Gender Peer Effects in High School: Evidence from India

Arka Roy Chaudhuri

with
Prerna Dewan and Tridip Ray

Indian Statistical Institute

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Introduction: What are Peer Effects?

- Peer effects encompasses nearly any externality in which peers' backgrounds, current behavior, or outcomes affect an individual's own outcome.
  - Market-based or price-based effects are excluded.
- Peer effects are ubiquitous
  - test scores, career choice, consumption, crime, drinking behaviour, teenage pregnancy, physical fitness among many others

Introduction: Peer Effects in Education

- Peer effects in education has been of increasing interest to both academics and policy makers in recent years.
- Peer effects in education has typically focussed on test scores.
  - These can either result from the outcomes of one's peers (Sacerdote 2001, Antecol et al. 2016), their academic background (Carrell et al. 2009, Zimmerman 2003) or their racial or gender identity (Hoxby 2000, Hanushek et al. 2009).

Introduction: What we do?

- In this paper we look at gender peer effects.
- We use a novel administrative dataset from the Central Board of Secondary Education which provides us information about secondary and higher secondary test scores of students linked with other student information.
- In particular, we look at how the proportion of female schoolmates impacts an students' test scores in the high-stakes class 12 board exams.
  - Class 12 board exams are extremely important as it determines subsequent college admission and in many cases employers take these test scores into account.

Introduction: What we do? (contd.)

- Our identification strategy exploits within school variation in the proportion of female students across cohorts.
- We find a positive, statistically significant gender peer effect.
  - survives a battery of robustness checks
- We show suggestive evidence that our results are primarily driven by changes in classroom environment (discipline/disruption) and not due to achievement/ability spillovers.

Motivation

- Existence of gender peer effects has implications for various educational policy debates.
  - Affirmative action for female students.
  - Co-educational versus Single-sex school
  - If peer effects exist in schools, then there may be an inefficiency in the existing distribution of students across schools; peer effect can be thought of as an externality which might call for a redistribution across schools along gender lines.
  - If gender peer effects exist, improving girls' access to education can lead to better educational outcomes for all - equal opportunity is an end in itself, but may also be the means to the goal of better achievement levels.
    - The question of peer effects assumes particular policy salience in the Indian context due to the poor state of India in female schooling and government initiatives to correct that state such as *Kasturba Gandhi Balika Vidyalaya* and *Beti Bachao Beti Padhao Yojana*.

Literature Review

- Natural experiments to study peer effects in test scores:
  - Randomly assigned room/dorm mates: Sacerdote (2001), Carrell et al. (2009), Jain and Kapoor (2015)
- Panel data sets and repeated cross-sections can be analyzed to control for various kinds of selection problems; some study the effects of the background (race, gender, domestic violence) of peers (Hoxby, 2000; Lavy and Schlosser, 2011; Carrell and Hoekstra, 2010)
- We add to this literature by looking at gender peer effects in the Indian high school context:
  - In the context of a developing country using an all-India dataset with test score outcomes which is rare in the Indian context
  - Control for ability and past inputs by using past test scores (class 10 marks)

Data

- We use a novel administrative data set of the Central Board of Secondary Education.
  - It contains test scores!
  - Studies on educational outcomes in India have suffered because of the lack of data regarding students' test scores(Kingdon, 2007)
- The data set contains the universe of students in CBSE-affiliated schools who appeared for their class 12 final exams in 2014, 2015 or 2016 - amounts to roughly 2.8 million students.
- The students are distributed among 10,153 schools across India. .
- The data set contains their total marks out of 500, other individual-level information such as sex, caste, annual family income, whether they have siblings or not, their marks in class 10 if they were enrolled in CBSE-affiliated schools at that time.

Sample of analysis

- Of the 2.8 million students, our main estimation sample includes those who also appeared for class 10 final exams under CBSE. This narrows the sample to 2.3 million students.
  - In one of the robustness checks, we relax this sample restriction.
- Since our identification strategy rests on cohort-to-cohort variation in proportion of female students within a school, we discard all the students of single-sex schools from the sample.
- This leaves us with roughly 1.9 million students, 1.1 million of whom are boys and about 0.8 million are girls.

