ICFES Referrals

10-minute internal presentation for data analysis

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27 March 2025

Selection into the experiment

○ Better students self select

	Admin Data	Sample	p
Reading score	62.651	65.183	0.000
Math score	63.973	67.477	0.000
GPA	3.958	4.012	0.000
Low-SES	0.343	0.410	0.000
Med-SES	0.505	0.499	0.763
High-SES	0.153	0.091	0.000
Observations	4,417	734	5,151

Selection into the experiment

- Better students self select
- Low and High SES self select

	Admin Data	Sample	p
Reading score	62.651	65.183	0.000
Math score	63.973	67.477	0.000
GPA	3.958	4.012	0.000
Low-SES	0.343	0.410	0.000
Med-SES	0.505	0.499	0.763
High-SES	0.153	0.091	0.000
Observations	4,417	734	5,151

Balance between treatments

◦ Successful randomization

|	**Baseline**	**Bonus**	**p**
Reading score	64.712	65.693	0.134
Math score	67.366	67.597	0.780
GPA	4.003	4.021	0.445
# connections	173.40	176.88	0.574
Tie strength	3.939	3.719	0.443
Low-SES	0.419	0.401	0.615
Med-SES	0.492	0.506	0.714
High-SES	0.089	0.094	0.824
Observations	382	352	734

Network size and tie strength by semester

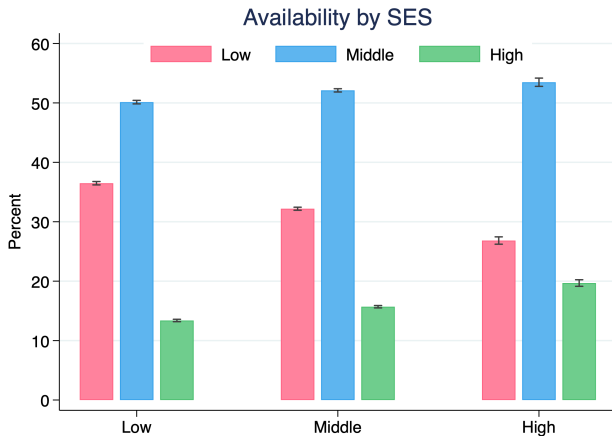◦ Classes together increases over time
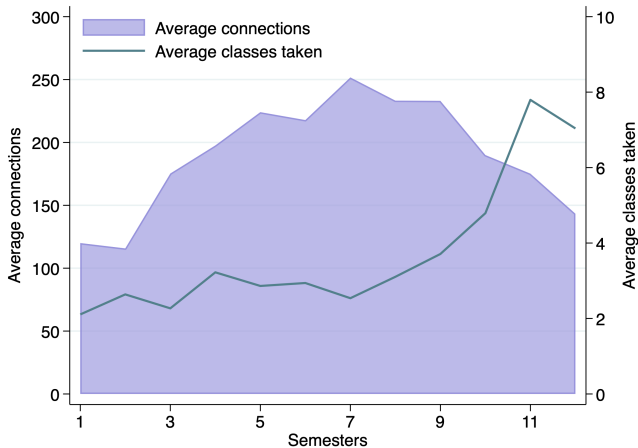
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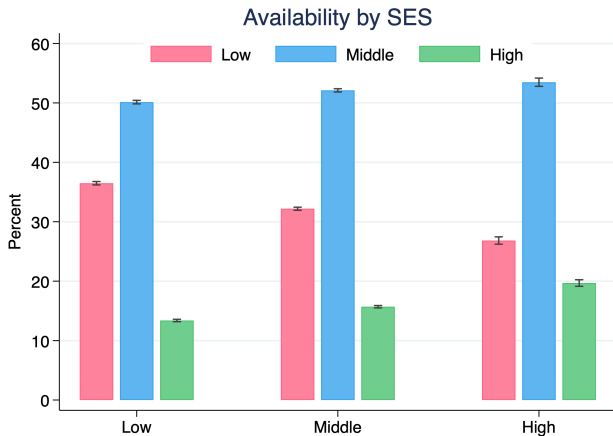- Connections peak around 7 semesters and decline as students graduate
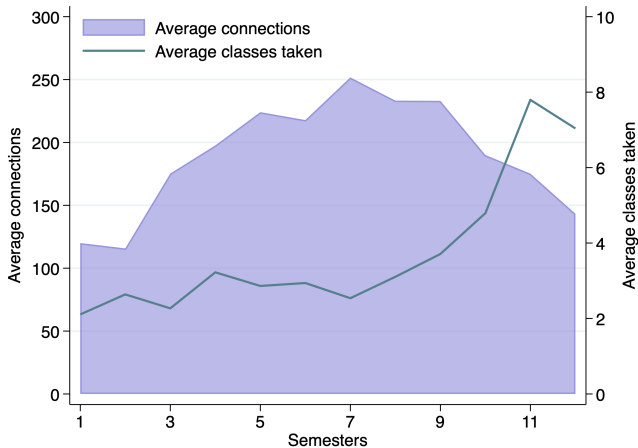
Referrer network composition by SES

