Paper Title Gender Equity in Access to Computer Science Versus Other Majors

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Gender equity in access to computer science versus other majors

Abstract

Computer scientists play a critical role in society and the economy, leading to more students applying for CS majors. University and departmental policies significantly impact access to CS programs and degree completion. This NSF-funded study examines equity in CS major applications and admissions, focusing on gender disparities. Analyzing data from two institutions, we find significant gender differences in CS applications and admissions, with female students less likely to apply compared to male students, unlike trends in other STEM and non-STEM majors. These disparities arise from both application behaviors and admissions processes.

(Word count: 91)

Objectives

Computer Science (CS) jobs are crucial to the future growth of the global economy. The demand for people educated in CS has grown tremendously over the past decade. Jobs in software development (a common career for CS students) are expected to grow by 24% between 2016 and 2026, making it fifth for careers with the most projected new jobs according to the Bureau of Labor Statistics (BLS Occupational Outlook Handbook, 2018). Moreover, in 2018, the median pay for a software developer with a CS Bachelor's degree was $105,590 (ibid.), compared to a median pay for college-educated workers in the United States in 2017 of $72,830 (BLS Career Outlook, 2019, median pay across all professions requiring a Bachelor's degree was not yet available for 2018).

Largely because of these factors, colleges and universities are seeing record-high numbers of CS majors (Camp et al., 2017), and many departments now limit admission to their courses and/or majors (Camp et al., 2017). The representation of women and students from underrepresented racial and ethnic groups may be growing modestly (Camp et al. 2017 reports growth, while a report from the National Academies of Sciences, Engineering and Medicine, 2018 (p. 113) reports mixed results), but this growth will continue to be highly dependent on universities' actions and policies (NASEM, 2018).

It is well-documented that CS is highly skewed toward males versus females and has skewed racial/ethnic distributions (NASEM, 2018; Camp et al., 2017; Hamrick, 2019). What is not fully understood is at what point these imbalances are greatest and the degree to which they change as students progress through CS undergraduate programs and whether these imbalances are unique to the CS major compared to other majors. As part of a large NSF-funded study, we examine associations between key student characteristics—both demographic characteristics (e.g., gender, race/ethnicity, socioeconomic status, first-gen status) and characteristics related to pre-college preparation (e.g., high school GPA, college entrance exam scores, AP test completion, and high school characteristics)—and application and entry in CS and other groups of majors. Two research questions guide our study:

1. Who applies to the CS major and are applicants' characteristics changing over time? How do application patterns in CS compare to application patterns of other STEM majors and popular non-STEM majors?
2. Who is admitted to and enrolled in the CS major? How does CS admittance compare to admittance in other STEM majors and popular non-STEM majors?

Perspectives

Who applies to and who is admitted to CS? Admission to college CS programs is influenced by various factors. Carter's early study (2006) revealed that students' decisions not to choose CS as a major were often due to the lack of desire to sit in front of a computer all day or their interest in another field. Gender differences were found, as males were drawn to CS by their interest in computer games, while females wanted to apply CS skills in other fields.

Equity issues are often explored concerning who chooses to study CS and who has access to it. Margolis and Fisher's work (2002) on gender and CS found that women were often discouraged and had limited home resources compared to men. Margolis (2008) later highlighted disparities related to race, where computing-rich schools were situated in predominantly White areas, while Latinx or Black areas had limited resources.

Larger quantitative studies commissioned by Google (Google Inc., 2014; Wang et al., 2015, 2016; Google Inc. & Gallup Inc., 2016) revealed that for high school students, encouragement and exposure were the most significant factors influencing women's decisions to pursue CS-related education but less significant factors influencing men's decisions. They also found structural and social barriers disproportionately affected Black and Latinx students. One pre-college experience associated with success in college-level CS courses is taking AP CS while in high school (Alvarado, Umbelino, & Minnes, 2018). Notably, large gender and racial disparities exist in students who take and pass AP CS Exams (Ericson, 2018).

While disparities in CS have been found, an important question is whether such disparity patterns exist in other majors as well or whether CS is unique in experiencing pronounced differences between genders (Cheryan et al., 2017, Stoet & Geary, 2018). For example, it has been documented that other STEM majors such as mathematics experience an underrepresentation of women from the major (Porter & Serra, 2020, Stoet et al., 2016, Nollenberger & Rodriguez-Planas, 2016). Much research also exists on gender disparities in engineering. Female representation in the major is far lower than males (e.g., Eccles, 2007; Master et al., 2021, Sax et al., 2016). Other popular majors such as biology (Rainey, 2018, Su & Rounds, 2015), economics (Emerson et al., 2017), and business (Krishna & Orhun, 2022) also experience gender gaps.

Data

We use ten years of admissions data from two separate institutions, beginning in the Fall of 2013 and ending in 2024. Institution 1 is a large R1 public university. Institution 2 is a mediumsized private university with a largely undergraduate focus. The variations in size and governance thus provide interesting comparisons across the institutions. Table 1 describes the two institutions and the proportions of female students who **applied** for CS and other majors of interest at each university.

The overall acceptance rate for institution 1 was 62.9% and the overall acceptance rate for institution 2 was 50.8%. Table 2 illustrates the proportions of female students who were **admitted** to CS and other majors of interest at each university.

The admissions data consists of student-level data on *all* students who applied to each university in each year. In the admissions data, the applicants fall into two categories: first-time collegegoers (i.e., freshmen) and transfer students. We focus the results of this presentation on the freshman only. Table 3 describes the available variables used as controls at each institution.

Methods

We employ regression-based approaches to answer RQ1 (*characteristics of CS applicants*) and RQ2 (*characteristics of CS admitted*). Using a logistic regression model, we estimate the probability of applying (and then being admitted) to CS conditional on a set of regressors, which is then estimated by maximum likelihood. The regressors include student characteristics (e.g., gender, racial/ethnic categories, high school GPA, and SAT/ACT score), to capture unobserved differences in preferences for different student characteristics across each of our four institutions.

Results

The plotted adjusted results show that gender differences exist in application rates across all majors. In institution 1, we see that males are more likely to apply than females to STEM majors, computer science, engineering, physical science, and business while females apply at higher rates in biology, life science, liberal arts, and social science (social science effect is driven by psychology). When we control for covariates, the gaps in application rates do not seem to reduce. For admittance, the gender differences in institution 1 are smaller than application differences (see Figure 2), and the gaps seem to reduce even more when we control for covariates.

At institution 2, we see similar results as institution 1 for applications. In institution 2, we see that males are more likely to apply than females to computer science, engineering, and business while females apply at higher rates in biology, liberal arts, life sciences, and social science (social science effect is driven by psychology). When we hold constant SAT scores across genders, we see less of a difference in application rates. This indicates that the SAT scores for males applying to CS in institution 2 are on average higher than those for females. However, although the difference narrows in the adjusted regressions, it does not disappear, and the likelihood of application to CS for males is still significantly higher than for females. For admittance, the gender differences in institution 2 are smaller than application differences (see Figure 4).

Gender inequalities still exist even in majors that are dominated at the application level by women. For example, with the exception of 2022, men are being admitted into STEM at higher rates than women even after controlling for SAT, etc. In computer science specifically, gender inequities were non-existent until the last year, 2023. We also see that in psychology, and social science men are being admitted at higher rates despite more females applying than men.

Overall, the results show that gender inequities in computer science occur at the application stage and are slightly mitigated at the admittance stage. This pipeline pattern is present in both institutions. In this presentation, we will explore these results in more detail also capturing the covid effects on all of the different majors.

