Desegregation and the Achievement Gap: Do Diverse Peers Help?

Jane Cooley

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Motivation
Model
Data
Identification
Heterogeneity
Estimation
Results
Policy Implications
Conclusion

Background

- 50 years after the end of de jure segregation in the South, public schools remain considerably segregated.
  - Around 70% of black students attend predominantly nonwhite schools. (Clotfelter (2004))
- The achievement gap between white and nonwhite students persists at a sizable magnitude.
- Research Question: **Can racially diverse classrooms help to narrow the achievement gap?**

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- The achievement gap between white and nonwhite students persists at a sizable magnitude.
  - By the end of grade 4, black and Hispanic students are already two years behind their white peers. (2000 NAEP)
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  - Spillovers may vary by achievement percentile and race.
    - Introduces possibility for efficiency gains.
    - Students may form different race-based reference groups within the classroom.

Contributions

- Incorporate mechanisms highlighted by psychological and sociological work into a production function type model
  - Write down model of student achievement which treats students as optimizing agents.
- Study identification of achievement "production function" in a general framework.
- Make use of quantile regression techniques to capture distributional peer effects.
- Simulate achievement under alternative classroom assignment policies.

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Intuition
Simple Example

- Achievement production function with peer spillovers:

$$Y_1 = \alpha_0 + \alpha_1 Y_2 + X_1\alpha_2 + X_2\alpha_3 + K\alpha_4 + \mu + \theta_1,$$
$$Y_2 = \alpha_0 + \alpha_1 Y_1 + X_2\alpha_2 + X_1\alpha_3 + K\alpha_4 + \mu + \theta_2,$$

  - Y_1, Y_2—achievement
  - X_1, X_2—individual characteristics
  - K—classroom inputs (observed to econometrician)
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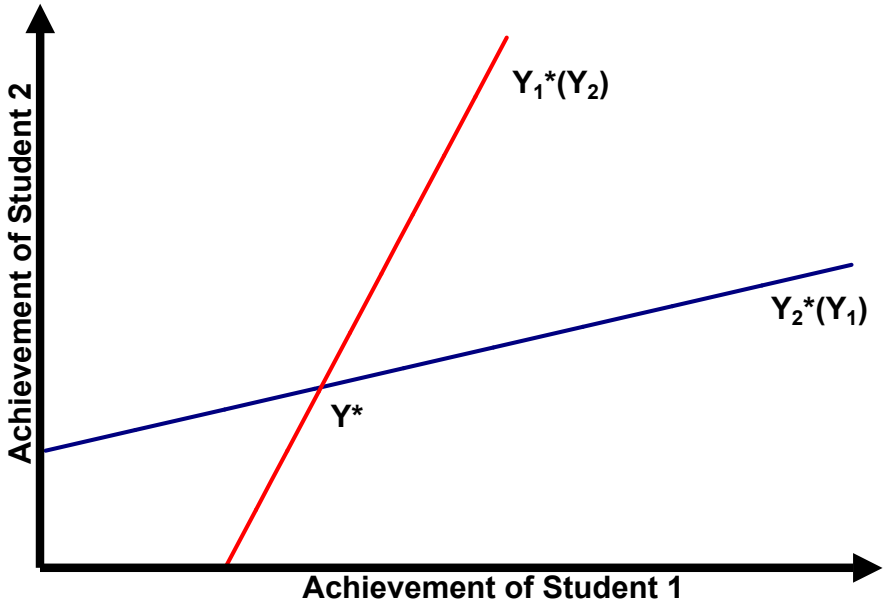

