Policy evaluation of gender affirmative action in engineering schools

Evidence from Chile

Valentina Contreras

London School of Economics and Political Sciences

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Gender imbalances in higher education

- There has been significant advances in female participation in higher education.
- Although women are half of the population, they are a minority in certain fields of study
  - On average **35% of students enrolled in STEM** are women.
  - Further stages of the academic track: On average, **30% of the world's researchers** are women.
- Disadvatageous for women: relevant explanation for the **gender wage gap**.

Affirmative action policies as a potential solution

- **Affirmative action** has been used in higher education to:
  1. Provide better opportunities to groups treated unjustly in the past (mainly in terms on race and caste)
  2. Respond to institutional interest gaining the positive academic and social benefits of a diverse student body
- The literature has mainly informed on (1), and it has focused on race, and caste policies[1]
- We know very little about the effects of gender affirmative action interventions.

[1] Race policies: Arcidiacono (2005), Long (2007), Epple et al. (2008), Howell (2010), Francis and Tannuri-Pianto (2012a), Francis and Tannuri-Pianto (2012b)). Caste affirmative action policies: Bertrand et al. (2010), Frisancho and Krishna (2016), De Zwart (2000), Bagde et al. (2016). Gender imbalances: Lihamba et al. (2006) and Onsongo (2009).

What do we need to know?

- Effectiveness: Can gender affirmative action help reduce gender imbalances in STEM? to what extent?
- Do affirmative action policies have a negative impact on academic quality?
- When a policy works: are there further effects?

This paper: first to evaluate gender affirmative action in centralised admission systems

- In 2014, two universities in Chile implemented **two distinct gender affirmative action policies** to increase the share of women in their **engineering schools**. (While other 28 schools in the same admission system did not)
- I evaluate them in terms of:
    - Effectiveness in reversing discrimination. **Attendance and academic ability** distribution of new students
    - Effects of increasing the share of women on the academic outcomes of all members of the student body. **Effects on peers:** grades and drop-outs.

Background

Chilean University admission system: Centralised and rules are clear and public

- **Centralised:** Students submit one application where they rank their choices from most preferred to least preferred
- A choice is a **Programme-university** (E.g. : engineering at The University of Chile or architecture at The Catholic University)
- Admissions depend only on student **application score**
- Students are admitted to their most preferred degree for which they achieved a sufficiently high score.

University of Chile Policy (UCH)

Policy 1 (UCH): Increases cohort size

- Adds forty **extra female-exclusive vacancies** to their engineering school (close to 4% of the total school offer).
- The universitiy assigns these slots to the 40 female applicants with the highest scores that didn't get a place through the Chilean centralised university admission system. **(Not a quota policy)**

Catholic University policy (PUC)

Policy 2 (Catholic University)

- **Changed the curriculum** and created new majors with specialities that combine engineering with disciplines of more significant interest to women, such as biomedicine, architecture or design
- **Increased the number of female faculty** members in the engineering school

Applications and attendance

1. Applications and Attendance

- I look at **regular admission** (without considering the 40 extra seats) and also total effect
- Why would we expect the UCH policy to have an effect on regular admisssions?
- Policies might **change women's preferences:**
  - Preferences for being in environments with higher percentage of women. Policy generates **incentives to apply**
  - Changes in aspiration (Lloyd et al. (2008) for Texas 10%)

Estimating equation: Differences in differences

- The treatments are heterogeneous as PUC and UCH implemented different initiatives:
  - Treatment 1: UCH
  - Treatment 2: PUC
  - Control: 28 Chilean engineering schools (part of the centralised admission system)
- University fixed effects and time fixed effects

$$Y_{i,t} = \beta_0 + \gamma_i + \delta_t + \beta_1 Treatment_{UCH,i,t} + \beta_2 Treatment_{PUC,i,t} + \epsilon_{i,t}$$

Where γ_i are university fixed effects and δ_t are time fixed effects $\epsilon_{i,t}$ is an error term.[2] β_1 and β_2 are the causal effects of interest.

[2] As the university is the level of analysis, the sample is small (N=318). Thus, I estimate errors and confidence intervals using case bootstrap.

Results: Applications

- 10.4% more female students applied to engineering at **UCH** as their first option
- 5,3% more female students applied to engineering at **PUC** as their first option

	Dependent variable:		
	Percentage of females among applicants		
	First Option	Second Option	First or Second Option
β_1 (UCH)	0.104***	0.101***	0.085***
	(0.012)	(0.038)	(0.009)
β_2 (PUC)	0.053***	0.051*	0.059***
	(0.012)	(0.028)	(0.012)
Observations	318	318	318
R^2	0.747	0.473	0.707
Adjusted R^2	0.708	0.393	0.663
Note:			*p<0.1; **p<0.05; ***p<0.01

Placebo test for applications: Placebo

Results: Attendance

- 4.4% more women enroled in UCH through the regular admission process (+ direct 4% increase from female-exclusive seats)
- 7,2% increase at PUC.