Significance

The work aims to uncover in what ways (if any) females are systematically less able to access different majors and note the factors that may lead to systemic exclusion. By comparing the CS major to other majors within STEM and also non-STEM, we can gain an understanding of how the discrepancies in CS are similar and different across majors at the application and admittance stage of the pipeline. Due to the magnitude and year span of our data including multiple cohorts over the course of a decade, our results provide a much-needed comprehensive and nuanced understanding of the CS pipeline. Our work fills gaps in the current literature that study the link between high school towards university access and lays the groundwork for universities to develop and promote policies that improve equity in access to CS.

(Word count: 1547)

Appendix

Table 1. The proportion of female students applied to majors

	Institution 1		Institution 2	
Applied Majors	Female pct	Total	Female pct	Total
Computer Science	**19.5%**	**53,706**	**30.1%**	**3,826**
Engineering	23.9%	57,286	28.6%	5,445
Physical Science	40.7%	43,259	53.3%	2,122
Business	46.3%	73,429	47.6%	24,710
STEM Majors	50.9%	242,874	60.9%	25,655
Social Science (exclud. Psychology)	52.1%	95,725	58.6%	10,769
Social Science	59.9%	145,108	69.3%	20,099
Life Science	63.8%	149,858	71.6%	18,835
Biology	64.4%	125,249	70.7%	9,616
Liberal Arts	67.9%	41,114	71.1%	14,302
Psychology	75.7%	48,052	81.7%	9,330
Total (all majors)	53.07%	614,325	59.8%	113,833

Table 2. The proportion of female students admitted to majors

	Institution 1		Institution 2	
Admitted Majors	Female pct	Total	Female pct	Total
Computer Science	**23.4%**	**23,639**	**31.2%**	**2,017**
Engineering	28.5%	33,671	30.1%	3,398
Physical Science	41.5%	27,836	52.4%	1,305
Business	48.5%	49,955	47.0%	13,447
Social Science (exclud. Psychology)	52.4%	67,181	56.1%	6,353
STEM Majors	52.7%	153,480	57.7%	13,424
Social Science	58.6%	94,263	66.7%	10,955
Life Science	63.7%	97,623	69.4%	9,156
Biology	64.1%	82,684	67.3%	4,873
Liberal Arts	68.9%	28,849	71.1%	8,168
Psychology	75.2%	25,758	81.2%	4,602
Total (all majors)	55.16%	386,572	59.6%	58,134

Table 3. Control variables

Variables	Institution 1	Institution 2
Gender	x	x
Race	x	x
First Generation	x	
Income	x	
SAT Scores	x	x
HS GPA	x	x
AP Information	x	
Freshman/Transfer	x	x

Figure 1: Predicted probability of applying to majors at institution 1

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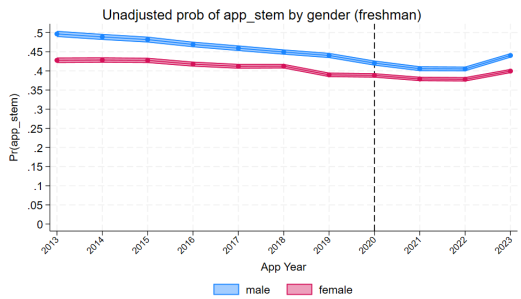
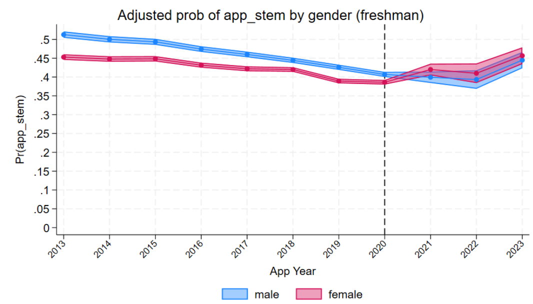
<tr><td>STEM majors</td><td>
</td><td>
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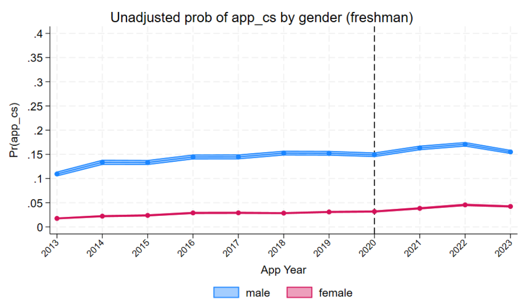
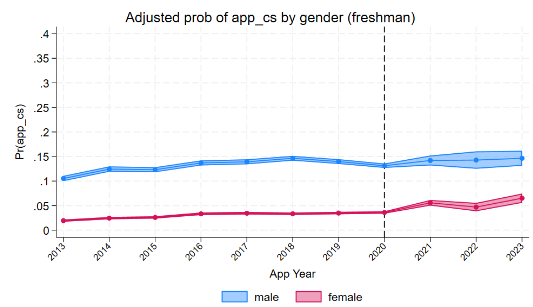
<tr><td>Computer Science</td><td>
</td><td>
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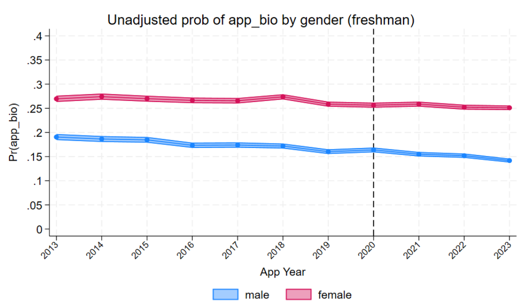
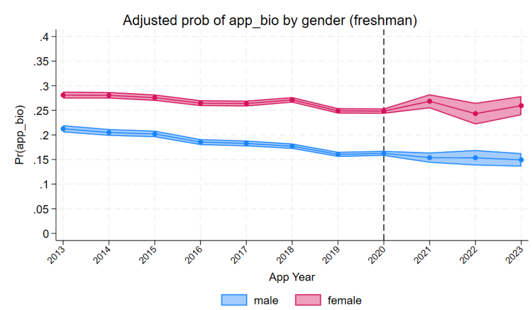
<tr><td>Biology</td><td>
</td><td>
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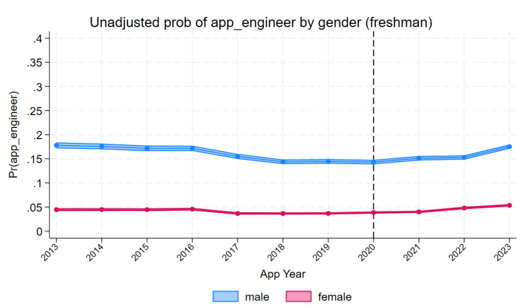
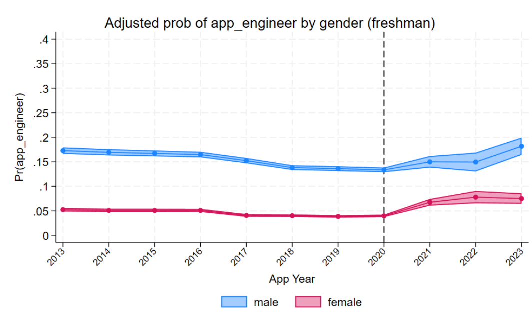
<tr><td>Engineering</td><td>
</td><td>
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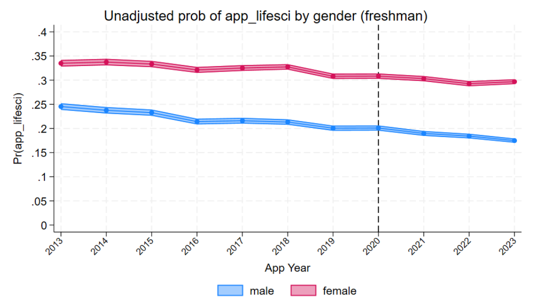
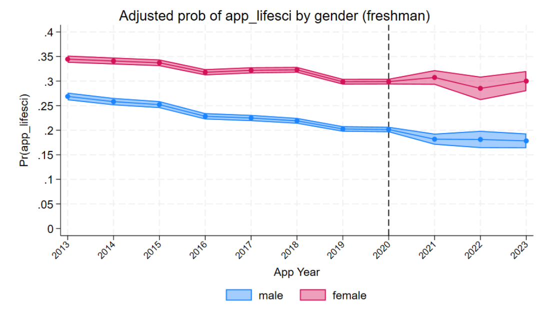
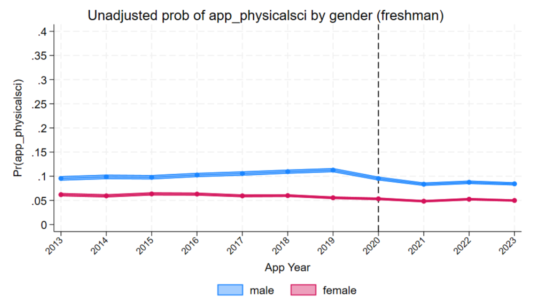
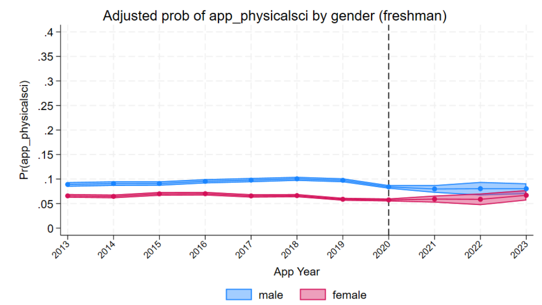
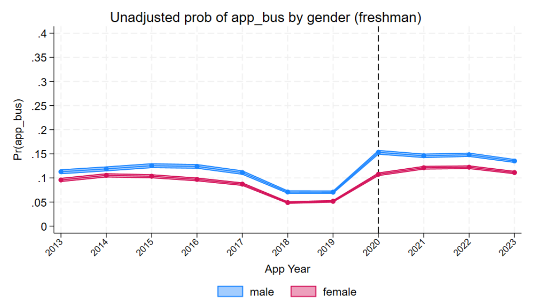
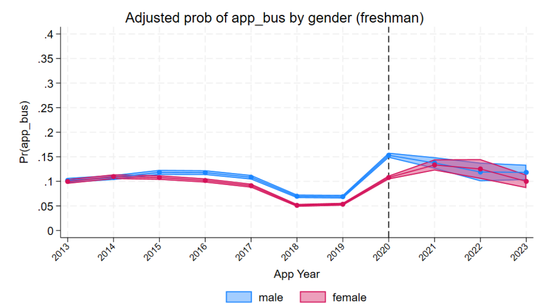
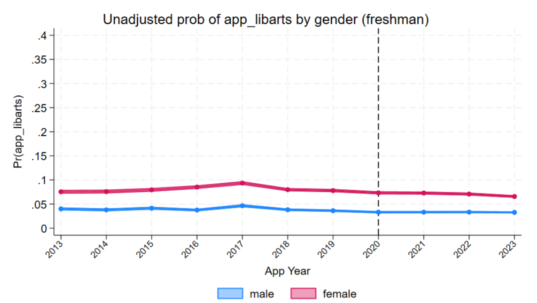
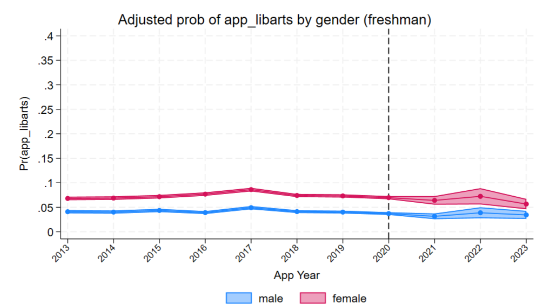
Life Science		
Physical Science		
Business		
Liberal Arts		