○ Monotonic increase in availability across SES

Availability by SES

Referrer network composition by SES

- Monotonic increase in availability across SES
- All differences are statistically significant ($p < 0.001$)

Availability by SES

Referrer network performance by SES

◦ Subject specific network-level standardization

Network Performance by SES

Referrer network performance by SES
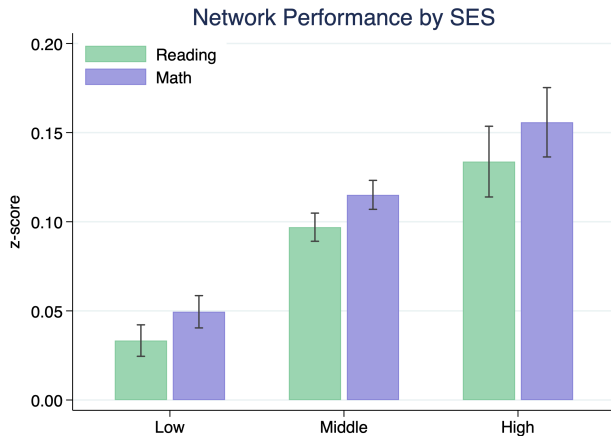
- Subject specific network-level standardization
- Performance increases with SES across math and reading

Network Performance by SES
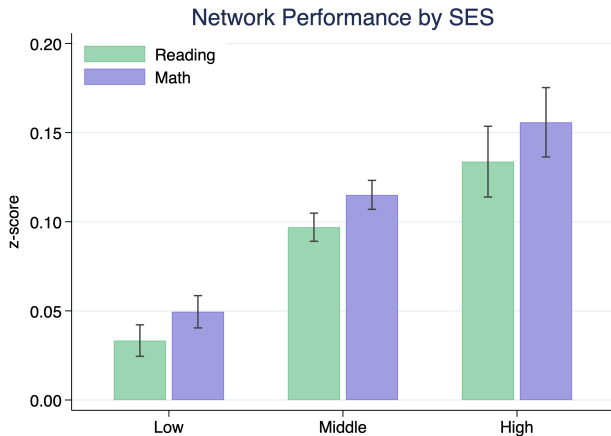
Referrer network performance by SES

- Subject specific network-level standardization
- Performance increases with SES across math and reading
- All differences are statistically significant ($p < 0.005$)
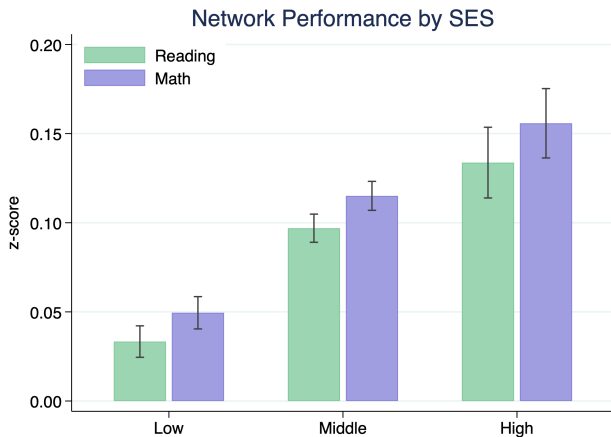
Network Performance by SES

Referrals for Reading

- Referrals have higher reading scores and much higher tie strength on aggregate (all $p < 0.001$)
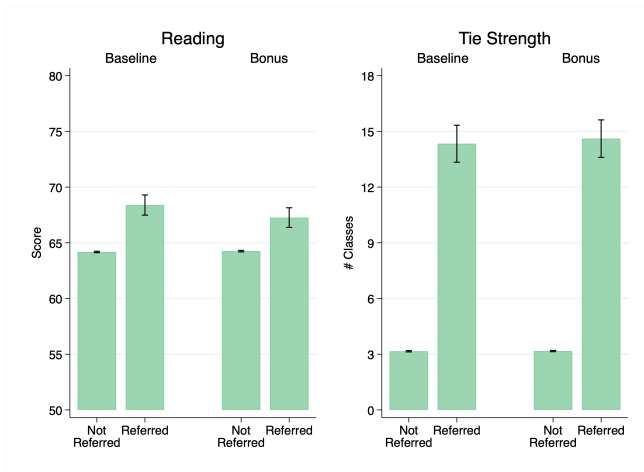
Referrals for Reading

