Gender Composition in Classrooms: Influences on Post-Secondary Schooling Choices

EEA Congress 2025

Bordeaux School of Economics

Polanco-Jiménez, Jaime [1]
LEER - KU Leuven
Pontifical Xavierian University

Kristof De Witte [2]
KU Leuven & UNU-Merit,
Maastricht University

Gloria L. Bernal [3]
Pontifical Xavierian University

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Contents

This Paper

Question: What is the effect of transitioning from female to coeducational schools on female enrollment in STEM fields?

Motivation: The decision regarding post-secondary studies carries profound implications, extending beyond career preferences to enduring consequences, notably in terms of income differentials.[1]

How:

- Staggered DiD (Callaway et al. 2021) estimation to identify the causal effect of the transition from a single-sex school (female) to coeducational on schooling decision.
  - i. Schooling Decision: ↑ Participation in STEM.
  - ii. Enrollment: → Overall Enrollment, ↓ University. ↑ Technological. ↑ Technical.

Heterogeneities:

- We examine majors of Science, Technology, Engineering, and Mathematics separately.
  - i. → Science, ↑ Technology, → Engineering, and → Mathematics
- We estimate the intensity of the transition.
  - i. Transition: $ATT_{\text{Accelerated}} \gg ATT_{Slow}$

[1] See, for example, Alesina, Giuliano, and Nunn (2013); Clifford D. Evans (2006); Evans and Diekman (2009); for Science and Statistics (2023); Lent, Brown, and Hackett (1994)

This Paper

Question: What is the effect of transitioning from female to coeducational schools on female enrollment in STEM fields?

Contributions:

1. **Causal evaluation of dismantling female schools system, providing a direct policy counterpoint to Jackson (2021).**

   While Jackson (2021) documents the benefits of *introducing* single-sex education in low-performing schools, we study the reverse policy: the abolition of single-sex schooling. This tests for policy symmetry and provides a more complete understanding of the potential gains and losses from such structural reforms.

2. **Uncovering a key, unintended consequence: a trade-off between field of study and type of degree.**

   We show the policy steers women towards STEM but simultaneously *away from* four-year university bachelor's degrees. This introduces a critical, previously undocumented cost-benefit dimension for policies aimed at closing occupational gender gaps.

3. **Demonstrating that initial school culture can dominate peer gender composition effects.**

   The policy's effect on female STEM choice *reverses* in formerly all-male schools. This finding provides a direct empirical challenge to simple peer effect models and adds critical context to the literature (*cf.* Lavy and Schlosser (2011); Brenøe and Zölitz (2020)), showing that pre-existing institutional norms are a first-order determinant of a policy's impact.

Educational System Overview

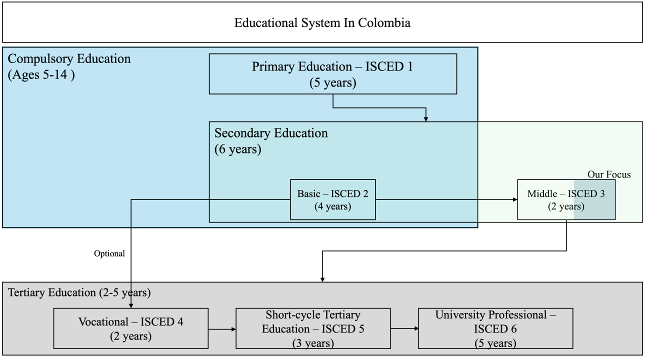


Figure: Structure of Colombia's education system[2]

The educational system in Colombia spans:

- **Primary School (5 years):** Ages 6–10.
- **Secondary School (6 years):** Divided into basic (4 years) and middle (2 years).
- **Tertiary Education:** Technical (2 years), technological (3 years), university (5 years).

[2] International Standard Classification of Education (ISCED)

The Policy Rationale: Proximity, Efficiency, and Cost

- **Standard Rule:** Municipalities assign school places based on student proximity.
  - **The Exception:** Single-sex schools add a gender filter (proximity + gender)[3].
- **The Inefficiency:** This exception creates logistical problems. For example, a girl living next to a boys' school must travel to a more distant girls' school.
- **The Cost:** This increases travel time and transportation costs for families, creating unequal access.
- **The Solution:** Transitioning single-sex schools to co-ed eliminates the gender filter, making the system more efficient and reducing costs for families by restoring the simple proximity rule for everyone.

[3] This priority was maintained until the Colombian National Education Plan (1996-2005)

Data Sources & Key Variables

- **SIMAT:** Student enrollment data of public schools (2012-2021).
- **SNIES:** Higher education enrollment and major choices (2012-2021).

Key Variables:

- Main Dependent Variable: Proportion of female students choosing STEM majors:
- Independent Variable: Transition to coeducation (indicator variable, timing of transition).
- Control Variables: Intensity of treatment (proportion of male students in former female schools).

Defining the Study Sample

Our analysis focuses on a specific set of schools and classrooms to ensure a clean identification of the policy's effect.

- **Universe:** All public secondary school classrooms in Colombia (2012-2020)

↓ **Filter 1:** Keep only schools that were single-sex (female) at baseline. *Excludes always-coed and male-only schools.*

↓ **Filter 2:** Keep only classrooms where students' recent prior education (grades 9-10) was also in a single-sex setting. *Ensures a clean measure of first co-ed exposure.*

		Female Proportion in the Classroom				
	Grade	t-2	t-1	t	t+1	t+2
Middle Secondary Education	11	100%	100%	<100%	<100%	<100%
	10	100%	100%	100%	<100%	<100%
	9	100%	100%	100%	100%	<100%

Figure: Staggered adoption of the coeducation policy in our final sample.