	Dependent variable:	
	Percentage of females enroled in first year	
	Regular admission	All
β_1	0.044**	0.084***
(UCH)	(0.022)	(0.022)
β_2	0.072***	0.072***
(PUC)	(0.022)	(0.022)
Observations	318	318
R^2	0.68	0.700
Adjusted R^2	0.651	0.654

Notes: β_1 and β_2 are the DD estimated coefficients. The dependant variable "regular admission" includes only women enrolled via regualr admission, while the varible "All" includes women enrolled via PEG. Bootstrap errors in parenthesis, *p<0.1; **p<0.05; ***p<0.01

Placebo test for applications: Placebo

Academic performance

3. Further effects: How changes in gender composition affect peers?

- Does improving gender diversity has any effects on peers?
- I use data from the University of Chile to determine the effects of classroom gender composition on male and female engineering students.

  1. Grades on first year subjects
  2. Grades on a collaborative engineering project
  3. Drop-out rates

Why do I focus on UCH?

- They implemented what can be considered a slightly more controversial policy
- Excellent setting to study peer compositional effects at University
  - Usually very difficult as university student self-select into courses which can bias the estimation[3]

[3] Oosterbeek and Van Ewijk (2014), and Shan (2022) study gender per effects for economics undergraduate students in study groups

Empirical setting

- No self- selection: First year **students are exogenously assigned to peer groups** of about 100 students. Exogenous variation on gender composition among groups.
  - N=71 groups.
  - Some variation on gender composition across classrooms. s.d.=7.4%
- **Data on relevant peers:** Students in the same group share a physical classroom and attend the lectures, seminars and teaching activities together during the first term.
- I can estimate effects using a linear **peer-effects model** (Manski, 1993)

Compositional effects on academic outcomes: grades and dropout

$$y_{ijc} = \alpha + \beta_1 X_{ijc} + \gamma_1 (ACA_{ijc}) + \gamma_2 A\bar{C}A_{-i,jc} + \delta P_{j,c} + \epsilon_{ijct} \quad (1)$$

y_{ijct} is the academic outcome: final grade of a male/female student i in classroom j, and cohort c. X_i is a vector of other characteristics of student i ()socioeconomic background and previous school (private, semi-private or public)); $P_{j,c}$ is the proportion of women in classroom j in cohort c; ACA_{ijc} is a vector with admission test scores and high school grades; $A\bar{C}A_{-i,jc}$ is the average application score of peers.

- I estimate this equation separately for men and women

Results: Grades

- The increase in the share of women has **no impact** on student's academic achievement in core courses (Physics, Calculus, Algebra, and Computer science). Coefficients
- Improves performance on the collaborative work project for men and women ("Introduction to engineering course"). Coefficients

Drop out after end of first term

- I look at the probability of drop out after the end of first term.
- Logistic regression, dependant variable is a dummy "Drop-out"=1 if the student doesn't enrol in the second term.
- Relevant to understand the reform implications for persistence.

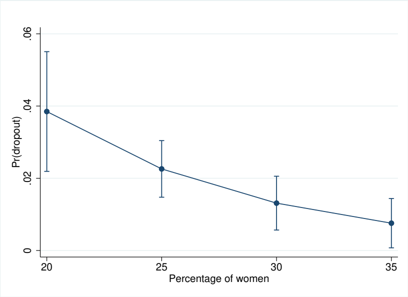
Drop out: Log-odds coefficients

	(1) Women	(2) Men
Women percentage	-0.112**	0.0139
	(-2.87)	(0.70)
Average PSU score - Class	0.0199	0.00337
	(1.28)	(0.60)
Application Score	-0.0324*	-0.0195**
	(-2.05)	(-2.79)
Mathematics Score	0.00527	-0.00162
	(0.63)	(-0.45)
High School Grades	0.00698	0.00365
	(1.33)	(1.64)
Constant	-0.986	6.873
	(-0.07)	(1.38)
Observations	1567	5651

Dependant variable is a Drop-out dummy, equal to 1 if a student does not enrol in any course after the first term. Models include year fixed effects, and controls for socioeconomic background. t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- There is an statistically significant effect for women but not for men.
- Incrases in the share of women reduces women's drop-out.
- What is the size of the effect?

Drop out: Predicted Probabilities (PP) for women



Size of the effect of the reform:

- Women's PP of drop out at 20% women is 3.8%
- PP at 28% women is 1.4% **more than 60% less**

Reform can help to increase the persistence of women in the programme

Sum up

- Take advantage of a "natural experiment" and use a difference in difference approach to investigate the effects of gender affirmative action.
- **Attendance:** Similar results for both policies - Succesful at increasing percentage of women in engineering schools
- Increases in the percentage of women stemmed from a **higher number of interested well prepared female applicants rather than from a lowering in the admission standards**
- I provide evidence that by bringing more women to these male-dominated fields, we can also reduce women drop-out rates and, therefore, their persistence in STEM.