- Referrals have higher reading scores and much higher tie strength on aggregate (all $p < 0.001$)

- No treatment effect on reading score or on on tie strength (all $p > 0.08$)
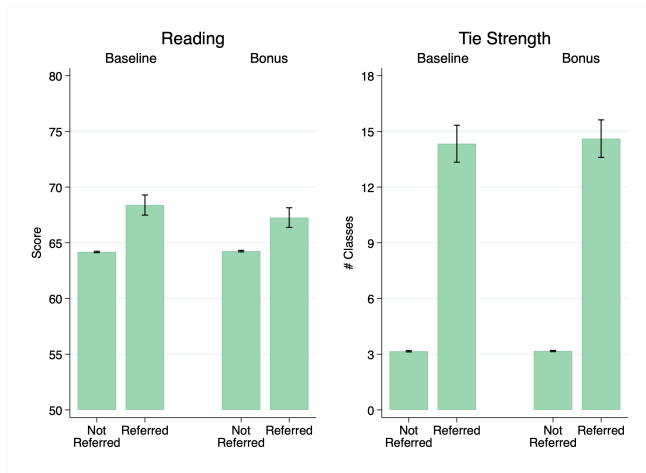
Referrals for Math

- Referrals have higher math scores and much higher tie strength on aggregate (all $p < 0.001$)
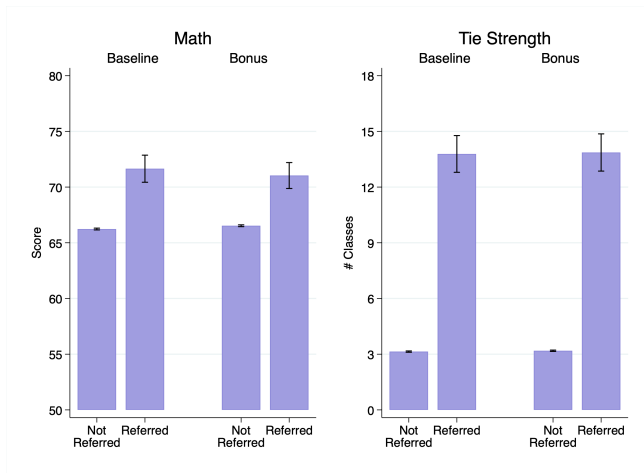
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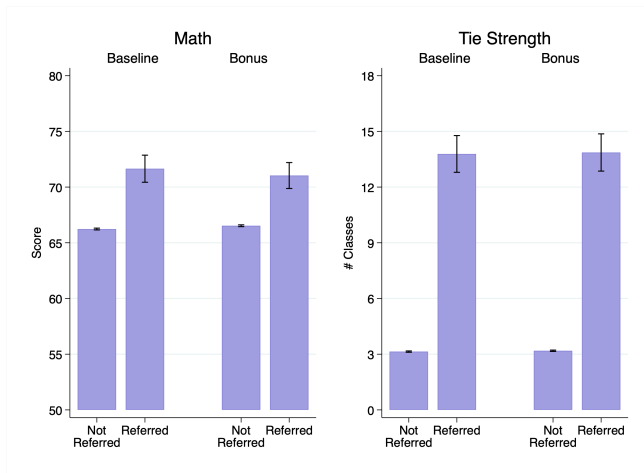
Baseline referrals

Baseline Referral Rates by SES / Baseline Referral Performance
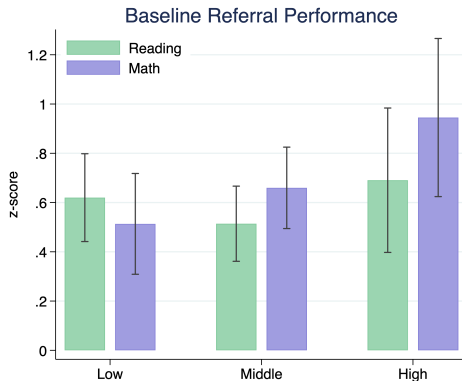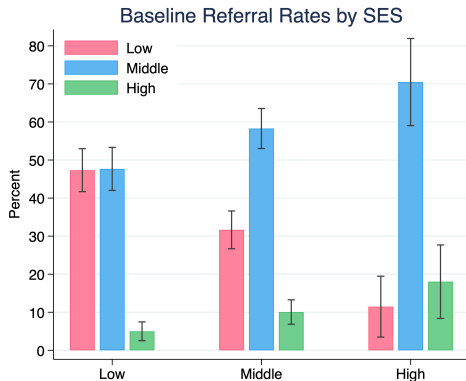
◦ Large monotonic differences in referral shares as SES increases (all $p < 0.1$)