Identification Strategy

- There are two main challenges in the identification of peer effects:
  - Reflection problem (Manski 1993): Since individual and peer effects are determined jointly, it is difficult to distinguish the effect that the peer group has on the individual from the effect that the individual has on the group. However this is a problem in the estimation of endogenous peer effects and not for the reduced form peer effects which we are estimating. →
  - Self-selection: Since individuals self select into peer groups, it is difficult to establish the causal effect since it might be contaminated by omitted variables which determine the selection into peer groups.

Identification Strategy(contd.)

- Regression specification:

$$Y_{ist} = \alpha + \beta P_{st} + \gamma X_{ist} + \eta_s + \mu_t + \phi_s t + \epsilon_{ist}$$

  - P_{st}: proportion of female students in class 12 in school s at time t
  - η_s: school fixed effects ensure that sorting of students across schools does not bias the estimate
  - μ_t: year fixed effects ensure that unobserved shocks affecting educational outcomes and gender composition of all schools does not bias the estimate
  - $\phi_s t$: school-wise time trends account for time varying unobservable trends specific to schools; residual variation in proportion of female students is arguably idiosyncratic (arising from natural biological variation, for instance)

- Hence identification is achieved from the deviation in the proportion of female students from the school specific linear trend.

- X_{ist}: We include a host of other controls:
  - We control for past scores as a proxy for past inputs and ability.
  - We also include mean cohort-level controls to control for additional sources of selection.
    - In particular, we include both average class 10 scores of girls in the cohort as well as average class 10 scores of all students in the cohort as controls in our specification.
  - We also include other individual level controls such as caste, income, age etc
- We standardize scores at the year level.
- We cluster standard errors at the school level.

Identification Strategy (contd.)

- Remaining threat to identification strategy: unobservable school level time varying factors correlated with both proportion of female students and test scores
  - To reiterate, we do control for school specific linear time trends.
  - We follow Oster (2017) and find out how important these unobservables need to be to drive our estimated relationship to a null result.
  - We implement falsification exercises to see if our treatment effects are capturing a spurious correlation between time varying school factors and proportion female.

Descriptive Statistics

	Girls		Boys		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Proportion of Female Students	0.43	0.12	0.38	0.11	0.40	0.12
Proportion of SC students	0.07	0.08	0.06	0.07	0.06	0.08
Proportion of ST students	0.05	0.15	0.04	0.13	0.04	0.14
Proportion of OBC students	0.21	0.19	0.21	0.19	0.20	0.18
Annual Income (in Rupees)	331618.50	713380.70	306935.20	1918428.00	316884.50	1549891.00
Total Score (out of 500) in Class 12	351.54	76.31	325.96	87.27	336.37	83.95
Total Score (out of 500) in Class 10	366.47	71.78	354.01	72.80	359.03	72.65
Observations	778806		1153331		1932137	

Validity of Identifying Assumption

Dependent Variables	Coefficient of Proportion of Female Students
Annual Income	14681.46
	(18506.39)
Only Child	-0.02
	(0.01)
SC	-0.008
	(0.006)
ST	0.004
	(0.004)
OBC	-0.01
	(0.01)
Year Fixed Effects	Yes
School Fixed Effects	Yes
School-specific Time Trends	Yes

Effect of Proportion of Female Classmates on Test Scores

	(1)	(2)	(3)
Proportion of Female Students	1.24***	0.30***	0.19***
	(0.05)	(0.02)	(0.03)
Marks in Grade 10	0.62***	0.62***	0.62***
	(0.00)	(0.00)	(0.00)
SC	-0.10***	-0.07***	-0.06***
	(0.01)	(0.00)	(0.00)
OBC	-0.16***	-0.05***	-0.05***
	(0.01)	(0.00)	(0.00)
ST	-0.20***	-0.08***	-0.08***
	(0.02)	(0.00)	(0.00)
Female	0.13***	0.13***	0.13***
	(0.00)	(0.00)	(0.00)
OnlyChild	0.05***	-0.03***	-0.03***
	(0.01)	(0.00)	(0.00)
Observations	1862369	1862369	1862369
Year Fixed Effects	Yes	Yes	Yes
School Fixed Effects	No	Yes	Yes
School-specific Time Trends	No	No	Yes

