohort that leave the school to attend the magnet school, L_{jt}:

$$X_{ijt}^{11} = g(s_j^{11}, c_j^{11}, \underline{sc}_{jt}^{11}, L_{jt}) + \varepsilon_{ijt}^{11}. \tag{2}$$

Leavers all score in the top national quartile and represent a decline in the quality of one's peers. The students' eighth grade scores determine the percentage of students from each school/cohort that leave.

The percentage of students scoring in each national quartile is a function of the school effect, the cohort effect, the school/cohort effect and the individual characteristics. For example, the percentage of students scoring in the top national quartile, top_{jt}^{8}, is:

$$\mathrm{top}_{jt}^{8} = \frac{\sum_{i=1}^{I}(f(s_j^8, c_j^8, \underline{sc}_{jt}^{8}) + \varepsilon_{ijt}^{8} \geq \kappa_{0.75})}{I} \tag{3}$$

where I is the total number of students in a school/cohort and $I(\cdot)$ is an indicator function equal to one if $f(s_j^8, c_j^8, \underline{sc}_{jt}^{8}) + \varepsilon_{ijt}^{8} \geq \kappa_{0.75}$ and zero otherwise. $\kappa_{0.75}$ is the cut-off for the top national quartile. Linearizing this function gives:

$$\mathrm{top}_{jt}^{8} = \beta_0 + s_j^8, c_j^8, \underline{sc}_{jt}^{8} \tag{4}$$

where sc_{jt}^{8} captures both the school/cohort effect, $\underline{sc}_{jt}^{8}$, and the average of the students' individual abilities, ε_{ijt}^{8}. Similarly, for the bottom national quartile:

$$\mathrm{bottom}_{jt}^{8} = \tilde{\beta} + s_j^8 + c_j^8 + \underline{sc}_{jt}^{8} \tag{4'}$$

Linearizing the 11th grade functions yields:

$$\mathrm{top}_{jt}^{11} = \alpha_0 + s_j^{11} + c_j^{11} + \underline{sc}_{jt}^{11} + \alpha_1 L_{jt}. \tag{5}$$

$$\mathrm{bottom}_{jt}^{11} = \tilde{\alpha}_0 + \tilde{s}_j^{11} + \tilde{c}_j^{11} + \tilde{s}c_{jt}^{11} + \tilde{\alpha}_1 L_{jt}. \tag{5'}$$

This paper estimates the effect of the departure of high-scoring classmates on the students staying behind, α_1 and $\tilde{\alpha}_1$.

The direction of peer effects determines the signs on α_1 and $\tilde{\alpha}_1$. In this analysis, peer quality shifts at the school level. The peer effect estimated may occur through shifts in peer quality outside the classroom, shifts in peer quality inside the classroom, or both. If all students benefit from having more high ability peers, α_1 would be negative and $\tilde{\alpha}_1$ would be positive. If students benefit from a more homogeneous peer group, α_1 would be positive and $\tilde{\alpha}_1$ would be negative.

3. Data

In the fall of 1985, Fairfax County, a Northern Virginia suburb of Washington, D.C., introduced a new Governor's school. This school, the Thomas Jefferson High School for Science and Technology (TJHSS&T), admits the top 2% of entering high school freshmen from the county. Entrants are selected on the basis of a weighted average of their GPA and their test score on the admission test (a standardized aptitude test). The magnet school redistributes ability within the school district and affects the distribution of student ability in both the magnet school and the existing regular public schools.[3]

To estimate peer effects, we need data on the percentage of students leaving each regular school and test scores. Individual level data for the years before and after the introduction of the magnet school would be ideal. Exact distributions would allow for a direct comparison of any distributional shift in test scores. Student test scores from eighth grade would eliminate cohort effects in the data. Data on racial composition, English as a Second Language students, students receiving free- or reduced-price lunch, and parental background would eliminate race, language, income and parent education as the determinants of changes in student achievement.[4,5]

The available data are, however, more limited. The data include annual national percentile equivalents for mean scale scores and the percent scoring in each national quartile. Fairfax County Public School Reports (Fairfax County Public Schools, 1987) and Fairfax County Public School Profiles (Fairfax County Public Schools, 1988–1992) provide these figures for each of the 19 high schools active during the relevant period. The data are a repeated cross-section of school level data.