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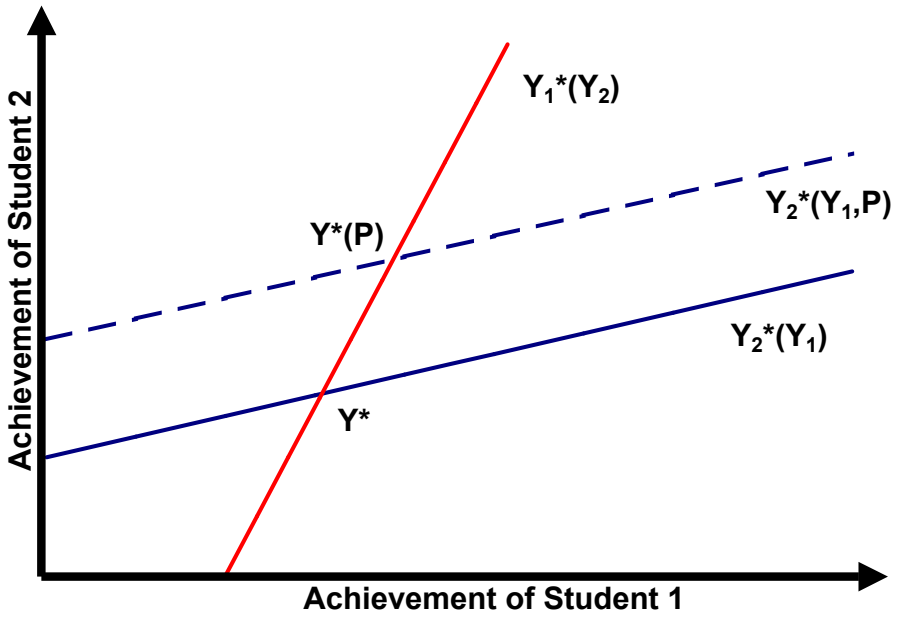

Primitives

- Achievement production:

$$Y_i = g(e_i, e_{-i}; X_i, X_{-i}, K, \mu, \theta_i). \tag{1}$$

  - Strategy of student (effort): $e_i \in [\underline{e}, \overline{e}]$
  - Peer effort: $e_{-i} = (e_1, ..., e_{i-1}, e_{i+1}, ..., e_N)$

- Utility function:

$$U_i = u(Y_i, c_i(e_i, e_{-i}); X_i, X_{-i}, K, \mu), \tag{2}$$

- Cost of effort: $\partial c_i(\cdot)/\partial e_i \geq 0$, $\partial U_i/\partial c_i < 0$.
  - *Interpretation*: Potentially captures a type of "peer pressure" (conformity) effect.

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Equilibrium

- Simultaneous move game of symmetric information (θ unobserved)
- Best response function, $e_i^*(e_{-i}; X_i, X_{-i}, K, \mu)$, solves:

$$e_i^*(e_{-i}; S) \in \text{argmax}_{e_i} \tilde{U}_i(e_i, e_{-i}; S), \tag{3}$$

- *Remaining problem*: effort is unobservable.
- Given $\partial g(\cdot)/\partial e_i > 0$, the game in effort maps into game in achievement.
- Achievement equilibrium:

$$Y_i^* = q(\tilde{Y}_{-i}^*, X_i, X_{-i}, K, \mu, \theta_i), \tag{4}$$

where
$\tilde{Y}_i = \int_\Theta g(e_i, e_{-i}; X_i, X_{-i}, K, \mu, \theta_i) f(\theta_i | X_i, \bar{X}_{-i}, K, \mu) d\theta_i.$

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Data

- Administrative Data: North Carolina public school students
  - Unit of observation: individual student ($i = 1, ..., N$)
  - Grades: 3-5 ($g = 3, 4, 5$)
    Academic years: 1998/99-2002/03 ($t = 1, ..., T$)
  - Peer groups identified at the classroom level.
  - Outcome measure: reading achievement on "End-of-Grade" exams (Y_{igt})
    - Standardized raw scores to have mean 0, std. dev. 1 for a given grade across all years
    - Benchmarked against cut-off for passing in each year (which is material-based) to make scores comparable across years for a given grade

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Summary Statistics

	White		Nonwhite	
	Mean	Std. Dev.	Mean	Std. Dev.
Reading score (standardized)	0.5238	0.8757	-0.1465	0.8760
Male	0.5060	0.5000	0.4902	0.4999
Parent HS/some post-sec.	0.5934	0.4912	0.7779	0.4156
Parent 4-year degree+	0.3608	0.4802	0.1115	0.3148
Class size	23.15	3.395	22.41	3.542
Characteristics of Classroom Peer Groups				
Avg peer reading	0.3211	0.4027	0.1429	0.4212
Avg. white peer reading	0.5126	0.4218	0.4107	0.4810
Avg. nonwhite peer reading	-0.0945	0.5126	-0.1664	0.4386
% white ach. level 1 or 2	0.1548	0.1389	0.1826	0.1799
% NW ach. level 1 or 2	0.3415	0.2432	0.3675	0.2101
% nonwhite	0.3160	0.1900	0.4902	0.2238
% parent with HS degree	0.6334	0.2201	0.6997	0.1977
% parents 4-year +	0.2928	0.2438	0.2243	0.2115
N	462,374		279,344	

