Decoding Choices: The Role of Classroom Gender Composition in Post-Secondary Preferences

Seminar in Economics

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April 10, 2024

Contents

This paper.

Question: Does the gender composition within classrooms "influence" the post-secondary schooling decision?

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:

1. Staggered DiD (Sun et al. 2020) estimation to identify the causal effect of transition from ex-female school to coeducational on schooling decision.
   i. Schooling Decision: ↑ Do not pursue any study, ↓ Participation in STEM.
2. Logistic regression model with fixed effects to identify the odd ratio of female students participating in STEM. As the male composition increases then:
   i. Schooling Decision: ↑ O.R. Do not pursue any study, ↓ O.R. Participation in STEM.
3. Heterogenities
   i. We examine 8 fields of study, and separately, we evaluate medicine and law

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

Importance of STEM Careers

- Between 2000-2003, 95% of US patents were related to the STEM field. (Rothwell 2013)
- As of 2011, 26 million U.S. jobs—20 percent of all jobs—require a high level of Study in any one STEM field. (Rothwell 2013)
- As of 2020, The direct STEM share of the economy of the US was 39.9% (FTI Consulting 2020)
- STEM fields are crucial for innovation, technology development, and economic growth.
- Countries with strong STEM workforces tend to be global leaders in research, new technologies, and high value-added industries.
- Each additional STEM job creates an extra 4-5 new jobs in the overall economy.

Mechanism: Factors Influencing Preferences

Proportion of male students in a classroom $\Rightarrow$

1. Female competitiveness
2. Social dynamics
3. Role models and mentors
4. Perceived stereotypes and bias

$\Rightarrow$ University major choice

1. High school being a critical period for STEM career choices can be linked to competitiveness, especially for girls in traditionally male-dominated fields (Buser, Niederle, and Oosterbeek (2014); Sadler et al., 2012; Mann et al., 2013; Mann et al., 2015; Mann Legewie, 2015; Olitsky, 2014; Delaney Devereux, 2019).
2. The social environment and their previous education in STEM fields can be a powerful social influence. (Pregaldini et al., 2020; Bottia et al., 2015; Shvetsova et al., 2020; Mael et al., 2005; Patterson Pahlke, 2011; Opie et al., 2019;).
3. Lack of female role models in STEM fields might be a contributing factor. (Giustinelli and Manski (2018); Valbuena (2011);).
4. The way schools are structured and societal norms can discourage girls from pursuing STEM careers. (Collard & Stalker, 1991; Crosby, 1994; Wang & Degol, 2013; Tyler-Wood et al., 2018).

Contribution: This paper studies how...

- Unlike prior studies that focus on social dynamics in general (e.g., Pregaldini et al., 2020; Shvetsova et al., 2020), this research isolates the influence of a **higher proportion of male students** in the classroom on girls' university major choices, particularly in STEM fields.
- Despite similarities to works examining classroom gender composition and STEM performance (e.g., Sadler et al., 2012; Bottia et al., 2015), this study directly evaluates the impact on **university major selection**, a more specific indicator of career path.
- The finding that a higher proportion of boys narrows the gender gap in STEM majors adds a new dimension to existing research. It highlights the **complex interplay between social dynamics and student choice** in STEM fields, which wasn't previously explored in detail (e.g., OECD. (2017). PISA 2015; Eisenkopf, Hessami, Fischbacher, and Ursprung (2015)).

Data

The data used for the develop of this research are:

- Student Enrollment System (SIMAT) from 2012 to 2019. (Restricted Access)
- National Higher Education Information System (SNIES) 2012-2021. (Restricted Access)
- DANE - Formal Education (EDUC) 2010-2020. (Open and Public)

Distribution of Proportion of Males in Class Groups

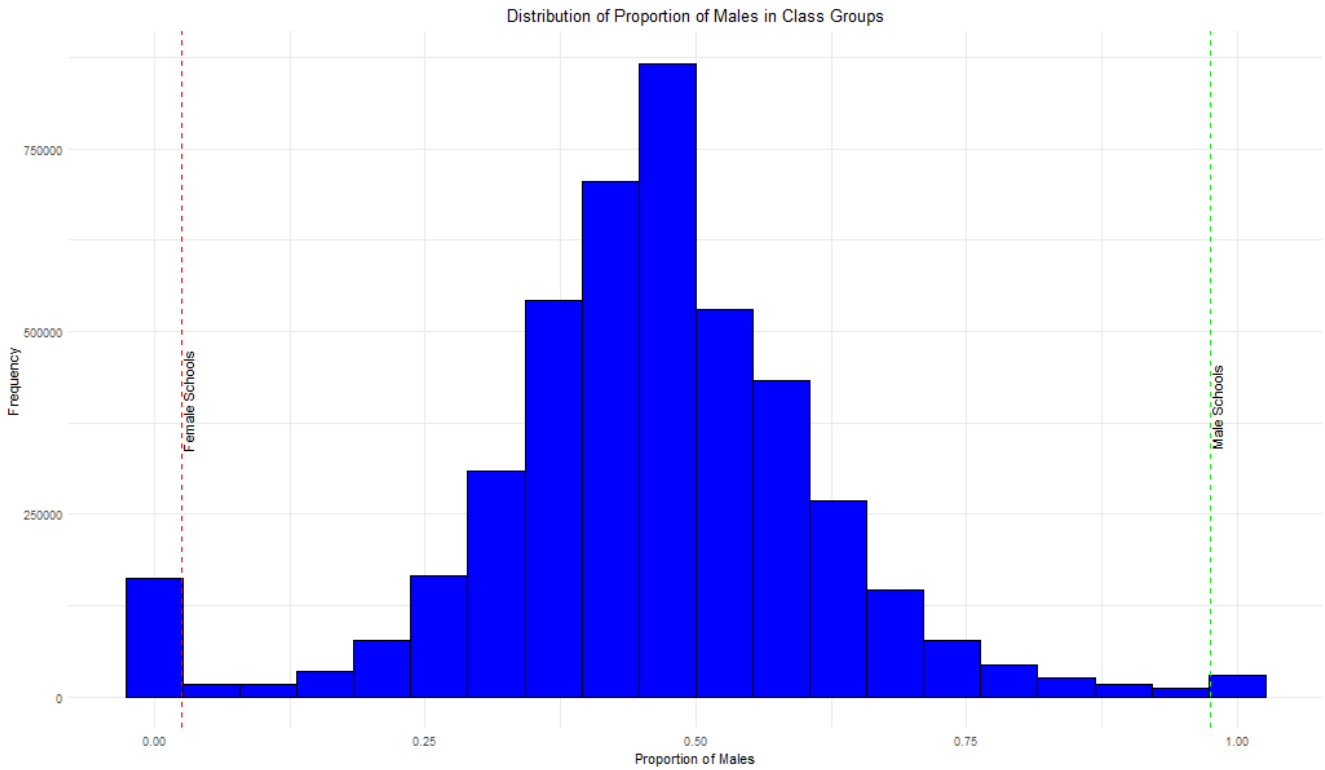


Figure: Distribution of Proportion of Males in Class Groups

Distribution by Gender according to the Field of Study

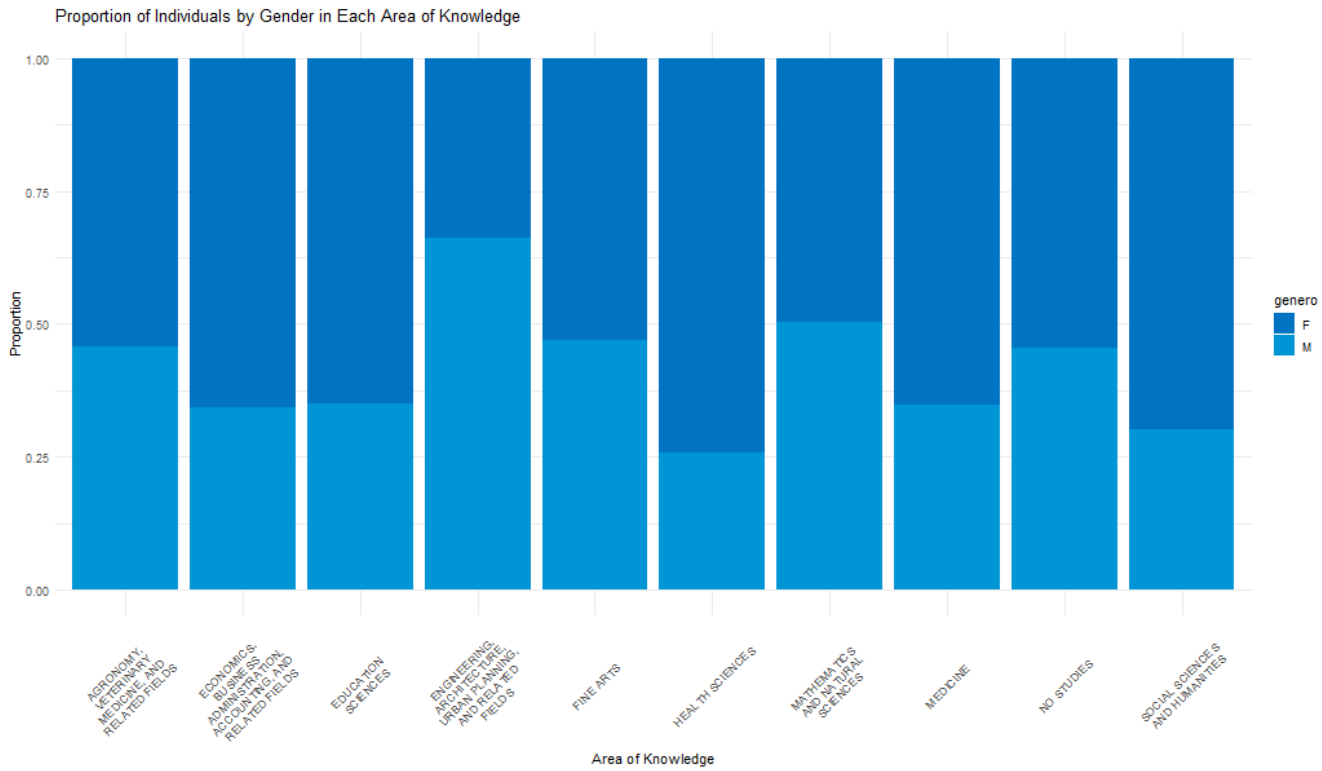


Figure: Distribution by Gender according to the Field of Study

Model Specification

$$\log\left(\frac{P(Y^c_{i,s,t}=1)}{1-P(Y^c_{i,s,t}=1)}\right) = \beta_1 \times Gender_{i,s,t} + \beta_2 \times X^c_{i,s,t} + \gamma_t + \gamma_s + \varepsilon_{i,s,t} \tag{1}$$

Where:

- $Y^c_{i,s,t}$: Binary response variable for student i who completed secondary school in school s, choosing university major c.
- $Gender_{i,s,t}$: Indicator for female students.
- $X^c_{i,s,t}$: Vector of student characteristics.
- γ_t: Year fixed effects.
- γ_s: School fixed effects.
- $\varepsilon_{i,s,t}$: Error term.

Jump to BCE

Staggered Difference-in-Differences (S-DiD) Design

To address potential biases intrinsic to fixed effect estimation, we employ a distinct approach by leveraging the transition from single-sex schools to co-educational settings.

$$\hat{\tau} = \bar{Participation}^{P}_{\text{after transition}} - \bar{Participation}^{P}_{\text{before transition}} \tag{2}$$

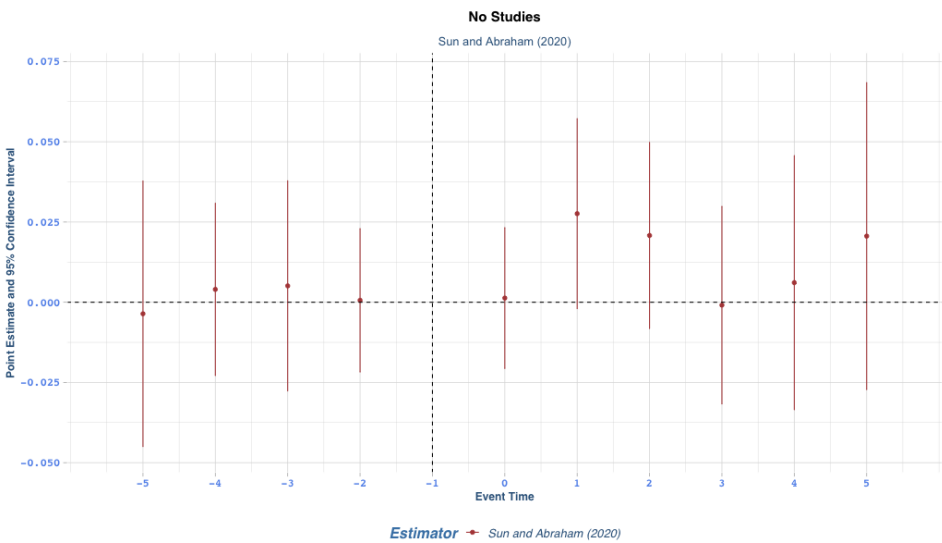
$$\text{Participation}^{P}_{c,t,j} = \beta_0 + \sum_{\varphi=-S}^{-2} \mu_\varphi \cdot D_{c,\varphi} + \sum_{\varphi=0}^{M} \mu_\varphi \cdot D_{c,\varphi} + \sigma_t + \gamma_c + \varepsilon_{c,t} \tag{3}$$

2

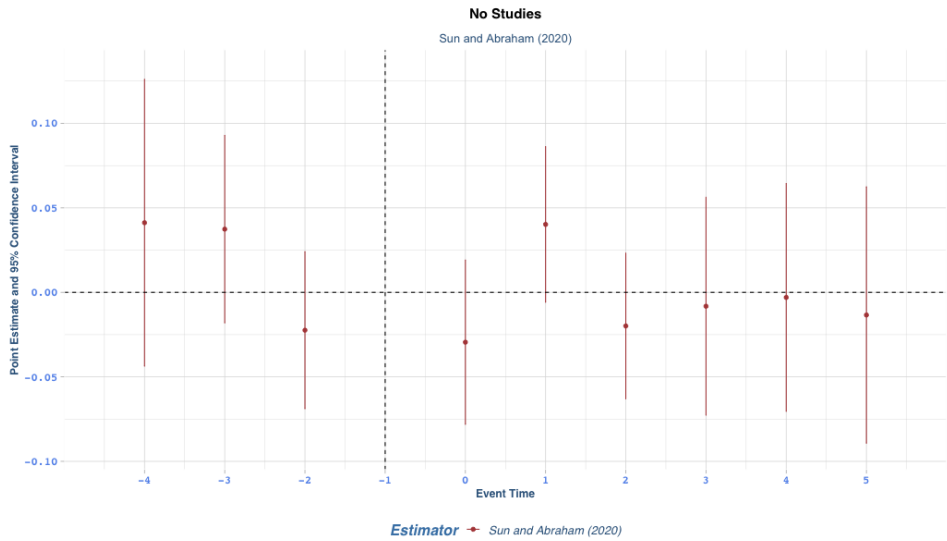
[2] Here $\text{Participation}^{P}_{c,t,j}$ represents the level of participation of students in major P at a particular school c and time t. β_0 is the intercept or baseline level of participation in major P. μ_φ are the parameters associated with the different time periods or treatment phases (φ). $D_{c,\varphi}$ are dummy variables denoting the treatment status (e.g., before and after the transition) for school c at time φ. σ_t captures time-specific effects. γ_c captures school-specific effects. $\varepsilon_{c,t}$ is the error term.

