Uncovering Peer Effects in Social and Academic Skills

Román Andrés Zárate

University of Toronto

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Outline

Motivation

- Social skills and connections are key determinants of labor market outcomes.
  - ⋆ Five more friends raises wages as much as one year of schooling (Lleras-Muney et al., 2020).
  - ⋆ The labor market increasingly rewards social skills (Deming, 2017).
  - ⋆ Complementary to cognitive skills (Weinberger, 2014).
- Affect productivity in organizations and firms:
  - ⋆ Team performance (Wooley et al., 2010; Weidmann & Deming, 2020).
  - ⋆ Management practices (Hoffman & Tadelis, 2020).
- There is still little evidence on how social skills are formed.

Motivation

- Socialization with others is an essential input for the formation of social skills.
- Childhood and adolescence are crucial for the malleability of personality and non-cognitive skills (Heckman & Mosso, 2014).
- The peers with whom we interact in schools can have short- and long-term consequences on our social capital.
- The literature on peer effects in education is extensive, but...
  - ⋆ Mainly focused on academic achievement.
  - ⋆ The evidence remains inconclusive.
  - ⋆ Random allocation to groups:
    - ∗ Weak variation in peer characteristics (Angrist (2014)).
    - ∗ Imprecise estimates.
    - ∗ Amplify bias.

This Paper

- Question: How peers' social centrality and academic achievement affect students' outcomes?
- I use an experimental approach to study peer effects:
  1. Students are classified into types.
  2. Randomize to the type of peers.
- Two advantages for identification that improve precision and bias:
  1. Strong variation in peer characteristics.
  2. Relies in variation across treatments rather than groups.
- Large-scale field experiment at selective boarding schools in Peru.
  1. Less or more central peers (friendship and study networks).
  2. Lower or higher-achieving peers (score in the admission test).
- Study mechanisms using a comprehensive survey that measures beliefs and social interactions.

Results

Main Results:

1. Boys with more central neighbors have more friends and better social skills. There are no effects on social outcomes for girls.
   - ⋆ They also drop out less and enroll at better colleges.
2. Academic peer effects are, on average, a precisely estimated zero.
   - ⋆ Negative impacts for lower-achieving girls.
3. No evidence of cross-skills peer effects.

Mechanisms:

- Gender differences in how students form beliefs about their abilities.
  - ⋆ Boys are more confident than girls in their social and academic skills.
  - ⋆ Girls think they are less sociable when assigned to more central neighbors, but boys believe the opposite.
  - ⋆ Similar evidence for academic peer effects.
- The formation of friendships or study groups is insufficient for peer effects.

Literature

1. Formation of social skills (Alan et al., 2020; Falk et al., 2018; Rao, 2018)
2. Peer effects on academic skills: (Angrist, 2014; Booji et al., 2017; Carrell et al., 2009; Carrell et al., 2013; Epple & Romano, 2011 ; Sacerdote, 2001; Sacerdote, 2014; Feld & Zolitz, 2017).
3. Cross-skill peer effects:
   - ⋆ Social norms (Bursztyn and Jensen, 2015; Bursztyn et al., 2018).
   - ⋆ Social networks and complementarities in effort (Calvo-Armengol et al., 2009).
4. Mechanisms:
   - ⋆ Self-confidence and ranking concerns (Benabou & Tirole, 2002; Compte & Postlewaite, 2004, Elsner and Isphording, 2017; Tincani, 2017; Murphy & Weinhardt, 2020).
   - ⋆ Social interactions (Calvo-Armengol et al., 2009, Carrell et al., 2013).

Outline

Peer Effects

- A general peer effect model corresponds to the following equation:

$$y_{ig} = \alpha + \pi_0 x_i + \pi_1 \overline{x}_g + \varepsilon_{ig} \tag{1}$$

- A common strategy is to exploit natural experiments of random allocation to groups.
- However, there are some concerns...
  - ⋆ The variation in peer characteristics from random groups is small.
  - ⋆ Manski: "random assignment will not work well in a large group setting, because all groups will have essentially the same distribution of types."
  - ⋆ Angrist (2014): "the interpretation of results from models that rely solely on chance variation in peer groups is therefore complicated by bias from weak instruments."

Peer effects:

Acemoglu & Angrist (2001) show that in equation 1:

$$\pi_1 = \frac{\psi_1 - \psi_0}{1 - \tau^2}, \tag{2}$$

- ψ_0 is the OLS estimator of the parameter ψ in the model $y_{ig} = \alpha + \psi x_i + \varepsilon_i$.
- ψ_1 is the 2SLS estimator of this model, using the vector of group dummies g as instruments for x_i.
- Angrist (2014): 2SLS can exceed OLS for other reasons than social influences.
  - ⋆ Weak instrument bias: 2SLS $\longrightarrow$ OLS.
  - ⋆ Measurement error: Feld & Zolitz (2017) show that peer effects are underestimated with:
    - ∗ Classical measurement error.
    - ∗ Random group assignment.

Why would peer effects increase with group size?

1. Precision: $var(\hat{\pi}_1) = \frac{N_g}{N_g - 1} N_g \frac{\sigma_\varepsilon^2}{\sigma_x^2}$
   - ⋆ Angrist argues this can explain the results in Glaeser et al. (2003).
   - ⋆ Precision would imply both large positive and large negative estimates.

2. Amplification of bias: $plim\ \psi_1 = \pi_0 + \frac{cov(\varepsilon_{ig}, \overline{x}_g)}{var(\overline{x}_g)}$.
   - ⋆ Similar to weak instruments: small violation of the exclusion restriction can lead to a large bias.
   - ⋆ Even if $cov(\varepsilon_{ig}, \overline{x}_g)$ also decreases with group size, but at a lower rate than $var(\overline{x}_g)$.

- simulations that illustrate both problems.

3. Multiple peer attributes (test scores, demographics, unobservables) vary simultaneously across groups.
   - ⋆ Can aggravate the weak variation concerns.

Outline

I use an experimental approach to study peer effects:

1. Define the students' attribute of interest, x.
2. Classify students by quantiles of x into types τ_i.
   - ⋆ In the simplest example using the median into two types $\tau_i = \{H, L\}$.
3. Randomly assign students to a treatment group defined by the type of peer $t_i = \{H, L\}$.
   - ⋆ Equivalent to randomizing students to student-peer-type combinations:

		Type of peer: High	Type of peer: Low
Type of student	High	Group A H=100%, L=0%	Group B H=50%, L=50%
	Low	Group B H=50%, L=50%	Group C H=0%, L=100%

Experimental Design:

4a. Use the allocation to student-peer-types combinations to organize the students on a list.