Effect Sizes

- Looking at column 3 of the table in the previous slide, a 10 percentage point increase in the proportion of female students leads to an increase of 1.97 percent of a standard deviation in the students' grade 12 test score.
- Thus a movement in the proportion of female students from 10th percentile of the distribution to the 90th percentile will raise the average test scores by 5.3 percent of a standard deviation.
- To benchmark these results, these results are similar in size to:
  - Muralidharan and Sundararaman (2011) study on teacher performance pay in Andhra Pradesh
  - reducing class size by about 25-30% (Angrist and Lavy, 1999)

Peer effects across Gender

	Girls Only	Boys Only	Entire Sample
Proportion of Female Students	0.15***	0.22***	0.19***
	(0.03)	(0.04)	(0.03)
Marks in Grade 10	0.59***	0.64***	0.62***
	(0.00)	(0.00)	(0.00)
SC	-0.07***	-0.06***	-0.06***
	(0.00)	(0.00)	(0.00)
OBC	-0.04***	-0.05***	-0.05***
	(0.00)	(0.00)	(0.00)
ST	-0.07***	-0.08***	-0.08***
	(0.01)	(0.01)	(0.00)
Female			0.13***
			(0.00)
OnlyChild	-0.03***	-0.03***	-0.03***
	(0.00)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes
School-specific Time Trends	Yes	Yes	Yes

Effects across Income Quartiles

	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Proportion of Female Students	0.25***	0.24***	0.14***	0.13***
	(0.05)	(0.06)	(0.05)	(0.05)
Marks in Grade 10	0.64***	0.63***	0.62***	0.60***
	(0.00)	(0.00)	(0.00)	(0.00)
SC	-0.05***	-0.06***	-0.07***	-0.08***
	(0.00)	(0.01)	(0.00)	(0.00)
OBC	-0.04***	-0.05***	-0.05***	-0.05***
	(0.00)	(0.00)	(0.00)	(0.00)
ST	-0.06***	-0.08***	-0.07***	-0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
Female	0.15***	0.15***	0.13***	0.09***
	(0.00)	(0.00)	(0.00)	(0.00)
OnlyChild	-0.03***	-0.03***	-0.03***	-0.03***
	(0.00)	(0.01)	(0.00)	(0.00)
Observations	467846	329009	385416	496999
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-specific Time Trends	Yes	Yes	Yes	Yes

Peer Effects across Caste Groups

	SC/ST	OBC	General
	(1)	(2)	(3)
Proportion of Female Students	0.26***	0.20***	0.17***
	(0.07)	(0.05)	(0.04)
Marks in Grade 10	0.55***	0.63***	0.63***
	(0.01)	(0.00)	(0.00)
Female	0.13***	0.15***	0.12***
	(0.00)	(0.00)	(0.00)
Only Child	-0.02**	-0.02***	-0.04***
	(0.01)	(0.00)	(0.00)
Observations	191609	382136	1287467
Year Fixed Effects	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes
School-specific Time Trends	Yes	Yes	Yes

Non-linear effects of the Proportion of Female Students

	(1) z-score in Class 12	(2) z-score in Class 12
Proportion of Female Students	0.62***	0.44***
	(0.15)	(0.14)
(Proportion of Female Students)^2	-0.42***	-0.29*
	(0.16)	(0.15)
Total Score in Class 10	0.63***	0.62***
	(0.00)	(0.00)
Female		0.13***
		(0.00)
SC		-0.06***
		(0.00)
OBC		-0.05***
		(0.00)
ST		-0.08***
		(0.00)
Only Child		-0.03***
		(0.00)
Observations	1912021	1862369
Year Fixed Effects	Yes	Yes
School Fixed Effects	Yes	Yes
School-specific Time Trends	Yes	Yes