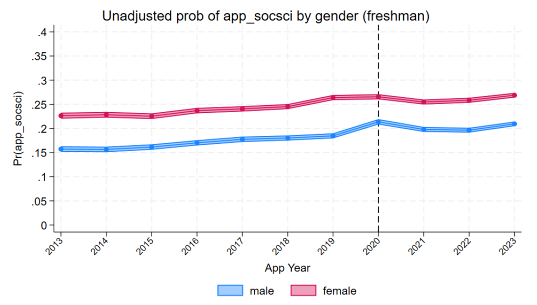
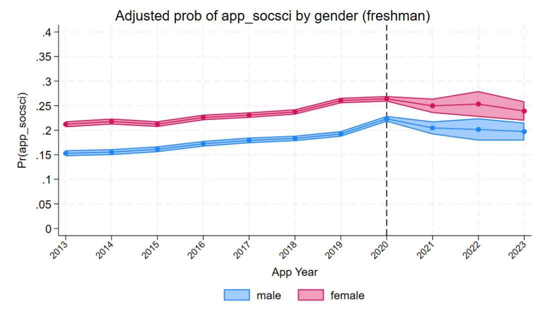
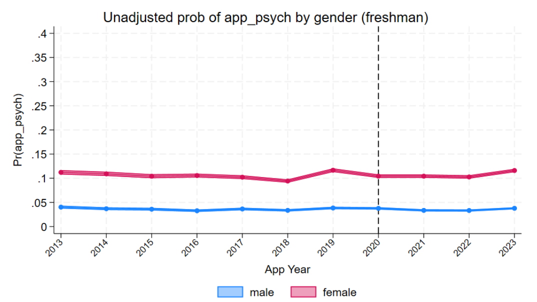
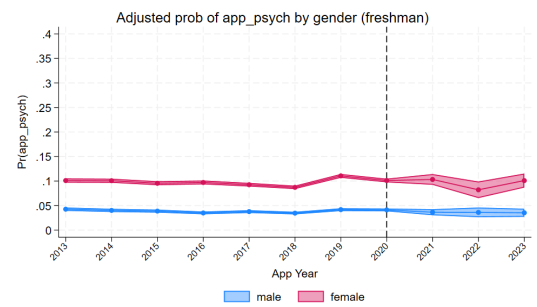
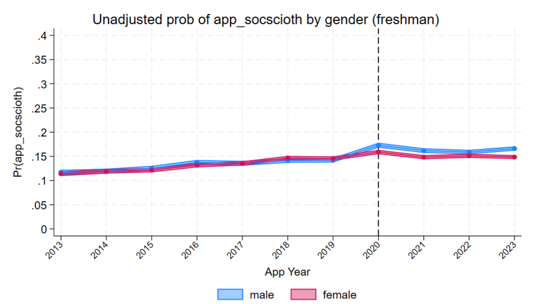
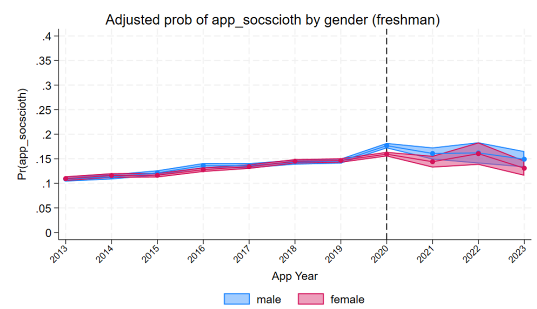
Social Science		
Psychology		
Social Science (exclude Psychology)		