- ⋆ Organize the names by student-peer-types combinations in a random order.
- ⋆ Within each group, the order of students is random but alternate different types.

$$\underbrace{H-H-H-H}_{\text{Group A}}-\underbrace{H-L-H-L}_{\text{Group B}}-\underbrace{L-L-L-L}_{\text{Group C}}$$

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4b. Use the list to organize the students into the context-specific groups.

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4b. Use the list to organize the students into the context-specific groups.

Dorm 1	**Dorm 2**	**Dorm 3**
Students:	**Students:**	**Students:**
H_1, H_2, H_3, H_4	L_1, L_2, L_3, L_4	H_5, L_5, H_6, L_6

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4b. Use the list to organize the students into the context-specific groups.

Dorm 1	**Dorm 2**	**Dorm 3**	**Dorm 4**
Students:	**Students:**	**Students:**	**Students:**
H_1, H_2, H_3	H_4, L_1, L_2	L_3, L_4, H_5	L_5, H_6, L_6

;

Advantages with respect to random allocation to groups

1. There is strong variation in peer characteristics.
   - ⋆ High-type student: Combination A vs Combination B.
   - ⋆ Low-type student: Combination B vs Combination C.
2. Identification comes from variation across treatments rather than groups (combinations).
   - ⋆ Students in the same combination belong to different treatments arms.
   - ⋆ Students in different combinations belong to the same treatment arm.

$$y_{ig} = \alpha + \pi_0 x_i + \pi_1 \overline{x}_g + \varepsilon_{ig}$$
$$\overline{x}_g = \mu_0 + \lambda h_{ig} + \mu_1 x_{ig} + \gamma H_{ig} + \nu_{ig}$$

- Improves precision and bias: simulations.

3. Generates an ex-ante commitment to study:
   - ⋆ A set of pre-specified characteristics.
   - ⋆ Non-linearities.
   - ⋆ Trade-off between statistical power and more treatments.

Outline

Selective Boarding Schools in Peru (COAR):

- Apply this design to study how peers' social centrality and academic achievement affect students' outcomes.
- Public school model for the most talented low-income students in the country.
- Operate for the last three years of high school.
- One school in each region of Peru (for a total of 25).
- Boarding schools.
- Work as elite private high schools in Latin America.
- Selective exam for admission.
- Each school had its own system to allocate students to dorms and classrooms before the intervention.
  - ⋆ Variation in types of dormitories across schools: pictures.

Classifying Students by Academic and Social Skills

1. Lower or higher-achieving students:
   - ⋆ The score in the admission test.
   - ⋆ Cells of school$\times$grade$\times$gender.
   - ⋆ Classification determined by the cell-specific median.
2. More or less sociable students:
   - ⋆ Baseline survey with four questions of social interactions: 1. roommates, 2. friends, 3. study partners, 4. social activities partners (playing sport or games).
   - ⋆ Undirected network with the four questions.
   - ⋆ Use the cell-specific median eigenvector centrality.
   - ⋆ Not available for the first-years.

Summary Statistics

	All Students	By Social Centrality				By Academic Achievement			
		Less Central		More Central		Lower-Achieving		Higher-Achieving	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Demographics									
Female (%)	0.57	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
Poor (%)	0.41	0.46	0.47	0.39	0.39	0.47	0.46	0.36	0.37
Rural (%)	0.26	0.31	0.30	0.25	0.22	0.31	0.29	0.22	0.21
Subsidized health insurance (%)	0.50	0.51	0.57	0.44	0.47	0.52	0.55	0.44	0.49
Baseline characteristics									
National standardized score*	1.81	1.51	1.26	1.79	1.61	1.52	1.42	2.23	2.08
	(0.95)	(0.96)	(0.98)	(0.93)	(0.95)	(0.83)	(0.84)	(0.85)	(0.97)
Connections	14.70	12.73	11.49	16.41	14.49	15.35	13.82	15.65	14.32
	(6.49)	(5.45)	(5.08)	(5.74)	(5.65)	(6.57)	(6.30)	(6.47)	(6.47)
Social skills index	-0.00	-0.14	-0.07	0.06	0.13	-0.07	0.00	-0.02	0.06
	(1.00)	(1.00)	(1.00)	(0.97)	(0.99)	(0.99)	(0.98)	(0.99)	(1.01)
Peers' perception	0.00	-0.29	-0.27	0.23	0.31	-0.14	-0.09	0.07	0.14
	(1.00)	(0.76)	(0.69)	(1.11)	(1.18)	(0.86)	(0.91)	(1.05)	(1.11)
Treatments									
Social centrality	-0.00	-0.73	-0.75	0.75	0.75	-0.06	-0.04	0.06	0.04
	(0.99)	(0.40)	(0.40)	(0.84)	(0.83)	(0.96)	(0.98)	(1.02)	(1.01)
Academic achievement	0.00	-0.06	-0.08	0.07	0.08	-0.79	-0.78	0.80	0.77
	(0.99)	(0.96)	(0.95)	(1.01)	(1.03)	(0.48)	(0.47)	(0.68)	(0.74)
N	6,148	753	1,079	737	1,085	1,332	1,737	1,329	1,750

Notes: This table reports summary statistics by type of student.

With two cross-randomized treatments there are four types of students and ten student-peer-type combinations:

Type of student	Type of peer: higher-achieving more central	higher-achieving less central	lower-achieving more central	lower-achieving less central
higher-achieving more central	Combination 1	Combination 2	Combination 3	Combination 4
higher-achieving less central	Combination 2	Combination 5	Combination 6	Combination 7
lower-achieving more central	Combination 3	Combination 6	Combination 8	Combination 9
lower-achieving less central	Combination 4	Combination 7	Combination 9	Combination 10

Outline

Outcomes:

- Social Networks: friendships, study partnerships, social partnerships (playing sports or board games).
- Social skills:
  - ⋆ Psychological tests: extraversion and agreeableness (Big Five), altruism, leadership, empathy, emotional intelligence, intercultural sensitivity, *reading the mind in the eyes* (Woolley et al., 2010; Deming & Weidmann, 2020).
  - ⋆ Number of peers who think the student is in the top 5 of leadership, friendliness, popularity, and shyness.
  - ⋆ Main outcome: social skill index using PCA on all the measures.
- Academic outcomes: grades and test scores.