Final Sample: 459 classrooms across 436 unique schools.

Study Sample

- Total classrooms: 459 (436 schools), distributed across years.
- Time period: 2012-2020

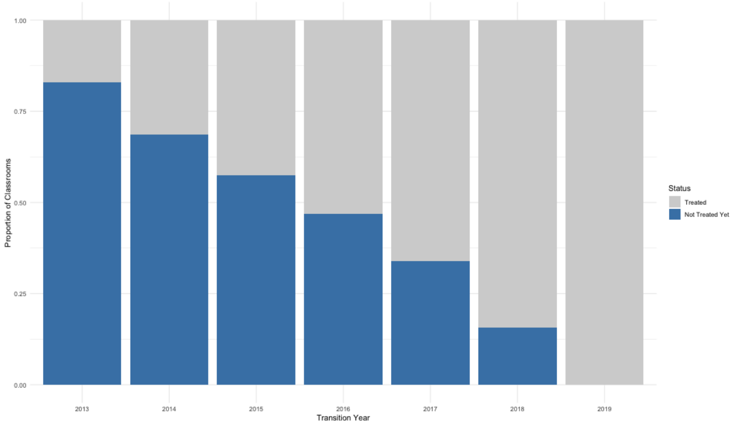


Figure: Proportion of Treated and Not-Yet-Treated Classrooms by Transition Year

Classroom Characteristics (At Baseline, Pre-Transition)

	Transition Year						
Variable	2013	2014	2015	2016	2017	2018	2019
Transitioned Schools	85	59	46	47	52	79	68
Transitioned Classrooms	90	62	46	49	56	83	73
Classroom Attributes							
Total Students (N)	8.9 (14.8)	18.3 (19.2)	13.7 (20.6)	11.3 (13.3)	11.3 (13.7)	15.2 (16.9)	13.6 (14.9)
Average Age (Years)	16.553 (1.385)	16.34 (0.655)	16.611 (1.162)	16.645 (1.115)	16.341 (0.736)	16.526 (1.044)	16.81 (2.084)
Student Characteristics							
Low Socioeconomic Level	0.794 (0.354)	0.852 (0.272)	0.86 (0.277)	0.822 (0.33)	0.814 (0.29)	0.758 (0.344)	0.72 (0.367)
Middle Socioeconomic Level	0.087 (0.234)	0.087 (0.204)	0.044 (0.092)	0.094 (0.257)	0.121 (0.242)	0.176 (0.293)	0.174 (0.287)
High Socioeconomic Level	0 (0)	0 (0.004)	0.001 (0.004)	0.019 (0.139)	0.002 (0.01)	0.02 (0.09)	0.019 (0.07)
Pass Rate for Last Year	0.88 (0.284)	0.951 (0.18)	0.914 (0.251)	0.974 (0.065)	0.973 (0.136)	0.907 (0.231)	0.895 (0.265)
Failure Rate for Last Year	0.013 (0.055)	0.005 (0.019)	0.024 (0.147)	0.014 (0.044)	0.011 (0.052)	0.039 (0.158)	0.053 (0.204)

Note: This table shows mean values (with standard deviations in parentheses) for relevant variables, measured one year prior to the classrooms' transition to coeducation, for each cohort defined by the transition year. Source: SIMAT and SNIES. "Transitioned Schools" indicates the number of unique schools that transitioned in the corresponding year.

Major Choice Proportions by Treatment Group (At Baseline, Pre-Transition)

	Transition Year						
Variable	2013	2014	2015	2016	2017	2018	2019
Post-secondary Major Choice Proportion in STEM							
STEM Fields	0.177 (0.242)	0.23 (0.212)	0.177 (0.21)	0.166 (0.198)	0.226 (0.248)	0.185 (0.172)	0.157 (0.18)
Non-STEM Fields	0.187 (0.275)	0.197 (0.205)	0.161 (0.19)	0.1 (0.146)	0.147 (0.224)	0.164 (0.184)	0.203 (0.186)
Not Continuing Education	0.636 (0.317)	0.573 (0.238)	0.662 (0.244)	0.733 (0.237)	0.627 (0.296)	0.651 (0.243)	0.639 (0.23)
Post-secondary Major Choice Proportion by Field of Knowledge							
Health Sciences	0.108 (0.258)	0.112 (0.17)	0.065 (0.178)	0.091 (0.207)	0.105 (0.202)	0.042 (0.075)	0.092 (0.226)
Social Sciences/Humanities	0.108 (0.258)	0.097 (0.147)	0.135 (0.254)	0.057 (0.109)	0.157 (0.274)	0.12 (0.211)	0.213 (0.283)
Law	0.019 (0.112)	0.008 (0.02)	0.02 (0.078)	0.005 (0.016)	0.013 (0.035)	0.018 (0.051)	0.019 (0.049)
Education Sciences	0.027 (0.096)	0.019 (0.038)	0.034 (0.078)	0.006 (0.019)	0.01 (0.024)	0.027 (0.113)	0.024 (0.07)
Economics/Business	0.157 (0.239)	0.155 (0.181)	0.124 (0.16)	0.136 (0.194)	0.086 (0.168)	0.121 (0.148)	0.079 (0.104)
Engineering/Architecture	0.047 (0.11)	0.128 (0.199)	0.064 (0.16)	0.025 (0.049)	0.071 (0.108)	0.078 (0.123)	0.06 (0.108)
Mathematics/Natural Sciences	0.013 (0.057)	0.004 (0.01)	0.016 (0.075)	0.019 (0.055)	0.02 (0.076)	0.007 (0.026)	0.022 (0.119)
Fine Arts	0.002 (0.009)	0.003 (0.013)	0.005 (0.021)	0.003 (0.009)	0.022 (0.134)	0.014 (0.044)	0.016 (0.049)
Agronomy/Veterinary	0.006 (0.031)	0.011 (0.057)	0.003 (0.012)	0.015 (0.048)	0.034 (0.108)	0.014 (0.057)	0.016 (0.067)

Note: This table shows the proportion of female students intending to pursue each field of study one year prior to their classrooms' transition to coeducation. Values are presented as means with standard deviations in parentheses, disaggregated by cohort transition year. Source: SIMAT and SNIES.