The test administered in the 11th grade for the school years 1985–1986 and 1986–1987 (classes of 1987 and 1988) was the 1978 edition of the SRA Achievement Series. This paper uses the composite scores on the SRA, a weighted average of the reading, mathematics, and language arts scores. The reading portion tests vocabulary and comprehension; the mathematics portion tests computation, problem solving, and mathematics concepts; and the language arts section tests spelling, usage, and mechanics. This analysis uses the national percentile scores.

During the school years 1987–1988 through 1990–1991 (classes of 1989–1992), Fairfax County administered the Tests of Achievement and Proficiency (TAP) to 11th graders. This analysis uses the TAP composite scores, a composite of student performance on vocabulary, reading comprehension, language skills, work-study skills, and mathematics skills. National percentile score equivalents are used.

In all schools, I observe only the percentage of students that scored in each national quartile. The descriptive statistics in Table 1 show that Fairfax County test scores are above average. Each year, about three-quarters of its students score in the top national quartile and less than 10% score in the bottom national quartile. Test scores after the magnet school are lower on average with more students scoring in the lowest quartile and fewer students scoring in the highest quartile. The drop in scores after the magnet school's introduction includes test effects, cohort effects, and peer effects.

The change in the test administered likely lowered mean scores. Although the county does not provide information on how the two tests directly compare, the introduction of a new test typically results in an initial drop and then rise in test scores as students generally perform better on exams that their teachers are more familiar with.[6] In addition, Fairfax County students may rank lower on skills that the old test did not evaluate but the new test does. However, using the variation in the number of students exiting regular public schools to estimate the peer effect minimizes the effect of the change in test.

Students leaving for the magnet school affect both the distribution of ability and the population of students at a school. If the student population at a school changes, the number of students scoring in a given quartile may not change but the percentage of students scoring in each quartile will change.[7] Ninety-seven percent of the magnet school students score in the top national quartile in 11th grade.[8] I assume that all of the magnet school students score in the top quartile to allow for a population correction.

To correct for the change in population, denote the number of remaining students scoring in the top quartile with z^{top} and the number of leavers with x. The uncorrected population of the school is pop. I adjust the percentage of students scoring in the top quartile to $(z^{\mathrm{top}} + x)/(\mathrm{pop} + x)$. Similarly, the lowest quartile is calculated as the number of remaining students scoring in the bottom quartile divided by the sum of the

[3]In 1993–1994, 7.8% of school districts had magnet schools. More importantly, nearly one-quarter of students in the nation (approximately 8.5 million students) lived in a school district with at least one magnet school. See DeAngelis and Rossi (1996).

[4]Many magnet schools intend to desegregate although desegregation is not the purpose of this Governor's school.

[5]For a richer analysis and to examine the long-term economic effects of peer quality, we could also look at other student achievement measures. For example, Evans et al. (1992) find peer influence on pregnancy and dropout rates.

[6]See, for example, Linn, Graue, and Sanders (1990).

[7]For example, consider a school where initially 50 students out of 200 (25%) score in the bottom quartile. Ten students (5%) leave for the magnet school. If the same 50 students con tinue to score in the bottom quartile, the change in population after the magnet school implies that 26.3% of students (50/290) score in the bottom quartile. Correcting for the popu lation change restores the percentage of students scoring in the bottom quartile to 25%.

[8]As admission test scores play a large role in admittance to the magnet school, we expect these high scores on other tests.