Empirical Strategy

- 2SLS:

$$y_i = \theta + \beta_s \bar{s}_{n_i} + \beta_a \bar{a}_{n_i} + \varphi' X_i + \sum_{\tau \in \mathcal{T}} \varrho_\tau t_{i\tau} + \varepsilon_i$$

- First Stage:

$$\bar{s}_{n_i} = \theta_s + \delta_s s_i + \phi_s a_i + \varphi_s' X_i + \sum_{\tau \in \mathcal{T}} \rho_{s\tau} t_{i\tau} + \xi_i$$

$$\bar{a}_{n_i} = \theta_a + \delta_a s_{i\tau} + \phi_a a_i + \varphi_a' X_i + \sum_{\tau \in \mathcal{T}} \rho_{a\tau} t_{i\tau} + \mu_i$$

⋆ Include strata fixed effects.

⋆ Covariates at baseline to increase precision and account for unbalance.

⋆ For the first-years include gender-by-classroom fixed effects.

⋆ The s.e. are clustered at the: group-by-type level (Abadie et al., 2018).

First Stage: Peer Characteristics

	Assigned Peers		Neighbors	
	Centrality	Academic Achievement	Centrality	Academic Achievement
	(1)	(2)	(3)	(4)
More central	0.886***	0.088***	0.544***	0.087***
	(0.016)	(0.017)	(0.019)	(0.020)
Higher-achieving	0.036***	0.942***	0.022*	0.570***
	(0.010)	(0.013)	(0.013)	(0.015)
Control mean	-0.22	-0.53	-0.13	-0.36
N	6,079	6,079	6,079	6,079

Notes: This table reports treatment effects on peers' characteristics. All models include strata fixed effects, classroom-by-gender fixed effects for the first-years, and control for a set of covariates at baseline. Standard errors are clustered at the group×type level; *** p-value<0.01, ** p-value<0.05, * p-value<0.1.

Outline

2SLS Effects on Social Skills

Group:	All students			Less central		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Neighbors' centrality	0.039	0.246***	-0.076	0.137**	0.486***	-0.047
	(0.046)	(0.084)	(0.053)	(0.069)	(0.115)	(0.083)
Neighbors' achievement	0.014	-0.000	0.002	-0.093	-0.093	-0.111
	(0.043)	(0.073)	(0.053)	(0.058)	(0.096)	(0.071)
F centrality	805.84	224.70	646.08	326.91	81.87	285.72
F achievement	817.96	323.53	508.51	374.30	198.76	195.68
N	3,654	1,490	2,164	1,832	753	1,079

Notes: This table reports 2SLS estimates of average centrality and academic achievement of neighbors on students' social outcomes, using treatment assignment as instruments. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method. RF estimates: all students, less sociable, and all measures. These effects are consistent with longer-term outcomes.

2SLS Effects on Math Scores

Group:	All students			Lower-achieving		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Neighbors' centrality	-0.032	-0.043	-0.027	-0.013	0.093	-0.083
	(0.038)	(0.074)	(0.043)	(0.053)	(0.102)	(0.056)
Neighbors' achievement	-0.046	-0.039	-0.044	-0.076*	-0.020	-0.116**
	(0.029)	(0.053)	(0.033)	(0.046)	(0.087)	(0.048)
F centrality	62.04	18.95	49.90	39.61	19.05	31.45
F achievement	100.56	42.05	62.95	38.40	16.29	26.64
N	5,681	2,505	3,176	2,778	1,236	1,542

Notes: This table reports 2SLS estimates of average centrality and academic achievement of neighbors on students' math scores, using treatment assignment as instruments. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method.

2SLS Effects on Reading Scores

Group:	All students			Lower-achieving		
	All	Boys	Girls	All	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)
Neighbors' centrality	0.054	0.132	0.007	0.086	0.149	0.053
	(0.049)	(0.086)	(0.058)	(0.071)	(0.119)	(0.088)
Neighbors' achievement	-0.059*	0.023	-0.120***	-0.076	-0.004	-0.136*
	(0.035)	(0.059)	(0.044)	(0.057)	(0.094)	(0.072)
F centrality	62.04	18.95	49.90	39.61	19.05	31.45
F achievement	100.56	42.05	62.95	38.40	16.29	26.64
N	5,796	2,540	3,256	2,860	1,260	1,600

