Gender, Grade Sensitivity, and Major Choice

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Abstract

The probability of women continuing their studies in or switching out of male-dominated fields –like STEM and business– depends more on their performance in relevant courses at the beginning of their college career relative to men. The reasons why women and men react differently to grades during college, and how this behavior impacts their major choices, are not well understood yet. Using novel survey data, I estimate students' sensitivity to grades and find that women value an extra GPA point about $3,000 more than men. I find that anticipated discrimination in the labor market of male-dominated fields is important to understand this gender gap in grade sensitivity. I further provide evidence of the gender differences in beliefs about labor market discrimination in different fields, and propose a theoretical framework that formalizes the intuition about how these beliefs can lead to the gender differences in persistence observed in STEM and business majors. My results show that beliefs about gender discrimination in the labor market account for 48% of the gender gap in grade sensitivity. Understanding why talented women with the potential to succeed in male-dominated fields drop out because of less-than-stellar grades in an introductory class is important for closing the gender gap in these areas, improving the labor market outcomes of highly skilled women, and achieving an efficient allocation of resources across fields of study and occupations.

1 Introduction

It has been documented that women in STEM and other male-dominated areas like Economics are more sensitive to grades than men, in the sense that the probability of women continuing their studies in or switching out of those fields is more affected by their performance in relevant courses at the beginning of their college career (Rask and Tiefenthaler, 2008; Ost, 2010; Goldin, 2015; Kugler et al., 2021). There is significant interest from universities, governments, and policymakers around the world in closing the gender gap in these areas.[1] In order to design policies that effectively encourage the participation of women in traditionally male-dominated fields, it is crucial to identify the primary factors that explain these gender differences in behavior. However, the mechanisms driving these grade sensitivity differences are still poorly understood.

Therefore, this project studies why women and men react differently to grades during college and how this behavior impacts their decision to persist or switch out of a given major. Specifically, I quantify how much students value grades and document significant gender differences in grade sensitivity. I argue that anticipated discrimination in the labor market of male-dominated fields is important to understand why women and men react to grades differently. I provide evidence of the gender differences in beliefs about labor market discrimination in different fields and propose a theoretical framework that formalizes the intuition about how these beliefs can lead to the gender differences in persistence observed in STEM and business majors.

Understanding why talented women with the potential to succeed in male-dominated fields drop out because of less-than-stellar grades in an introductory class is important for several reasons. From a gender equality perspective and given that field of study is a key determinant of occupational choices and earnings (Gemici and Wiswall, 2014; Golan and Sanders, 2019; Patnaik et al., 2021), this could have important implications for the labor

[1] For example, in October 2021, the White House released the National Strategy on Gender Equity and Equality which "seeks to close gender gaps in STEM fields so that women and girls can shape the workforce of the future."

market outcomes of highly skilled women because jobs in male-dominated fields like STEM, Economics, and business pay higher wages than other areas (Altonji et al., 2012, 2014, 2016). Understanding these mechanisms is also important for a society interested in promoting economic growth through the most efficient possible allocation of talent and resources across fields of study and occupations since a higher rate of women dropping out of traditionally male majors is potentially consistent with a misallocation of talent and labor market inefficiencies (Hunt, 2016; Hammond et al., 2020).

First, I document the grade sensitivity patterns among undergraduate students at Arizona State University (ASU), one of the largest public universities in the United States. ASU's administrative data allows me to trace the trajectory of students as they progress through their college careers, including all field of study switches. Using a logit model, I calculate the probability that freshmen students remain in their first-year major conditional on their first-year GPA. Majors are grouped into three broad categories: STEM, Business/Economics (BEC), and Humanities/Social Sciences (SSH). I find that the gender gap (male-female) in the probability of staying in STEM and BEC majors increases as GPA decreases. However, such a relationship is not observed in other majors like SSH, where the gender gap in the probability of staying in those majors remains constant regardless of first-year GPA.