Empirical Strategy: Identification

- **Staggered Difference-in-Differences (SDiD):** Exploits variation in timing of school transitions to coeducation.
- **Callaway & Sant'Anna (2020) Estimator:** Addresses treatment effect heterogeneity and dynamic effects. Robust to "negative weighting" and "forbidden comparisons" issues in TWFE. Callaway and Sant'Anna (2021); Goodman-Bacon (2021)
- **Comparison Group:** "Not-yet-treated" classrooms provide a valid counterfactual.
- **Event Study Design:** Examines treatment effects across multiple periods before and after the transition.

Empirical Strategy: Event Study Specification

For simplicity let's look at TWFE shape[4].

$$Y_{cst} = \sum_{r=-S}^{-2} \beta_r \cdot D_{c,r} + \sum_{r=0}^{r} \beta_r \cdot D_{c,r} + \text{Intensity}_{cst} + \sigma_t + \gamma_c + \epsilon_{cst} \quad (1)$$

We use the Callaway and Sant'Anna (2021) estimator, which is robust to treatment effect heterogeneity and avoids biases associated with traditional Two-Way Fixed Effects (TWFE) models. Here we are interested in β_r [5]

$$\hat{\beta}_r = \sum_g \omega_g A\hat{T}T(g, g+r) \quad (2)$$

[4] Where: Y_{cst}: Outcome (e.g., proportion of females choosing STEM in classroom c, school s, time t). $Intensity_{cst}$: Proportion of male students. γ_s, λ_t: School and year fixed effects. ϵ_{cst}: Error term, clustered at the school level.

[5] where $A\hat{T}T(g, g+r)$ represents a DiD estimate that compares the evolution of the proportion of female students who choose a specific major for units first treated at period g to units first treated after period $g+r$, between time periods $g-1$ and $g+r$. These event-study coefficients capture the average treatment effect at different relative time periods (r) before and after the transition to coeducation.

Empirical Strategy: Assumptions

- **Parallel Trends:** Treated and comparison groups would have followed similar trends in the absence of treatment. Tested using pre-treatment event study coefficients
  i. Wald pre-test of the parallel trends assumption
  ii. Uniform confidence bands covering 0 in all pre-treatment periods.
- **No Anticipation:** Post-secondary schooling decision of a school previous her transition does no depend on her future treatments. Further assessed with event study plots.
- **Irreversible Treatment:** Schools remain coeducational after the transition (Verified with the data).
- **SUTVA (Partially Relaxed):** Treatment intensity variable helps address potential spillover effects within schools (no hidden variation in treatment). Robustness checks include analyses restricted to single-classroom schools (no interference between units).

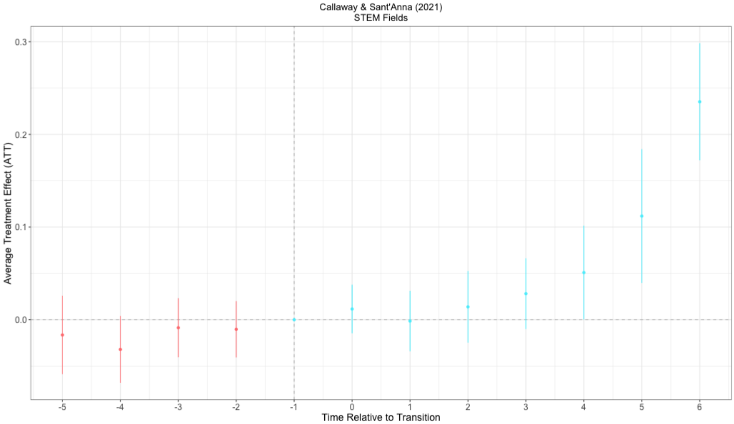
Empirical Strategy: Event Study Plot

Figure: Average Female Enrollment in STEM by Year for Different Transition Periods

Contents

STEM Fields

Average Treatment Effect (ATT) and Parallel Trends Analysis



The transition from single-sex (female) to coeducational, increase in 6.43pp the participation of female students in STEM (Overall ATT = 0.0643 (0.0151)***) Wald Statistic (p-value): **0.71059** [6]