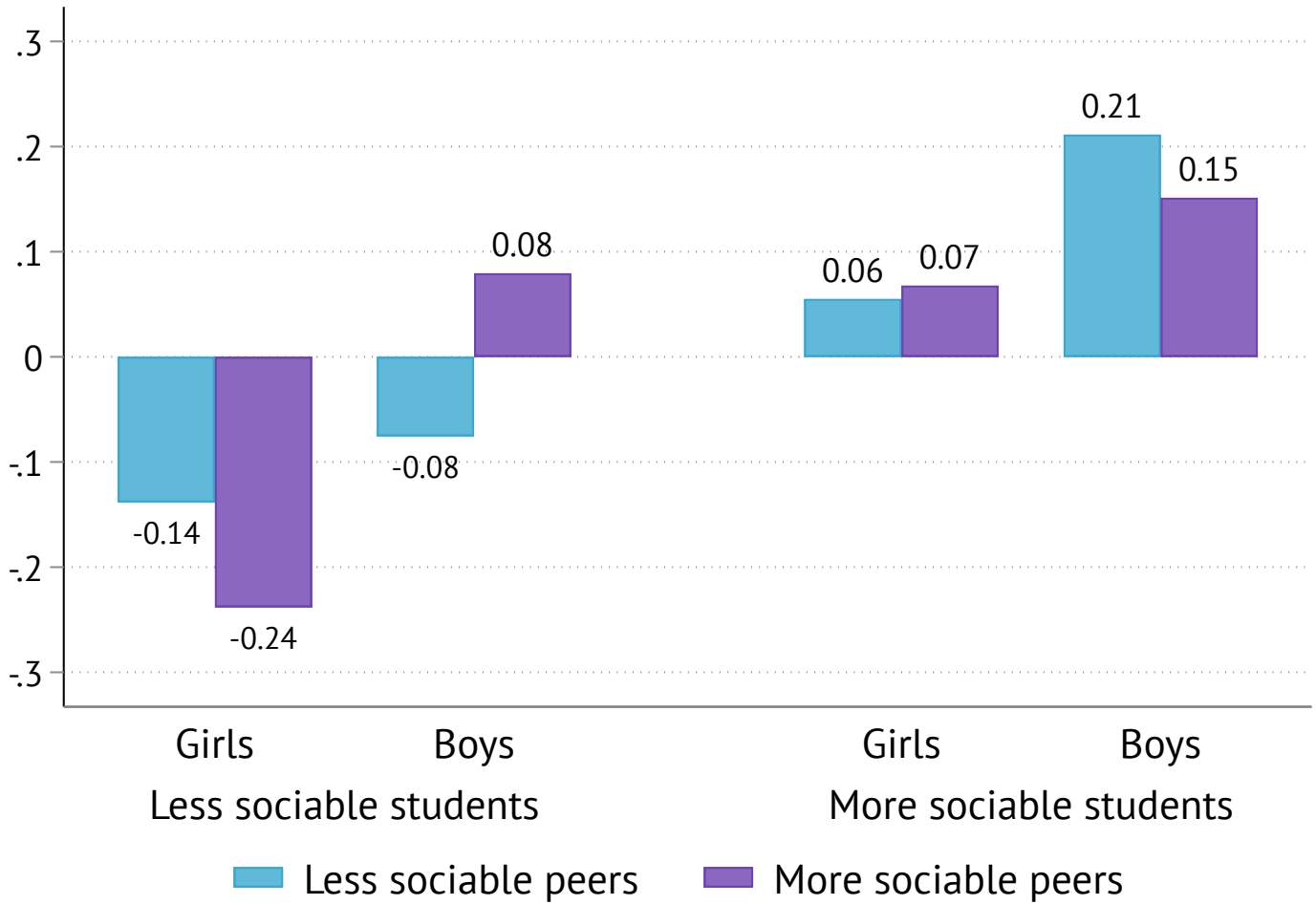
Notes: This table reports 2SLS estimates of average centrality and academic achievement of neighbors on students' math scores, using treatment assignment as instruments. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method.

Outline

Mechanisms

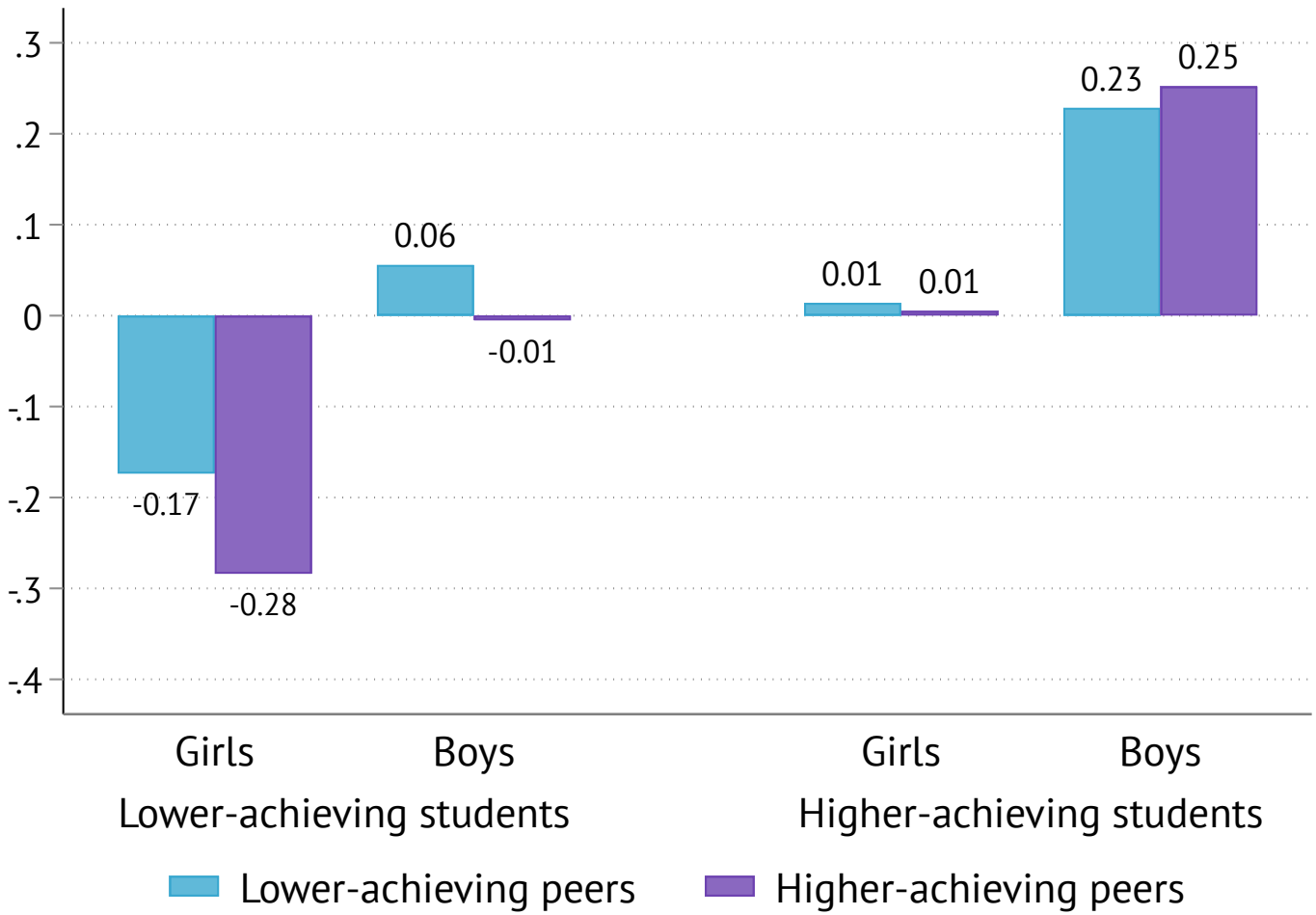
1. Self-confidence:
   - ⋆ The big-fish–little-pond effect (Marsh & Parker, 1984): individuals compare their own self-concept with their peers.
   - ⋆ Effort and confidence are complements in education production functions (Benabou & Tirole, 2002).
   - ⋆ Confidence-enhanced performance (Compte & Postlewaite, 2004).
   - ⋆ Gender differences in the formation of beliefs (Bordalo et al., 2019; Mobius et al., 2014) and social comparisons (Pulford et al., 2018).
2. Friendships and study groups:
   - ⋆ Peers' effort decisions are strategic complements (Calvo-Armengol et al., 2009).
   - ⋆ Existing empirical evidence is consistent with friendships and study groups being an important mediator of peer effects (Carrell et al., 2013).