The fact that women's probability of persisting in STEM and BEC majors is more responsive to their first year GPA than men's suggests that women care more about grades than men. However, it is not clear why those gender differences in sensitivity to grades arise, and what exactly are the mechanisms through which they impact major decisions. Administrative data provide information about students' actual choices. Therefore, concerns about selection due to unobserved tastes for each major limit the ability of these data to shed light on what exactly leads to those patterns. Given this limitation, I designed an online survey to collect novel data that allow me to (1) quantify students' sensitivity for grades, and (2) investigate how gender differences in grade sensitivity impact students' decision to persist or switch out of a given major. Around 2,000 ASU students participated in the study.

To quantify the gender differences in grade sensitivity, I adapt the hypothetical scenarios methodology in Wiswall and Zafar (2018) to the major choice context. With this approach, I collect data on students' preferences for different attributes that characterize majors: average GPA at graduation, average weekly study time, and average earnings at a full-time job after graduation. The survey includes 10 different individual-specific hypothetical scenarios. In each scenario, participants report the probability that they would choose each of the three majors (SSH, BEC, STEM) given the attributes in that scenario. This design generates a panel of probability choices, which allows me to estimate preferences at the individual level.

I find that on average, students have preferences reflecting a distaste for study time, and a taste for a higher GPA at graduation. Based on the estimated preferences for average GPA at graduation, I calculate a willingness-to-pay (WTP) measure. This WTP measure is interpreted as the amount of annual earnings a participant is willing to forego for a one-point increase in the average GPA at graduation in a given major. I find that on average, students are willing to pay 16% ($8,309) of annual earnings for an extra average GPA point at graduation. Conditional on background characteristics, I find that women are willing to pay $3,057 more of the annual earnings relative to men. I interpret this difference as the gender gap in grade sensitivity. Moreover, stratifying the sample by students' reported major of enrollment suggests that the gender gap is concentrated among STEM/BEC students, for whom the gender difference in WTP for a GPA increase reaches $3,760. This result is consistent with the results from the administrative data: women in STEM and BEC majors are more sensitive to grades than men, but this gap is not observed in other majors.

These results are also consistent with previous literature. For example, in Ahn et al. (2022), the authors estimate model of course choices and grading policies, and find that women value grades more than men. Kaganovich et al. (2021) finds that the effect of grade sensitivity on major persistence is stronger for women than men in STEM but there is no difference in other academic disciplines like business, social sciences, humanities, and education. Ost (2010) finds that women majoring in physical sciences are also more responsive to grades than men: a one point increase in GPA in physical sciences courses increases the probability of persistence in the major by 13.4% for women and only 10.7% for men. In Kugler et al. (2021), the authors conclude that women are more likely to switch out of male-dominated STEM majors if they have a low GPA. Goldin (2015) documents that women that receive grades lower than B in their introductory economics courses are less likely to graduate with an economics major than similarly-achieving men. Using data from a highly selective liberal arts college, Rask and Tiefenthaler (2008) shows that when deciding whether to take one more economics course, women are significantly more responsive to the grades they received in previous economics classes than men, especially women in the bottom half of the grade distribution.

Many potential mechanisms could explain the gender differences in sensitivity for grades that I document. For example, gender differences in risk aversion (Paola and Gioia, 2012), willingness to compete (Buser et al., 2014), self-confidence (Ellis et al., 2016; Moakler and Kim, 2014), and beliefs about what it takes to graduate from a male-dominated major (Owen, 2020). I collect information about some of these hypotheses. However, a much less explored possibility and the primary focus of this paper is anticipated gender discrimination in the labor market (Steele et al., 2002; Alston, 2019).

There is evidence that women face gender discrimination in the labor market, especially in the form of different or more rigorous standards than men in terms of hiring and promotion decisions. In a lab experiment, Foschi et al. (1994) finds that men exhibit a double standard in their hiring decisions for engineering positions. When the male candidate has a better performance than the female one, the male candidate was chosen more and was considered more competent and suitable for the job. However, the same was not true when the candidate with the best performance was a female. In Goldin and Rouse (2000), the authors provide evidence of sex-biased hiring in symphony orchestras against women, since a blind audition that conceals the candidate's identity (and gender) increases the probability of women being hired. Quintero (2008) finds that during the recruitment process for government jobs in

Spain, women are treated worse than men even when there is no evidence of lack of ability, and men are subject to a more lenient standard. In Funk and Parker (2018), the authors conduct a nationally representative survey of U.S. adults and find that 50% of the women that work in STEM jobs report having experienced gender discrimination at work.[2] Among the participants that say their gender has made it harder to succeed in their job, 14% say it is because they are held to different standards. In a survey of female scientists, Williams et al. (2014) finds that 64% of the participants believe they needed to provide more evidence of competence than others to prove themselves to their colleagues.