Robustness Check: Controlling for Enrolment and Mean Controls

	(1)	(2)	(3)
Proportion of Female Students	1.14***	0.34***	0.26***
	(0.10)	(0.04)	(0.05)
Marks in Grade 10	0.62***	0.62***	0.62***
	(0.00)	(0.00)	(0.00)
SC	-0.06***	-0.06***	-0.06***
	(0.00)	(0.00)	(0.00)
OBC	-0.05***	-0.05***	-0.05***
	(0.00)	(0.00)	(0.00)
ST	-0.07***	-0.08***	-0.08***
	(0.00)	(0.00)	(0.00)
Female	0.13***	0.13***	0.13***
	(0.00)	(0.00)	(0.00)
OnlyChild	0.04***	-0.03***	-0.03***
	(0.01)	(0.00)	(0.00)
Observations	1862369	1862369	1862369
Control for Enrolment	Yes	Yes	Yes
Mean Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
School Fixed Effects	No	Yes	Yes
School-wise Time Trends	No	No	Yes

Robustness Check: Including Students from Non-CBSE Boards

	Original Sample	Including Students from Non-CBSE Boards
	(1)	(2)
Proportion of Female Students	0.21***	0.21***
	(0.03)	(0.04)
Female	0.24***	0.25***
	(0.00)	(0.00)
SC	-0.19***	-0.19***
	(0.00)	(0.00)
OBC	-0.06***	-0.06***
	(0.00)	(0.00)
ST	-0.22***	-0.22***
	(0.01)	(0.01)
Only Child	-0.00	-0.00
	(0.00)	(0.00)
Observations	1862369	2222854
Year Fixed Effects	Yes	Yes
School Fixed Effects	Yes	Yes
School-specific Time Trends	Yes	Yes

Robustness Check: Students who changed schools vs. those who didn't

	Did Not Change Schools	Changed School
Proportion of Female Students	0.19***	0.17***
	(0.03)	(0.06)
Marks in Grade 10	0.67***	0.59***
	(0.00)	(0.00)
SC	-0.05***	-0.09***
	(0.00)	(0.00)
OBC	-0.03***	-0.06***
	(0.00)	(0.00)
ST	-0.05***	-0.10***
	(0.00)	(0.01)
Female	0.11***	0.16***
	(0.00)	(0.00)
OnlyChild	-0.04***	-0.02***
	(0.00)	(0.00)
Observations	1272375	589711
Year Fixed Effects	Yes	Yes
School Fixed Effects	Yes	Yes
School-specific Time Trends	Yes	Yes

Robustness Check: Bound Analysis(Oster 2017)

- The stability of the coefficient of interest to the inclusion of additional controls is commonly used for making inferences about the robustness of the treatment effect to omitted variable bias.
  - selection on observables is informative about the selection on unobservables (Altonji et al. 2005; Oster (2017))
- Oster (2017) derives the relationship between coefficient movement, R^2 movements and omitted variable bias assuming proportional selection relationship between observables and unobservables, the degree of proportionality being denoted by δ.
- Oster (2017) suggests $\delta = 1$ is a reasonable value for δ.
- She suggests $R^2_{max} = min(\pi . R^2_{controlled}, 1)$. Based on simulations using data from papers which use randomized data, Oster (2017) suggests $\pi = 1.3$ as the cutoff value.
- Similarly, one can calculate δ corresponding to zero treatment effect, given R^2_{max}. A value of δ greater than 1 would suggest a robust coefficient.

Robustness Check: Bound Analysis(Oster 2017)(contd.)