Table 1
Descriptive statistics

Variable	Classes of 1987 and 1988	Classes of 1989–1992
	Mean (SD)	Mean (SD)
Regular high schools		
Eleventh grade test scores		
Mean national percentile score	77.31 (7.06)	71.86 (7.95)
% of students scoring in the bottom quartile	6.03 (3.69)	8.66 (4.61)
% of students scoring in the top quartile	55.58(10.36)	49.52 (10.96)
Eighth grade test scores		
Mean national percentile score	77.33 (6.20)	75.35 (7.11)
% of students scoring in the bottom quartile	3.41 (2.33)	4.32 (3.51)
% of students scoring in the top quartile	58.53 (10.29)	54.73 (11.54)
Magnet school		
Eleventh grade test scores		
Mean national percentile score		97.25 (0.50)
% of students scoring in the bottom quartile		0.05 (0.10)
% of students scoring in the top quartile		99.25 (0.58)
Average % of students attending magnet school		3.40 (1.62)

uncorrected population, pop, and the number of leavers, x. This correction makes the percentage of students scoring in the bottom and top quartiles after the magnet school directly comparable to those from before the magnet school. In the first 2 years, no students leave for the magnet school and no correction is needed.[9]

The student directory for the magnet school (TJHSS&T, 1987 and 1988) provides the elementary school attended by each of the approximately 400 Fairfax County students each year. I use the Fairfax County Public School Attendance Boundaries (Fairfax County Public Schools, 1984–1985) to match the elementary schools to their high schools. Students are counted as leaving the high school that students from their elementary school attend. The majority of Fairfax County elementary schools feed directly into one high school; almost a quarter feed into more than one high school. For the split feeders, I allocate the students to each high school using the percentage of elementary and intermediate school general membership attending each intermediate and high school. I omit the 7% of students that did not list the elementary school attended. I also exclude those students who list a private elementary school, assuming their parents would have continued to enroll them in private school.[10] For each school, I calculate the percentage of leavers by dividing the number of students leaving for the magnet school by the sum of the students remaining and the students leaving. On average, 3.2% of students from each regular school attend the magnet school.

4. Empirical strategy and results

This paper estimates the effect of removing the highest ability students from regular schools on the students left behind. Examining the introduction of a magnet school is advantageous because the change in the peer group is

[9]Using the percent leavers to construct the dependent vari able, however, introduces another potential source of bias. By definition, the number of leavers is positively correlated with the corrected percentage of students scoring in the top quartile and negatively correlated with the corrected percentage of students scoring in the bottom quartile. This biases the top quartile estimates upward and the bottom quartile estimates downward. I correct for this using the average number of leavers for a school over the 6 years, $\bar{x}$, to construct the dependent variable. For example, the percentage of students scoring in the top quartile is $(z^{\text{top}}+\bar{x})/(\text{pop}+\bar{x})$. The estimates, available from the author, are smaller but qualitatively similar.

[10]About 6% of Fairfax County's high school-aged students attended private schools in 1985–1986 (author's calculations from figures from Virginia's Triennial School Census 1986 provided by Laura Robinson, FCPS). Prior to the magnet school, students that attended public elementary schools may have been more likely to enroll in private high schools. If, in the absence of the magnet school, all leavers would have left their regular high school for a private school, then the intro duction of the magnet school would not change peer quality. This biases my estimates towards not finding evidence of peer effects.

not largely affected by Tiebout sorting. Using a single school district requires less data since levels of spending, student/teacher ratios, and other quality measures are the same.

Some sources of bias remain. Some of these bias the estimates toward finding evidence of positive peer effects. For example, if schools that lost more students also lost more high quality teachers, the estimates are biased downward for the top quartile of students and upward for the bottom quartile of students. About half of the original teachers in the magnet school transferred from other Fairfax County public schools.[11] This represents 0.6% of the high school teachers in Fairfax County Public Schools.[12] Since the magnetschool particularly searches for teachers skilled in dealing with gifted students, the loss of these teachers most likely affected the higher achieving students remaining in the regular schools.