Changes in Proportion of Students Not Pursuing Further Studies

Changes in the Proportion of Students That Not Pursue Further Studies in Schools Transitioning from Single-Sex to Coeducational



Ex female schools



Ex male schools

Likelihood of Not Pursuing Further Studies

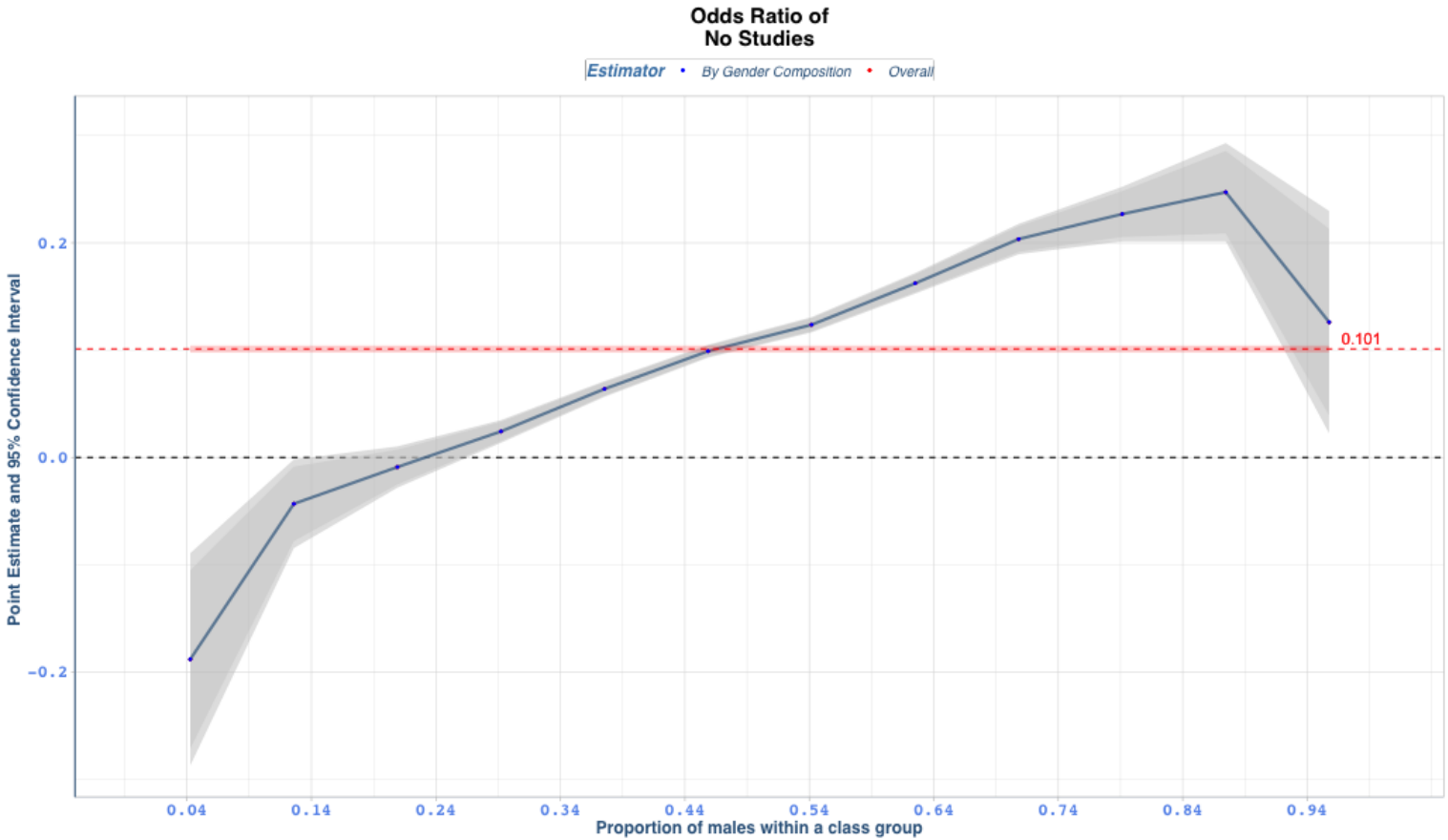
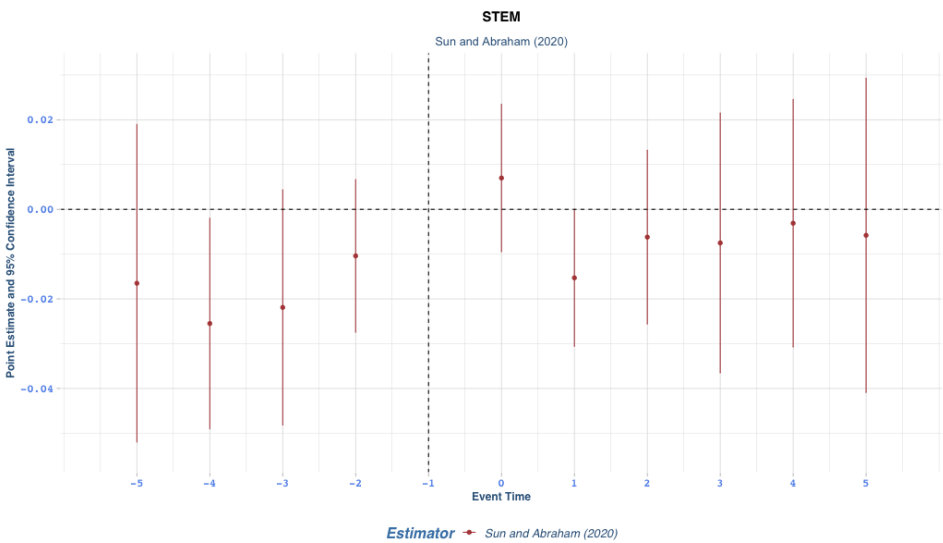


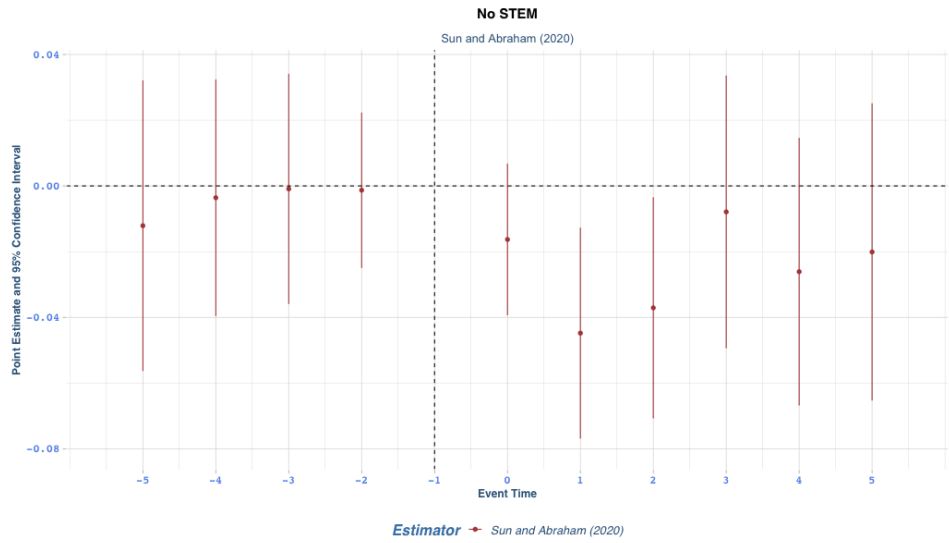
Figure: Likelihood of a female student choosing not to pursue further studies

Changes in Proportion of Students Choosing STEM

Changes in the Proportion of Students Choosing STEM Majors in Schools Transitioning from Single-Sex to Coeducational



Ex female schools



Ex female schools

Likelihood of a female student choosing STEM

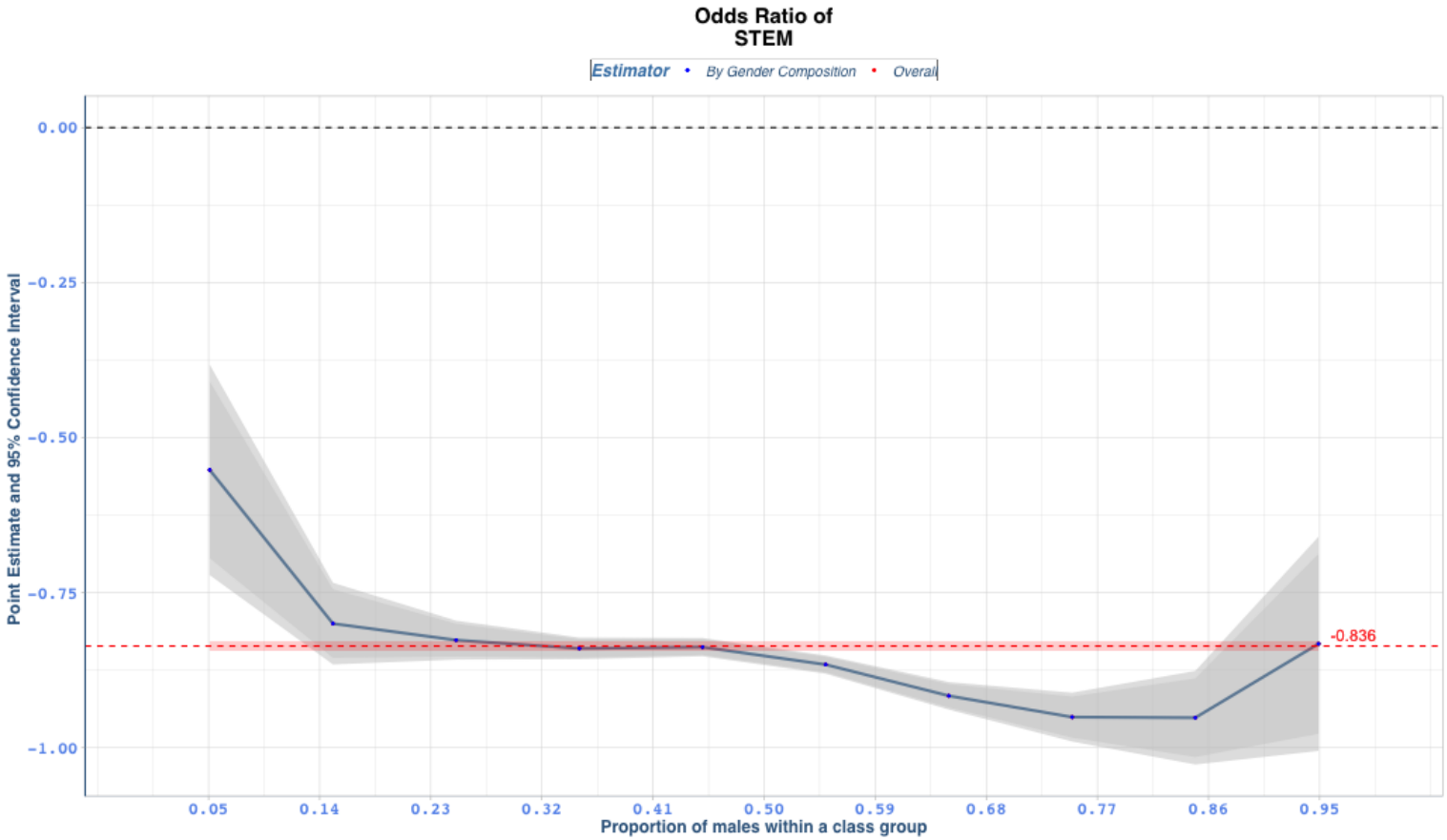


Figure: Likelihood of a female student choosing not to pursue further studies

Conclusion

- Our study highlights how classroom gender composition influences university major decisions.
- More male students led to increased interest for female students in traditionally male-dominated fields like engineering, architecture, and mathematics.
- More male students in a classroom led to increased interest in humanities, social sciences, education science, etc.
- Minimal gender differences are observed in agriculture, veterinary sciences, and medicine, suggesting limited influence of classroom gender compositions in these domains.

Decoding Choices: The Role of Classroom Gender Composition in Post-Secondary Preferences

9th LEER Conference on Education Economics

Thank You!