▸ See Results on Human Capital Stagnation

[6] *This provides strong evidence that the parallel trends assumption holds.*

Science, Technology, Engineering and Mathematics

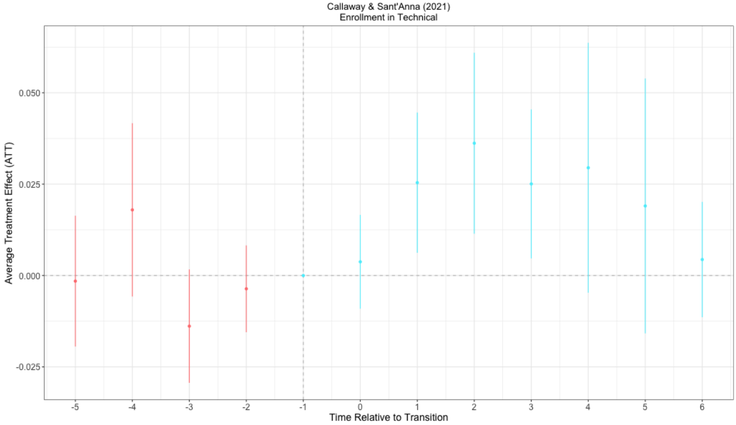
Table: Effect on STEM Fields Separately

STEM Field	Overall ATT	Wald Test p-value
Science	0.0071 (0.0063)	0.69987
Technology	0.0466 (0.0162)	0.99169
Mathematics	0.0065 (0.0031)	0.73259
Engineering	0.0147 (0.0079)	0.19854

Note: This table shows the effect en percentage points on female students who choose STEM Careers. of female students intending to pursue each field of study one year prior to their classrooms' transition to coeducation. Values are presented as ATT with standard errors in parentheses. Wald Test provides evidence about the parallel trends assumption

Enrollment in Technical

Average Treatment Effect (ATT) and Parallel Trends Analysis

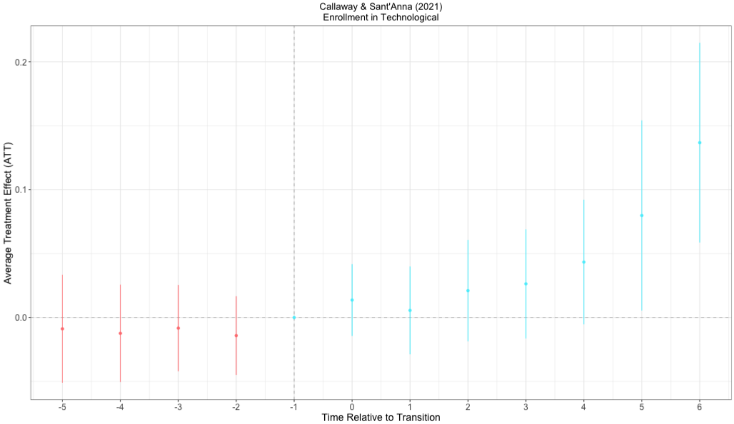


There is evidence that students from an ex-female school increase in 2pp the participation in technical tertiary education. (Overall ATT = 0.0205 (0.0069)).

Wald Statistic (p-value): **0.601**

Enrollment in Technological

Average Treatment Effect (ATT) and Parallel Trends Analysis

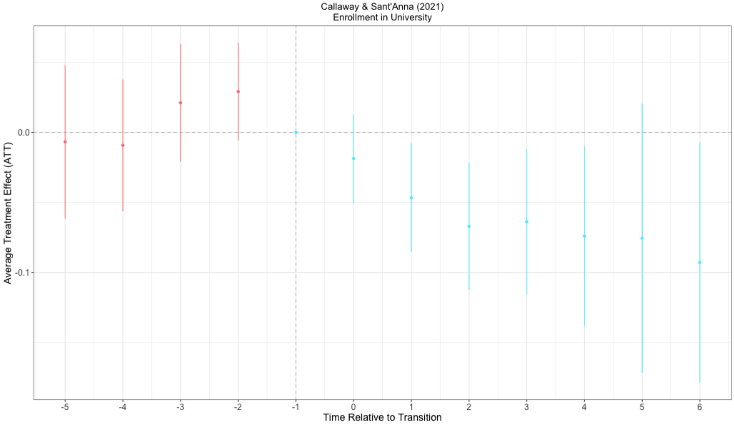


There is evidence that students from an ex-female school increase in 4pp the participation in Technological tertiary education. (Overall ATT = 0.0466 (0.0161)).

Wald Statistic (p-value): **0.99169**

Enrollment in University

Average Treatment Effect (ATT) and Parallel Trends Analysis

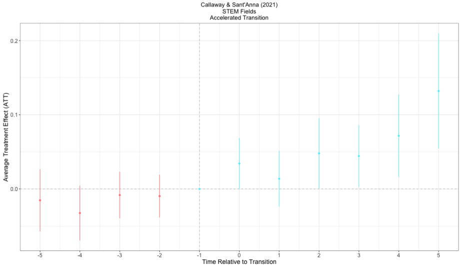


There is evidence that students from an ex-female school decrease in 6pp the participation in University tertiary education. (Overall ATT = -0.0626 (0.0192)).

Wald Statistic (p-value): **0.99169**

STEM Fields

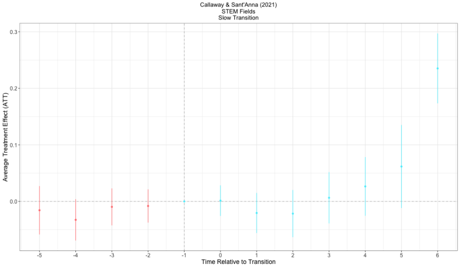
Average Treatment Effect (ATT) and Parallel Trends Analysis



Accelerated Transition.

ATT: 0.0573 (0.0168)

P-Value Wald = 0.71



Slow Transition

ATT: 0.0413 (0.0152)

P-Value Wald = 0.71

Conclusion

- **Key Finding:** Transitioning from single-sex to coeducational schools increases female students' participation in STEM fields by 6.43 percentage points. This effect is statistically significant and robust to various checks.
- **Nuance:** The positive effect on STEM is primarily driven by Technology fields. Other STEM areas show smaller or non-significant changes. This suggests that the impact of coeducation might be field-specific within STEM.
- **Overall Educational Pathways:** While STEM participation increases, overall university enrollment decreases, with a corresponding rise in technical and technological tertiary education enrollment. This shift in educational pathways has implications for longer-term career outcomes and warrants further investigation.
- **Policy Implications:** Our findings highlight the importance of considering gender composition in educational settings. Policies promoting coeducation may encourage more girls into STEM, but it is also crucial to understand the potential trade-offs regarding other educational pathways. Further research is needed to explore the mechanisms driving these effects and to identify complementary interventions that support girls' diverse educational and career aspirations.