Baseline referrals

Baseline Referral Rates by SES

Baseline Referral Performance
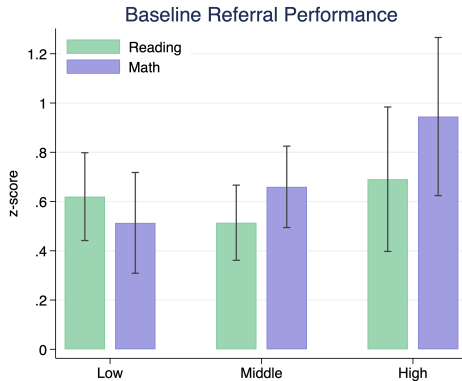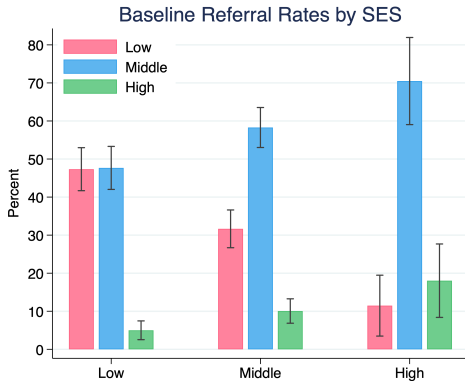
- Large monotonic differences in referral shares as SES increases (all $p < 0.1$)
- Small differences in math and reading performance across SES (all $p > 0.08$)

Treatment effects on referrals

Bonus on Referral Rates by SES

Bonus on Referral Performance by SES
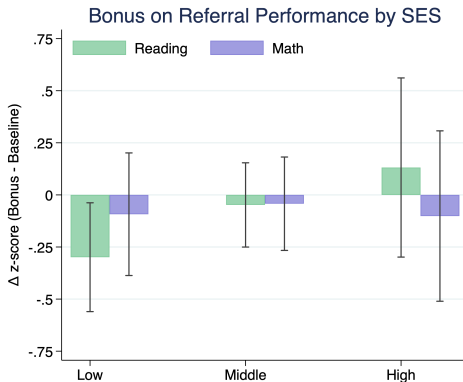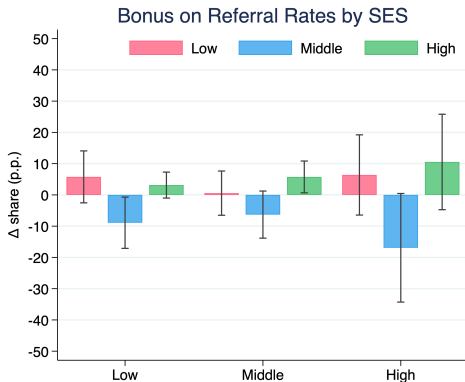
○ No meaningful changes in referral shares with bonus

Treatment effects on referrals

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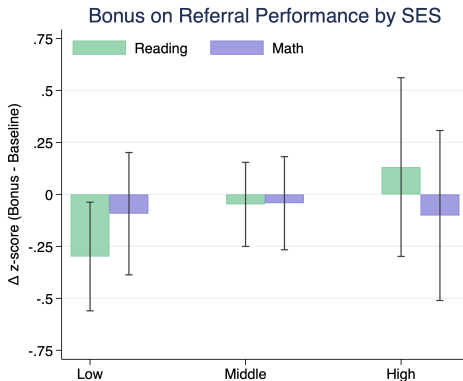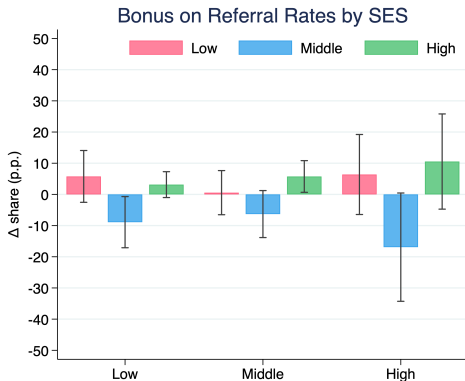
- ○ No meaningful changes in referral shares with bonus
- ○ No meaningful changes in reading and math performance with bonus