The county's admissions policies may also bias the estimates of peer effects. The county may smooth the number of students attending the magnet school from each regular school. Then, students drawn from schools with disproportionately large percentages of students scoring in the top 2% of the county are likely to be of higher quality than those drawn from less affected schools.[13] The drop in quality for highly affected schools would then be larger than that reflected by the percentage of leavers. More importantly, as the county implicitly raises admission standards for that school's students, the students remaining in the regular school may be of higher quality. This implies greater correlation between the errors and the percentage of leavers and biases the estimated coefficient on the percentage of leavers for the top quartile and downward for the bottom quartile.[14]

This paper does not explicitly correct for demographic changes in the student body. Student achievement may change because the socio-economic or racial make-up of a school shifts and because the distribution of peer quality shifts. Hoxby (2000) finds stronger intra-race peer effects and peer effects that act through gender rather than ability. Not accounting for the changing demographics may bias the estimates; the direction of the bias depends on the direction of demographic change. Demographics usually change quite slowly; the included time trend controls for any county trends in demographics.

Students leaving for the magnet school may affect class size, biasing the estimates of peer effects. Losing only a few students may reduce class size. At some point, however, a school may lose enough students to have one less class, potentially increasing class size. A decrease in class size would bias the estimates upward for the bottom quartile and downward for the top quartile.

There is some evidence of parents pressuring the regular schools to improve so that their children can get into the magnet school. In the mid-1980s, only a handful of eighth graders were sent to local high schools for Geometry class. In 2001, about 3% of eighth graders in the school district were enrolled in Geometry.[15] Also, families may move into the county in the hopes of sending their child to the magnet school, increasing the demand for school resources. Both pressures presumably raise the overall quality of students in the county. This would bias the estimates upward for the top quartile and downward for the bottom quartile. Considering only the initial, transitional years of the magnet school and including a time trend should minimize this problem.

Figs. 1 and 2 present scatter plots of the average change in the percentage of students scoring in the top and bottom national quartiles on the mean percentage of leavers, making the appropriate student population correction. If high quality students benefit from having high quality peers in school with them, the introduction of the magnet school should decrease the percentage of remaining students scoring in the highest quartile. As a larger proportion of students leave for the magnet school, the larger decline in mean peer ability should lead to a larger decrease in high-scoring students. Similarly, if low ability students benefit from high ability peers, the percentage of remaining students scoring in the lowest national quartile should increase and increase more as larger percentages of students leave for the magnet school. Finding little change in student achievement or change that does not increase with a greater loss of high ability peers would contradict the presumption of meaningful peer effects.

The negative correlation of -0.33 (p-value $= 0.18$) for the top quartile suggests that having more leavers decreases the percentage of students scoring in the top national quartile. The positive correlation of 0.40 (p-value $= 0.10$) for the bottom quartile suggests that

[11] Personal communication with Geoff Jones, former principal at TJHSS&T.

[12] See www.tjhsst.edu and nces.ed.gov/pubs2002/2002351.pdf for figures. Numbers are the author's calculations.

[13] I thank Caroline Hoxby for pointing this out to me.

[14] A similar concern is that more involved parents may pressure their children to apply to the magnet school. Then, schools with many leavers would be filled with more interested parents and would have a higher quality of leaver. On the other hand, high achieving students at a lower quality school may have more to gain by applying to and attending the magnet school. This implies that the highly affected schools are lower quality schools. As this paper observes those students left behind, for whom the number of peers leaving for the magnet school is exogenous, this source of bias should not greatly affect the results.

[15] Communication with Ron Zirkle, Math Curriculum Specialist in Fairfax County.