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April 10, 2024

Fields of Study Preferred by Female Students

Economics, Business and Related Majors

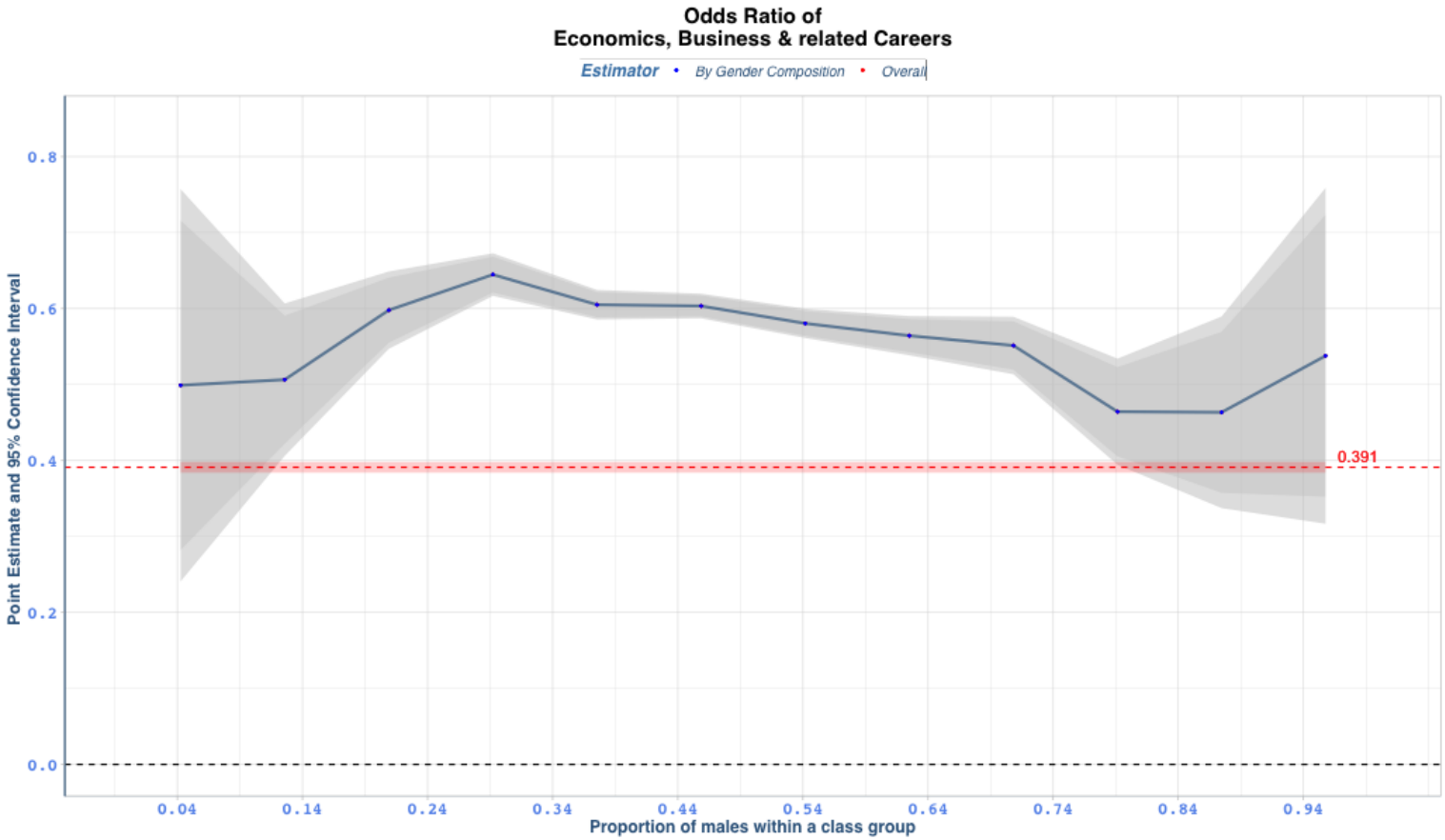

Figure: Likelihood of a female student choosing economics/business-related majors

Fields of Study Preferred by Female Students

Social Sciences/Humanities Majors

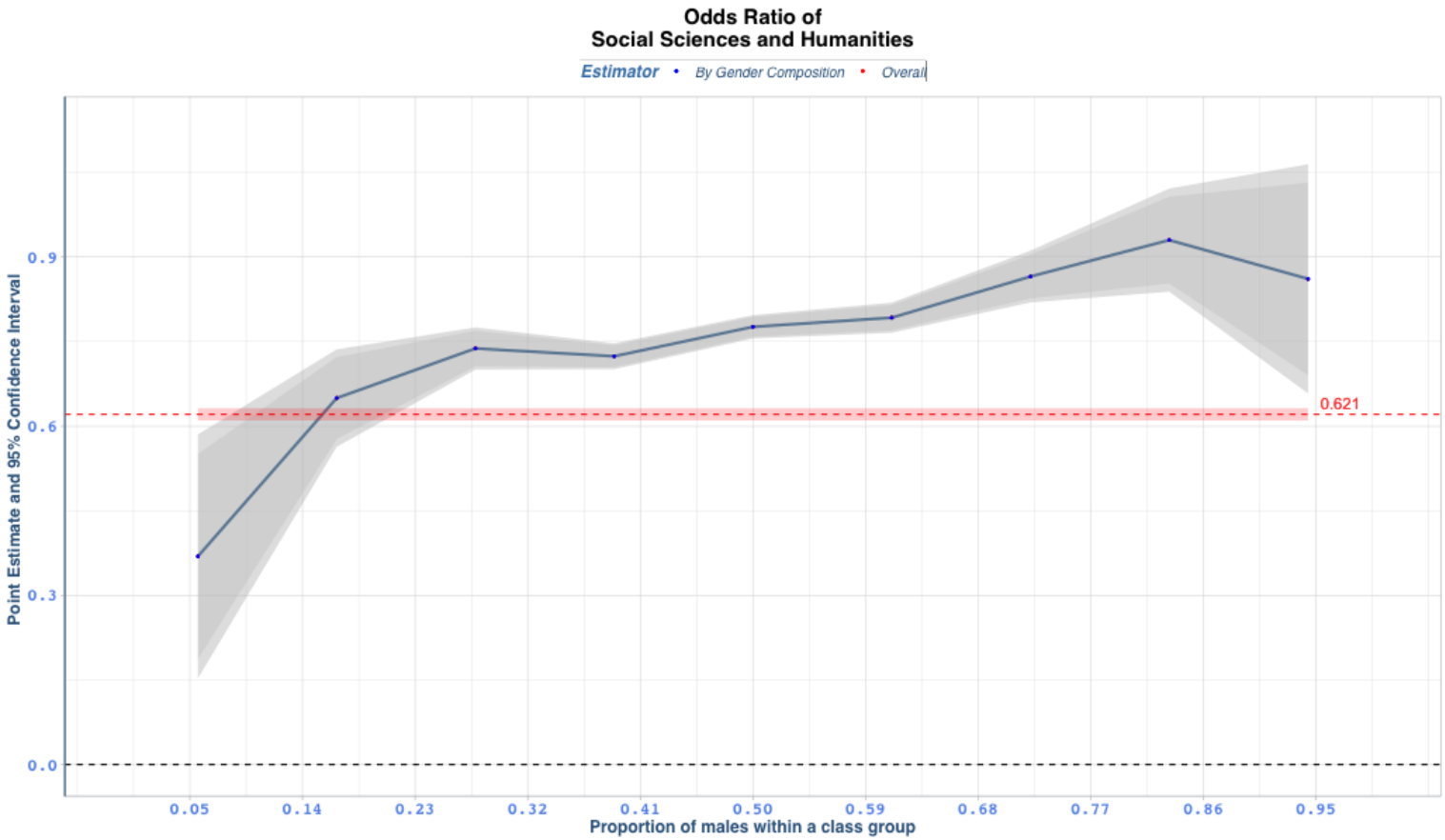

Figure: Likelihood of a female student choosing social sciences/humanities majors

Fields of Study Preferred by Female Students

Education Sciences Majors

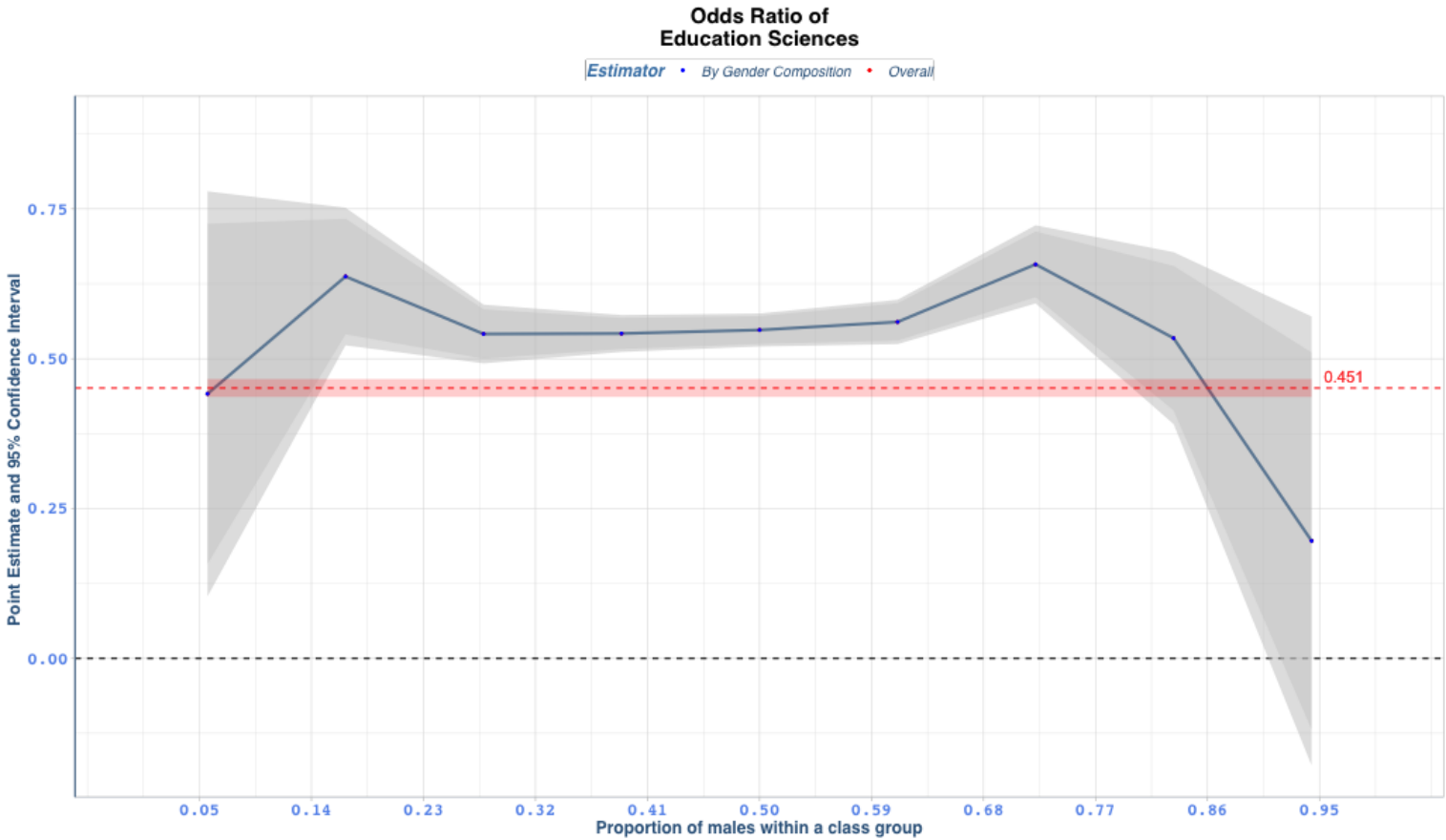

Figure: Likelihood of a female student choosing education sciences majors

Fields of Study Preferred by Female Students

Health Sciences Majors (Except Medicine)