Figure 2: Predicted probability of admitting to majors at institution 1

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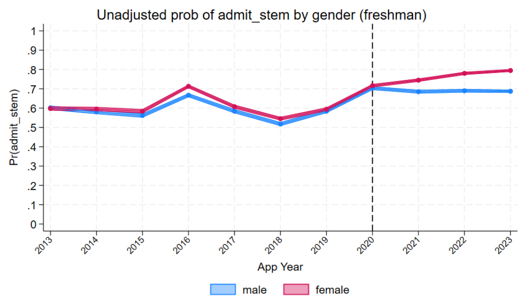
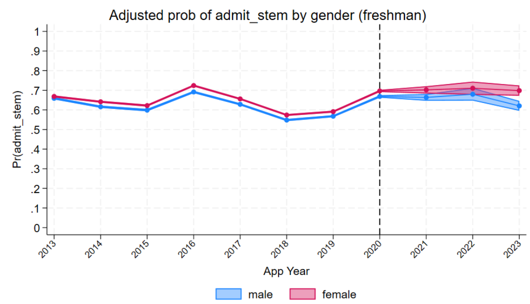
<tr><td>STEM majors</td><td>
</td><td>
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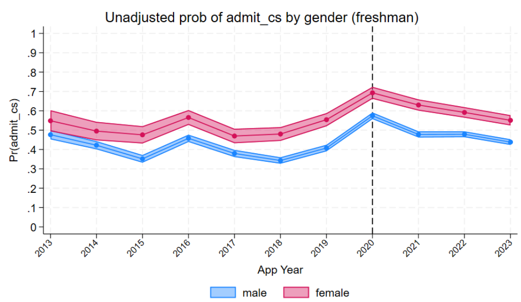
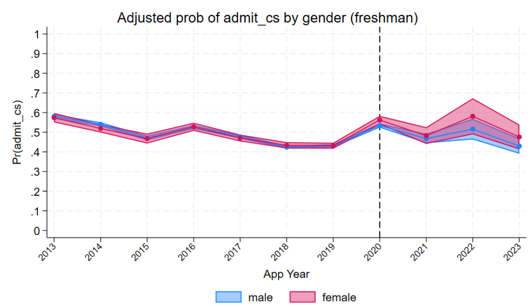
<tr><td>Computer Science</td><td>
</td><td>
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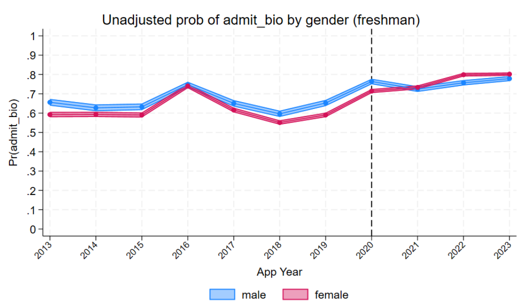
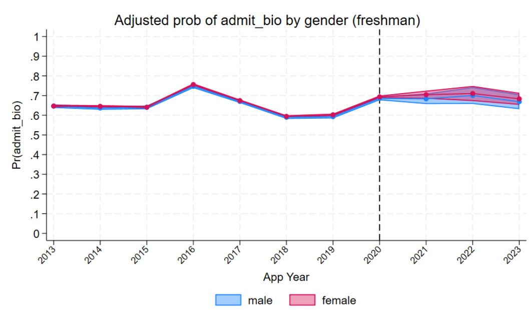
<tr><td>Biology</td><td>
</td><td>
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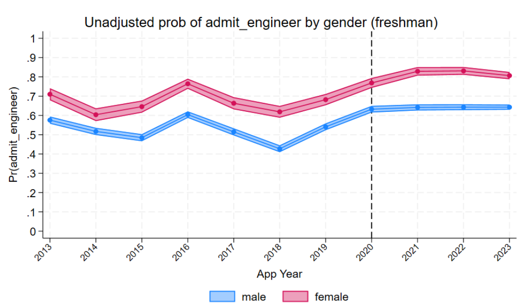
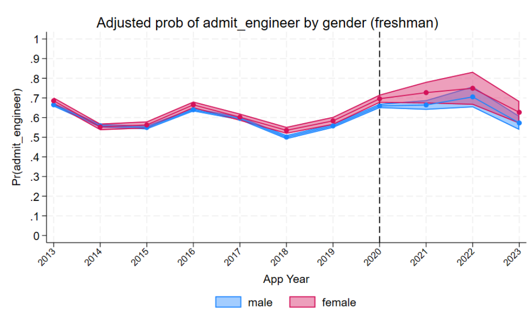
<tr><td>Engineering</td><td>
</td><td>
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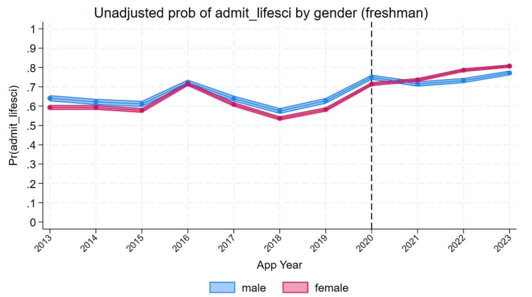

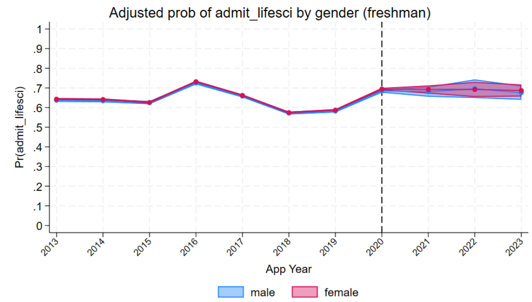

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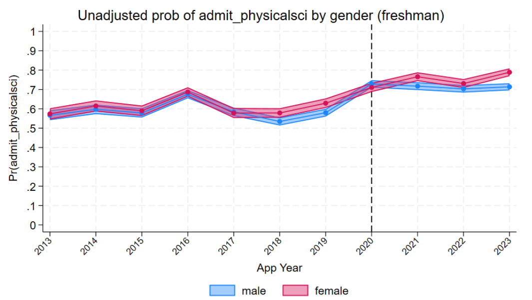

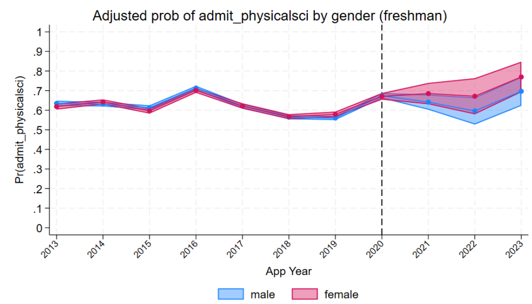

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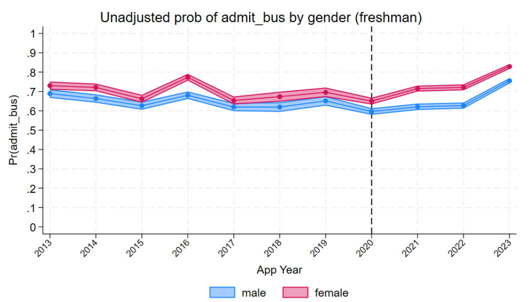