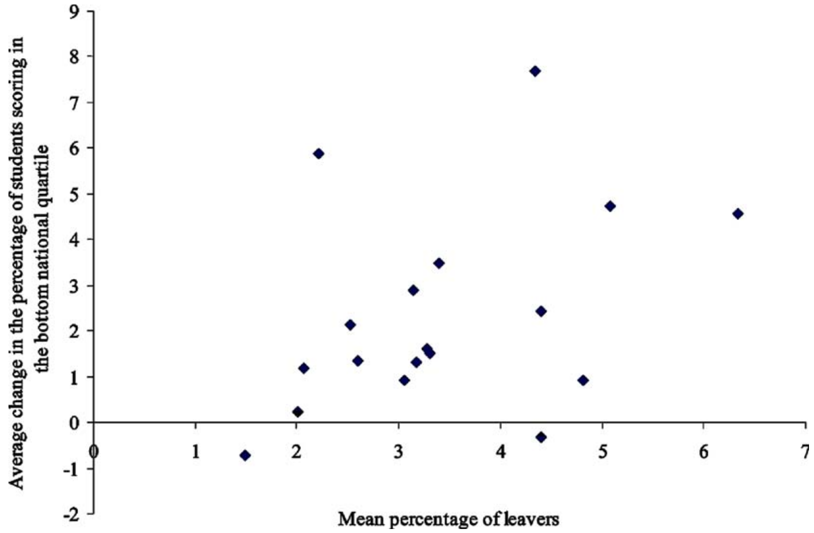

Fig. 1. Bottom national quartile.

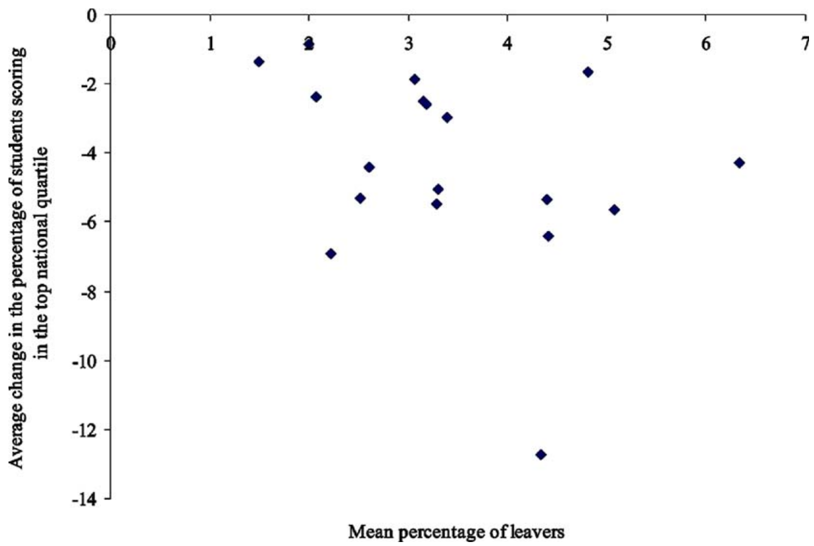

Fig. 2. Top national quartile.

having more leavers increases the percentage of students scoring in the bottom national quartile. Both of these results suggest that high- and low-scoring students score lower when their high-scoring peers leave.

4.1. OLS and IV estimates using 11th grade test scores

I first estimate the peer effect using OLS. The quartile figures are corrected for changes in the school population during the magnet school years. I estimate Eqs. (5) and (5′) including year dummies and school fixed effects. These results, in Table 2, suggest that students leaving for the magnet school have no effect on the students remaining in the regular schools. The departure of an additional 1% of the high-scoring students leads to a 0.16 percentage point increase in the remaining students scoring in the bottom national quartile and a 0.04 percentage point increase in the remaining students scoring in the top national quartile. These estimates are small and not statistically different from zero.

OLS estimation of Eq. (5) yields biased results. This bias arises from treating the school/cohort shock as the error term. A particularly good year of students in a school's community leads to a larger percentage of

Table 2
Ordinary least squares and instrumental variables estimates of peer effects

	% scoring in bottom quartile		% scoring in top quartile	
	OLS	IV[a]	OLS	IV[a]
% leaving$_t$	0.155 (0.169)	0.702 (0.316)	0.036 (0.273)	−0.742 (0.524)
R^2	0.87	0.86	0.94	0.93
Number of observations	108	108	108	108
F-test (,)	8.04	33.33	11.80	81.61
Prob $>F$	0.0000	0.0000	0.0000	0.0000

Robust standard errors in parentheses. Year dummies and school fixed effects are included and jointly significant. The percentage of students scoring in each quartile is corrected for the change in population occurring with the loss of the magnet school students, assuming that all magnet school students score in the top national quartile. Thus, coefficients should be interpreted as peer effects.
[a]School-specific indicator variables for the magnet school policy are used to instrument for the percent leaving.

leavers as well as fewer students in the lowest quartile and more students in the upper quartile. This biases peer effects estimates upward for the top quartile and downward for the bottom quartile.