Gender Composition in Classrooms: Influences on Post-Secondary Schooling Choices

Jaime Polanco-Jimenez[1]

[1] PhD Student - LEER KU Leuven - PUJ

Thank you!

Dankjewel!

Obrigado!

Merci!

Gracias!!!!

https:/polanco-jaime.github.io/

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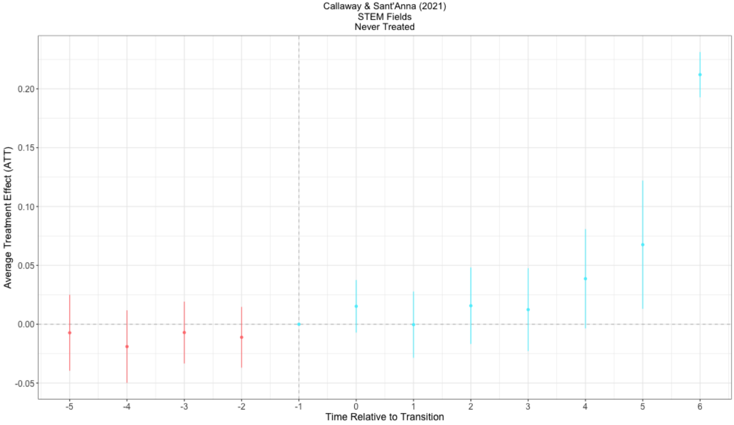
STEM Fields (Never Treated)



Sensitivity to Pre-Treatment Periods

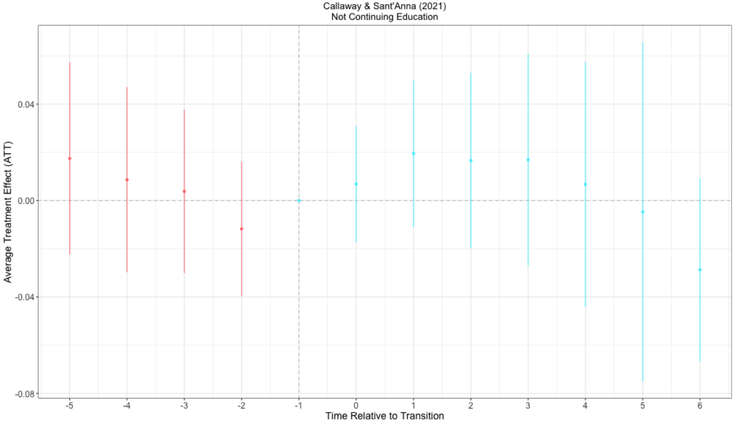
Table: Overall ATT for STEM Majors with Different Pre-Treatment Periods

Pre-Treatment Period	ATT	Wald Test P-Value
2012-2019	3.83*	1.52
2014-2020	0.0152 (0.0193)	0.54992

Note: This table presents the overall average treatment effect on the treated (ATT) estimates, expressed in percentage points, for the proportion of female students choosing STEM majors after the transition from a female school to a coeducational setting, using different pre-treatment periods. Standard errors are clustered at the school ID level. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Human Capital Stagnation

Average Treatment Effect (ATT) and Parallel Trends Analysis



There is no evidence showing changes in the proportion of students who abandon their desire to continue their education (Overall ATT = 0.0047 (0.0147)).

Wald Statistic (p-value): **0.84913** [7]

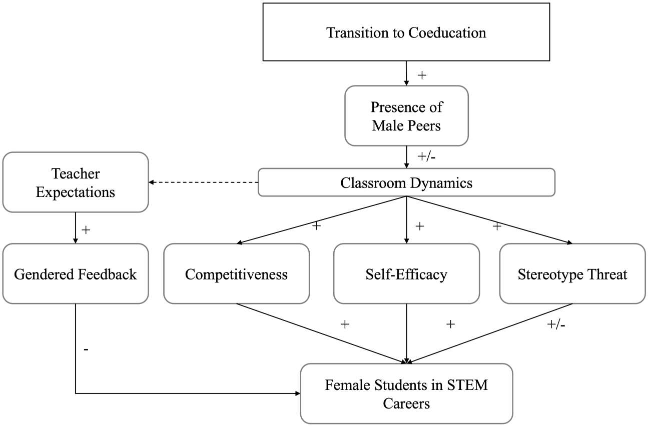
[7] *This provides strong evidence that the parallel trends assumption holds.*