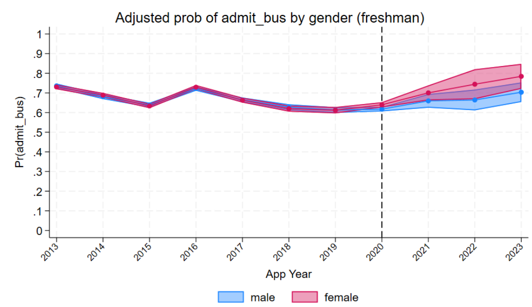

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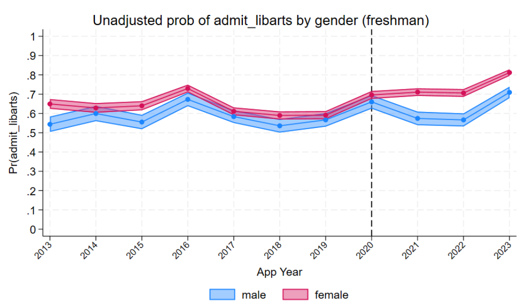

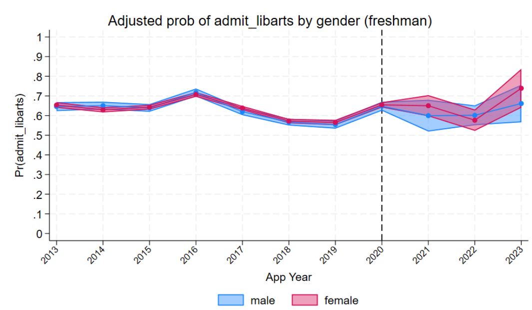

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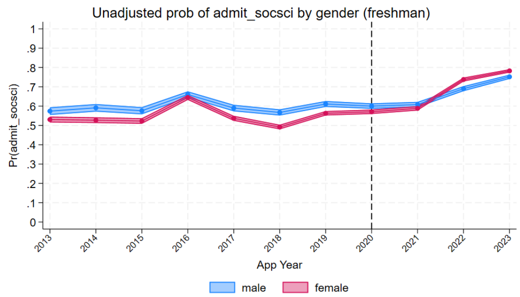
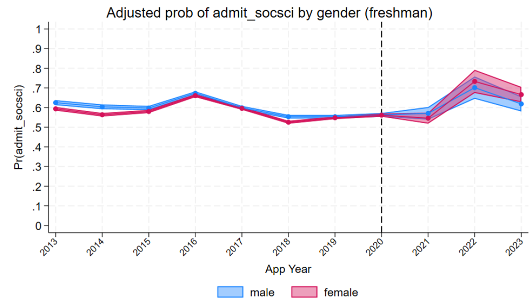
<tr><td>Social Science</td><td>
</td><td>
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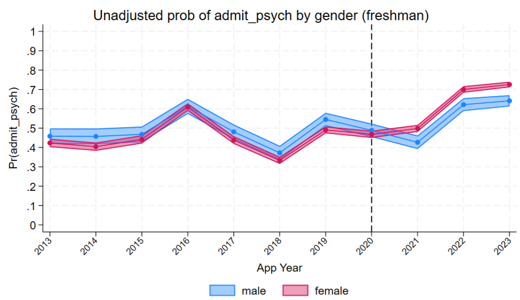
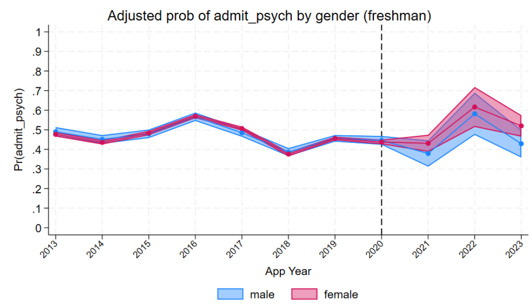
<tr><td>Psychology</td><td>
</td><td>
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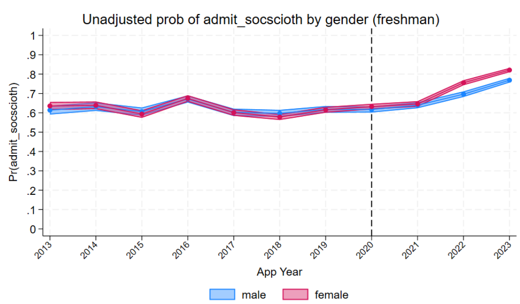
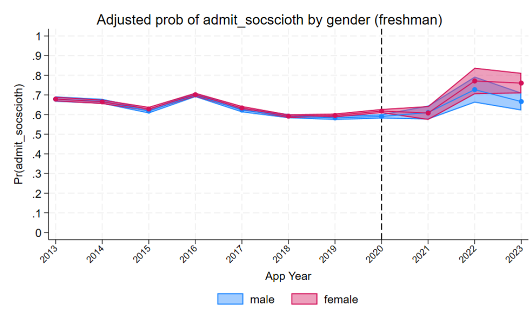
<tr><td>Social Science (exclude Psychology)</td><td>
</td><td>
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Figure 3: Predicted probability of applying to majors at institution 2