Instrument

- Student accountability policy:
  - Sets a minimum achievement level (Achievement Level III) for automatic promotion to the next grade
  - Enacted for 5th graders in 2000/01 academic year
- Necessary conditions:
  - Accountability affects students "in danger of being retained," but not binding for others.
  - % of students in danger of failing under the new standards for promotion is independent of unobserved classroom-level effects.
  - Does not affect the incentives of teachers or schools directly (i.e., does not shift unobserved classroom-level input).
    - Preceded by School Accountability in 1996, which provided incentives for schools and teachers to shift resources to low achievers.

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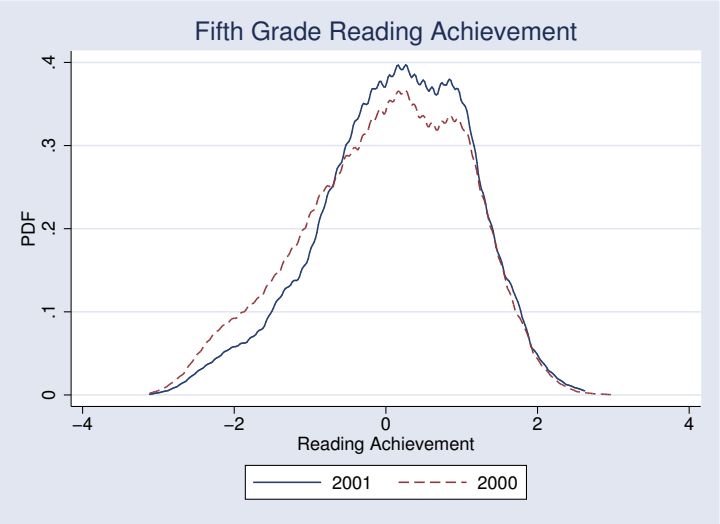
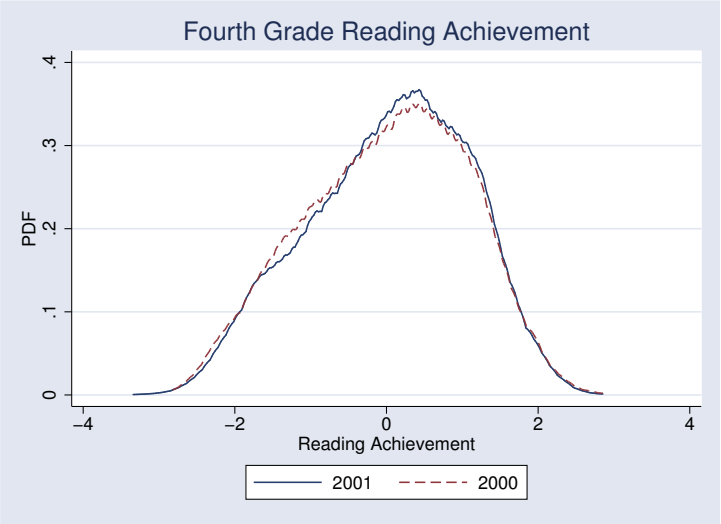
Effect of Student Accountability

Charlotte-Mecklenburg Schools





Effects of student accountability:

- Primarily shifts performance of low achievers.
- Does not affect students in grade 4 where it is not binding (i.e. does not appear to be a school-wide response to new student accountability standards).

Important Sources of Heterogeneity

- Peer effects may vary across the percentiles of the achievement distribution.
  - *Intuition:* Low-achieving students may respond more to increases in average peer achievement than high-achieving students
  - *Implication:* Racially-diverse classrooms may be more "efficient" as well as more equitable
- Students may form different race-based reference groups within the classroom.
  - *Intuition:* Students may seek to conform more to the behavior of peers of the same race.
  - *Implication:* Creating racially-diverse classrooms would have limited effects in the absence of cross-racial spillovers.