An alternative to OLS is to instrument the percentage of leavers with indicator variables for the introduction of the magnet school. The introduction of the magnet school is presumably exogenously determined among the school district's schools and so uncorrelated with the school/cohort shocks. P_{jt} denotes a school-specific policy dummy for school j equal to one during a time, t, that the magnet school exists and zero otherwise. These school-specific policy dummies all equal zero for the first 2 years and one for the next 4 years. Table 2 presents results from the instrumental variables (IV) estimation using the policy dummies as instruments for the percentage of leavers.[16]

The IV estimates reveal the expected bias in the OLS estimates. The peer effect is larger, suggesting that cohort effects help determine both the percentage of leavers and 11th grade performance. The IV estimates show that an additional 1% of students leaving for the magnet school leads to a 0.7 percentage point increase in the remaining students scoring in the bottom national quartile, a 9% increase at the mean. An additional 1% of students leaving for the magnet school leads to a 0.7 percentage point decrease in the percentage of remaining students scoring in top national quartile, a 1.3% decrease at the mean. The estimate for the bottom quartile is statistically different from zero at the 5% level; the estimate for the top quartile is not statistically different from zero. These estimates are statistically different from each other. Also, the estimates of peer effects on the bottom quartile and on the top quartile are jointly significant at the 5% level. Low ability students suffer from the loss of their high-scoring peers; the high ability students may be unaffected by this loss.

The school-specific policy dummies used as instruments in Table 2 all equal zero in the first 2 years and one in the next 4 years. Using these instruments is essentially the regression of the change in the average percentage scoring in a given quartile from before to after the magnet school on the mean percentage of leavers for the first 4 years of the magnet school. Estimating this regression using the average changes and the average percentage of leavers provides more accurate standard errors. However, even allowing for more conservative standard errors, the results are quantitatively and qualitatively equivalent to the estimates in Table 2.[17]

4.2. OLS and IV estimates using 11th and eighth grade test scores

Eighth grade performance data also permit differences-in-differences estimates of the peer effect, α_1 and $\tilde{\alpha}_1$. The differences-in-differences specification uses a different source of identification for peer effects than the IV estimation and is robust under different assumptions. The first difference is over a cohort's eighth and 11th grade scores and directly controls for school/cohort effects. The second difference is over time and eliminates the school effects. The remaining right hand side variables are the cohort effect, the school/cohort effects, and the difference in the percentage of leavers between years. Differencing Eqs. (4) and (5) at times t and t–1 yields:

$$\begin{aligned}(\mathrm{top}^{11}_{jt} - \mathrm{top}^{8}_{jt}) - (\mathrm{top}^{11}_{jt-1} - \mathrm{top}^{8}_{jt-1}) \\ = (c^{11}_{t} - c^{11}_{t-1}) - (c^{8}_{t} - c^{8}_{t-1}) + (sc^{11}_{jt} - sc^{11}_{jt-1}) \\ (sc^{8}_{jt} - sc^{8}_{jt-1}) + \alpha_1(L_{jt} - L_{jt-1}). \qquad (6)\end{aligned}$$

[16]The first stage of the IV estimation is presented in Table A1. The instruments are fairly good with significant explanatory power.

[17]Results available from author upon request.

Consistent estimation of α_i using (6) requires some assumptions on the cohort effects, c_t and the school/cohort effects, sc_{jt}. The differences between the cohort effects $(c_t^{11} - c_{t-1}^{11}) - (c_t^{8} - c_{t-1}^{8})$ must not be correlated with the change in the percentage of leavers. This difference would be identically zero if either $(c_t^{11} - c_t^{11})$ over all t or if $c_t^{11} - c_{t-1}^{11}$ and $c_t^{8} - C_{t-1}^{8}$ over all t. The first condition means that every cohort gets the same value added in 11th grade as in eighth grade. The second implies that every cohort gets the same value added from the county. A similar assumption must be made for the school/cohort effects sc_{jt}'s: the difference between the school/cohort effects $(sc_{jt}^{11} - sc_{jt-1}^{11}) - (sc_{jt}^{8} - sc_{jt-1}^{8})$ must not be correlated with the difference in the percentage of leavers. This difference would be identically zero if, over all t, $(sc_{jt}^{11} - sc_{jt-1}^{11}) = (sc_{jt}^{8} - sc_{jt-1}^{8})$; intuitively, the value added by the school is the same across cohorts. A similar analysis can be done for the bottom quartile using Eqs. (4′) and (5′).