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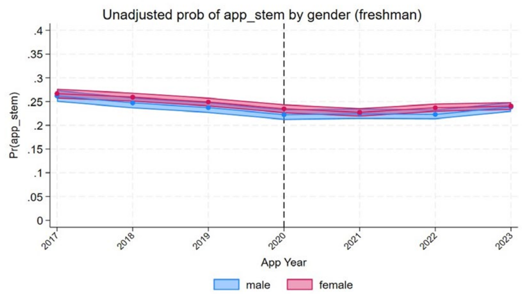
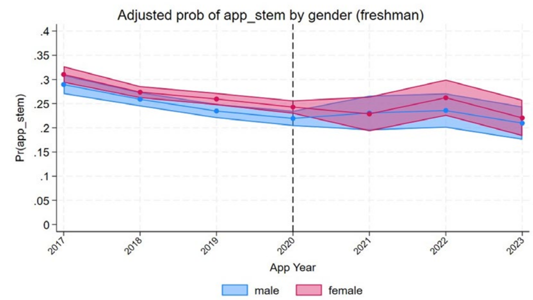
<tr><td>STEM majors</td><td>
</td><td>
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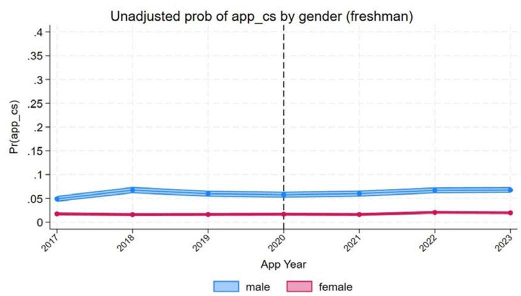
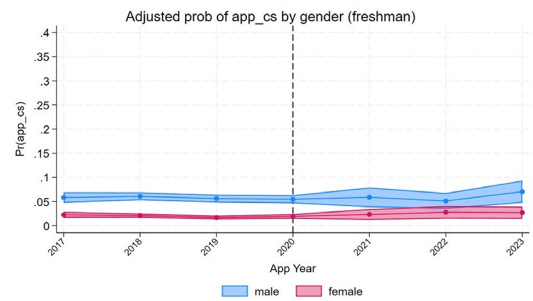
<tr><td>Computer Science</td><td>
</td><td>
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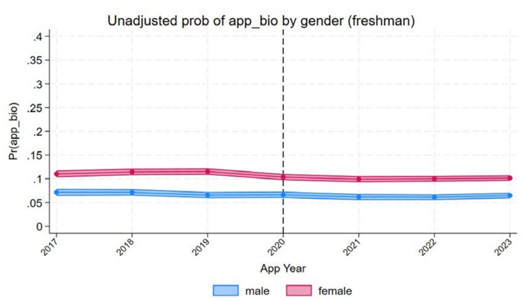
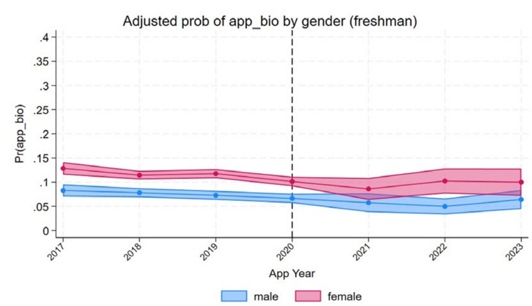
<tr><td>Biology</td><td>
</td><td>
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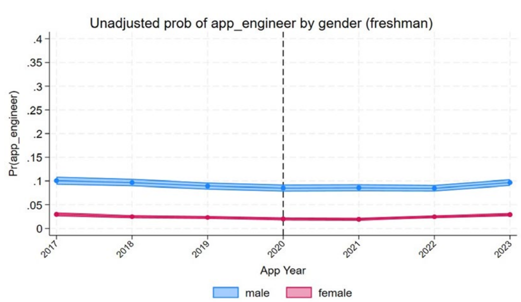
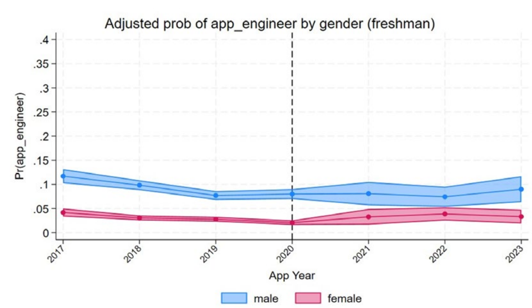
<tr><td>Engineering</td><td>
</td><td>
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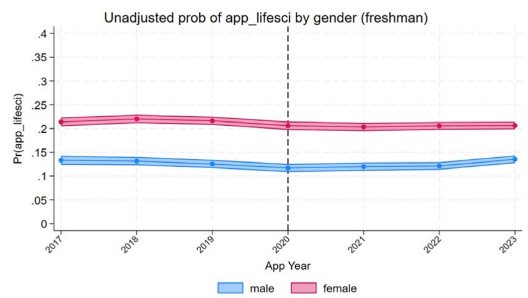
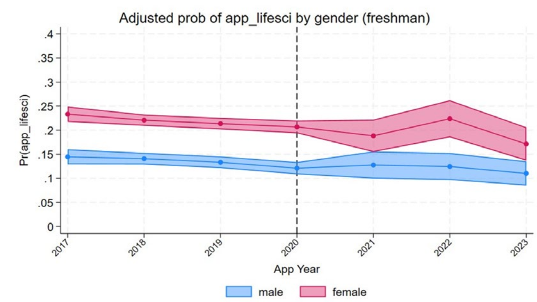
<tr><td>Life Science</td><td>
</td><td>
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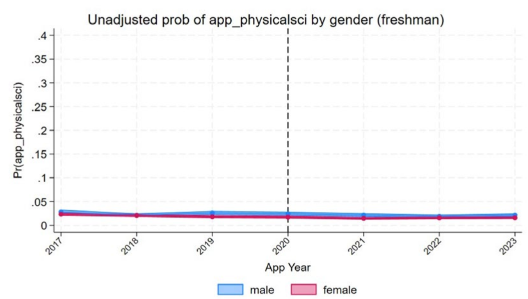
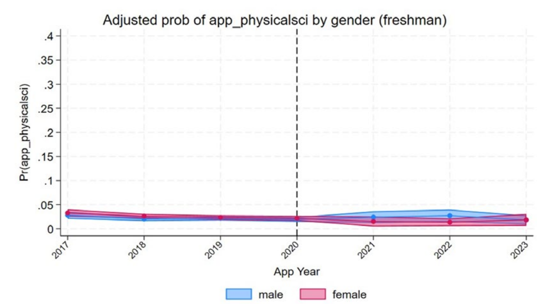
<tr><td>Physical Science</td><td>
</td><td>