	Uncontrolled	Controlled	Estimated Bias	
			R^2_{max} = 0.532	
			β for δ = 1	δ for β = 0
	(1)	(2)	(3)	(4)
β	0.40	0.20	0.14	3.24
R^2	0.00	0.41		

Falsification Exercise

	2014 and 2015		2015 and 2016	
	(1)	(2)	(3)	(4)
Proportion of Female Students	0.27***		0.25***	
	(0.03)		(0.03)	
Proportion of Female Students in *t+1*		-0.04		
		(0.03)		
Proportion of Female Students in *t-1*				-0.03
				(0.03)
Female	0.12***	0.12***	0.14***	0.14***
	(0.00)	(0.00)	(0.00)	(0.00)
Marks in Grade 10	0.63***	0.63***	0.62***	0.61***
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	1212462	1209333	1277387	1232124
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes

Alternative Strategy: Individual Fixed Effects

- Since we have grades for both class 10 and 12 board exams, we can run an individual fixed effect model.
- Omitted variables would be even less of a concern here.

$$Y_{igst} = \alpha_i + \mu_g + \beta P_{sgt} + \gamma X_{sgt} + \epsilon_{igst}$$

where Y_{igst} is the test score of student i in grade g, in school s and in year t. P_{sgt} denotes the proportion of female students. α_i and μ_g are individual and grade fixed effects respectively. X_{sgt} are school-grade-year level controls which include the average scores of girls and the average scores of all other students in grade g of school s and at time t.

Alternative Strategy: Individual Fixed Effects (contd.)

	(1)	(2)
Proportion of Female Students	0.37***	0.27***
	(0.051)	(0.048)
Observations	3821792	3821792
Cohort Controls	No	Yes

Possible Mechanism

- We have showed that there is a statistically significant positive and very robust effect of the proportion of female classmates on student's test scores.
- There have been primarily two channels suggested in the literature behind peer effects(Hoxby, 2000; Lavy and Schlosser, 2011:
  - Achievement/ability spillovers
  - Classroom Environment
- Our data does not allow us to test for these channels explicitly.
- The previously shown heterogenous effects show that a)boys and b) students from disadvantaged background experience higher gender peer effects.
  - To the extent that disadvantaged students are more likely to attend schools with higher levels of disruptions, these results point to a classroom environment story.
- We show more suggestive evidence in the following slides that the ability/achievement channel is not the whole story and changes in classroom environment might be the main driver.

Mechanism: Suggestive Evidence

Peer Effects in School-Cohorts of Different Quality Quartiles: Average Ability of Female Students

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Proportion of Female Students	0.38***	0.19*	0.22*	0.05
	(0.11)	(0.10)	(0.12)	(0.07)
Marks in Grade 10	0.62***	0.62***	0.62***	0.62***
	(0.01)	(0.00)	(0.00)	(0.00)
Female	0.17***	0.16***	0.12***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes

Mechanism: Suggestive Evidence (contd.)

Peer Effects in School-Cohorts of Different Quality Quartiles: Average Ability of Male Students

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Proportion of Female Students	0.39***	0.35***	-0.00	0.02
	(0.11)	(0.11)	(0.09)	(0.07)
Marks in Grade 10	0.64***	0.63***	0.60***	0.61***
	(0.01)	(0.00)	(0.00)	(0.01)
Female	0.18***	0.16***	0.12***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes

Mechanism: Suggestive Evidence (contd.)

Peer Effects in School-Cohorts of Different Quality Quartiles: Average Ability of All Students

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Proportion of Female Students	0.45***	0.39***	0.23***	0.02
	(0.13)	(0.09)	(0.09)	(0.06)
Marks in Grade 10	0.63***	0.63***	0.60***	0.61***
	(0.01)	(0.00)	(0.00)	(0.01)
Female	0.17***	0.17***	0.12***	0.08***
	(0.01)	(0.00)	(0.00)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes

Mechanism: Suggestive Evidence (contd.)

Peer Effects in School-Cohorts of Different Quality Quartiles: Non-Linear Effects Revisited

	Female Peer Quartile 1 (1)	Female Peer Quartile 2 (2)	Female Peer Quartile 3 (3)	Female Peer Quartile 4 (4)
Proportion of Female Students	0.095*	0.22***	0.23***	0.019
in Quartile 1	(0.051)	(0.074)	(0.069)	(0.041)
Proportion of Female Students	0.104*	0.110*	0.116**	0.044
in Quartile 2	(0.056)	(0.059)	(0.053)	(0.033)
Proportion of Female Students	0.03	-0.045	0.046	0.005
in Quartile 3	(0.055)	(0.054)	(0.057)	(0.031)
Proportion of Female Students	0.140**	-0.056	-0.12	-0.019
in Quartile 4	(0.067)	(0.072)	(0.077)	(0.041)
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes

Mechanism: Suggestive Evidence (contd.)