Self-confidence in Social Skills



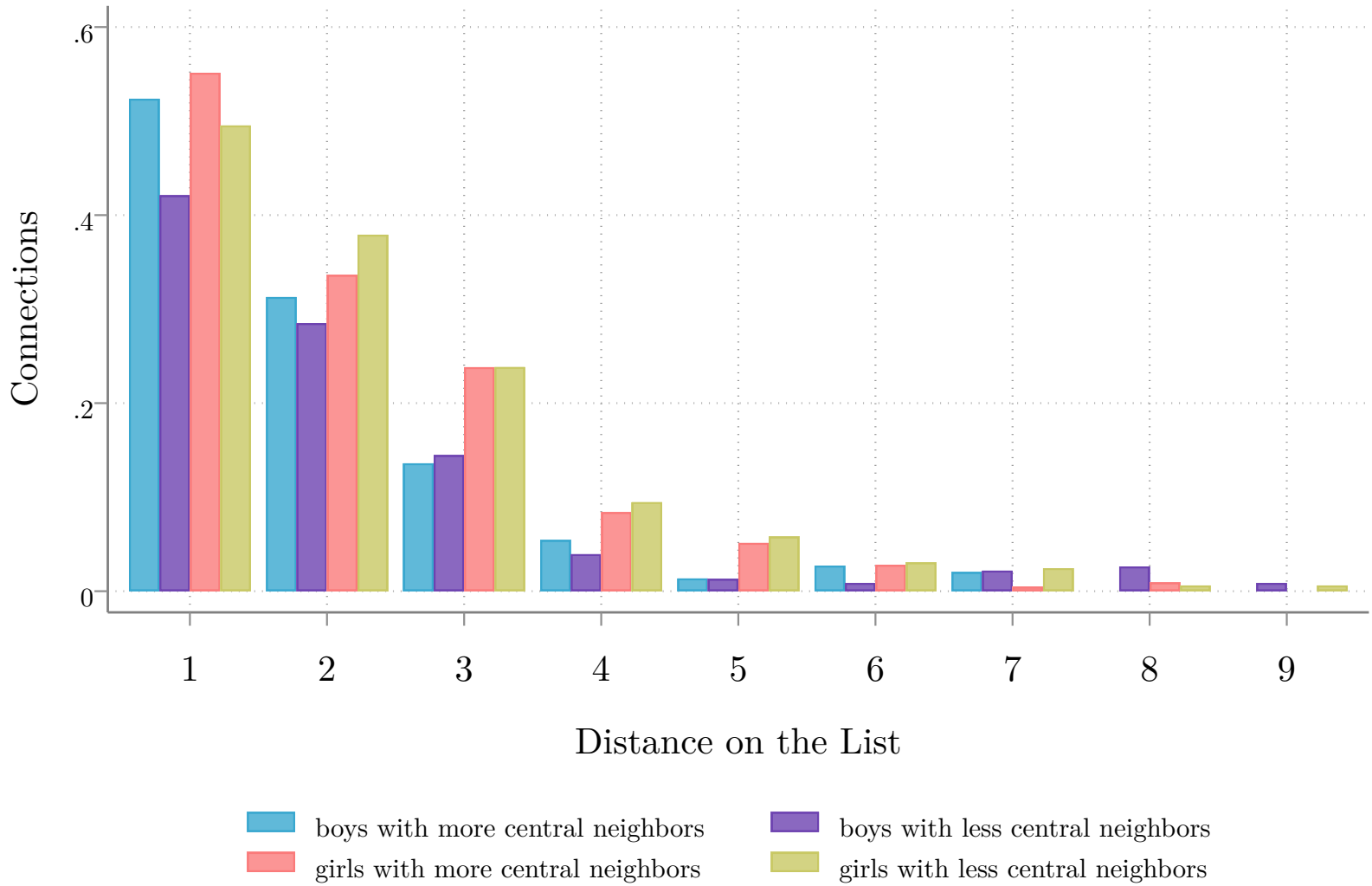
Index: popularity rankings and self-nominations in social skills.