For the OLS differences-in-differences estimates, time dummies proxy for the cohort effects. IV may also be used. Using the indicator variable for the magnet school policy, P_t, as an instrument requires only that the policy is not correlated with the differences either between the cohort effects or between the school/cohort effects. This instrument, however, precludes the use of time dummies as proxies for the c_t's. A time trend is included instead.

Table 3 presents the OLS differences-in-differences estimates. The full differences-in-differences specification in columns (3) and (6) suggests that there is no peer effect. The differences between columns (2) and (3) and between columns (5) and (6) imply that cohort effects, as before, help determine both the percentage of leavers and 11th grade performance.

I instrument for the change in the percent leavers using the change in the magnet school policy. This is a good instrument; the F-test for the first stage regression is 33.16 with a p-value of zero. The second stage results for the IV differences-in-differences regressions are in Table 4.

These estimates imply that a 1% increase in the percentage of leavers decreases the percentage of remaining students scoring in the top quartile by about 0.5 percentage points. At the mean, this corresponds to about a 1% decline. The same 1% increase in the percentage of leavers increases the percentage of remaining students scoring in the bottom quartile by about 1.2 percentage points. At the mean, this is about a 13% increase. The estimate for the bottom quartile is statistically different from zero at the 5% level; the estimate for the top quartile is not statistically different from zero. These estimates are statistically different from each other. Also, the estimates of peer effects on the bottom quartile and on the top quartile are jointly significant at the 10% level. Low ability students suffer from the loss of their high-scoring peers; the high ability students may be unaffected by this loss.

As expected, these results are qualitatively and quantitatively similar to the earlier IV estimates. The instruments used in the initial IV estimation corrected for school-specific changes in cohort quality. The direct correction allowed for with differences-in-differences produces a similar result.

Table 3
Ordinary least squares differences-in-differences estimates of peer effects

	Differences-in-difference in % scoring in bottom quartile $(11th_t–8th_t)–(11th_{t-1}–8th_{t-1})$			Differences-in-difference in % scoring in top quartile $(11th_t–8th_t)–(11th_{t-1}–8th_{t-1})$		
	(1)	(2)	(3)[a]	(4)	(5)	(6)[a]
% leaving$_t$−% leaving$_{t-1}$	0.827	0.679	0.277	−0.982	−0.746	−0.008
	(0.171)	(0.167)	(0.185)	(0.310)	(0.323)	(0.339)
Time trend		−0.744			1.180	
		(0.231)			(0.415)	
Constant	−1.012	2.067		1.849	−3.036	
	(0.346)	(0.974)		(0.659)	(1.746)	
R^2	0.19	0.26	0.44	0.08	0.16	0.43
Number of observations	90	90	90	90	90	90
F-test (,)	23.53	14.53	9.68	10.02	10.67	17.58
Prob >F	0.0000	0.000	0.0000	0.0021	0.0001	0.0000

Robust standard errors in parentheses. The percentage of students scoring in each quartile is corrected for the change in population occurring with the loss of the magnet school students, assuming that all magnet school students score in the top national quartile. Thus, coefficients should be interpreted as peer effects.

[a]Year dummies included and jointly significant.