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- Peer effects may vary across the percentiles of the achievement distribution.
  - *Intuition:* Low-achieving students may respond more to increases in average peer achievement than high-achieving students
  - *Implication:* Racially-diverse classrooms may be more "efficient" as well as more equitable
- Students may form different race-based reference groups within the classroom.
  - *Intuition:* Students may seek to conform more to the behavior of peers of the same race.
  - *Implication:* Creating racially-diverse classrooms would have limited effects in the absence of cross-racial spillovers.

Estimation

- Estimation proceeds in 2 steps:
  1. *1st stage*: Estimate reduced form equation of peer achievement on independent variables and instrument (mean regression).
     - Recover predicted residual from 1st stage.
  2. *2nd Stage*: Estimate quantile regression of achievement on peer achievement of each reference group, controlling for first stage residual.
- In linear-in-means case, method equivalent to 2SLS

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First Stage

- Peer achievement:

$$\bar{Y}^{k}_{-ict} = \alpha_0 + X_{it}\alpha_1 + \bar{X}_{-ict}\alpha_2 + \alpha_3 P_{it} + \vec{\bar{P}}_{-ict}\alpha_4 + K^1_{ct}\alpha_5 + SchYr_{it} + \mu_{ct} + \delta_{ict},$$

  - $k \in \{W, NW\}$ indexes race subgroup, c classrooms
  - X_{it}— parental education, sex, portion free reading time, low-performing dummy based on prior year test scores (whether scores below 30th percentile),
  - $\bar{X}_{-ict}$—mean characteristics of peers
  - $P_{it} \equiv$ low performing $\times$ 5th grader in 2001 and beyond
  - K^1_{ct}—indicator for student accountability policy, dummy for no peers of other race
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Second stage

- Quantile structural function:

$$Y^*_{ict} = \beta_0 + \beta_1 \bar{Y}^W_{-ict} + \beta_2 \bar{Y}^{NW}_{-ict} + X_{it}\beta_3 + \bar{X}_{-ict}\beta_4 + \beta_5 P_{it}$$
$$+ K^1_{ct}\beta_6 + \beta_7 \hat{SchYr}^W_{it} + \beta_8 \hat{SchYr}^{NW}_{it} + \beta_9 \hat{\mu}^W_{ct} + \beta_{10} \hat{\mu}^{NW}_{ct} + u_{ict},$$

- $\hat{\mu}_{ct} \equiv \mu_{ct} + \delta_{ict}$ (1st stage resid.)
- β's are quantile-specific ($\beta(\theta_i)$) and race-specific.

$$\text{argmin}_{\vec{\beta}(\tau)} \frac{1}{NGT} \sum_i \sum_g \sum_t \rho_\tau(u_{ict})$$
$$\text{where } \rho_\tau(u_{ict}) = \tau u^+_{ict} + (1-\tau) u^-_{ict}.$$

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First Stage: White

	White	
Dependent Variable	Avg. White	Avg. NW
Acct*% white ach. 1 or 2	0.2808***	0.0217
	[0.0200]	[0.0318]
Acct*% white ach. 3	0.1538***	-0.0169
	[0.0148]	[0.0249]
Acct*% NW ach. 1 or 2	-0.017	0.1676***
	[0.0132]	[0.0302]
Acct*% NW ach. 3	-0.0093	0.0977***
	[0.0131]	[0.0289]