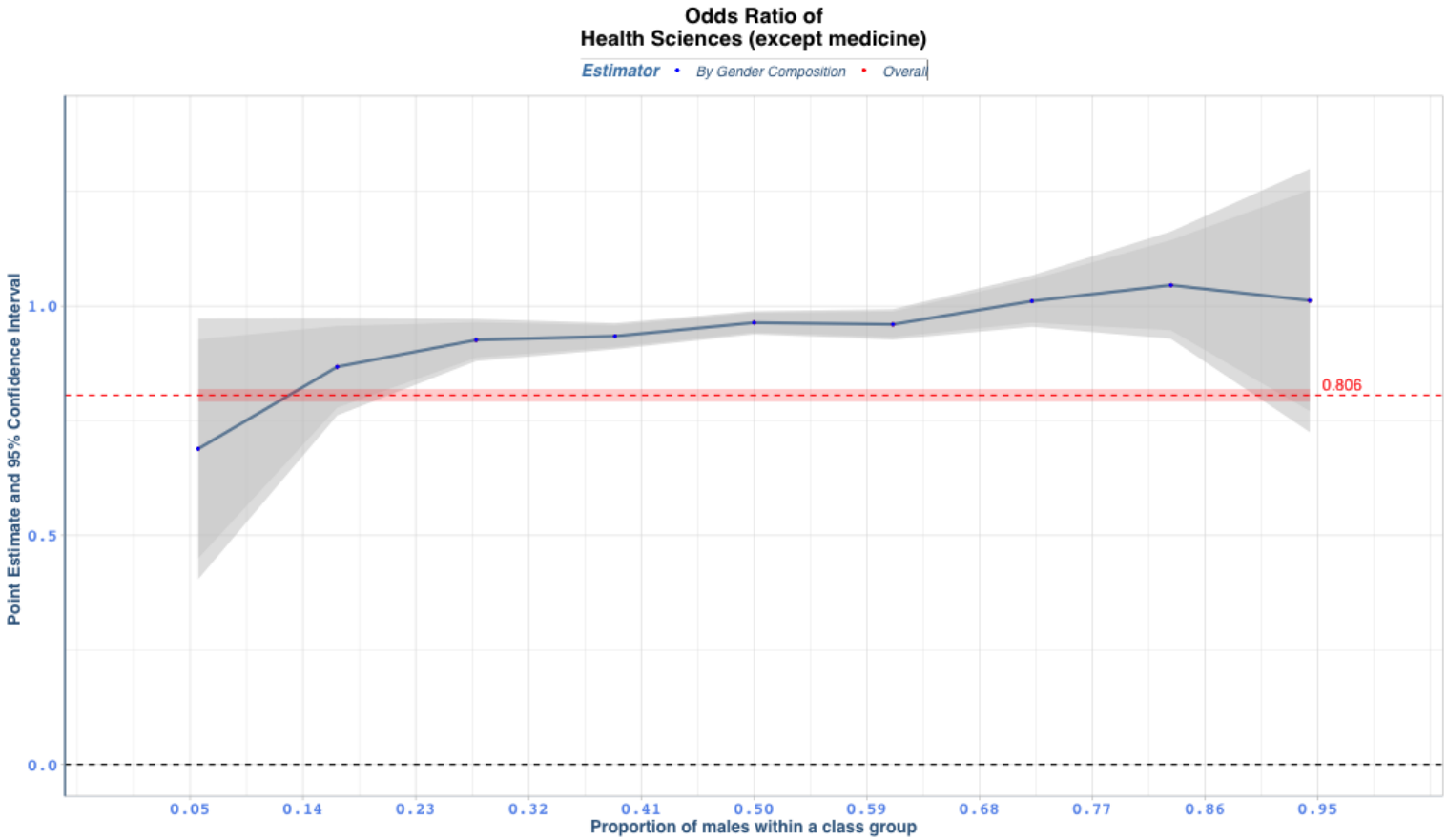

Figure: Likelihood of a female student choosing health sciences majors

Fields of Study Preferred by Female Students

Medicine Major

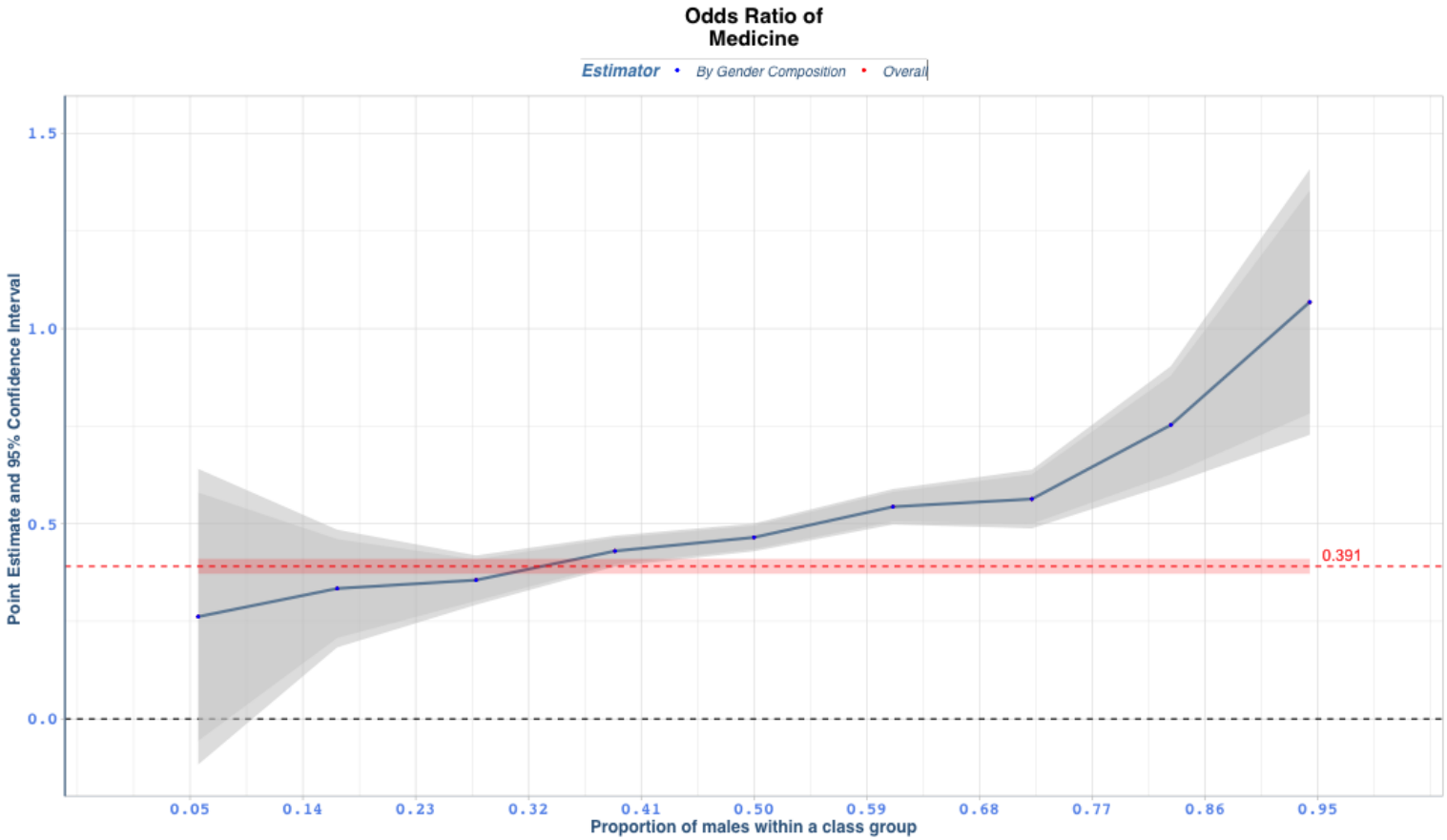

Figure: Likelihood of a female student choosing medicine majors

Fields of Study Preferred by Female Students

Law Major

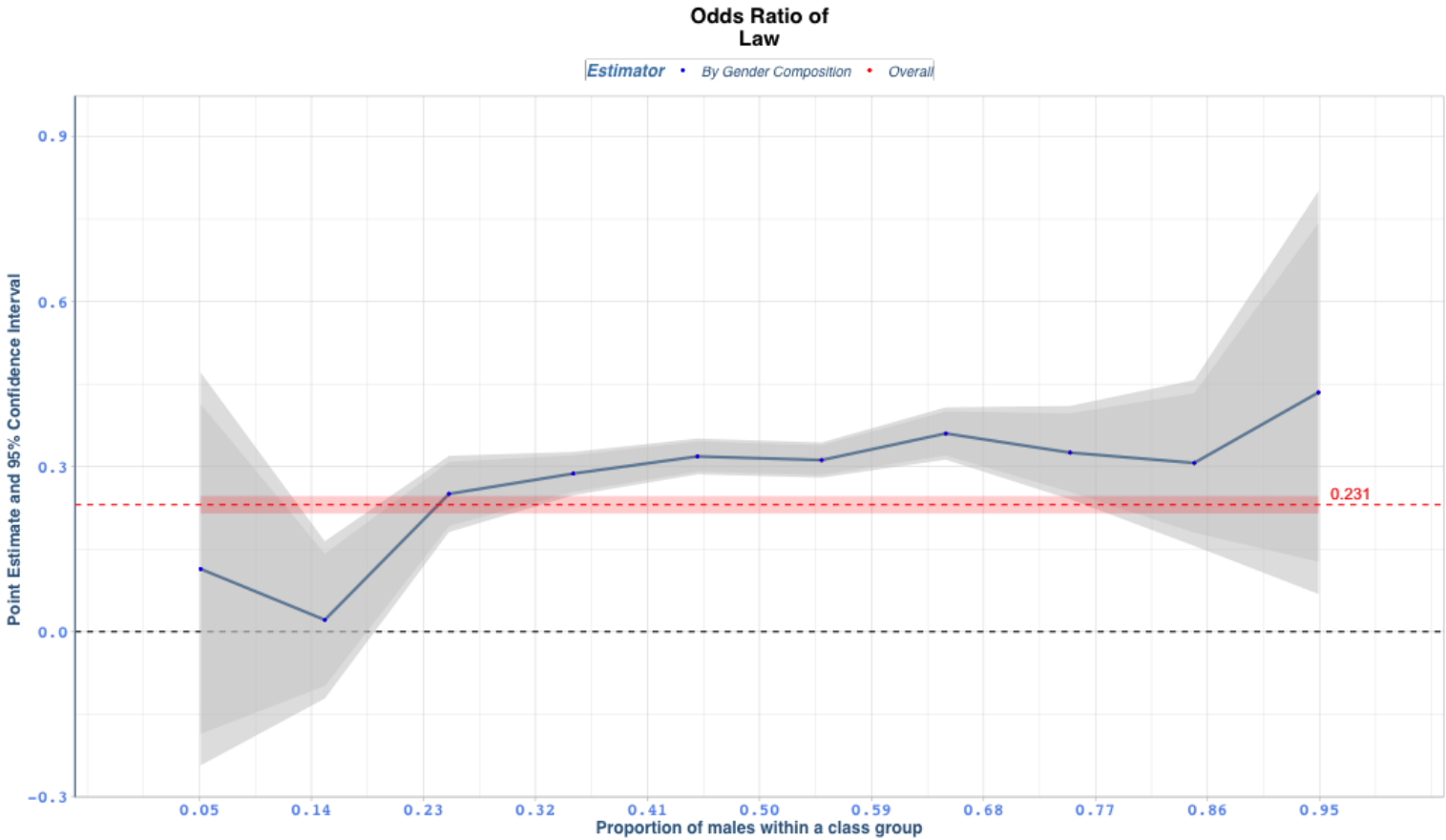

Figure: Likelihood of a female student choosing law majors

Factors Influencing Preferences

Proportion of male students in a classroom $\Rightarrow$ Female competitiveness; Social dynamics; Role models and mentors; Perceived stereotypes and bias $\Rightarrow$ University major choice

- Fields of Study Preferred by Female Students Jump to Results
- Fields of Study Less Preferred by Female Students Jump to Results
- Fields with Similar Preferences Between Genders Jump to Results

Fields of Study Less Preferred by Female Students

Engineering/Architecture Related Majors

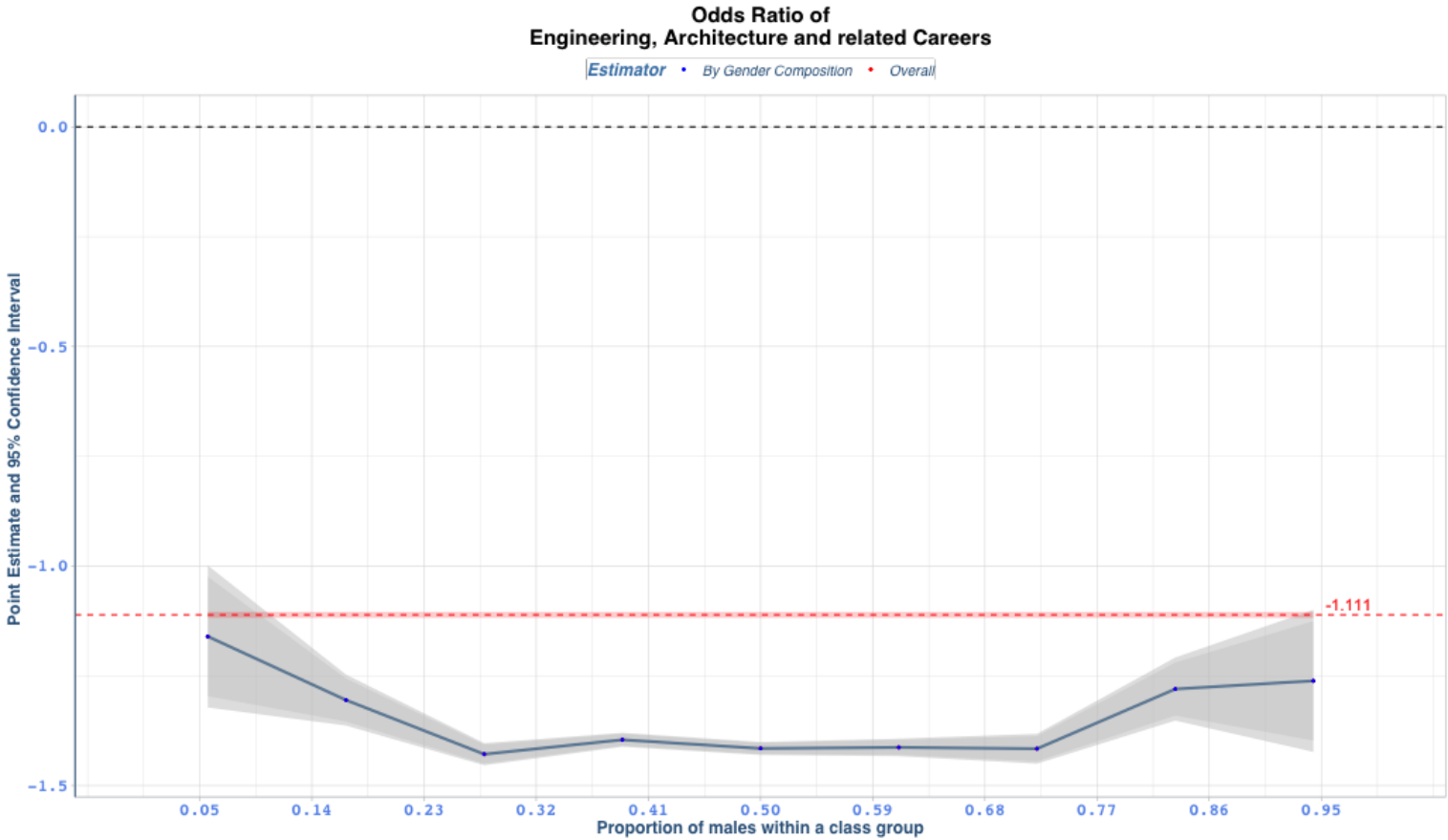

Figure: Likelihood of a female student choosing engineering/architecture-related majors