Treatment effect on referral tie strength
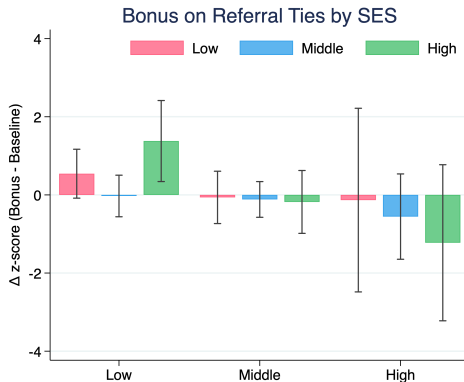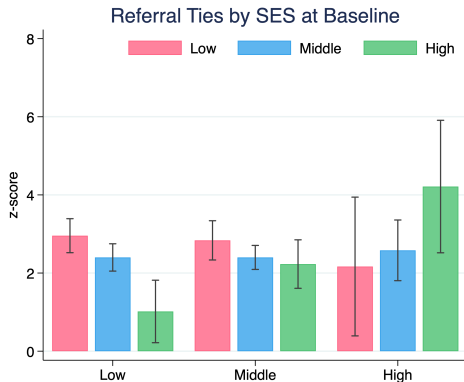
- Small differences in referral tie strength at baseline

Treatment effect on referral tie strength
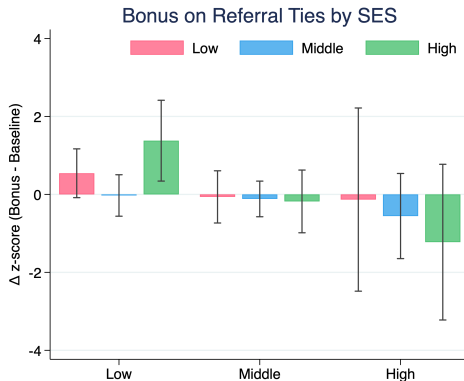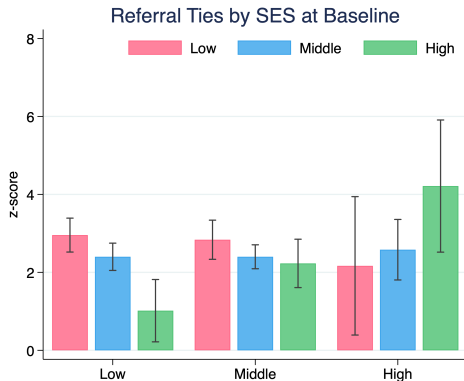
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Regression Analysis

Empirical specification

○ Model the referral choice using a mixed multinomial logit model for each referrer's choice set (average 175 potential nominees) [McFadden and Train, 2000]

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- Model the referral choice using a mixed multinomial logit model for each referrer's choice set (average 175 potential nominees) [McFadden and Train, 2000]

- The probability that student i refers student $j \in N_i$ is given by

$$\frac{e^{\beta_i x_{ij}}}{\sum_{j=1}^{N_i} e^{\beta_i x_{ij}}}$$

  where x_{ij} is the vector of characteristics of j (low-SES, test score, tie strength) and β_i is a vector of individual-specific parameters comprising of a constant and a random component

Is there a Low-SES bias in Reading referrals?

○ Reading score and tie strength are strong predictors of referrals

	(1)	(2)	(3)
Low-SES	0.199**	0.041	0.042
	(0.083)	(0.100)	(0.100)
Reading Score		0.561***	0.509***
		(0.044)	(0.048)
Tie		0.951***	0.941***
		(0.031)	(0.032)
Score × Tie			0.029
			(0.018)
Observations	128,847	128,847	128,847
Individuals	673	673	673

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- Reading score and tie strength are strong predictors of referrals
- No interaction between reading score and tie strength
- No evidence for a Low-SES bias in referrals when controlling for referral score and tie strength

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Is there a Low-SES bias in Math referrals?

- Math score and tie strength are strong predictors of referrals

	(1)	(2)	(3)
Low-SES	0.220***	0.049	0.050
	(0.083)	(0.097)	(0.098)
Math Score		0.653***	0.538***
		(0.040)	(0.041)
Tie		0.887***	0.854***
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Score × Tie			0.088***
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Observations	128,150	128,150	128,150
Individuals	669	669	669

Is there a Low-SES bias in Math referrals?

- Math score and tie strength are strong predictors of referrals

- Significant but small interaction between math score and tie strength

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Do grades predict Reading referrals?

- GPA correlates weakly with reading score ($\rho = 0.18$)

	(1)	(2)	(4)
GPA	0.759***	0.640***	0.578***
	(0.044)	(0.059)	(0.070)
Reading Score		0.407***	0.344***
		(0.048)	(0.068)
Tie Strength		0.936***	0.911***
		(0.031)	(0.032)
Score $\times$ Tie			0.010
			(0.022)
Score $\times$ GPA			0.017
			(0.056)
GPA $\times$ Tie			0.028
			(0.026)
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Do grades predict Math referrals?