Given this evidence, it is possible that female students anticipate facing gender discrimination in the labor market, particularly in male-dominated fields like STEM and business. I develop a theoretical framework to formalize the intuition behind how these beliefs can lead to gender differences in grade sensitivity and major choices. In the model, students choose between a humanities and a science major but can switch out of it after receiving new information about their ability in the form of grades. I allow the utility of each major to depend on the probability of finding a job. Students believe that employers make their hiring decisions as in the model of labor market discrimination in Coate and Loury (1993), where if employers discriminate against women they set higher or more rigorous standards to hire them. This means that women believe they have lower chances of getting a job in that field. By allowing major choices to be affected in this way by discrimination, and assuming women believe they are discriminated against in the science field, women and men that receive the same grades make different decisions about staying or leaving the major. Women are more likely to leave the science major than men that get the same grades because they believe they will be treated differently in the labor market given their gender.

In the survey, I collect data about perceived gender discrimination in each field and beliefs about the standards faced in the labor market to get a job. For each major, I ask participants how likely they think it will be that finding a job in that field would be harder because of

[2] The figure is 78% for majority-male workplaces.

their gender, and how likely it would be that their boss or peers would treat them differently because of their gender. Using their responses, I create an anticipated gender discrimination index for each major. I find that men believe that they are less likely to experience gender discrimination in the labor market than women. Additionally, women believe they are more likely to face gender discrimination in the STEM/BEC labor market than in SSH.

In terms of labor market standards, I ask participants their beliefs about the minimum GPA required to secure a full-time job in each major. On average, participants believe that the standards are lower in the SSH field. Although women anticipate higher standards than men in all fields, they expect to face higher standards in terms of GPA in STEM and BEC majors than in SSH. There is a positive relationship between these beliefs about labor market standards and the beliefs about the likelihood of experiencing gender discrimination in the labor market, particularly for women.

When studying the gender gap in WTP for GPA, I find that the beliefs about GPA standards and anticipated gender discrimination reduce the gap by 48%, making it no longer statistically significant. This means that when comparing men and women that expect to face the same level of gender discrimination and GPA standards in the labor market, on average there is no statistical difference in how much they value grades. In fact, according to an Oaxaca-Blinder decomposition, these beliefs explain 55% of the gender gap in WTP for GPA. These results imply that to understand why women and men value grades differently, especially in STEM and BEC majors, it is important to consider beliefs about labor market standards and gender discrimination.

I do not claim that these beliefs are the only mechanism driving the gender differences in grade sensitivity. However, there are several reasons why anticipated discrimination is an important mechanism worth investigating. First, there is a considerable amount of work about gender discrimination in the labor market, but much less on anticipated discrimination or its relation with major choices. For example, in economics, Alston (2019) is one of the first papers to study anticipated discrimination as a reason that could explain why women are underrepresented in certain occupations. In the psychology literature, Steele et al. (2002) documents that female undergraduate students in mathematics, science, and engineering majors anticipate encountering more discrimination in their careers than women in the arts, humanities, and social sciences. Therefore, my results contribute to improving our knowledge about the effects of gender discrimination in different aspects of life. Second, some of the other explanations for the gender differences in grade sensitivity rest on inherent differences between women and men like risk aversion, self-confidence or willingness to compete. However, it is important to investigate mechanisms that instead rest on beliefs about the labor market, like anticipated gender discrimination, because evidence in favor of them suggests very different policy implications.

I also collect data about self-confidence and beliefs about grades in different fields as potential explanations for why women and men value grades differently. However, they are not able to explain as much of the variation in WTP for GPA as anticipated discrimination.