Fields of Study Less Preferred by Female Students

Mathematics and Natural Sciences Majors

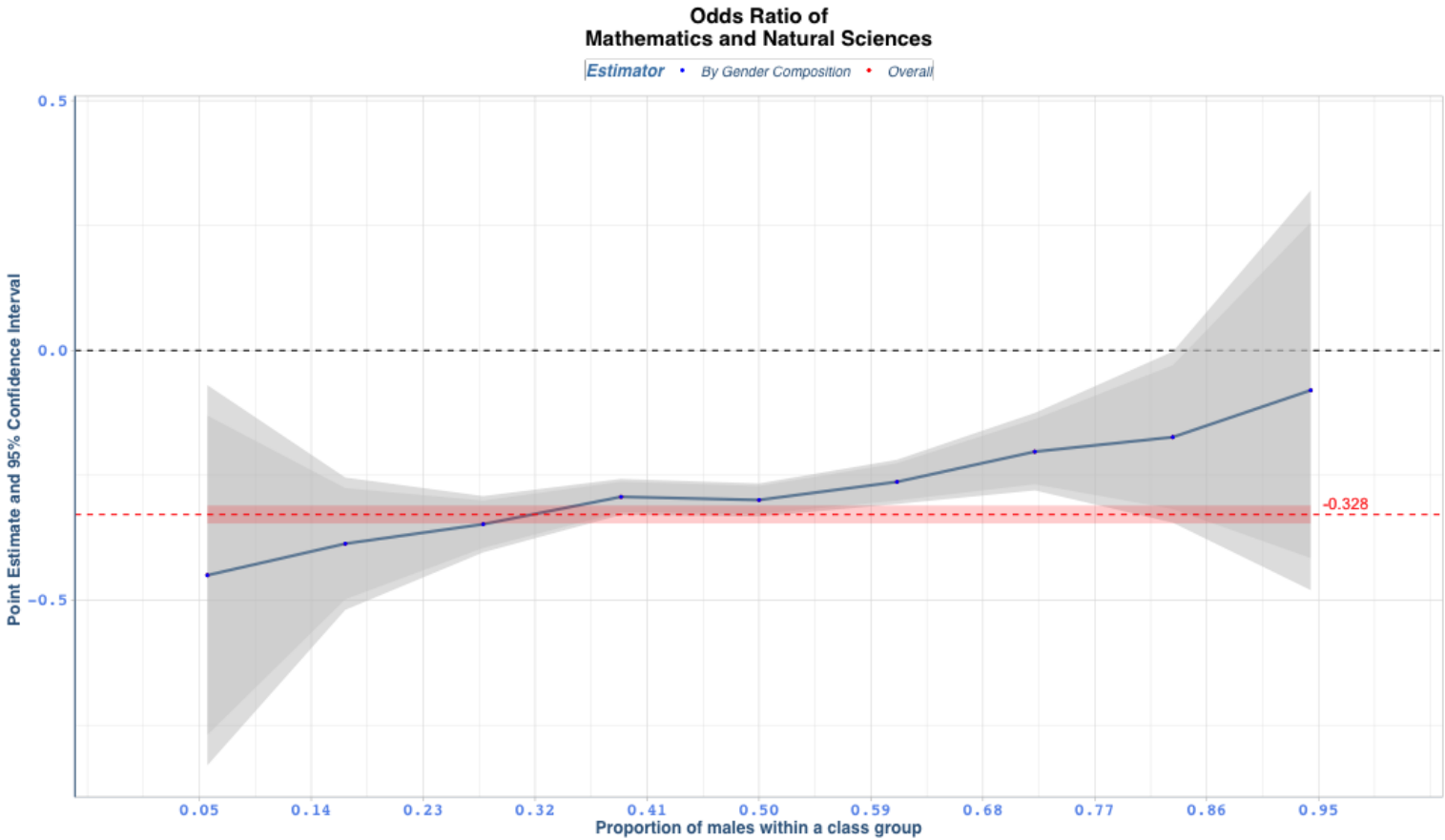

Figure: Likelihood of a female student choosing mathematics/natural sciences majors

Factors Influencing Preferences

Proportion of male students in a classroom $\Rightarrow$ Female competitiveness; Social dynamics; Role models and mentors; Perceived stereotypes and bias $\Rightarrow$ University major choice

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Fields with Similar Preferences Between Genders

Fine Arts Majors

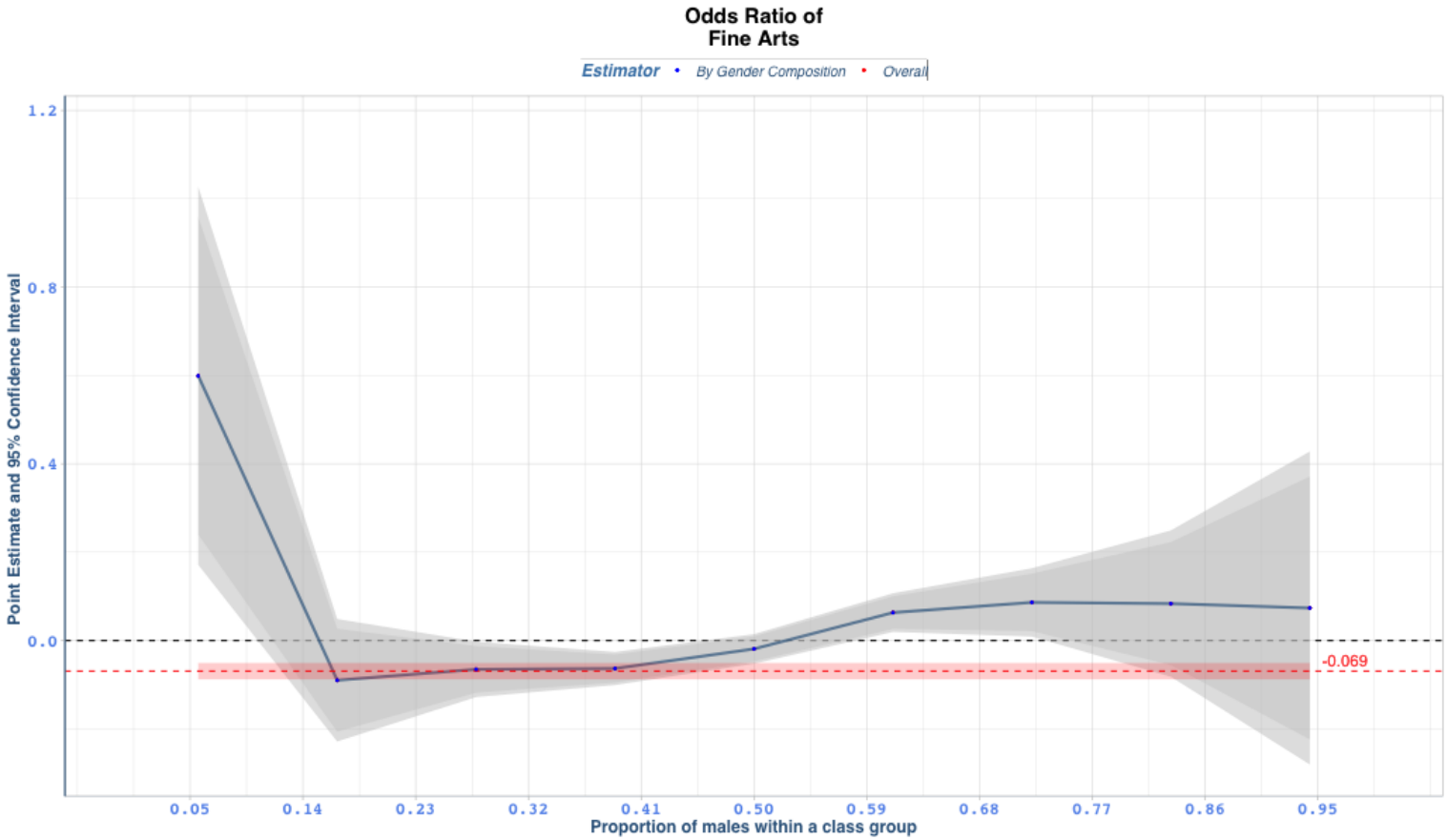


Figure: Likelihood of a female student choosing fine arts majors

Fields with Similar Preferences Between Genders

Agronomy/Veterinary Related Majors

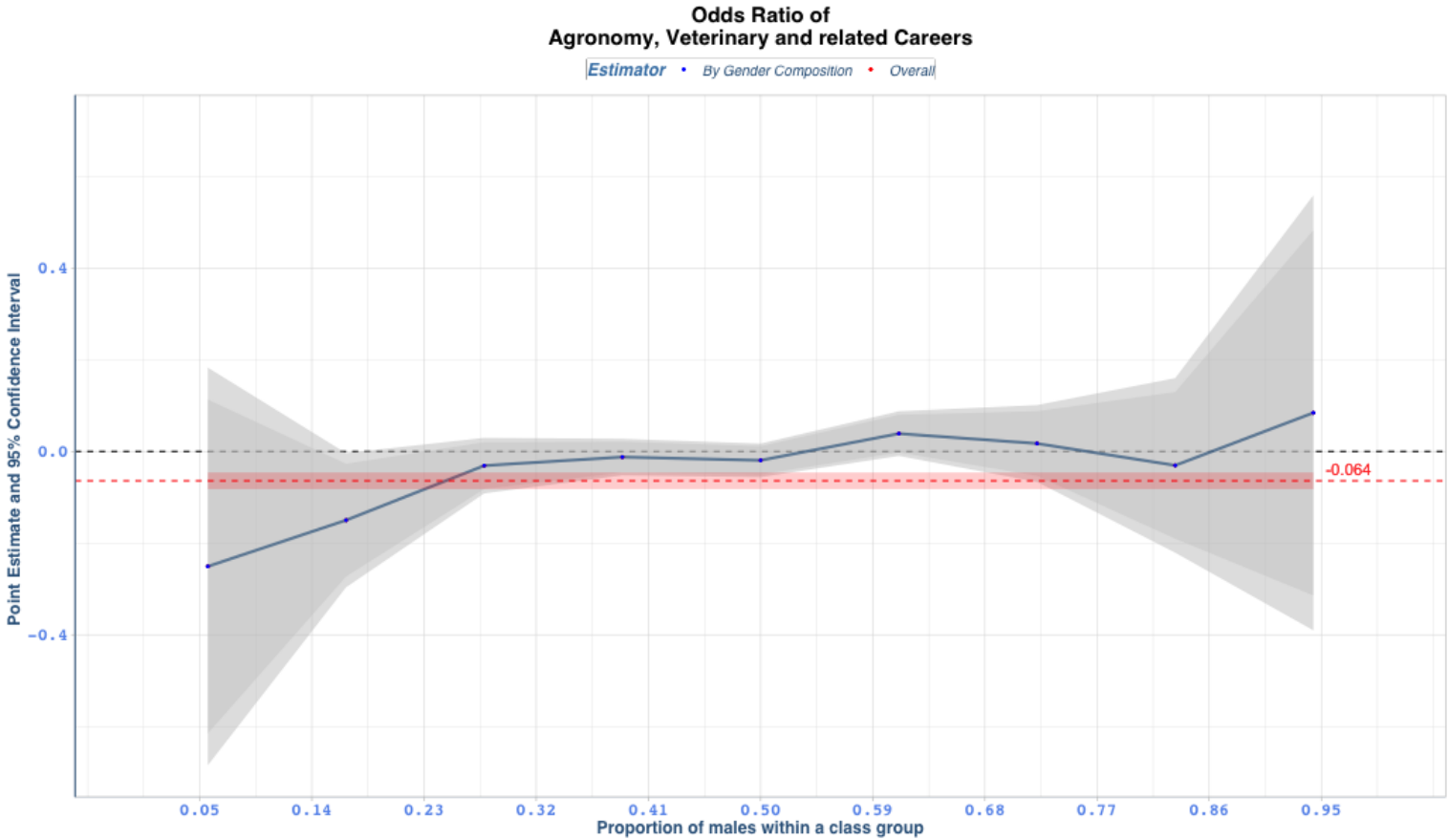


Figure: Likelihood of a female student choosing agronomy/veterinary-related majors

Optimal Bandwidth Estimation based on Binary Cross-entropy

In order to analyze the probability that a secondary school student chooses an Field of Study P to pursue post-secondary studies, we examine the probability according to different gender compositions in the classrooms. Therefore, we assume that there exists a fixed value that allows us to subset by $\exists X_{\text{optimal}}$.

The formal representation using mathematical notation for the partitioning of the range into fixed intervals:

$$
\begin{aligned}
X_1 &= [0, X_{\text{optimal}}) \\
X_2 &= [X_{\text{optimal}}, 2X_{\text{optimal}}) \\
X_3 &= [2X_{\text{optimal}}, 3X_{\text{optimal}}) \\
&\dots \\
X_n &= [(n-1)X_{\text{optimal}}, nX_{\text{optimal}})
\end{aligned}
$$

These representations X_i cover the entire range in fixed intervals of X_{optimal} and define distinct subsets, each representing an interval of size X_{optimal} within the overall range.