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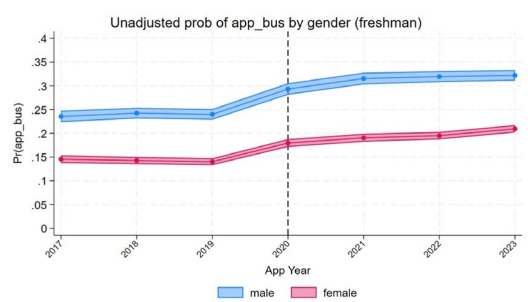
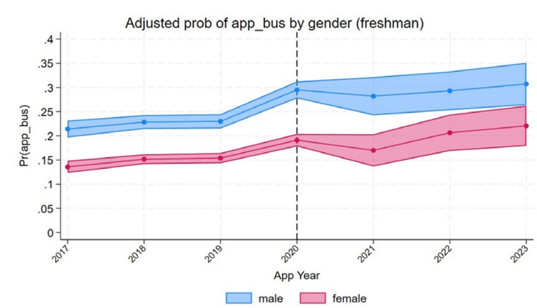
<tr><td>Business</td><td>
</td><td>
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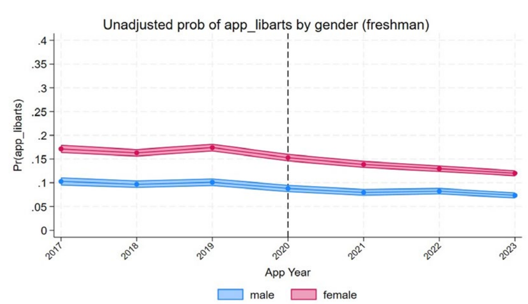
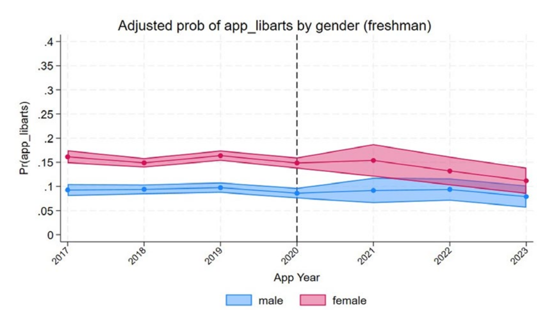
<tr><td>Liberal Arts</td><td>
</td><td>
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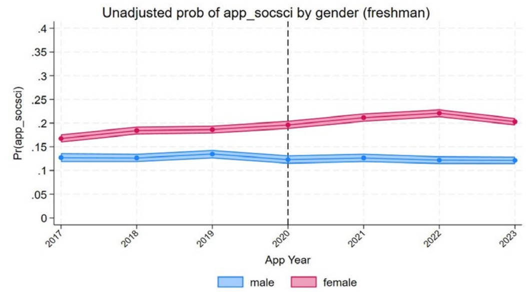
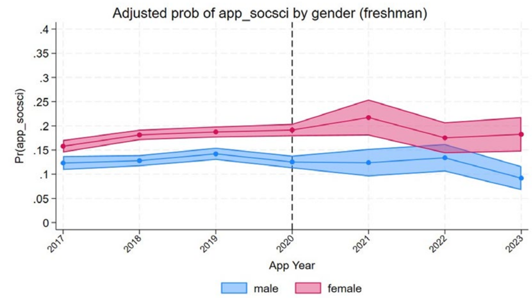
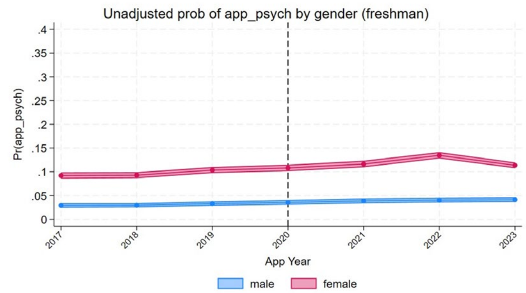
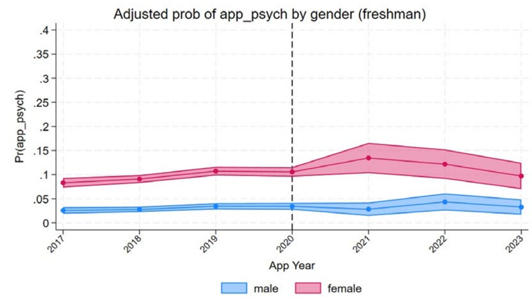
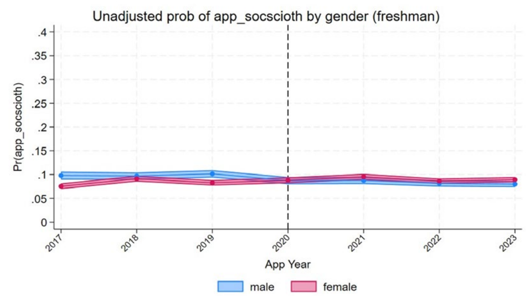
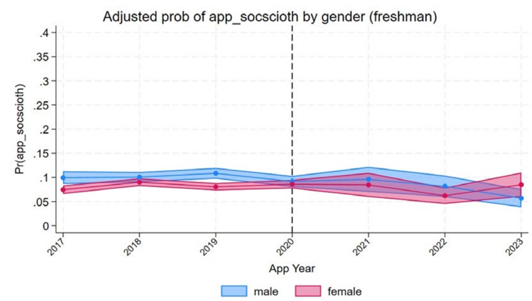
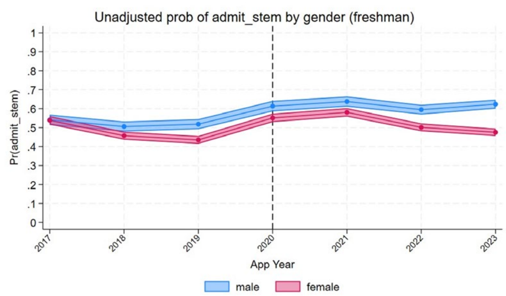
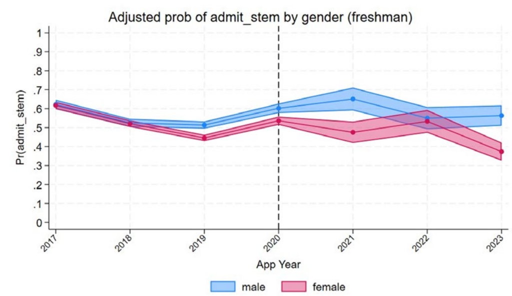
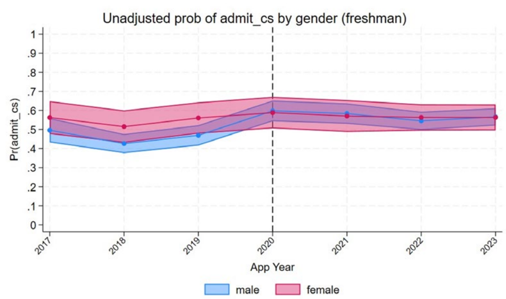
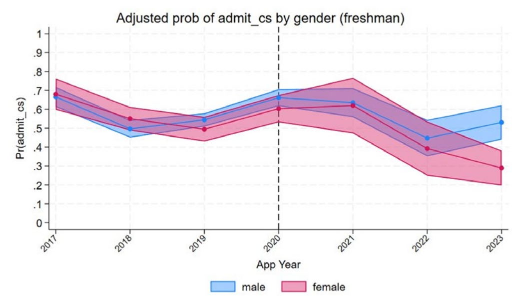
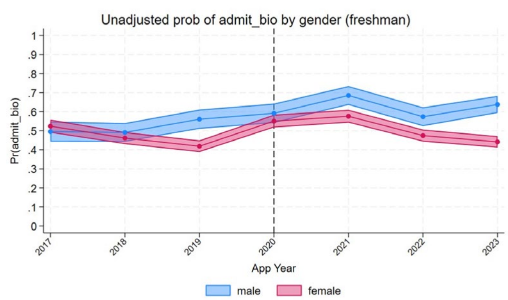
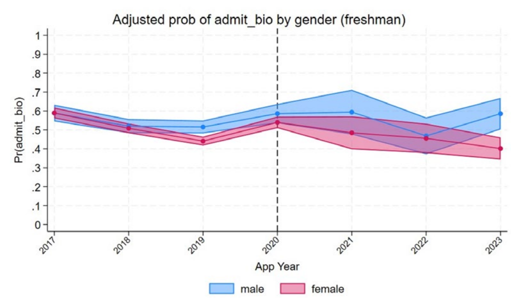
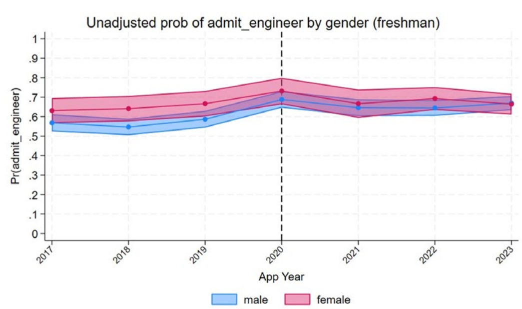
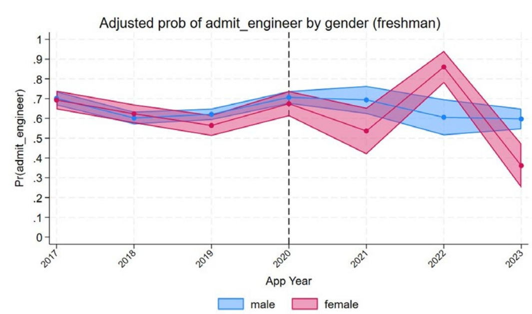
Social Science		
Psychology		
Social Science (exclude Psychology)		