Self-confidence in Academic Skills

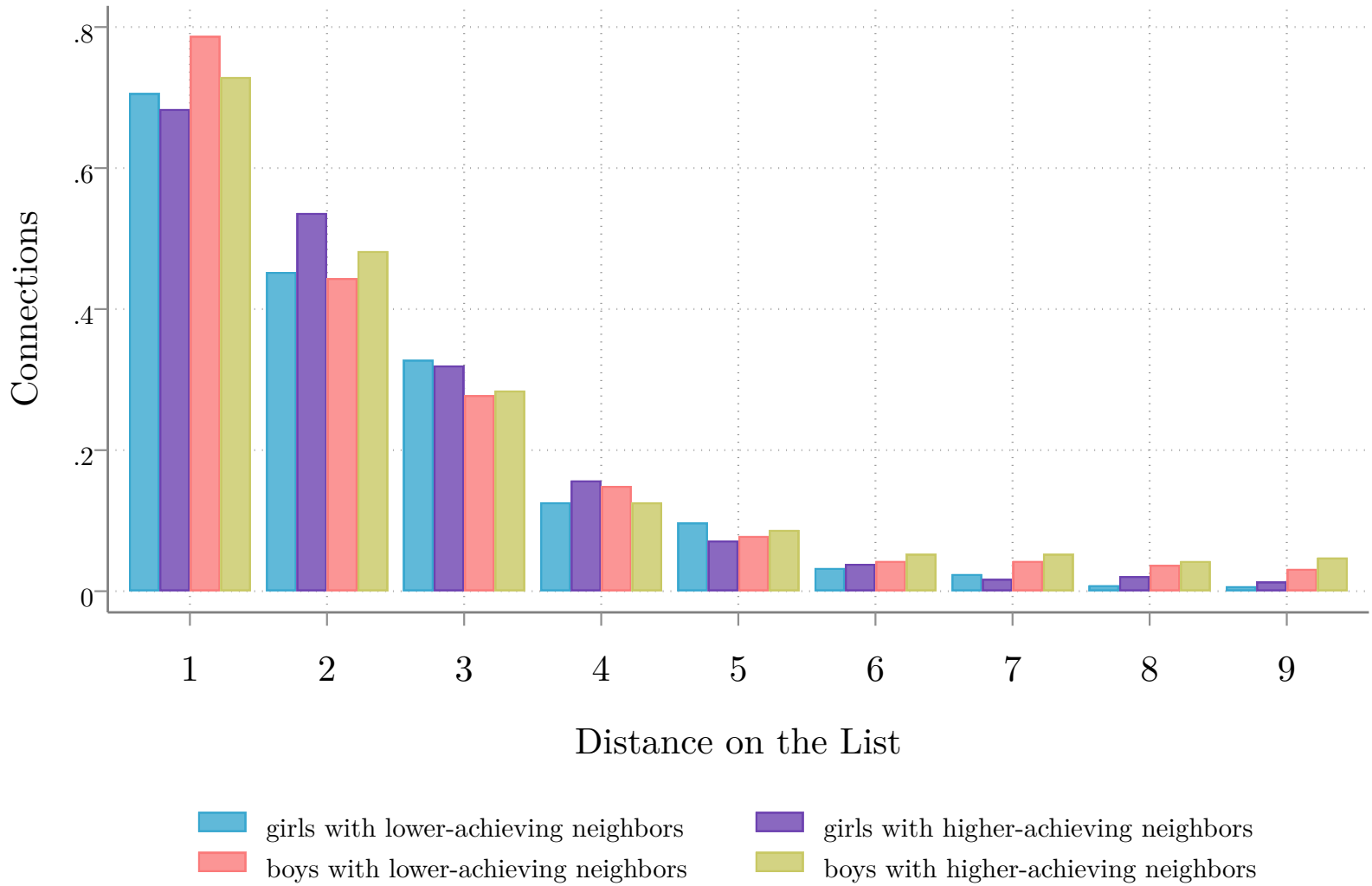


Index: popularity rankings, self-nominations in academic skills, relative performance goals.