To estimate X_{optimal}, we modify the methodology proposed in Imbens and Kalyanaraman (2012). In it, the key step is to replace the mean squared error (MSE) criterion with a

Optimal Bandwidth Estimation based on Binary Cross-entropy

The key outcome we are trying to predict is a binary variable indicating whether a student chooses a particular Field of study (e.g. science, humanities, etc.) or not. Let's call this $Y_i \in \{0, 1\}$.
$Y_i = 1$ means student i chose that Field of study, and $Y_i = 0$ means they did not choose that Field. Our regression discontinuity model is estimating the probability $p_i = P(Y_i = 1|X_i)$ that the student chooses that Field, conditioned on the gender composition in classrooms X_i.
Let's call this estimated probability $m(X_i)$, which depends on the bandwidth h.
The BCE loss for a single data point measures how well our model is estimating this probability. It is:

$$\text{BCE}_i = \begin{cases} -\log(m(X_i)), & \text{if } Y_i = 1 \\ -\log(1 - m(X_i)), & \text{if } Y_i = 0 \end{cases}$$

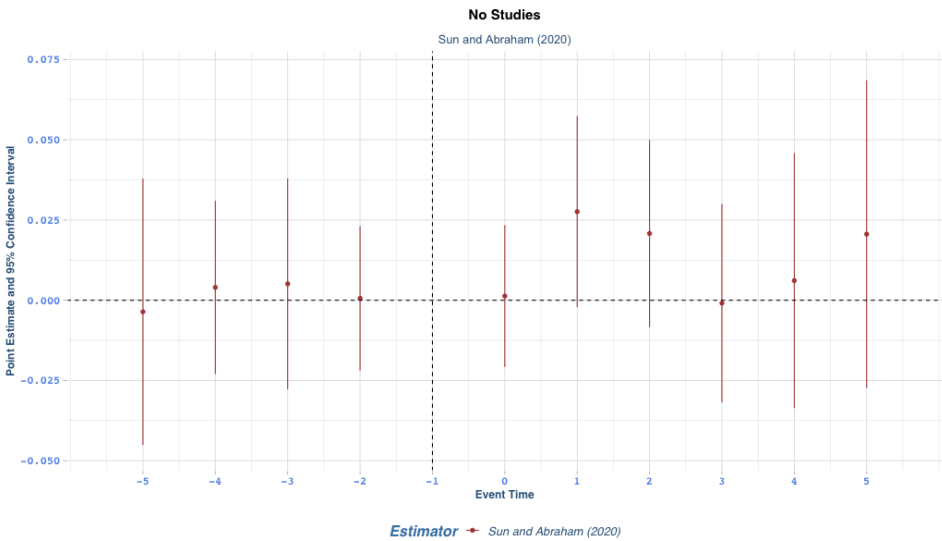
This penalizes underestimating probability if the actual outcome is 1 and penalizes overestimating probability if the actual outcome is 0. We then define the overall expected BCE loss over the distribution of (X_i, Y_i) as:

$$\text{BCE}(h) = E[-Y_i \log(m(X_i)) - (1 - Y_i) \log(1 - m(X_i))]$$

Minimizing this BCE(h) gives the optimal bandwidth for our model. Jump Back

Changes in Proportion of Students Not Pursuing Further Studies

Changes in the Proportion of Students That Not Pursue Further Studies in Schools Transitioning from Single-Sex to Coeducational



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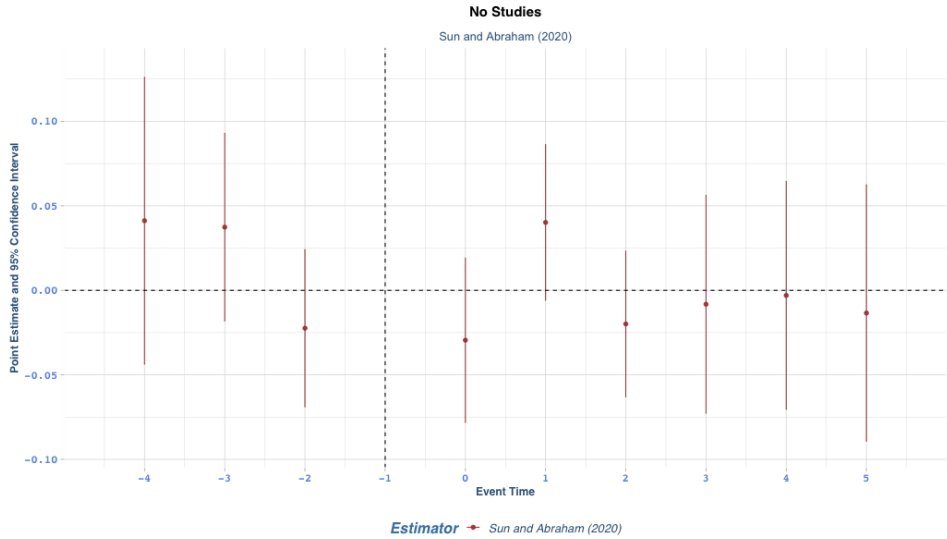
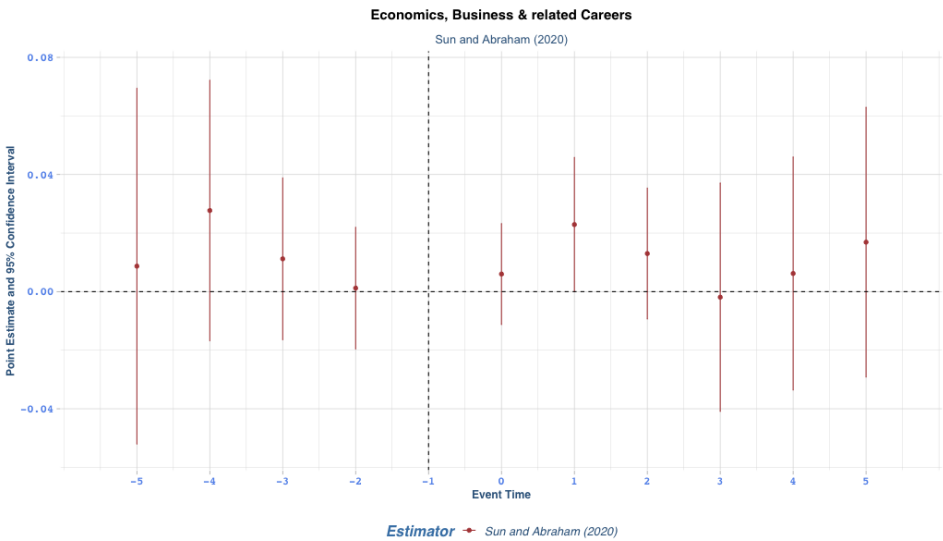


Ex male schools

Economics, Business and Related Majors:

Changes in the Proportion of Students Choosing Economics and Business Related Majors in Schools Transitioning from Single-Sex to Coeducational



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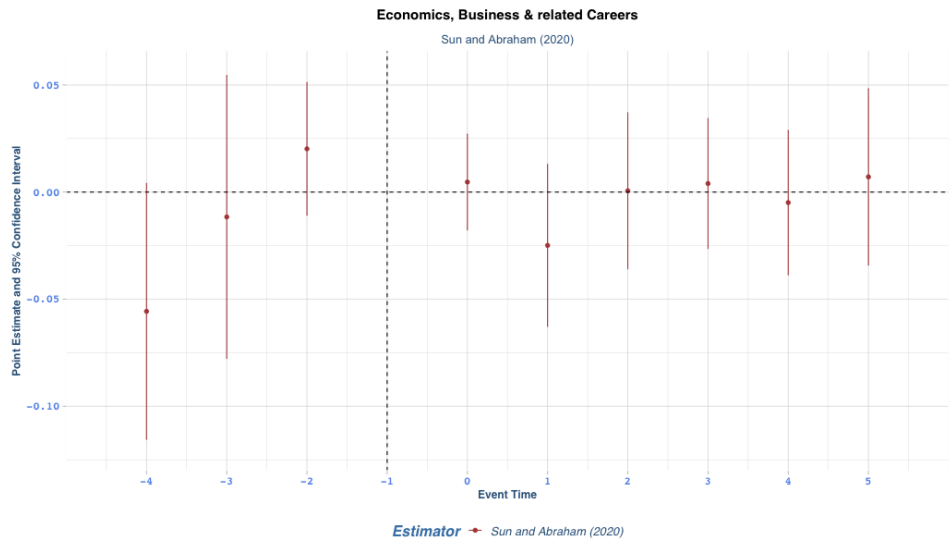
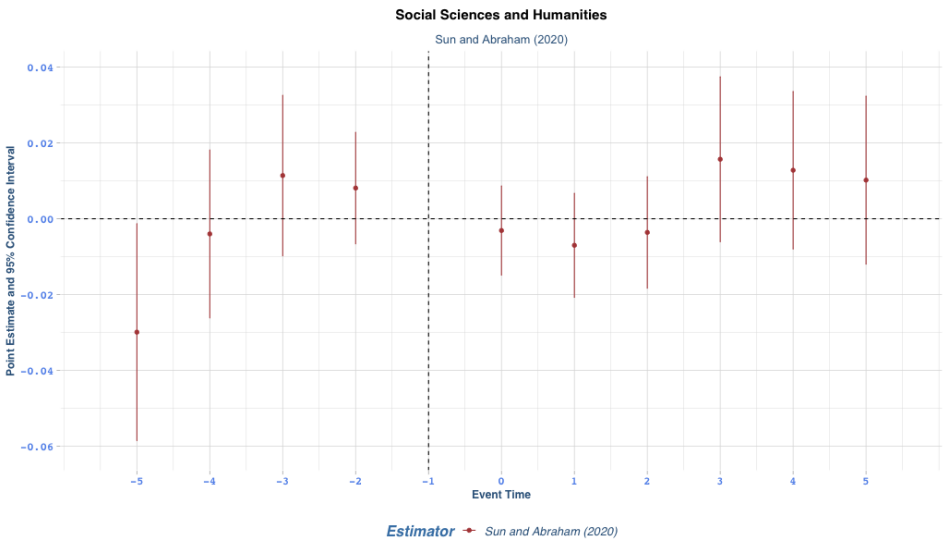


Ex male schools

Social Sciences/Humanities Majors:

Changes in the Proportion of Students Choosing Social Sciences in Schools Transitioning from Single-Sex to Coeducational



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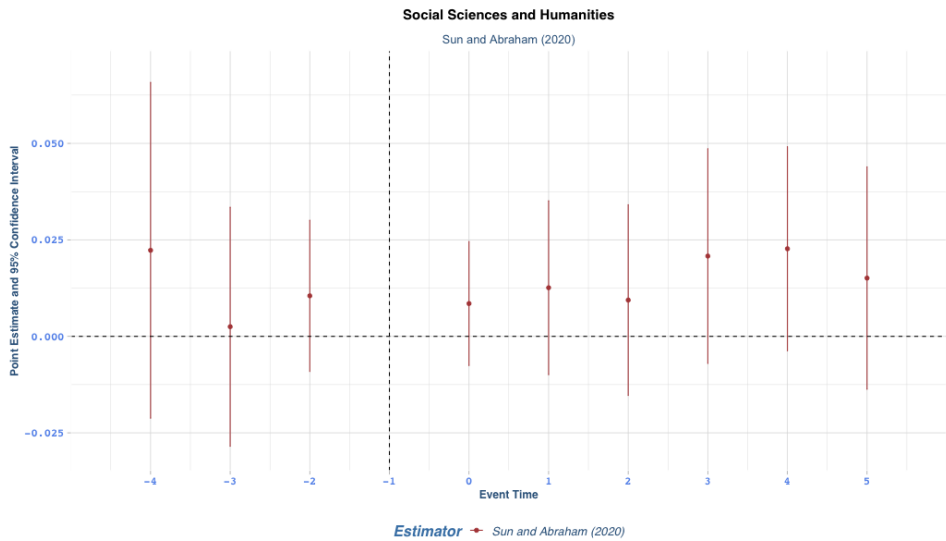
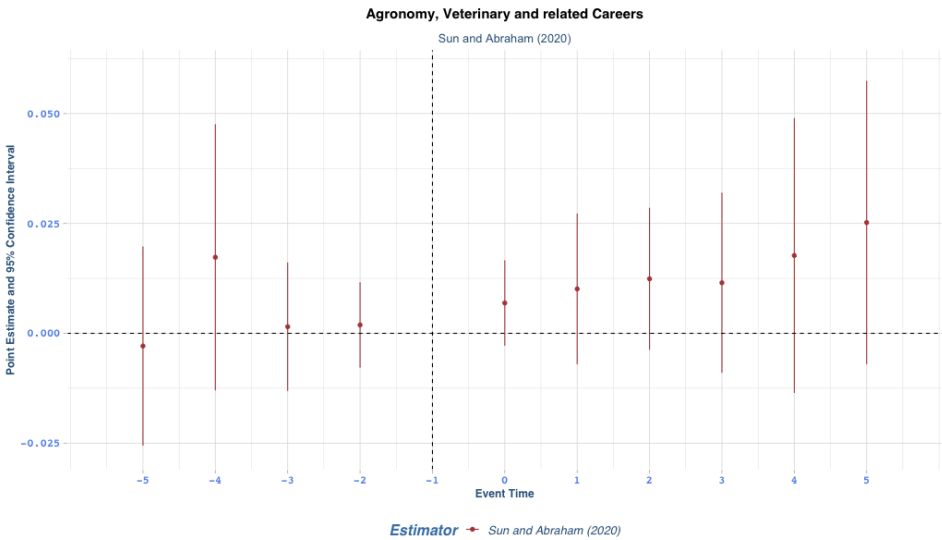


Ex male schools

Education Sciences Majors:

Changes in the Proportion of Students Choosing Education Sciences Majors in Schools Transitioning from Single-Sex to Coeducational