Peer Effects in School-Cohorts of Different Quality Quartiles: Non-Linear Effects Revisited (contd.)

	Male Peer Quartile 1 (1)	Male Peer Quartile 2 (2)	Male Peer Quartile 3 (3)	Male Peer Quartile 4 (4)
Proportion of Female Students	0.10**	0.20***	-0.04	0.07**
in Quartile 1	(0.05)	(0.07)	(0.06)	(0.03)
Proportion of Female Students	0.12**	0.09	0.09*	-0.01
in Quartile 2	(0.05)	(0.06)	(0.05)	(0.03)
Proportion of Female Students	0.03	0.02	0.06	-0.01
in Quartile 3	(0.05)	(0.07)	(0.08)	(0.03)
Proportion of Female Students	0.16**	0.06	-0.04	-0.03
in Quartile 4	(0.06)	(0.07)	(0.06)	(0.04)
Year Fixed Effects	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes

Mechanism: Suggestive Evidence (contd.)

Peer Effects Across Different Subjects and Streams

Panel I: Peer Effects	(1) English	(2) Science(PC)	(3) Science(PCM)	(4) Math	(5) Biology	(6) Arts(HP)	(7) Commerce(AB)
Proportion of Female Students	0.19***	0.15***	0.18***	0.17***	0.11	0.06	0.24***
	(0.05)	(0.04)	(0.04)	(0.05)	(0.07)	(0.25)	(0.06)
Marks in Grade 10	0.52***	0.77***	0.81***	0.75***	0.71***	0.77***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
Female	0.16***	-0.07***	-0.11***	-0.12***	0.00	0.04***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel II: Ability of Girls	(1) English	(2) Science(PC)	(3) Science(PCM)	(4) Math	(5) Biology	(6) Arts(HP)	(7) Commerce(AB)
Marks in Grade 10	0.05***	0.25***	0.20***	0.25***	0.12***	-0.07***	-0.10***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	1013262	1013262	1013262	1013262	1013262	1013262	1013262
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School-wise Time Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Conclusion

- We have evaluated the effect that the gender composition of a student's cohort has on their test scores by studying the universe of students who appeared for CBSE board exams in 2014, 2015 or 2016.
- Identification of this gender peer effect is achieved by making use of the credibly idiosyncratic variation in the proportion of female students across successive cohorts within schools.
- The proportion of female schoolmates is shown to exert a significant and positive effect on students' test scores.
- Boys and girls both benefit from increases in proportion of female schoolmates (the effects for boys is higher in magnitude.)

Conclusion

- Students from disadvantaged backgrounds experience higher gender peer effect.
- Results are broadly robust for students across different streams.
- We show suggestive evidence that peer effects are not primarily driven through ability/achievement spillovers but seems to be driven by changes in the classroom environment due to the presence of female students.

Reduced Form

Consider a system of two equations:

$$Y_i = \alpha_1 + \beta_1 \overline{Y}_{-i} + \gamma_1 X_i + + \delta_1 \overline{X}_{-i} + \epsilon_{1i} \quad (1)$$

$$\overline{Y}_{-i} = \alpha_2 + \beta_2 Y_i + \gamma_2 X_i + + \delta_2 \overline{X}_{-i} + \epsilon_{2i} \quad (2)$$

where $\overline{Y}_{-i}$ and $\overline{X}_{-i}$ are peer outcomes and background respectively. Instead of recovering both parameters β_1 and δ_1, we can estimate the reduced-form effects of peer background on one's own outcomes. From (1) and (2):

$$Y_i = \pi_1 + \pi_2 X_i + + \pi_3 \overline{X}_{-i} + \mu_i \quad (3)$$

where $\pi_3 = \frac{\beta_1 \delta_2 + \delta_1}{1 - \beta_1 \beta_2}$. Hence π_3 contains a direct effect of peers' background and and indirect component channeled through peer outcomes.

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