◦ Significant but small interactions between tie strength and both performance variables

	(1)	(2)	(4)
GPA	0.765***	0.621***	0.500***
	(0.044)	(0.059)	(0.068)
Math Score		0.531***	0.400***
		(0.044)	(0.065)
Tie Strength		0.871***	0.808***
		(0.029)	(0.030)
Score $\times$ Tie			0.068***
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Score $\times$ GPA			0.026
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			(0.022)

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Is there in-group homophily in Reading referrals?

○ Restrict sample by SES of referrer

	Low-SES (1)	Med-SES (2)	High-SES (3)
Homophily	0.300**	0.203	-0.354
	(0.152)	(0.125)	(0.344)
Reading Score	0.433***	0.353***	0.674***
	(0.074)	(0.067)	(0.170)
Tie	0.860***	0.991***	1.061***
	(0.043)	(0.048)	(0.134)
GPA	0.648***	0.667***	0.477**
	(0.094)	(0.081)	(0.228)
Observations	54,611	64,596	9,640
Individuals	275	340	58

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- Define homophily as same SES referrer-nominee dyad

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- Only Low-SES exhibit homophily for other Low-SES

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Homophily	0.282*	0.161	-0.030
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Tie	0.823***	0.892***	1.046***
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GPA	0.580***	0.675***	0.519**
	(0.093)	(0.083)	(0.219)
Observations	55,531	62,492	10,127
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Empirical Specification

OLS Model:

$$\text{Score}_{ij} = \beta_0 + \beta_1 \cdot X_i + \beta_2 \cdot \text{Mean Score}_j + \beta_3 \cdot \text{SD Score}_j + \varepsilon_{ij}$$

- Score_{ij}: Test score of the nominee from referrer i in subject j

Features:

Empirical Specification

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- Mean Score_j and SD Score_j: Mean and SD of i's network performance in subject j

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Features:

- Sample restricted to nominated students only
- Controls for network-level performance differences
- Standard errors clustered at individual level

Do Low-SES refer better?

◦ No evidence that Low-SES refer better in reading or math

	Reading (1)	Math (2)
Med-SES	-1.213**	-0.816
	(0.607)	(0.731)
High-SES	0.438	0.937
	(1.085)	(1.287)
Mean Score	1.250***	1.399***
	(0.096)	(0.074)
SD Score	0.233	0.163
	(0.409)	(0.318)
Constant	-13.062	-21.571***
	(8.006)	(6.373)
Observations	673	669

Do Low-SES refer better?

- No evidence that Low-SES refer better in reading or math

- Better referrals depend on average network performance

	Reading (1)	Math (2)
Med-SES	-1.213**	-0.816
	(0.607)	(0.731)
High-SES	0.438	0.937
	(1.085)	(1.287)
Mean Score	1.250***	1.399***
	(0.096)	(0.074)
SD Score	0.233	0.163
	(0.409)	(0.318)
Constant	-13.062	-21.571***
	(8.006)	(6.373)
Observations	673	669

Is there performance homophily in referrals?

◦ Significant but small effect of
  own test score on referral score

|	Reading (1)	Math (2)
Own Score	0.177***	0.176***
	(0.035)	(0.036)
Mean Score	1.020***	1.186***
	(0.101)	(0.082)
SD Score	0.056	0.155
	(0.398)	(0.310)
Constant	-9.126	-19.835***
	(7.835)	(6.240)
Observations	673	669

Is there performance homophily in referrals?

- Significant but small effect of
  own test score on referral score

- Very large difference between
  the average network test score
  versus referrer performance
  (about 6 times)

	Reading (1)	Math (2)
Own Score	0.177***	0.176***
	(0.035)	(0.036)
Mean Score	1.020***	1.186***
	(0.101)	(0.082)
SD Score	0.056	0.155
	(0.398)	(0.310)
Constant	-9.126	-19.835***
	(7.835)	(6.240)
Observations	673	669

Is there performance homophily in referrals?