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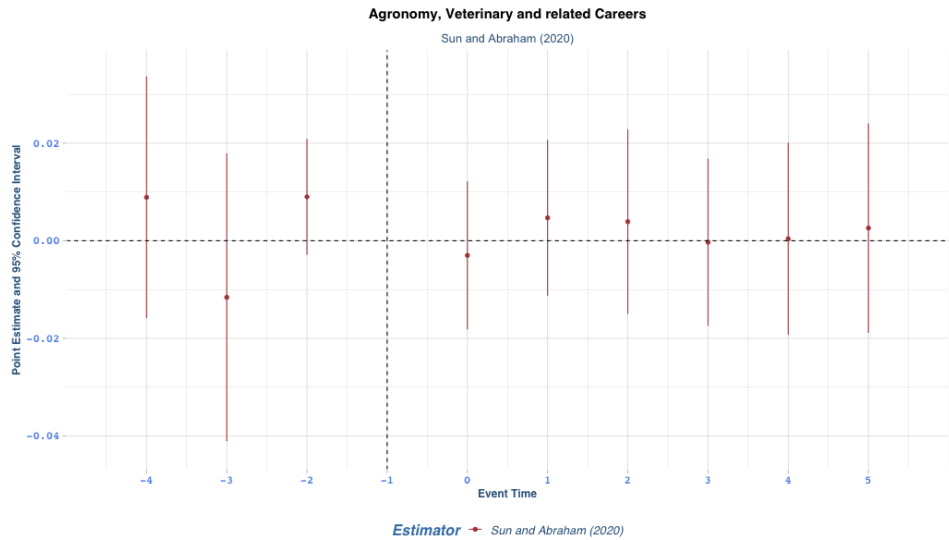
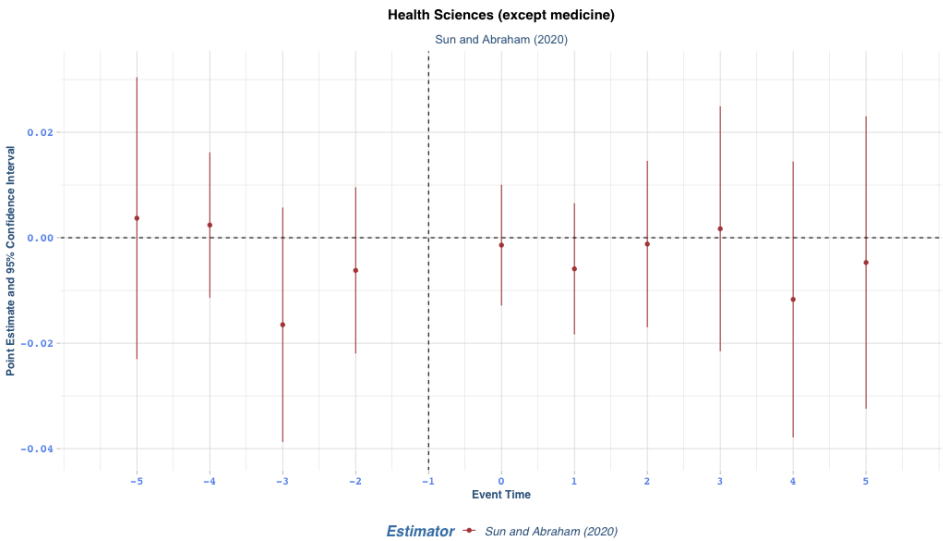


Ex male schools

Health Sciences Majors (Except Medicine):

Changes in the Proportion of Students Choosing Health Science Majors (Except Medicine) in Schools Transitioning from Single-Sex to Coeducational



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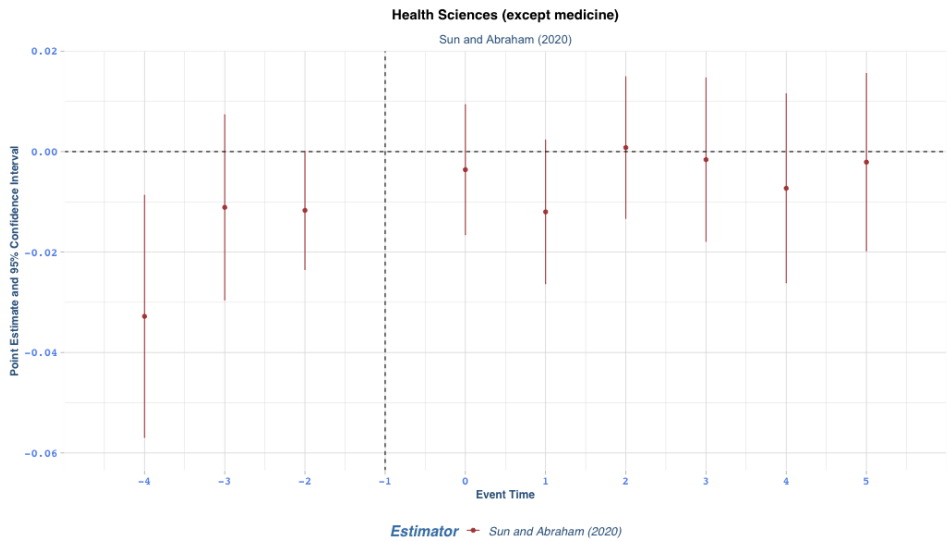
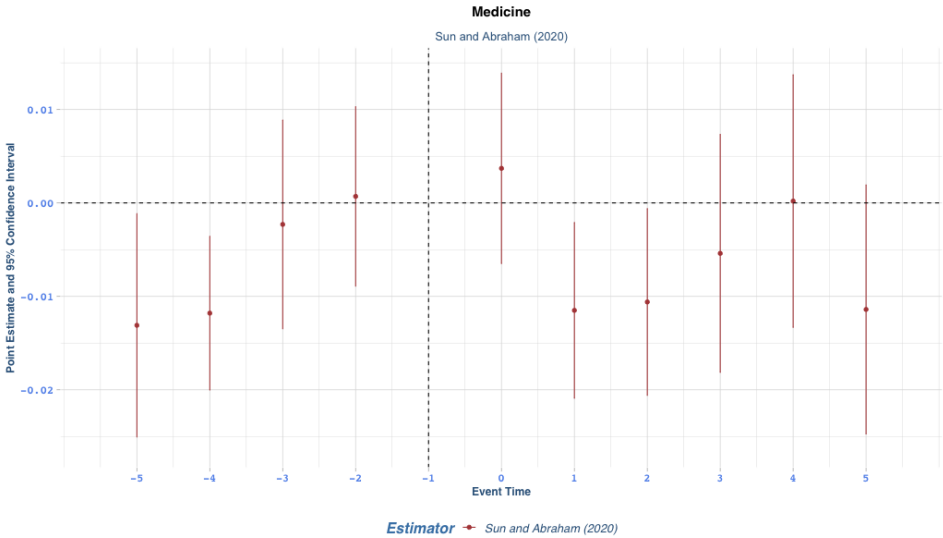


Ex male schools

Medicine Major:

Changes in the Proportion of Students Choosing A Major in Medicine from Schools Transitioning from Single-Sex to Coeducational



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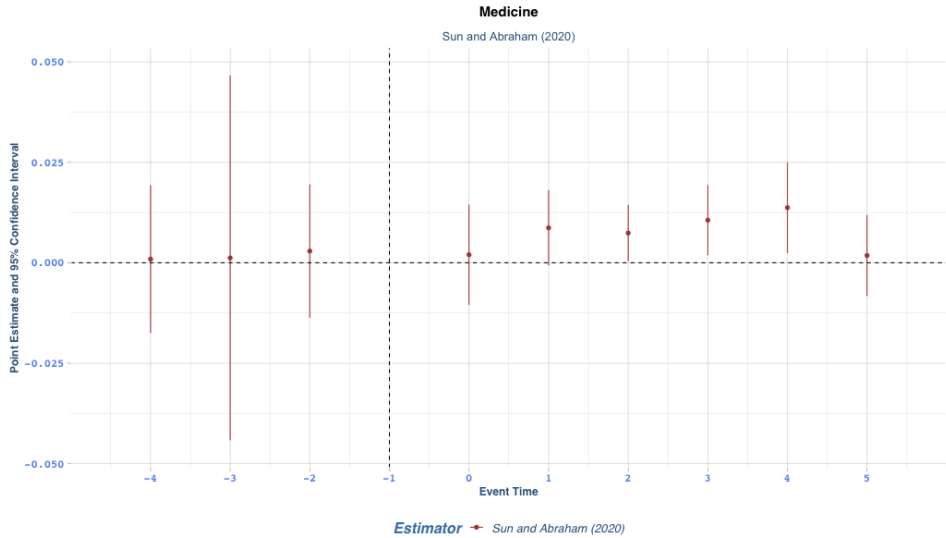
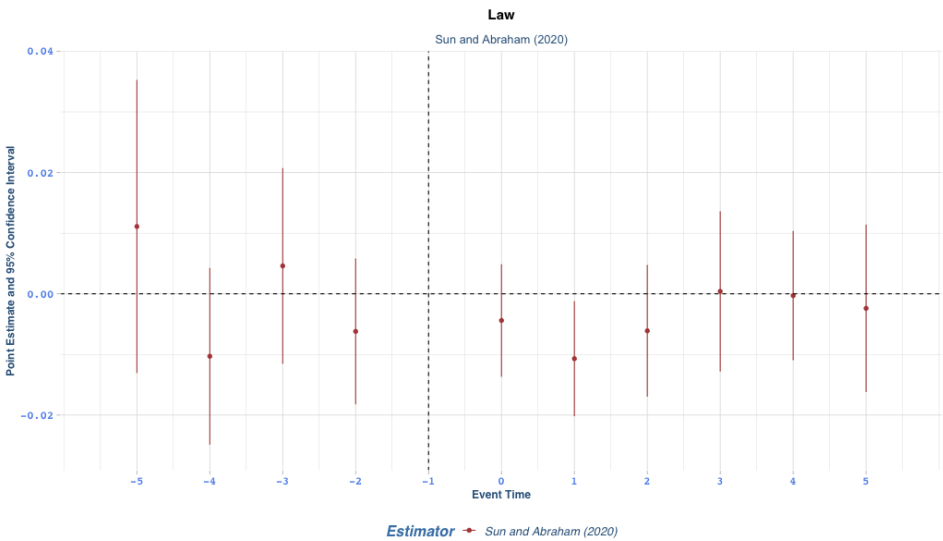


Ex male schools

Law Majors:

Changes in the Proportion of Students Choosing a Major in LAW in Schools Transitioning from Single-Sex to Coeducational



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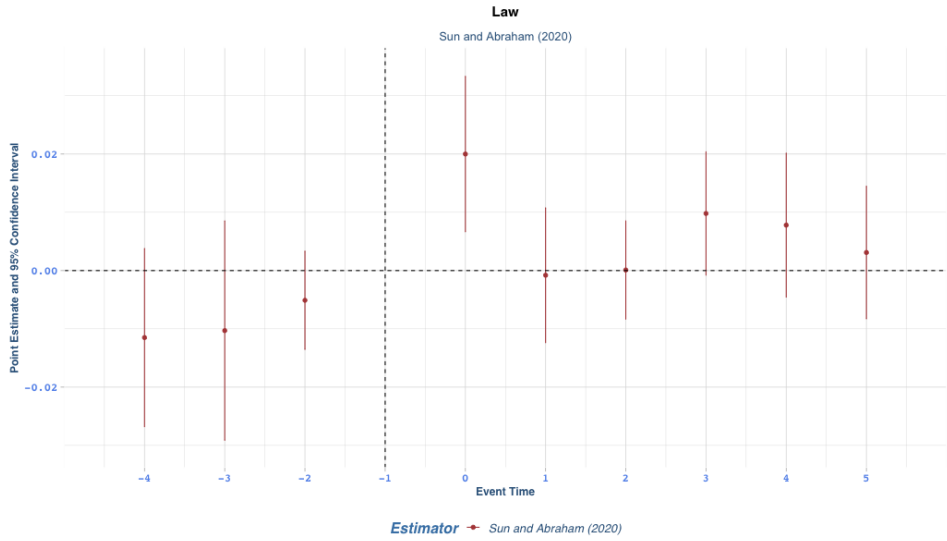
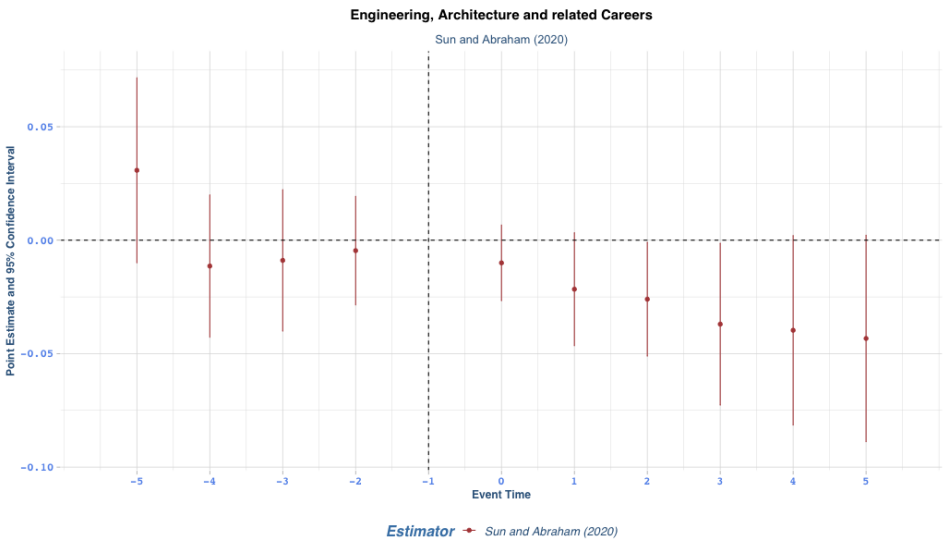


Ex male schools

Engineering/Architecture Related Majors:

Changes in the Proportion of Students Choosing Engineering, Architecture and Related Majors in Schools Transitioning from Single-Sex to Coeducational