Figure 4: Predicted probability of admitting to majors at institution 2

	Unadjusted	Adjusted
STEM majors		
Computer Science		
Biology		
Engineering		

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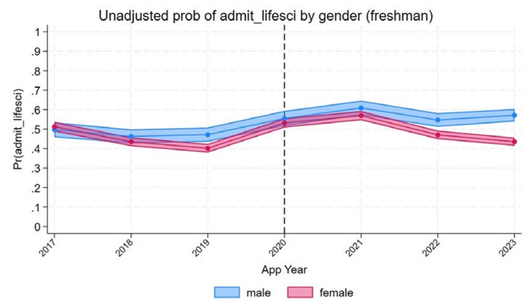

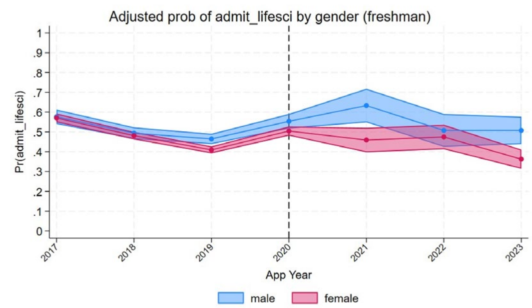

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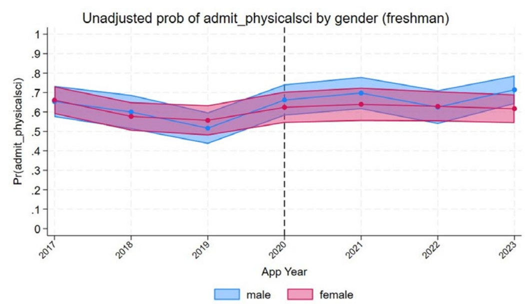

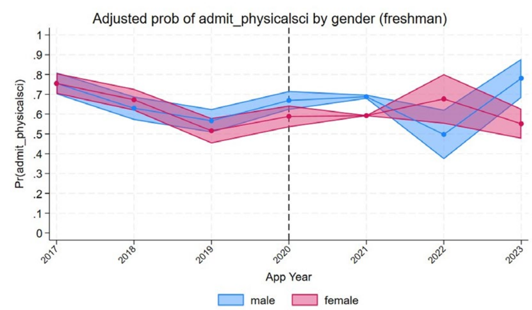

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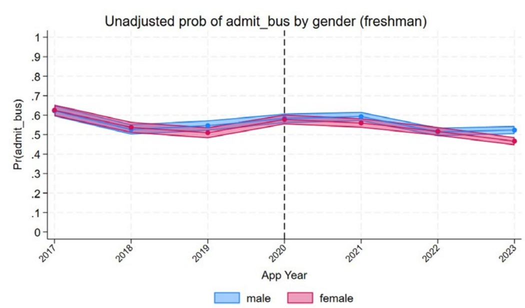

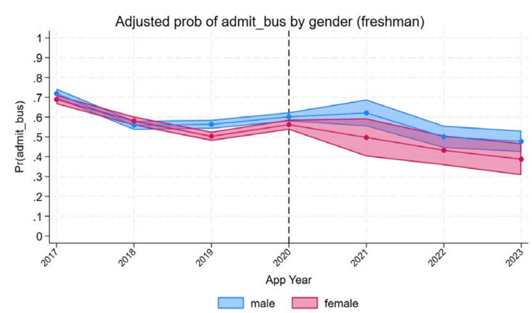

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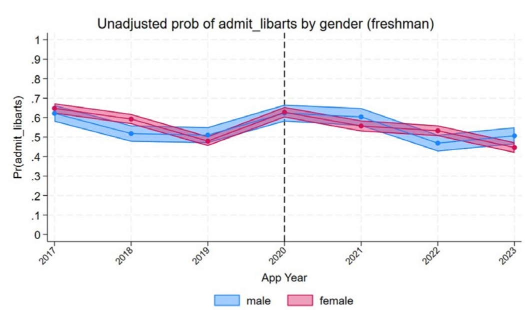

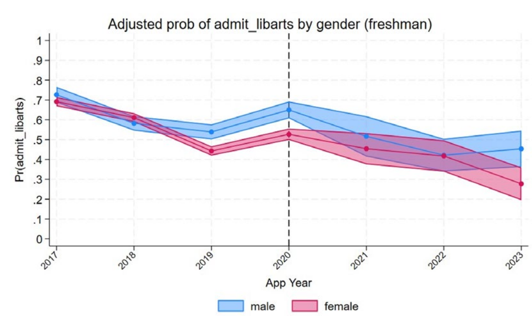

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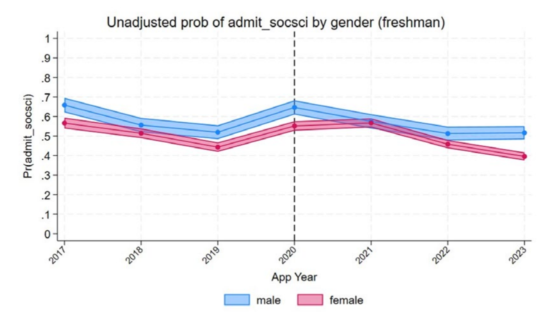
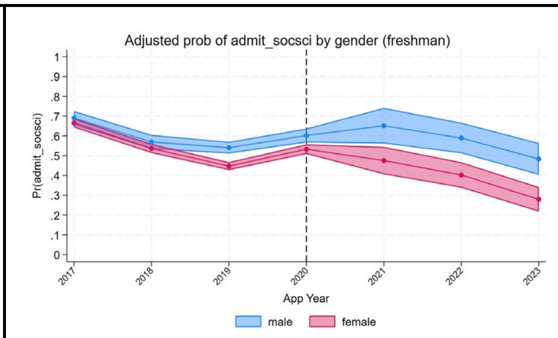
<tr><td>Social Science</td><td>
</td><td>
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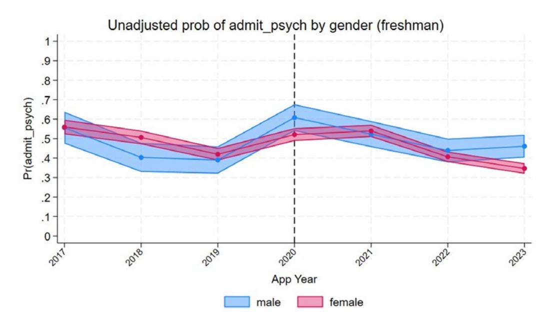
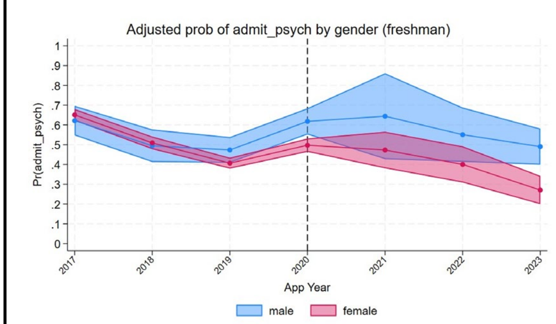
<tr><td>Psychology</td><td>
</td><td>
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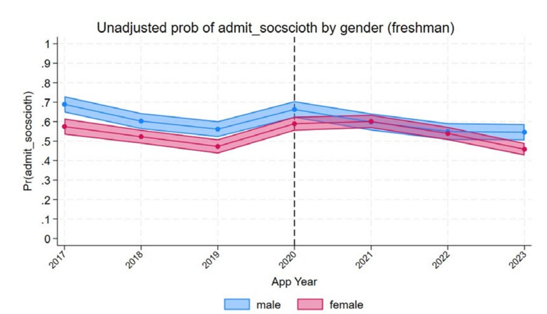
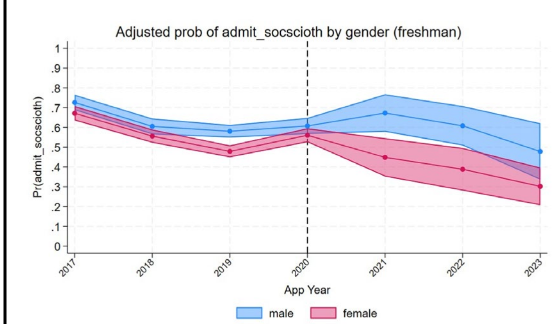
<tr><td>Social Science (exclude Psychology)</td><td>
</td><td>
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