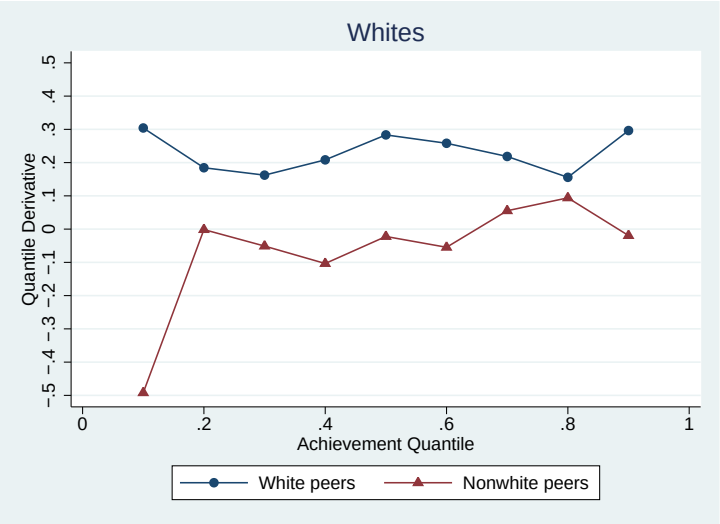
First Stage: Nonwhite

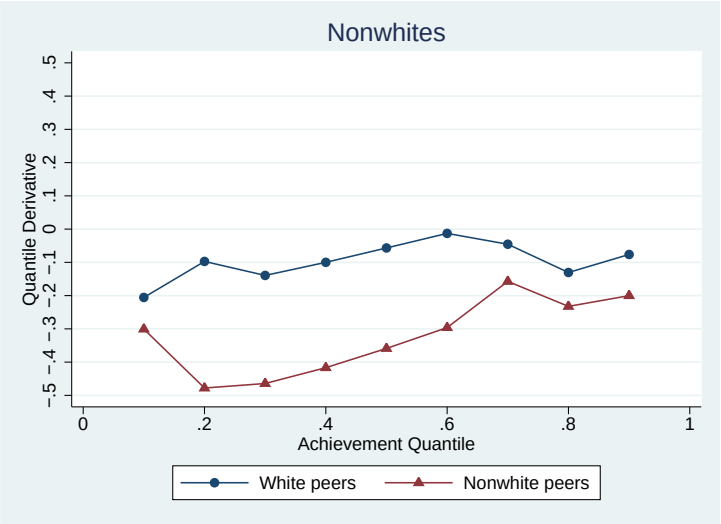
Dependent Variable	Nonwhite	
	Avg. White	Avg. NW
Acct*% white ach. 1 or 2	0.2234***	-0.0123
	[0.0318]	[0.0229]
Acct*% white ach. 3	0.1612***	-0.01
	[0.0254]	[0.0189]
Acct*% NW ach. 1 or 2	-0.0337*	0.1980***
	[0.0202]	[0.0202]
Acct*% NW ach. 3	-0.0193	0.1240***
	[0.0183]	[0.0196]

Effect of Peer Achievement by Race: Median

Dependent Variable	White	Nonwhite
Avg. white reading	0.2816***	0.0755
	[0.0589]	[0.1072]
Avg. nonwhite reading	-0.0207	-0.1515
	[0.0688]	[0.1106]
Accountability	-0.0439***	0.0278**
	[0.0078]	[0.0145]
Achievement level 1 or 2	-1.6203***	-1.5672***
	[0.0049]	[0.0091]
Achievement level 3	-0.7415***	-0.6954***
	[0.0030]	[0.0084]
Accountable*Level 1 or 2	0.2741***	0.2019***
	[0.0080]	[0.0090]
Accountable*Level 3	0.1073***	0.0573***
	[0.0048]	[0.0077]
N	462,374	279,344

Quantile Treatment Effects





Average Marginal Effects of Peers for Whites

	Mean	.1 Quantile	Median	.9 Quantile
Avg. white peer reading	0.0926***	0.0830*	0.1188***	0.1236***
	[0.0304]	[0.0469]	[0.0248]	[0.0306]
Avg. nonwhite peer reading	-0.0139	-0.1743**	-0.0106	0.0496
	[0.0478]	[0.0822]	[0.0353]	[0.0520]
% white ach. level 1 or 2	0.0375**	0.0291	0.0507***	0.0553***
	[0.0160]	[0.0246]	[0.0130]	[0.0160]
% white ach. level 3	0.0115	0.0055	0.0186***	0.0189**
	[0.0079]	[0.0122]	[0.0064]	[0.0079]
% NW ach. level 1 or 2	-0.0147	-0.1137**	-0.0110	0.0253
	[0.0286]	[0.0490]	[0.0211]	[0.0313]
% NW ach. level 3	-0.0089	-0.0415***	-0.0077	0.0059
	[0.0092]	[0.0154]	[0.0069]	[0.0101]
% nonwhite	-0.0151***	-0.0329***	-0.0136***	-0.0040
	[0.0038]	[0.0061]	[0.0032]	[0.0037]
% male	-0.0017	-0.0071***	-0.0003	0.0003
	[0.0018]	[0.0027]	[0.0014]	[0.0020]
% Parents HS Degree	-0.0038	0.0294*	-0.0077	-0.0213**
	[0.0092]	[0.0153]	[0.0074]	[0.0107]
% parents 4-year degree	0.0041	0.0663**	-0.0091	-0.0333
	[0.0178]	[0.0303]	[0.0141]	[0.0212]