The rest of the paper is organized as follows. Section 2 describes the administrative data and documents gender gaps in grade sensitivity among ASU students. Section 3 introduces the survey and describes the sample. Section 4 presents the hypothetical scenarios from the survey and section 5 explains how to use that data to estimate preferences and WTP for GPA measures. In section 6, I focus on anticipated discrimination as a potential mechanism that could explain the gender differences in WTP documented in the previous section, and in section 7, I analyze the role of other mechanisms. Finally, section 8 concludes.

2 Women are more sensitive to grades

In this section, I use anonymized transcript-level data for 180,000 first-time freshmen at Arizona State University (ASU), one of the largest public universities in the United States, to provide suggestive evidence that women are more sensitive to grades in STEM and Business majors.

The administrative data set goes back to the year 2000 and traces the trajectory of students as they progress through their college careers, including all fields of study switches. Majors are grouped into three broad categories: STEM, Business/Economics (BEC), and Humanities/Social Sciences (SSH).[3] I refer to these categories simply as majors.

The probability that freshmen remain in their first-year major conditional on their first-year GPA is calculated from the logit estimation of model (1) for each major separately.

$$\mathbb{1}(\text{Stay})_{ikt} = \delta_0 + \delta_1 Female_i + \delta_2 GPA_{ik} + \delta_3 GPA_{i-k} + \mathbf{M}_i + \mathbf{N}_i + \gamma_t + \epsilon_{ik} \quad (1)$$

where $k \in \{\text{SSH, BEC, STEM}\}$, $\mathbb{1}(\text{Stay})_{ikt}$ is an indicator variable equal to one when student i from cohort t registered in major k during their freshman year remains in major k during their sophomore year. $Female_i$ is equal to one when student i is female. GPA_{ik} represents cumulative GPA for student i at the end of their freshman year in major k, and GPA_{i-k} is a vector that contains the cumulative GPA in the other majors besides k. To create GPA_{ik} and GPA_{i-k}, all courses were classified into one of the three major categories (SSH, BEC, STEM) and the respective GPA was calculated using only the courses that correspond to that major. $\mathbf{M}_i$ is a set of academic controls: ACT/SAT test scores, high school GPA, and indicators for honors and exploratory students.[4] $\mathbf{N}_i$ includes controls for minority, income, in-state student, and first-generation status. Finally, γ_t represents cohort fixed effects.

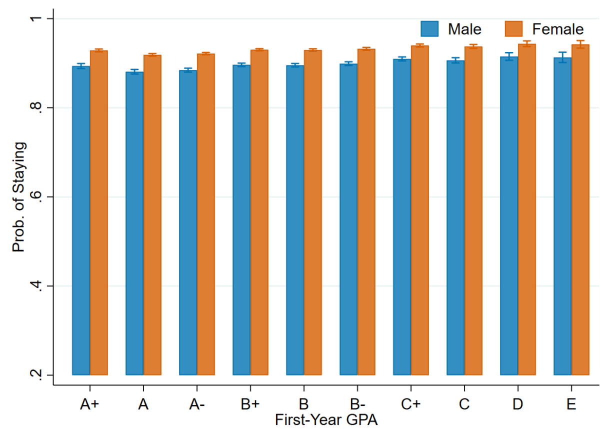
The results from this exercise are summarized in Figure 1. The bars represent the probability of staying in the major indicated at the top of each panel given the first-year GPA level on the horizontal axis. In panels (1b) and (1c), the probability of staying in STEM and BEC majors decreases as the GPA decreases, which means that students are more likely to switch out of these majors when they have low grades. Additionally, this pattern is sharper for

[3]The SSH category includes any majors that could not be classified as STEM or Business/Economics.