Mechanisms Influencing Female Students' STEM Major Choices

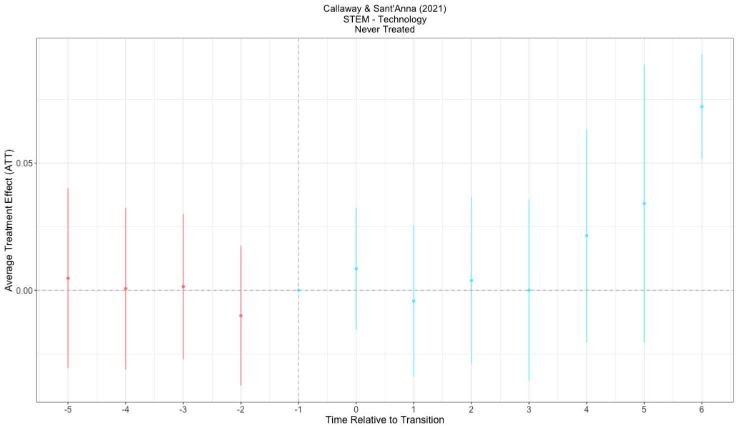
1. **Increased Competitiveness:**
    - Introduction of male students creates a new competitive dynamic.
    - Males tend to exhibit higher levels of competitiveness, particularly in spatial and motor tasks relevant to STEM (Gindi et al. (2019); Sutter and Rützler (2010)).
    - This may motivate some confident female students to pursue STEM, while potentially discouraging others (Niederle and Vesterlund (2011)).
2. **Peer Influence and Social Dynamics:**
    - Exposure to male peers interested in STEM can broaden female students' academic horizons.
    - Conversely, peers reinforcing traditional gender stereotypes can have a negative impact (Bandura (1997)).
3. **Self-Efficacy:**
    - Coeducation can introduce social comparison with male peers, potentially leading to stereotype threat (Steele and Aronson (1995)).
    - However, positive male role models in STEM can also boost female students' confidence (Lent et al. (1994)).
4. **Teacher Expectations (Potential Indirect Effect):**
    - While teachers are assigned centrally, coeducation might subtly influence their behavior and expectations towards different genders (Pachon (2023)).
    - This can indirectly affect students' choices, even if unintentional.

Mechanisms Influencing Female Students' STEM Major Choices

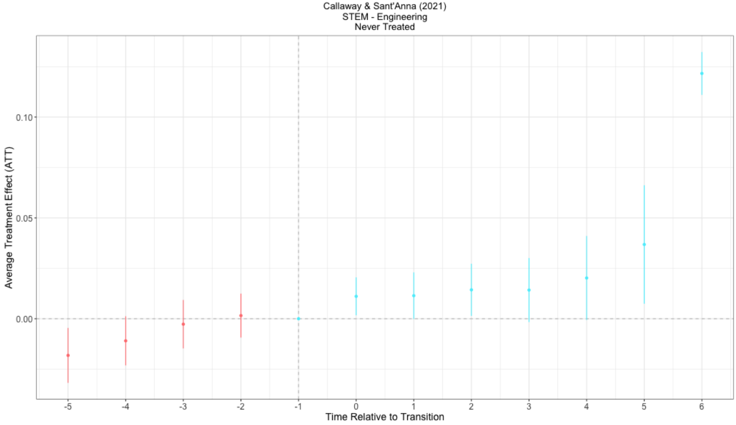
1. Increased Competitiveness
2. Peer Influence and Social Dynamics
3. Self-Efficacy
4. Teacher Expectations (Potential Indirect Effect)



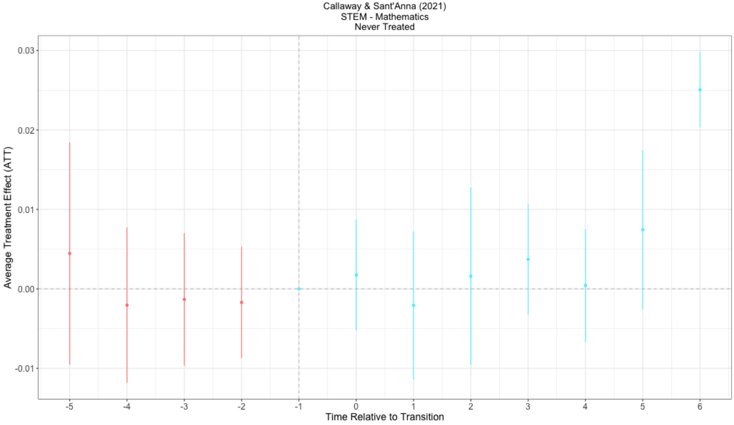
STEM - Technology (Never Treated)



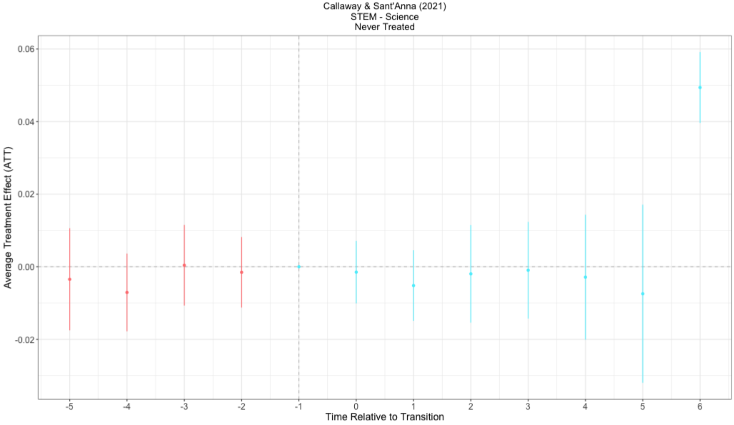
STEM - Engineering (Never Treated)



STEM - Mathematics (Never Treated)



STEM - Science (Never Treated)