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Placebo test: Applications DD

	Dependent variable:		
	Percentage of females among applicants		
	First Option	Second Option	First or Second Option
β_1	0.002	0.109	0.003
(UCH)	(0.009)	(0.043)	(0.010)
β_2	0.018	−0.010	0.016
(PUC)	(0.010)	(0.027)	(0.010)
Observations (N)	167	167	167
R^2	0.716	0.451	0.716
Adjusted R^2	0.638	0.300	0.638

Notes: β_1 and β_2 are the DD estimated coefficients as if treatment had happened in 2010. The dependant variable for "First or Second Option" is the percentage of women in each cohort t who ranked a university i in the first or second place in their application list. Bootstrap errors in parenthesis, *p<0.1; **p<0.05; ***p<0.01

Figure: Placebo test - Applications

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Placebo test: Enrolments DD

	Dependent variable:
	Percentage of females enrolled in first year
β_1	0.001
(UCH)	(0.015)
β_2	0.009
	(0.014)
(PUC)	
Observations (N)	168
R^2	0.699
Adjusted R^2	0.613

Notes: β_1 and β_2 are the DD estimated coefficients as if treatment had happened in 2010. Bootstrap errors in parenthesis, *p<0.1; **p<0.05; ***p<0.01

Figure: Placebo test - Enrolments

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Estimated coefficients - Grades

	(1) Physics-W	(2) Physics-M	(3) Calculus-W	(4) Calculus-M	(5) Algebra-W	(6) Algebra-M
Percentage of women	0.000874	-0.00368	0.00430	0.00335	0.00250	0.00442
	(0.21)	(-1.48)	(1.11)	(1.45)	(0.59)	(1.80)
Average PSU score - Class	-0.457**	0.131	-0.355*	0.321***	-0.500***	0.130
	(-3.02)	(1.42)	(-2.54)	(4.04)	(-3.62)	(1.65)
Application Score	1.839***	1.327***	1.827***	1.203***	1.925***	1.286***
	(12.58)	(21.03)	(12.95)	(19.52)	(13.75)	(21.73)
Mathematics Score	-0.151	0.124**	-0.139	0.304***	-0.125	0.252***
	(-1.81)	(3.26)	(-1.76)	(8.23)	(-1.58)	(7.05)
High School Grades	0.000735	0.105***	0.00196	0.107***	0.0124	0.114***
	(0.04)	(6.12)	(0.12)	(6.46)	(0.77)	(7.21)
Constant	-4.561***	-7.529***	-5.927***	-10.12***	-5.379***	-8.742***
	(-3.69)	(-10.23)	(-4.95)	(-15.43)	(-4.66)	(-13.69)
Observations	1460	5312	1613	5658	1556	5599

Notes: Dependant variable is average mark in the course, columns names that end in W display estimated coefficients for women, and in M for men. All models include year fixed effects, and controls for socioeconomic background t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Estimated coefficients - Grades in collaborative project

	(1) Women	(2) Men	(3) Women	(4) Men
Low women	-0.073*	0		
	(-2.22)	(.)		
High women			0.132*	0
			(1.97)	(.)
Average PSU score - Class	-0.133	0.008	-0.259	0.008
	(-0.50)	(0.07)	(-1.01)	(0.07)
Application Score	0.415***	0.141***	0.424***	0.141***
	(4.77)	(3.88)	(4.88)	(3.88)
Mathematics Score	-0.139**	-0.026	-0.146**	-0.026
	(-2.75)	(-1.18)	(-2.88)	(-1.18)
High School Grades	-0.003	0.053***	-0.005	0.053***
	(-0.31)	(5.10)	(-0.49)	(5.10)
Constant	4.830*	4.482***	5.737**	4.482***
	(2.44)	(4.70)	(2.97)	(4.70)
Observations	1328	4940	1328	4940

Variable "low women" is a dummy equal to 1 for classrroms where there is maximum 1 women per team."High women" indicates that more than half of the team in the classroom have a least 2 women in the team. All models include year fixed effects, and controls for socioeconomic background. t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Differential trends analysis

- I examine differential trends in **average application scores of women and men before and after the policies**
- I use data from 3 years before and 3 years after the policy and estimate a linear equation with a gender dummy and a reform dummy (Similar to DiD).
- I do this analysis for the two treated schools.

Changes in ability distribution - Results

- **No significant changes in incoming student's average academic ability**
- Changes in gender composition did not increase the ability gender gap

	(1) UCH	(2) PUC
Reform	-0.08 ***	-0.18***
	(-6.65)	(-16.19)
Women	-0.05***	-0.04**
	(-4.52)	(-3.23)
Reform * Women	-0.05***	0.01
	(-3.31)	(0.98)
Constant	7.58***	7.83***
	(855.45)	(1032.99)
N	4145	3711

Notes: Dependent variable is average aplication score per cohort of incoming students at UCH and PUC respectively. Reform is a dummy equal to 1 for post-reform years. t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$