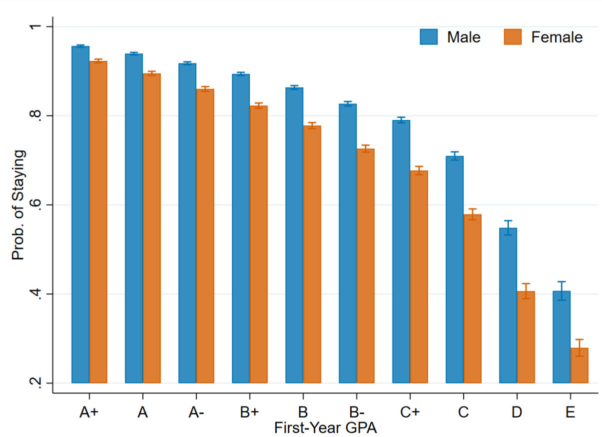
[4]The exploratory indicator identifies students that did not declare a major in their freshman year. However, exploratory students are enrolled in special programs that allow them to explore several majors within an area, which facilitates their classification in one of the three broad categories. The most common exploratory programs are health and life sciences; humanities, fine arts and design; mathematics, technology, engineering, and physics; and social and behavioral sciences.

Figure 1: Probability of Persisting in a Major by First Year GPA

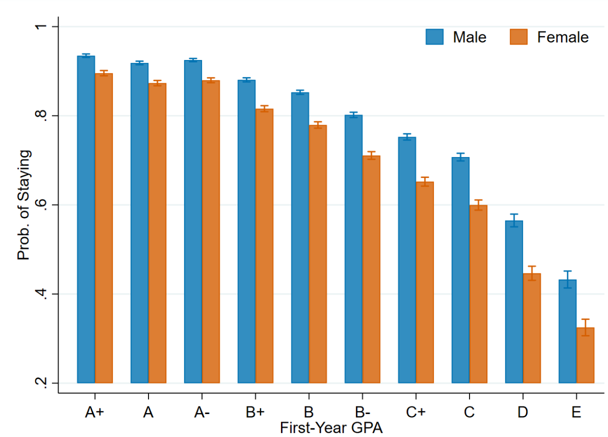
(a) SSH



(b) STEM



(c) BEC



Notes: Bars represent the probability of staying in the major indicated at the top of each panel given the first-year GPA level on the horizontal axis, estimated from a logit model that regresses an indicator for staying in the same major as in the first year on a female indicator, the GPA in that major, and the GPA in the other majors. All regressions control for minority status, family income, first generation, in-state, honors and exploratory status, ACT/SAT, high school GPA, and cohort FE. Spikes represent 95% CI.

women than for men, which illustrates the fact that women are more responsive to grades in these majors than men.[5] However, such a gender difference is not observed in SSH in panel (1a), where the gender gap in the probability of staying in that major remains constant regardless of first-year GPA.

These results are consistent with previous literature on grade sensitivity (Rask and Tiefenthaler, 2008; Ost, 2010; Goldin, 2015; Kugler et al., 2021; Kaganovich et al., 2021), and suggest that women care about grades more than men, particularly in STEM/BEC majors. However, due to selection concerns and confounders like tastes for different majors, observational data alone have a limited ability to shed light on what exactly leads to these patterns. For that reason, I designed a survey to collect data that allow me to quantify student's sensitivity to grades, and understand better why women and men could value grades differently and how those differences impact their decision to persist or switch out of a given major. I describe the survey in the next section. Given the similar patterns for STEM and BEC in Figure 1, for most of the analysis these two categories will be pooled into one.

3 Survey Data

3.1 Survey

The data come from an original online survey of undergraduate students at ASU. Students were directly invited to participate via email. Additionally, the study was advertised on the My ASU website, accessible only through the student's ASU ID and password. Students were invited to participate in a study about how they chose their major and the relationship between study time and grades, for which they would enter a lottery for one of 350 $20 eGift Cards. Data collection started on April 5th, 2021 and lasted for about two weeks.

The survey was programmed in Qualtrics. It also collected data on students' demo-

[5]The difference between the blue and orange bars is statistically different from zero at 1% for all GPA levels.

graphics, family background, major, academic performance, and study time. The survey instrument can be found here.