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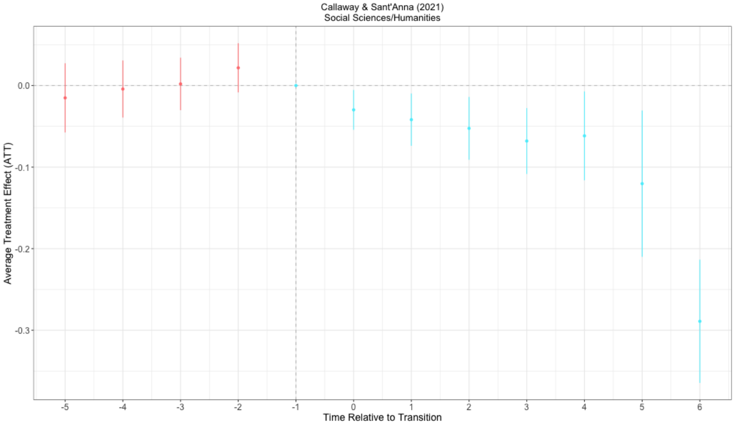
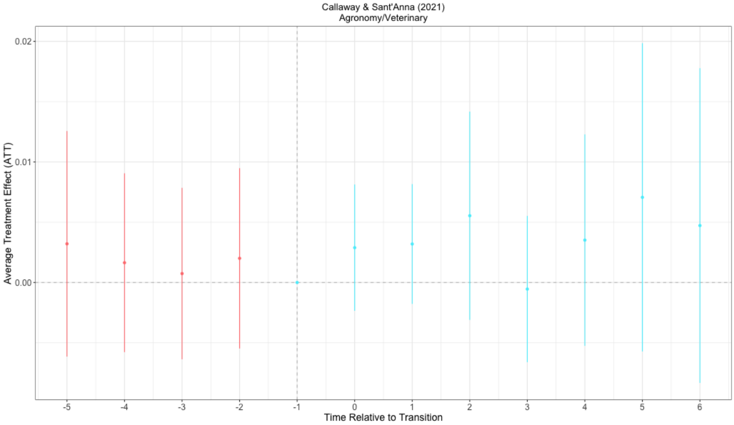
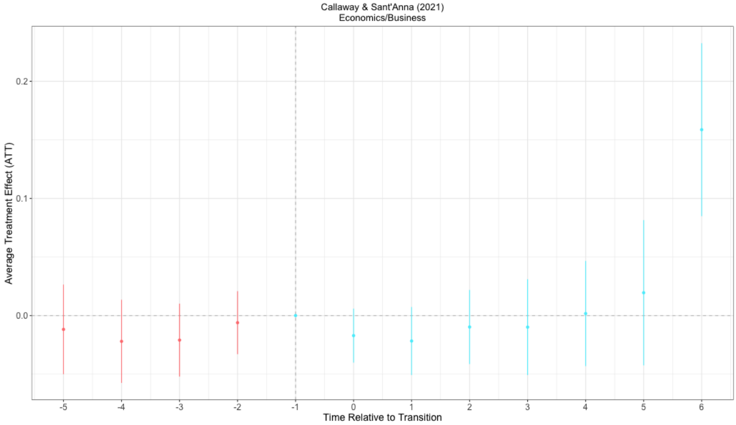
Social Sciences and or Humanities