- Significant but small effect of own test score on referral score
- Very large difference between the average network test score versus referrer performance (about 6 times)
- Performance homophily is nearly not as important as network composition

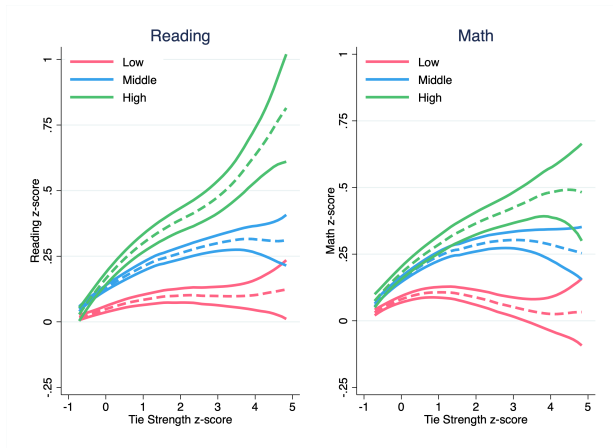|	Reading (1)	Math (2)
Own Score	0.177***	0.176***
	(0.035)	(0.036)
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Prelude

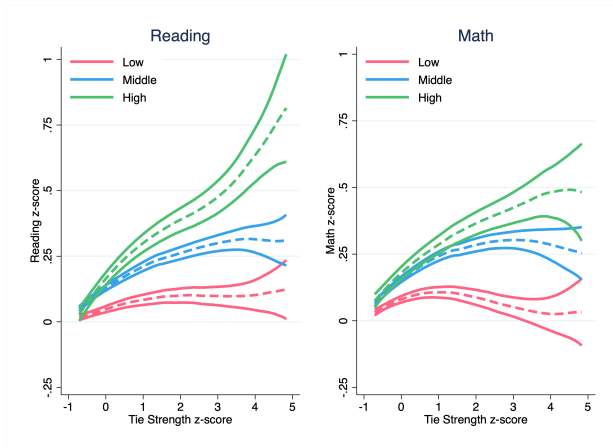∘ No evidence for a Low-SES bias in referrals
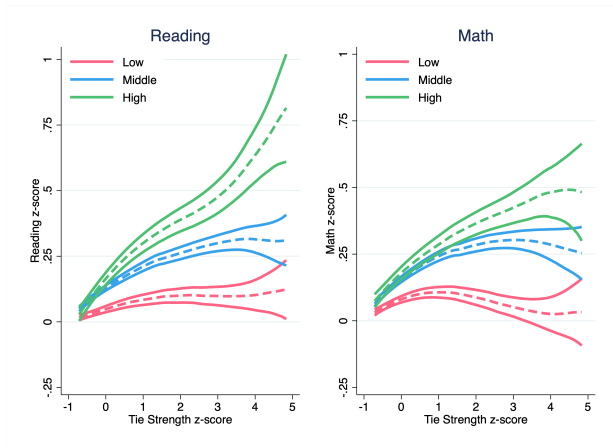
Prelude

- No evidence for a Low-SES bias in referrals
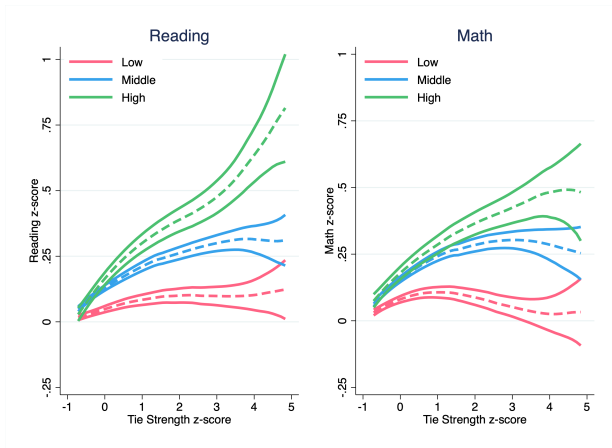- Referrers pick nominees based on performance and tie strength

Prelude

○ No evidence for a Low-SES bias in referrals

○ Referrers pick nominees based on performance and tie strength

○ Referral performance depends heavily on referrer network composition

Prelude

- No evidence for a Low-SES bias in referrals
- Referrers pick nominees based on performance and tie strength
- Referral performance depends heavily on referrer network composition
- Which SES group has the better network?

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

- Mean Score$_{ij}$: Average network test score of referrer i in subject j

Features:

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

- Mean Score$_{ij}$: Average network test score of referrer i in subject j
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Features:

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

- Mean Score$_{ij}$: Average network test score of referrer i in subject j
- Score$_{ij}$: Test score of referrer i in subject j
- Low-SES$_i$: Referrer i is Low-SES

Features:

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

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Features:

- Sample restricted to referrers only

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

- Mean Score$_{ij}$: Average network test score of referrer i in subject j
- Score$_{ij}$: Test score of referrer i in subject j
- Low-SES$_i$: Referrer i is Low-SES

Features:

- Sample restricted to referrers only
- Estimated at relevant tie-strength z-score thresholds (z_tie $\geq$ 0, 1, 2, 3)

Empirical Specification

OLS Model:

$$\text{Mean Score}_{ij} = \beta_0 + \beta_1 \cdot \text{Score}_{ij} + \beta_2 \cdot \text{Low-SES}_i + \varepsilon_{ij}$$

- Mean Score$_{ij}$: Average network test score of referrer i in subject j
- Score$_{ij}$: Test score of referrer i in subject j
- Low-SES$_i$: Referrer i is Low-SES

Features:

- Sample restricted to referrers only
- Estimated at relevant tie-strength z-score thresholds (z_tie $\geq$ 0, 1, 2, 3)
- Standard errors clustered at individual level

Do Low-SES have worse networks in Reading?