3.2 Sample

A total of 2,036 respondents completed the survey. 3% of participants that identify as non-binary or decided not to disclose their gender were excluded from the analysis. Additionally, responses in the 1st and 99th percentile of survey duration were excluded, leading to a final sample size of 1,936. The median completion time was 23 minutes (43 minutes on average).

Women comprise 64% of the sample. Although they are over-represented in the survey sample relative to ASU's student population (51% female), there is no differential selection on observables across genders (see Table 1).

For the survey, majors were grouped into the same three broad categories: STEM, Business/Economics (BEC), and Humanities/Social Sciences (SSH).[6] I refer to these categories simply as majors. The last three rows in Table 1 show the proportion of women and men in each major. The sample includes fewer men in BEC and fewer students in SSH than in ASU's student population. However, the gender gap in STEM is the same in the survey sample and the ASU student body (20% gap).

4 Hypothetical Scenarios

To quantify gender differences in grade sensitivity, I collected data on students' preferences for different major attributes by adapting the methodology described in Wiswall and Zafar (2018) for job attributes. Specifically, the survey included a hypothetical scenarios module that presented students with 10 different scenarios. In each scenario, majors were characterized by three attributes: average GPA at graduation, average weekly study time,

[6] The SSH category includes any majors that could not be classified as STEM or BEC.

Table 1: Sample Compared to ASU Population

	Survey			ASU			P-value[c]
	Female	Male	Diff.	Female	Male	Diff.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Black	0.05	0.03	0.02	0.04	0.03	0.01	0.134
White	0.66	0.70	-0.04	0.46	0.48	-0.02	0.498
Hispanic	0.23	0.18	0.05	0.29	0.23	0.07	0.284
First Generation[a]	0.29	0.23	0.06	0.31	0.23	0.08	0.263
Family Income[b]	102	109	-7.1	126	151	-26	0.181
Freshman	0.22	0.20	0.02	0.26	0.25	0.01	0.776
Sophomore	0.24	0.23	0.00	0.26	0.25	0.01	0.853
Junior	0.30	0.30	0.01	0.22	0.22	0.00	0.806
Senior	0.24	0.27	-0.03	0.26	0.28	-0.02	0.742
ACT	27.71	28.56	-0.85	23.98	25.62	-1.64	0.003
STEM	0.38	0.58	-0.20	0.25	0.46	-0.20	0.689
BEC	0.18	0.21	-0.03	0.18	0.27	-0.10	0.000
SSH	0.44	0.22	0.22	0.57	0.27	0.30	0.001
Sample Size	1,236	700		22,755	21,637		0.000[d]

Notes: ASU data includes everyone taking at least one class for credit during the Spring semester of 2021 and attending ASU as their first full-time university. Income and first generation variables for the ASU data are constructed with the first year of available data, which it is not the freshman year all the sample.
[a] Students with no parent with a college degree.
[b] Family income in thousands of dollars.
[c] P-value for whether the gender differences in the survey sample and the ASU population are different.
[d] P-value for the difference in females proportion between the survey sample and ASU population.

and average earnings at a full-time job after graduation. Scenarios appeared one at a time. Table 2 is an example of how each scenario was presented to the participants.

Table 2: Scenario Example

	Av. GPA	**Av. Study Hours per week**	**Av. Earnings after Grad. (full-time job)**
SSH	3.47	8.0	\$24,000
BEC	2.23	7.0	\$49,000
STEM	2.00	22.0	\$46,000

Scenarios are individual-specific to guarantee that each situation presented the student with attributes for each major that are realistic given the student's beliefs. Concretely, each scenario is a perturbation of the student's beliefs about the average GPA at graduation, study time, and full-time earnings for each major.

Table 3 reports the mean and standard deviation of participants' beliefs about each of the attributes for each major. Participants believe that SSH has the highest average GPA and STEM the lowest, with STEM also having the highest variance in terms of grades. Beliefs about BEC in terms of grades are similar to STEM. Regarding weekly study time, participants believe that on average students enrolled in SSH and BEC study slightly less than 14 hours per week. On the other hand, on average, the belief is that students in STEM study 22 hours per week. In terms of annual earnings, participants believe that average earnings are higher in STEM, at around \$66,000, followed by BEC at \$54,500 and then SSH (\$41,000).