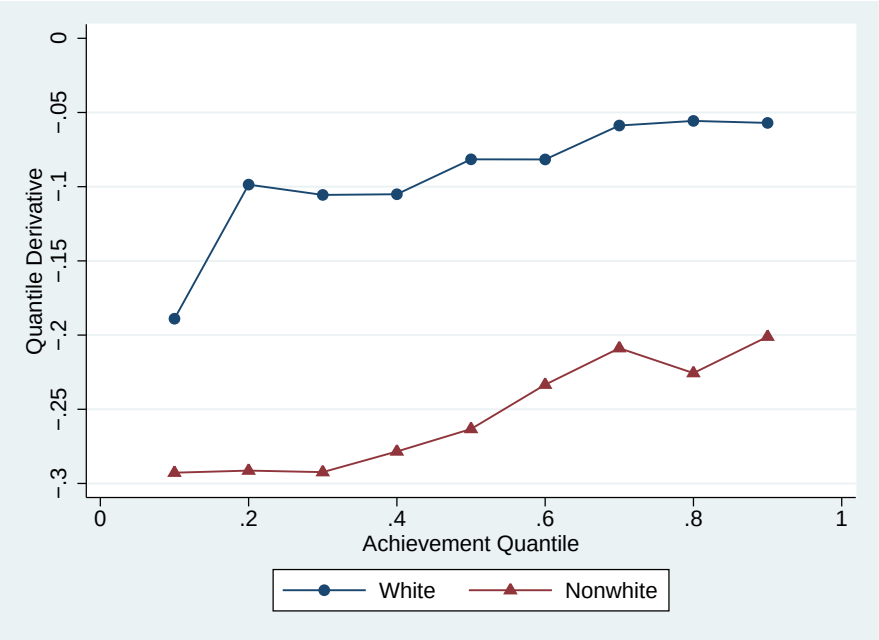
Defn: Marginal effect of 1 std. dev. increase in peer variable (mean averages over quantiles)

Average Marginal Effects of Peers for Nonwhites

	Mean	.1 Quantile	Median	.9 Quantile
Avg. white peer reading	0.0177	-0.0374	0.0363	0.0494
	[0.0580]	[0.0809]	[0.0516]	[0.0558]
Avg. nonwhite peer reading	-0.0796	-0.1928**	-0.0665	0.0078
	[0.0574]	[0.0959]	[0.0485]	[0.0483]
% white ach. level 1 or 2	-0.0059	-0.045	0.0057	0.0177
	[0.0338]	[0.0463]	[0.0299]	[0.0327]
% white ach. level 3	-0.0011	-0.0208	0.0045	0.0082
	[0.0150]	[0.0205]	[0.0131]	[0.0148]
% NW ach. level 1 or 2	-0.0631*	-0.1194**	-0.0572**	-0.0175
	[0.0325]	[0.0545]	[0.027]	[0.0272]
% NW ach. level 3	-0.0243***	-0.0323**	-0.0238***	-0.0195***
	[0.0081]	[0.0138]	[0.0066]	[0.0067]
% nonwhite	-0.0480***	-0.0668***	-0.0467***	-0.0330***
	[0.0071]	[0.0097]	[0.0065]	[0.0066]
% male	-0.0058*	-0.0115***	-0.0059**	-0.0027
	[0.0031]	[0.0044]	[0.0027]	[0.0030]
% Parents HS Degree	0.0007	0.0188	-0.0026	-0.0148
	[0.0114]	[0.0178]	[0.0093]	[0.0092]
% parents 4-year degree	0.0327	0.0807**	0.0228	-0.0036
	[0.0248]	[0.0365]	[0.0209]	[0.0218]

Defn: Marginal effect of 1 std. dev. increase in peer variable (mean averages over quantiles)

Peer Group Composition Effects (%NW)



Policy Experiments

- What happens if desegregate peer groups?
- Merge predominately white, higher-achieving district with neighboring predominately nonwhite, lower-achieving district.
- Isolate peer from resource effect.