◦ Average referral tie strength is around 2.7 SD for reading scores

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score reading	0.212***	0.233***	0.245***	0.313***
	(0.017)	(0.020)	(0.024)	(0.029)
Low-SES	-1.295***	-0.777**	-0.891**	-0.589
	(0.304)	(0.358)	(0.427)	(0.517)
Constant	50.629***	49.356***	48.777***	44.443***
	(1.124)	(1.321)	(1.557)	(1.953)
Observations	673	651	560	471

Do Low-SES have worse networks in Reading?

- ◦ Average referral tie strength is 2.7 SD for reading scores

- ◦ Referrer reading score has a significant effect at thresholds [0, 2]

	Tie $\geq$ 0 (1)	Tie $\geq$ 1 (2)	Tie $\geq$ 2 (3)	Tie $\geq$ 3 (4)
Score reading	0.212***	0.233***	0.245***	0.313***
	(0.017)	(0.020)	(0.024)	(0.029)
Low-SES	-1.295***	-0.777**	-0.891**	-0.589
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Constant	50.629***	49.356***	48.777***	44.443***
	(1.124)	(1.321)	(1.557)	(1.953)
Observations	673	651	560	471

Do Low-SES have worse networks in Reading?

- Average referral tie strength is 2.7 SD for reading scores

- Referrer reading score has a significant effect at thresholds [0, 2]

- Higher SES referrers have better networks across thresholds

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score reading	0.212***	0.233***	0.245***	0.313***
	(0.017)	(0.020)	(0.024)	(0.029)
Low-SES	-1.295***	-0.777**	-0.891**	-0.589
	(0.304)	(0.358)	(0.427)	(0.517)
Constant	50.629***	49.356***	48.777***	44.443***
	(1.124)	(1.321)	(1.557)	(1.953)
Observations	673	651	560	471

Do Low-SES have worse networks in Math?

◦ Average referral tie strength is around 2.5 SD for math

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score math	0.333***	0.356***	0.395***	0.391***
	(0.019)	(0.022)	(0.025)	(0.032)
Low-SES	-1.847***	-1.343***	-1.122**	-1.321**
	(0.428)	(0.478)	(0.560)	(0.653)
Constant	44.215***	42.696***	40.197***	40.698***
	(1.326)	(1.490)	(1.756)	(2.195)
Observations	669	648	559	464

Do Low-SES have worse networks in Math?

- Average referral tie strength is around 2.5 SD for math

- Referrer math score has a significant but small effect at each tie strength threshold

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score math	0.333***	0.356***	0.395***	0.391***
	(0.019)	(0.022)	(0.025)	(0.032)
Low-SES	-1.847***	-1.343***	-1.122**	-1.321**
	(0.428)	(0.478)	(0.560)	(0.653)
Constant	44.215***	42.696***	40.197***	40.698***
	(1.326)	(1.490)	(1.756)	(2.195)
Observations	669	648	559	464

Do Low-SES have worse networks in Math?

- Average referral tie strength is around 2.5 SD for math

- Referrer math score has a significant but small effect at each tie strength threshold

- Higher SES referrers have much better networks at each tie strength threshold

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score math	0.333***	0.356***	0.395***	0.391***
	(0.019)	(0.022)	(0.025)	(0.032)
Low-SES	-1.847***	-1.343***	-1.122**	-1.321**
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Constant	44.215***	42.696***	40.197***	40.698***
	(1.326)	(1.490)	(1.756)	(2.195)
Observations	669	648	559	464

Do Low-SES have worse networks in Math?

- Average referral tie strength is around 2.5 SD for math

- Referrer math score has a significant but small effect at each tie strength threshold

- Higher SES referrers have much better networks at each tie strength threshold

- Systematic network inequality is constraining Low-SES referrals

	Tie ≥ 0 (1)	Tie ≥ 1 (2)	Tie ≥ 2 (3)	Tie ≥ 3 (4)
Score math	0.333***	0.356***	0.395***	0.391***
	(0.019)	(0.022)	(0.025)	(0.032)
Low-SES	-1.847***	-1.343***	-1.122**	-1.321**
	(0.428)	(0.478)	(0.560)	(0.653)
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