In each scenario, students reported the probability that they would choose each of the three majors given the characteristics.[7] Participants were asked to report probabilities because the scenarios they were facing were not fully specified. Majors can be characterized by more than the three attributes included in the survey. Therefore, participants are allowed

[7] See the survey instrument here for exact wording.

Table 3: Beliefs about Major Attributes

	Av. GPA		Av. Study Time		Av. Earnings	
	Mean	SD	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)
SSH	3.44	0.28	13.91	8.04	41.02	11.95
BEC	3.34	0.32	13.75	8.08	54.50	16.69
STEM	3.31	0.34	22.18	10.14	65.63	21.02

Notes: Earnings in thousands of dollars.

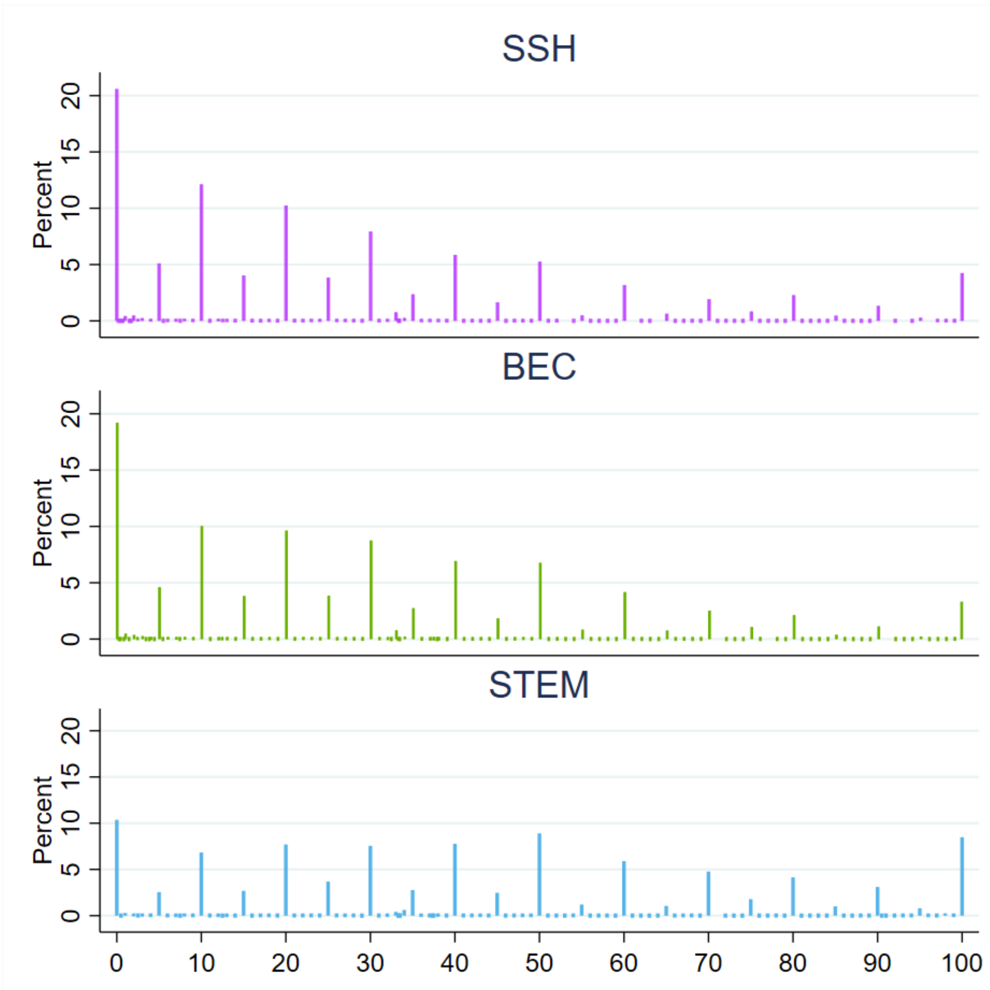
to express their uncertainty about what they would choose given the incompleteness of the scenarios. Figure 2 shows the histogram of elicited choice probabilities for each major pooled across the ten hypothetical scenarios. As is common for probabilistic belief data (Manski, 2004), responses tend to be multiples of 5 and 10, which likely reflects minor rounding bias.[8] Figure 2 also shows that responses covered the whole support and not only values like 0, 50, or 100, which would reflect a problem with gross rounding (Manski, 2004). Additionally, 86% of the participants reported interior probabilities (not 0 or 100) in all their responses, which underscores the importance of allowing participants to express uncertainty in their choices.[9]