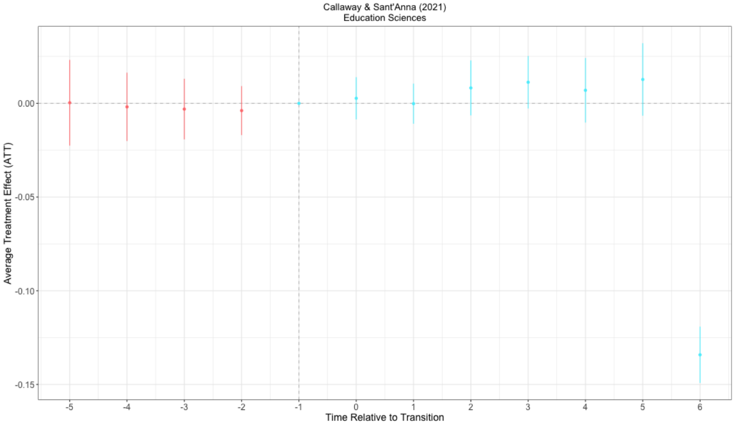
Agronomy and or Veterinary



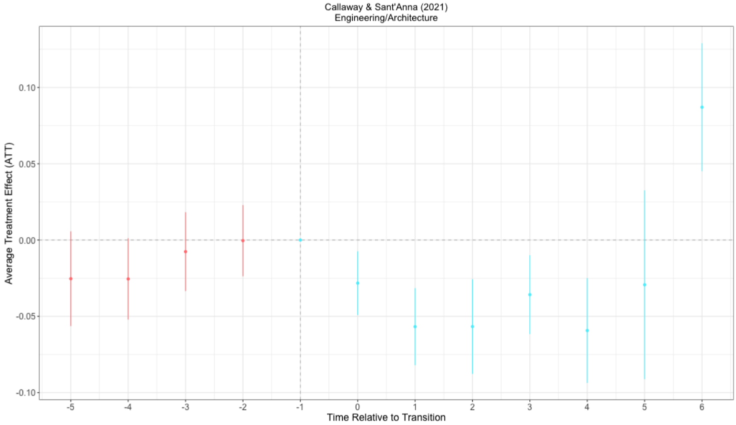
Economics and or Business



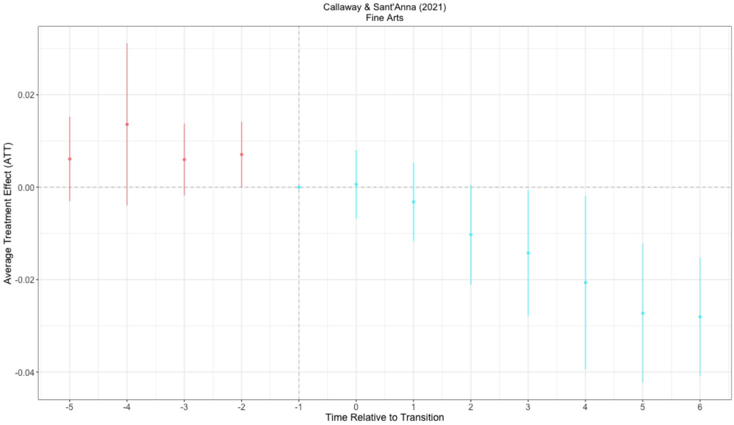
Education Sciences



Engineering and or Architecture

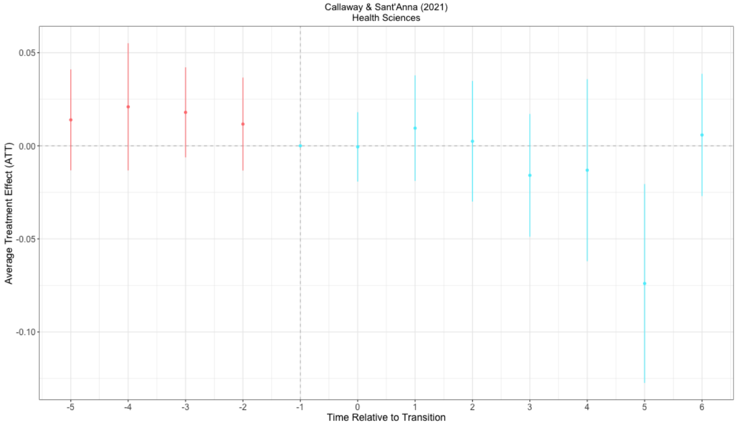


Fine Arts

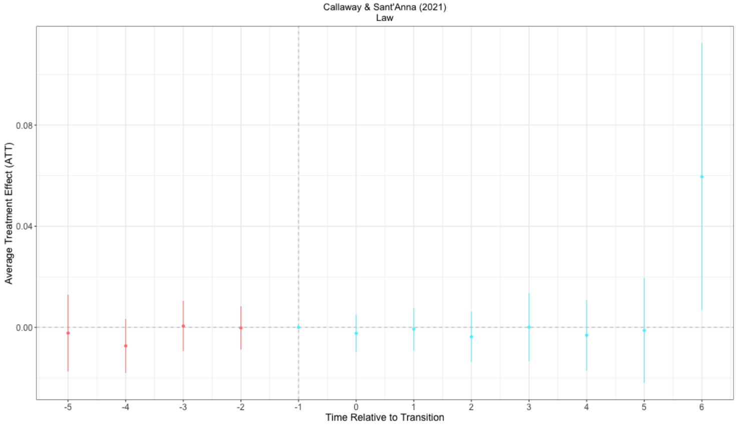


Callaway & Sant'Anna (2021)
Fine Arts
Average Treatment Effect (ATT)
0.02
0.00
-0.02
-0.04
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Time Relative to Transition

Health Sciences

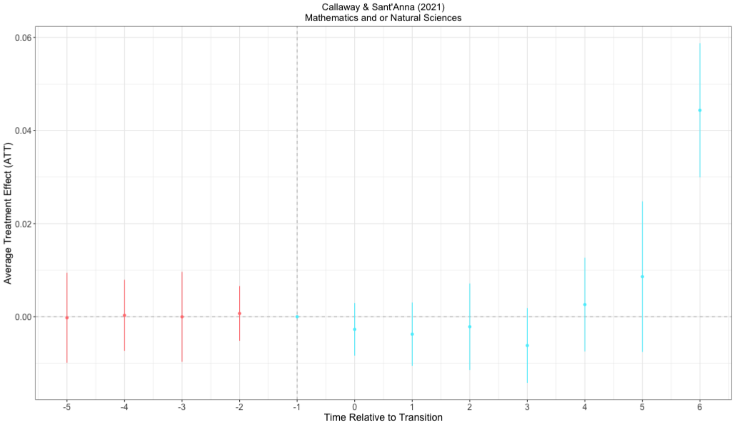


Law

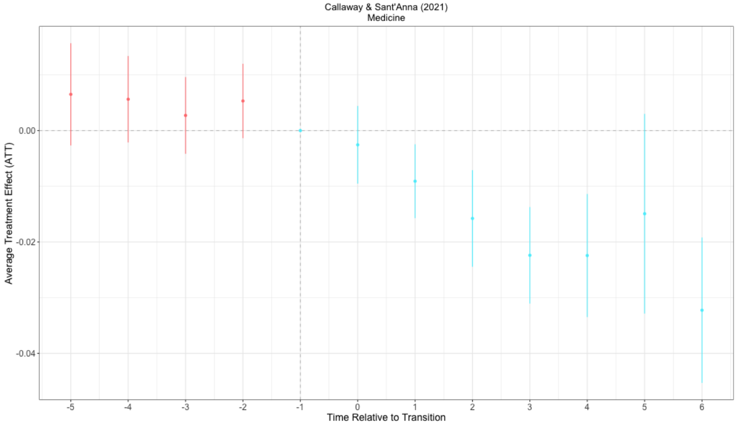


Callaway & Sant'Anna (2021)
Law
Average Treatment Effect (ATT)
0.08
0.04
0.00
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Time Relative to Transition

Mathematics and or Natural Sciences



Medicine


Callaway & Sant'Anna (2021)
Medicine
Average Treatment Effect (ATT)
0.00
-0.02
-0.04
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Time Relative to Transition

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