Table 4
Instrumental variables differences-in-differences estimates of peer effects ($11th_t$–$8th_t$)–($11th_{t-1}$–$8th_{t-1}$)

	% scoring in bottom quartile		% scoring in top quartile	
% $leaving_t$ −% leaving $_{t-1}$	1.467 (0.331)	1.153 (0.338)	−1.157 (0.521)	−0.484 (0.564)
Time trend		−0.591 (0.253)		1.264 (0.446)
Constant	−1.459 (0.440)	1.125 (1.079)	1.972 (0.812)	−3.556 (2.106)
R^2	0.08	0.23	0.08	0.15
Number of observations	90	90	90	90
F-test (,)	19.67	13.29	4.93	7.25
Prob $>F$	0.0000	0.0000	0.0289	0.0012

Robust standard errors in parentheses. The percentage of students scoring in each quartile is corrected for the change in population occurring with the loss of the magnet school students, assuming that all magnet school students score in the top national quartile. Thus, coefficients should be interpreted as peer effects. The change in percent leaving is instrumented using the change in the magnet school policy.

5. Concluding remarks

The results presented above suggest that removing high quality students from a school adversely affects their low ability peers remaining behind. The use of school-specific policy dummies as instruments leads to plausibly unbiased estimates of peer effects. Specifically, the departure of an additional 1% of high-scoring students increases the percentage of remaining students scoring in the bottom national quartile by about 9%. The departure of an additional 1% of high-scoring students decreases the percentage of remaining students scoring in the top national quartile by about 1%, although this effect is not statistically different from zero.

Previous estimates find moderately sized peer effects. Hoxby (2000), for example, finds that a one standard deviation increase in the average test score of a student's classmates, increases the average test score of the student by about 0.4 standard deviations. Sacerdote (2001) finds that a one standard deviation increase in a student's randomly assigned college roommate's GPA is associated with about a 0.05 standard deviation increase in the student's own GPA.

The magnitude of the estimates in this paper, because of the discrete nature of scoring in a national quartile, depends on the distribution of scores around the cut-off points. If students are bunched immediately above the 25th national percentile, a small shift in test scores may lead to a large change in the percentage of students scoring in the bottom quartile. Also, these estimates reflect a three-year change in peer quality.

The magnitude may be more striking since I consider changes in the school population, not changes in the ability of peers in the same classroom. Given the popularity of tracking programs, where high ability students are rarely in classes with low ability students, this suggests that peer effects are likely to be occurring not in the classroom, but rather in the hallways, at athletic events, during study halls, and the like.[18] This is consistent with previous literature, such as Sacerdote (2001) and Case and Katz (1991), which find evidence of peer effects outside of the classroom.

The asymmetry of the peer effect is also consistent with the previous literature. Although Slavin (1990) finds no differential effect of peer quality on student achievement, Argys, Rees, and Brewer (1996) find that ability grouping helps the average and above-average students and harms, to a lesser extent, the below-average students. Betts and Shkolnik (1999) argue that, once adequate controls for class ability are included, this result is diminished in size.

A more complete analysis than the current one would compare the adverse effects to the remaining students to the potential benefits to the magnet school students. Also, since the data are limited to the ability of the students, these peer effects may be working through ability, or they may work through other factors correlated with ability such as family wealth or income, gender, and race.

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Appendix

Table A1.

[18] In the nationally representative sample from 1987 to 1992 used in Betts and Shkolnik (1999), 73% of middle and high school students are tracked.

Table A1
First stage of instrumental variables estimation

	% leaving$_t$
P_{1t}	4.339 (0.492)
P_{2t}	3.152 (0.49)
P_{3t}	6.334 (1.229)
P_{4t}	2.003 (1.229)
P_{5t}	1.495 (0.393)
P_{6t}	2.068 (0.741)
P_{7t}	2.522 (0.267)
P_{8t}	3.392 (0.808)
P_{9t}	3.062 (0.592)
P_{10t}	3.282 (0.695)
P_{11t}	4.399 (0.813)
P_{12t}	2.217 (0.471)
P_{13t}	4.406 (0.569)
P_{14t}	3.175 (0.55)
P_{15t}	5.08 (0.355)
P_{16t}	2.606 (0.229)
P_{17t}	4.812 (0.912)
P_{18t}	3.306 (0.665)
R^2	0.80
Number of observations	108
F-test (,)	49.84
Prob $>F$	0.0000

Robust standard errors in parentheses.

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