Social Interactions by Social Treatment: Less Central Students



Social Interactions by Academic Treatment: Lower-achieving Students

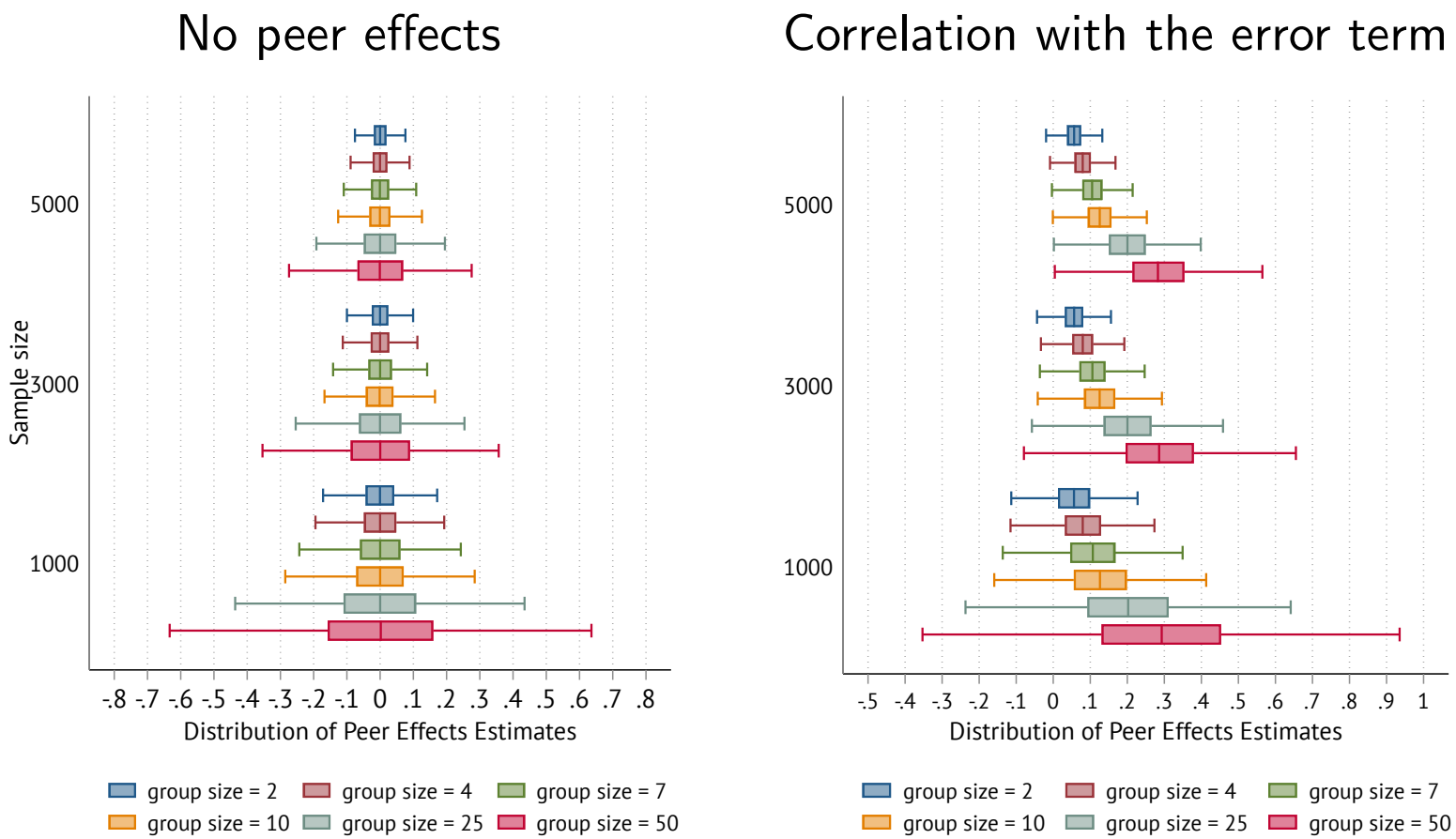


Outline

Conclusion

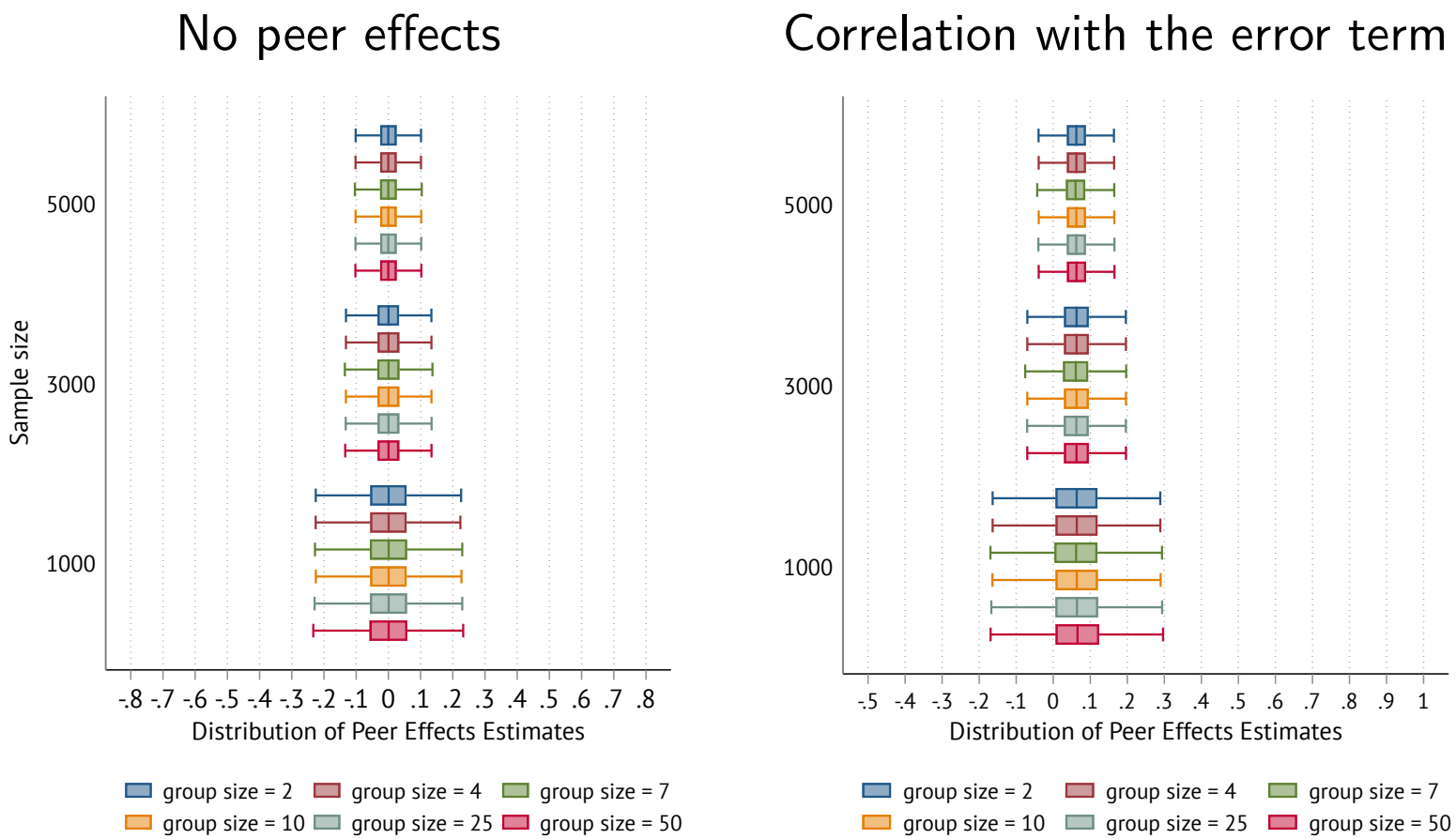
- Public policies and the literature on peer effects have mainly focused on academic achievement.
  - ⋆ The evidence of academic peer effects is mixed.
  - ⋆ I address the weak variation problem and do not find strong evidence of academic peer effects.
  - ⋆ Higher-achieving peers appear to reduce the performance of lower-achieving girl.
- A more natural dimension through which peers can affect students' outcomes is social skills.
  - ⋆ Evidence that more sociable peers enhance the formation of social skills of boys.
  - ⋆ This impact translates into lower dropout rate and better college quality.
- Both results are explained by changes in the level of the self-confidence of the students.

Simulations of Peer Effects Estimates: Random Allocation to Groups



Notes: Monte Carlo simulations based on 10,000 repetitions of the estimate of parameter π_1 in equation 1. In the left column, $\pi_0 = 1$, $\pi_1 = 0$, and $\varepsilon_{ig} = \nu_{ig}$. In the right column, $\pi_0 = 1$, $\pi_1 = 0$, and $\varepsilon_{ig} = 0.1 \times I(\bar{x}_g \geq 0) + \nu_{ig}$.

Simulations of Peer Effects Estimates: Experimental Design



Notes: Monte Carlo simulations based on 10,000 repetitions of the estimate of parameter π_1 in equation 1. In the left column, $\pi_0 = 1$, $\pi_1 = 0$, and $\varepsilon_{ig} = \nu_{ig}$. In the right column, $\pi_0 = 1$, $\pi_1 = 0$, and $\varepsilon_{ig} = 0.1 \times I(\bar{x}_g \geq 0) + \nu_{ig}$.

Dormitories

RF Estimates on Social Skills: All Students

Dependent variable:	Connections		Centrality		Psychological tests		Peers' perception	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: All students				
More central	0.006	-0.334*	0.012	-0.048	0.070***	0.020	0.029	0.011
	(0.143)	(0.181)	(0.024)	(0.031)	(0.027)	(0.034)	(0.020)	(0.025)
Higher-achieving	-0.021	-0.128	0.011	-0.013	-0.018	-0.010	0.015	0.036
	(0.127)	(0.169)	(0.019)	(0.025)	(0.021)	(0.028)	(0.017)	(0.022)
More central × boy		0.834***		0.148***		0.123**		0.043
		(0.293)		(0.049)		(0.055)		(0.041)
Higher-achieving × boy		0.249		0.056		-0.020		-0.049
		(0.256)		(0.038)		(0.043)		(0.036)
mean control	13.78	13.78	-0.05	-0.05	-0.03	-0.03	-0.05	-0.05
p-val mc boys		0.029		0.009		0.001		0.091
p-val ha boys		0.528		0.138		0.372		0.636
N	6,079	6,079	6,079	6,079	6,079	6,079	6,079	6,079