Durham and Chapel Hill

Summary Statistics (Grade 5, Academic Year 2001-02)

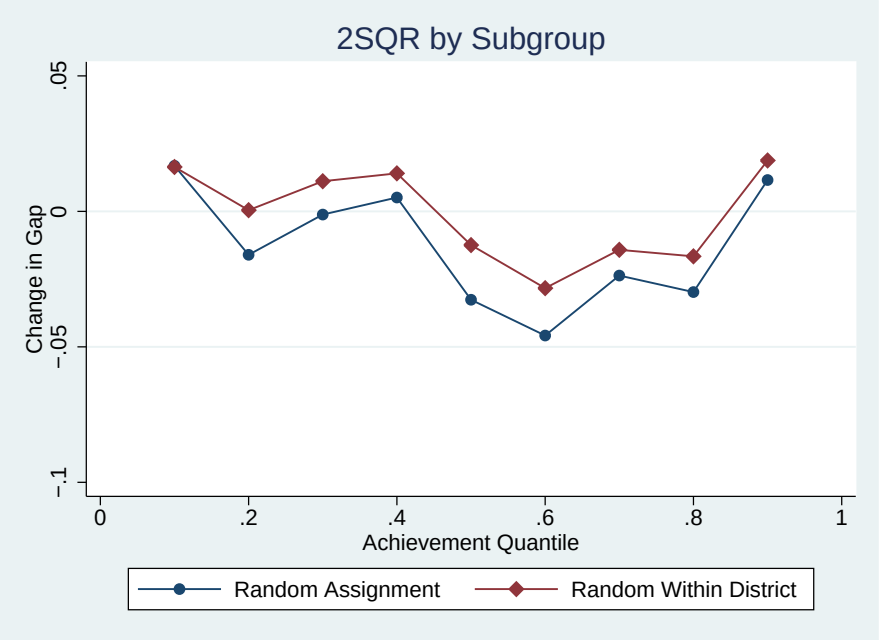
	Durham	Chapel Hill
Reading	0.4040	0.9385
Avg. white reading	0.7387	1.1316
Avg. nonwhite reading	0.0909	0.1769
% Nonwhite	0.5610	0.2231
%NW in avg. white class	0.4584	0.2223
%NW in avg. nonwhite class	0.6408	0.2258
% Parents with HS degree	0.5559	0.1984
% Parents with 4-year degree	0.4029	0.7910
N	1,538	593

Merger of Durham and Chapel Hill Districts

	Nonwhite	White	Gap	Average
Durham Students (N=1,538)				
Observed	0.0858	0.8359	0.7501	0.4140
Deseg. within district	0.0905	0.8269	0.7364	0.4127
Deseg. across district	0.1316	0.8562	0.7246	0.4487
Chapel Hill Students (N=593)				
Observed	0.2272	1.1461	0.9190	0.9478
Deseg. within district	0.2058	1.1533	0.9476	0.9488
Deseg. across district	0.1085	1.0962	0.9878	0.8830
Overall				
Observed	0.1040	0.9627	0.8587	0.5625
Deseg. within district	0.1053	0.9603	0.8549	0.5619
Deseg. across district	0.1286	0.9543	0.8257	0.5695

2SQR vs. 2SLS

Changes in Quantile Achievement Gap



Durham to Chapel Hill

	Nonwhite	White	Gap	Average
Durham 5th graders 2001-02 (N=1,538)				
Observed	0.0858	0.8359	0.7501	0.4140
Counterfactual	0.2348	0.9072	0.6724	0.5290
Change	0.1490	0.0713	-0.0777	0.1150
Low Equilibrium Durham Schools (N=201)				
Observed	-0.1599	0.2395	0.3994	-0.0744
Counterfactual	0.0689	0.4308	0.3619	0.1463
Change	0.2288	0.1913	-0.0375	0.2208
Chapel Hill 5th graders 2001-02 (N=593)				
Observed	0.2272	1.1461	0.919	0.9478
Counterfactual	0.0688	1.0249	0.9561	0.8185
Change	-0.1584	-0.1212	0.0371	-0.1292

Main Results

- Large behavioral spillovers between peers in a classroom
- Stronger peer spillovers within race than across races
- Lower-achieving nonwhites receive negative spillovers from nonwhite peers, while whites across the percentiles of the achievement distribution receive positive spillovers from white peers
- Desegregating peer groups may not be the most effective way to narrow the achievement gap.
- However, desegregating peer groups raises the achievement of the target population—low-achieving nonwhites (and whites) who are caught in the low-equilibrium peer groups.

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