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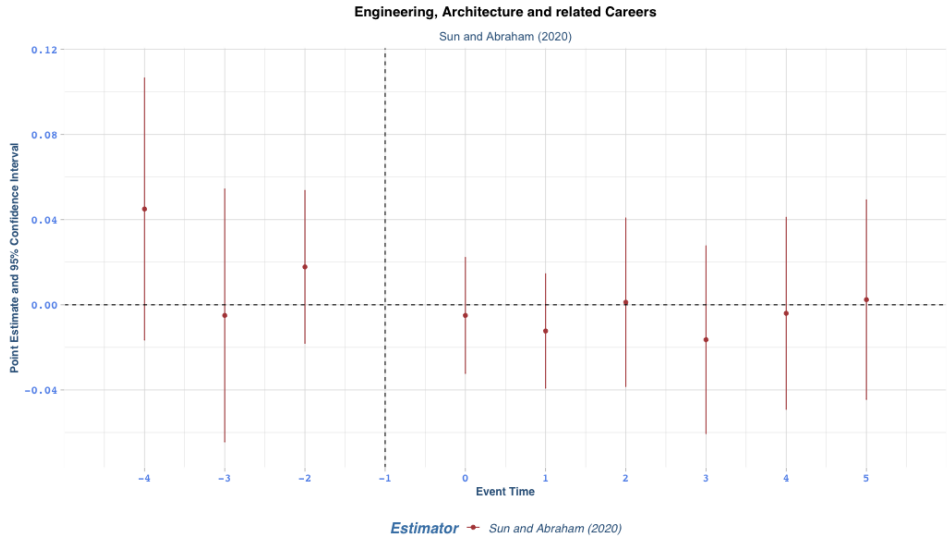
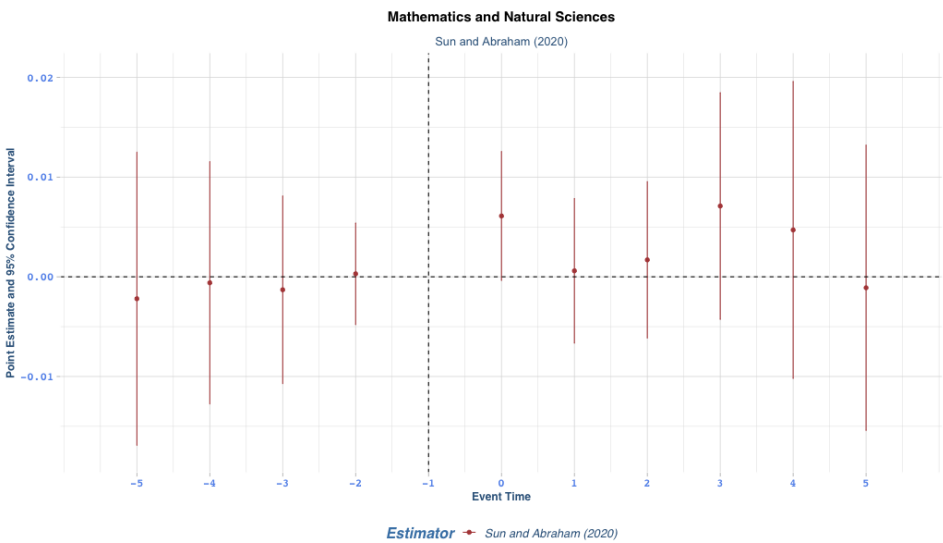


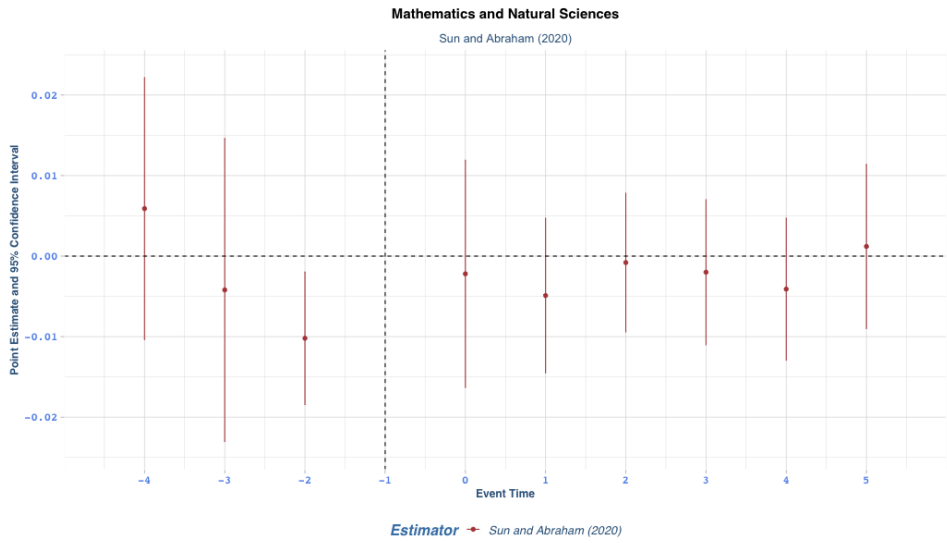
Ex male schools

Mathematics and Natural Sciences Majors:

Changes in the Proportion of Students Choosing Mathematics, Natural Sciences and Related Majors in Schools Transitioning from Single-Sex to Coeducational



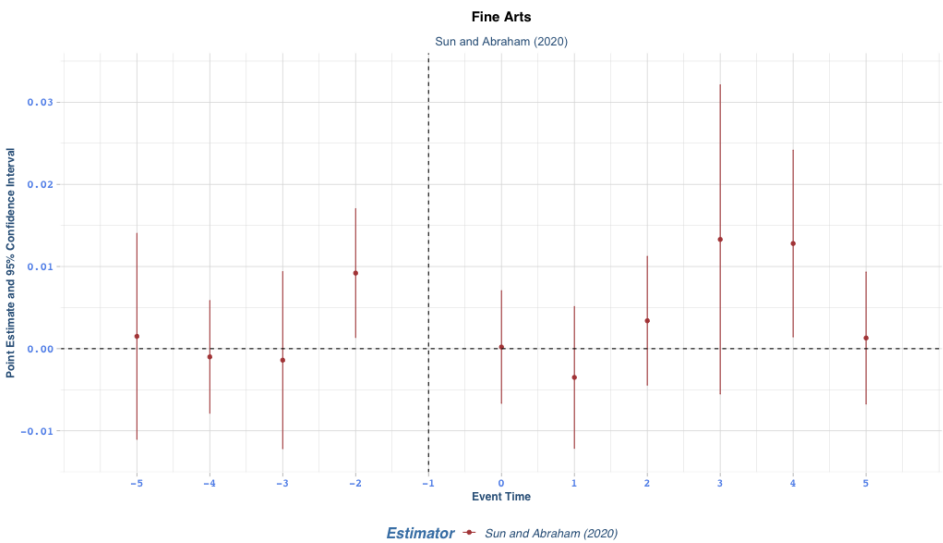
Ex female schools



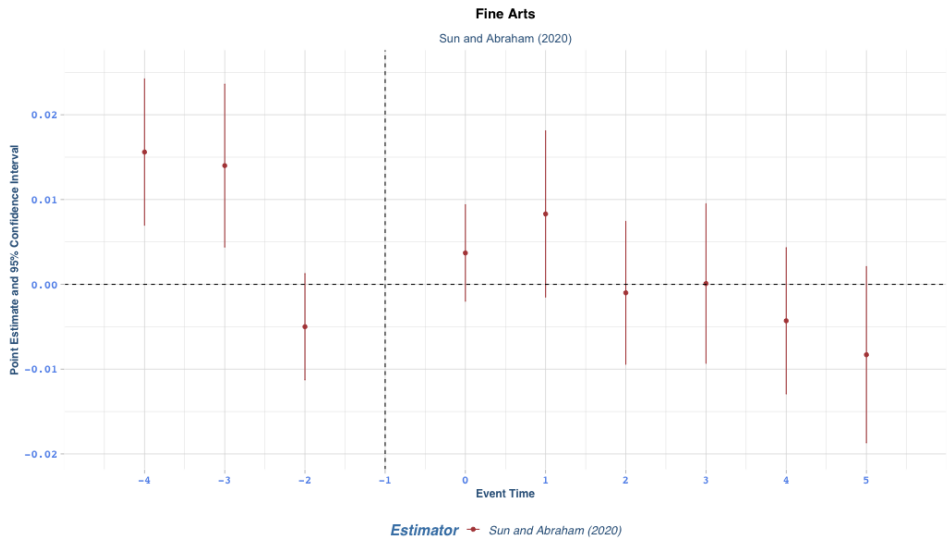
Ex male schools

Fine Arts Majors:

Changes in the Proportion of Students Choosing Fine Arts and Related Majors in Schools Transitioning from Single-Sex to Coeducational



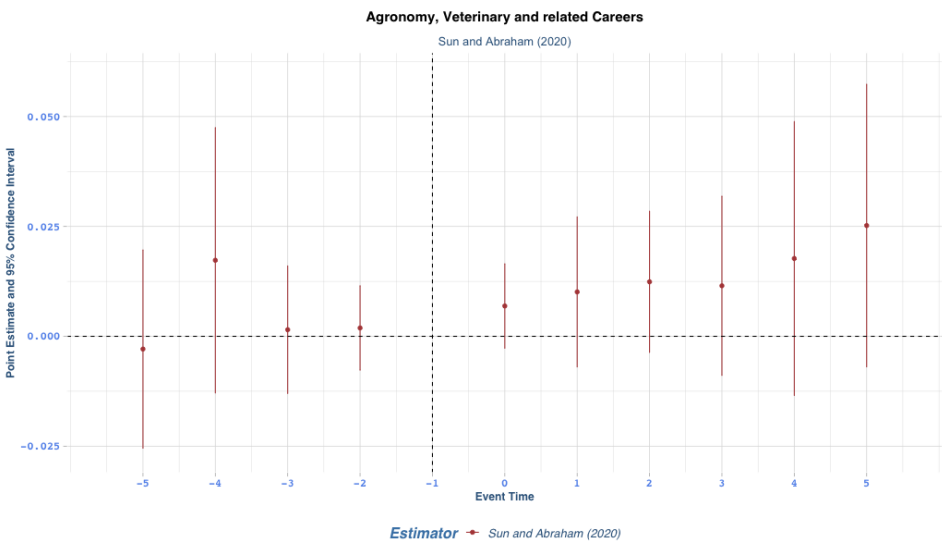
Ex female schools



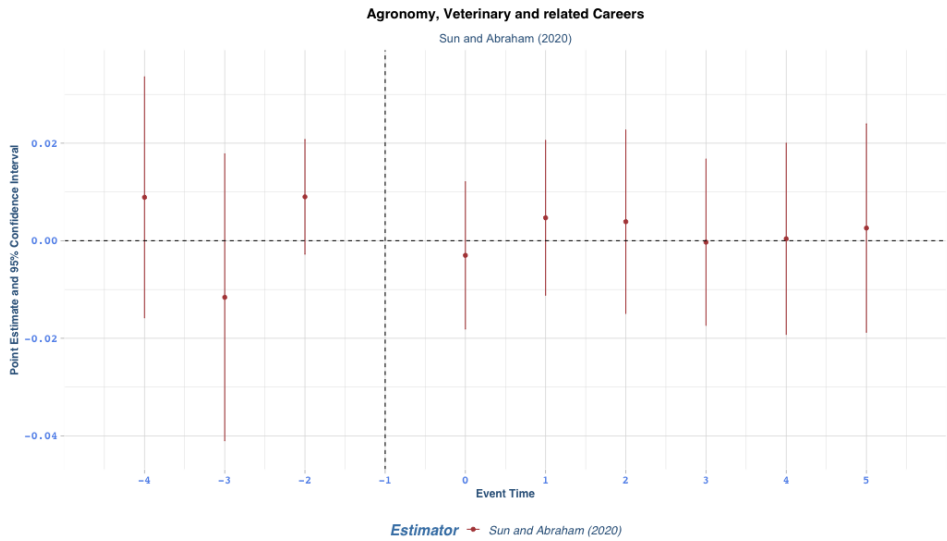
Ex male schools

Agronomy/Veterinary Related Majors:

Changes in the Proportion of Students Choosing Agronomy, Veterinary, and Related Majors in Schools Transitioning from Single-Sex to Coeducational



Ex female schools



Ex male schools

Alesina, A., Giuliano, P., & Nunn, N. (2013). On the origins of gender roles: Women and the plough. *Quarterly Journal of Economics*, *128*(2), 469-530.

Buser, T., Niederle, M., & Oosterbeek, H. (2014, 05). Gender, Competitiveness, and Career Choices *. *The Quarterly Journal of Economics*, *129*(3), 1409-1447. Retrieved from `https://doi.org/10.1093/qje/qju009` doi: 10.1093/qje/qju009

Clifford D. Evans. (2006). Life GOALS: Antecedents IN GENDER BELIEFS AND EFFECTS ON GENDER-STEREOTYPICAL CAREER INTEREST.

Eisenkopf, G., Hessami, Z., Fischbacher, U., & Ursprung, H. W. (2015). Academic performance and single-sex schooling: Evidence from a natural experiment in switzerland. *Journal of Economic Behavior Organization*, *115*, 123-143. Retrieved from `https://www.sciencedirect.com/science/article/pii/S0167268114002236` (Behavioral Economics of Education) doi: https://doi.org/10.1016/j.jebo.2014.08.004

Evans, C. D., & Diekman, A. B. (2009, 6). On Motivated Role Selection: Gender

Beliefs, Distant Goals, and Career Interest. *Psychology of Women Quarterly*, *33*(2), 235–249.

Giustinelli, P., & Manski, C. F. (2018). Survey measures of family decision processes for econometric analysis of schooling decisions. *Economic Inquiry*, *56*(1), 81-99. Retrieved from `https://onlinelibrary.wiley.com/doi/abs/10.1111/ecin.12322` doi: https://doi.org/10.1111/ecin.12322

Imbens, G., & Kalyanaraman, K. (2012). Optimal bandwidth choice for the regression discontinuity estimator. *The Review of Economic Studies*, *79*(3), 933–959. Retrieved 2023-11-27, from `http://www.jstor.org/stable/23261375`

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79-122. Retrieved from `https://www.sciencedirect.com/science/article/pii/S000187918471027X` doi: https://doi.org/10.1006/jvbe.1994.1027

National Center for Science and Engineering Statistics. (2023). *Diversity and stem: Women, minorities, and persons with disabilities* (Report No. NSF 23-315). Retrieved from `https://ncses.nsf.gov/pubs/nsf23315/report`

Valbuena, J. (2011). *Family background, gender and cohort effects on schooling decisions* (School of Economics Discussion Papers Nos. 11,14). Canterbury. Retrieved from `https://hdl.handle.net/10419/50631`