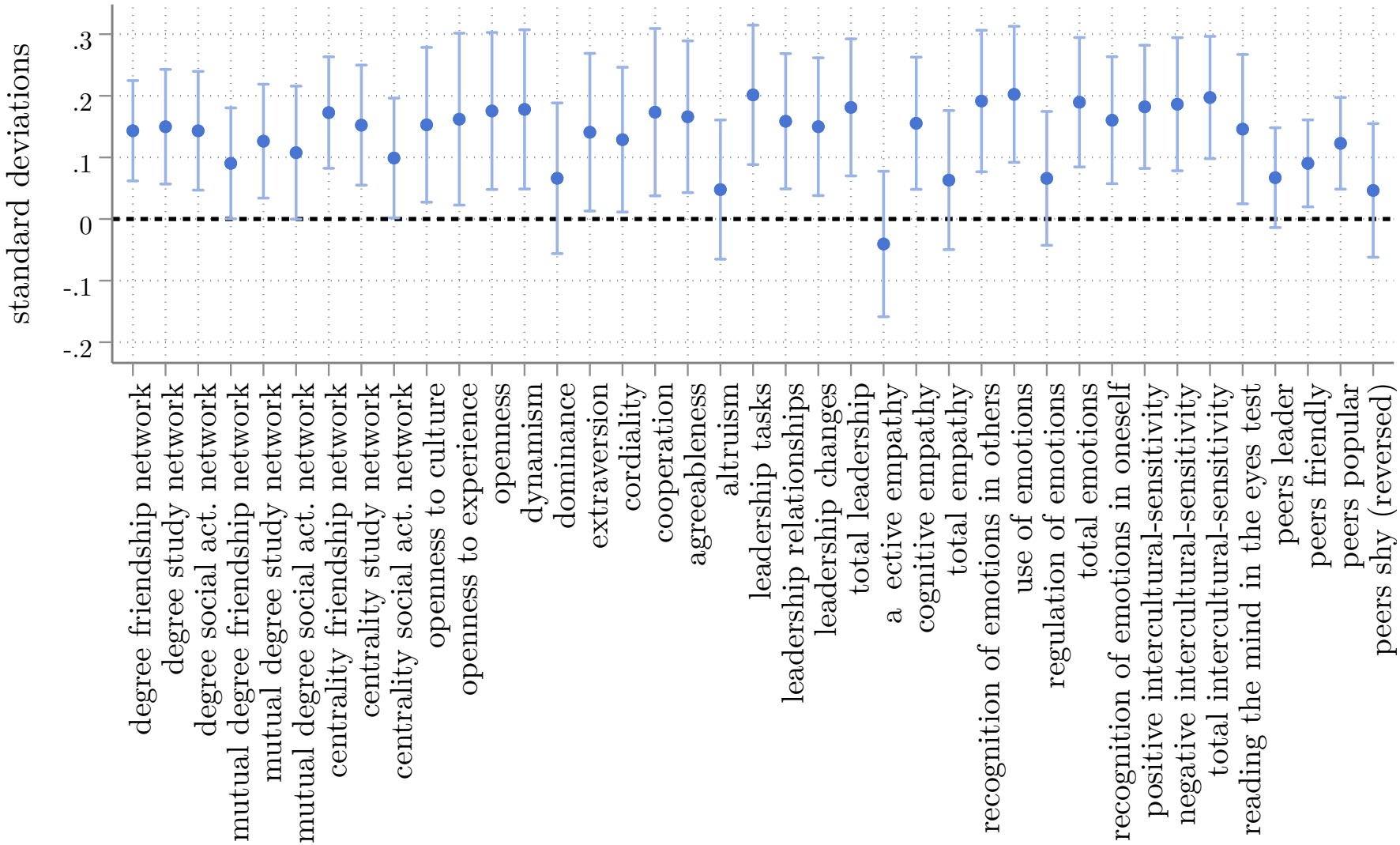
Notes: This table reports the effect of being assigned to more sociable and higher-achieving peers on social skills outcomes. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method. 2SLS social skills.

RF estimates on Social Skills: Less Central Students

Dependent variable:	Connections		Centrality		Psychological tests		Peers' perception	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
More central	0.290	-0.159	0.051	-0.046	0.133***	0.063	0.045**	0.012
	(0.197)	(0.261)	(0.032)	(0.041)	(0.039)	(0.048)	(0.022)	(0.027)
Higher-achieving	-0.133	-0.177	0.007	-0.011	-0.032	-0.085*	-0.064***	-0.052*
	(0.198)	(0.261)	(0.033)	(0.042)	(0.038)	(0.047)	(0.024)	(0.030)
More central × boy		1.093***		0.236***		0.169**		0.080*
		(0.397)		(0.065)		(0.080)		(0.045)
Higher-achieving × boy		0.096		0.040		0.127		-0.029
		(0.390)		(0.064)		(0.078)		(0.047)
mean control	11.24	11.24	-0.25	-0.25	-0.16	-0.16	-0.29	-0.29
p-val mc boys		0.002		0.000		0.000		0.012
p-val ha boys		0.783		0.558		0.499		0.027
N	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832

Notes: This table reports the effect of being assigned to more sociable and higher-achieving peers on social skills outcomes. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method. 2SLS social skills.

RF Estimates on All measures of Social Skills: Less Central students



RF Estimates on Longer-term Outcomes: Less Central Students

Dependent variable:	Dropout		College enrollment		Top 20 college		Certified college	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
More central	-0.001	0.015	-0.013	-0.020	0.017	-0.018	-0.001	-0.040*
	(0.007)	(0.010)	(0.021)	(0.028)	(0.019)	(0.024)	(0.018)	(0.023)
Higher-achieving	0.019***	0.019**	-0.030	-0.045	-0.015	-0.018	-0.019	-0.029
	(0.007)	(0.010)	(0.020)	(0.028)	(0.019)	(0.025)	(0.018)	(0.023)
More central × boy		-0.039***		0.016		0.086**		0.094***
		(0.013)		(0.040)		(0.039)		(0.035)
Higher-achieving × boy		0.001		0.036		0.008		0.024
		(0.014)		(0.041)		(0.040)		(0.036)
mean control	0.02	0.02	0.58	0.58	0.26	0.26	0.22	0.22
p-val mc boys		0.004		0.901		0.028		0.049
p-val ha boys		0.041		0.770		0.735		0.854
N	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832

Notes: This table reports the effect of being assigned to more sociable and higher-achieving peers on dropout rate and college outcomes. All models include strata fixed effects and control for the selected baseline characteristics using the double post-lasso method. 2SLS social skills.