This design generates a panel of probability choices at the individual level, with 30 observations per participant, which allows me to estimate the distribution of preferences without any distributional assumptions. The next section describes the estimation procedure, and how the estimated preferences are used to calculate a measure of willingness-to-pay (WTP).

[8]Section 5 explains how the rounding bias is handled.

[9]Only 3% reported that they would choose one of the majors with 100% probability in all scenarios.

Figure 2: Choice Probabilities by Major



Notes: Histograms of choice probabilities for each major pooled across all scenarios.

5 Preferences for Major Attributes

Similar to Wiswall and Zafar (2018), I use a simple model of expected utility of major choices that provides a framework to recover quantitative measures of WTP for the different major attributes. In particular, the model intends to recover how the utility of choosing a given major varies with GPA.

Let U_{ij} denote the utility that student i gets from major j. This utility is given by

$$U_{ij} = X'_{ij}\beta_i + \kappa_{ij} + \epsilon_{ij} \tag{2}$$

where X_{ij} is a vector that contains the attributes of the major: average GPA, average weekly study time, and the natural logarithm of the average earnings. κ_{ij} is a major-specific constant that captures tastes for the major.[10] Finally, since the scenarios in the survey are not fully specified, ϵ_{ij} represents students' uncertainty about other attributes of the major.

The key identifying assumption is that, conditional on major, $\{\epsilon_{ij}\}_{j=1}^{J}$ represents idiosyncratic variation which is orthogonal to the major attributes included in $\{X_{ij}\}_{j=1}^{J}$. Additionally, as it is common to assume in choice models, $\{\epsilon_{ij}\}_{j=1}^{J}$ is i.i.d Type I extreme value. Therefore, the probability that student i chooses major j is given by:

$$p_{ij} = \frac{exp(X'_{ij}\beta_i + \kappa_{ij})}{\sum_{j'=1}^{J} exp(X'_{ij'}\beta_i + \kappa_{ij'})} \tag{3}$$

Applying the log-odds transformation to equation (3) results in the linear model in (4).

$$ln\left(\frac{p_{ij}}{p_{ij'}}\right) = (X_{ij} - X_{ij'})'\beta_i + (\kappa_{ij} - \kappa_{ij'}) \tag{4}$$

As is common in the literature (Blass et al., 2010; Wiswall and Zafar, 2018), I introduce measurement error to the model in (4) to account for the possibility of the minor rounding

[10] For estimation purposes the constant for SSH major is normalized to zero, therefore the tastes for other majors are relative to SSH.

bias mentioned earlier. The assumption is that measurement error takes a linear-in-logs form, therefore the reported log-odds ratio is

$$ln\left(\frac{\tilde{p}_{ij}}{\tilde{p}_{ij'}}\right) = (X_{ij} - X_{ij'})'\beta_i + (\kappa_{ij} - \kappa_{ij'}) + \omega_{ij} \tag{5}$$

where $\tilde{p}_{ij}$ is the reported choice probability that measures the true probability, p_{ij}, with measurement error ω_{ij}. Additionally, the measurement error has a median of zero conditional on X.

Therefore, (5) is estimated using the Least Absolute Deviations (LAD) estimator. Since the left-hand side variable in (5) is the logarithm of the ratio of probability choices, extreme answers like 0 or 100 must be changed such that the natural logarithm is always defined. The LAD estimator has the advantage of not being sensitive to the values used to replace these extreme probabilities.[11] Variation in major attributes and variation in participant's choice probabilities across the 30 observations per respondent allows identifying the vector β_i for each student i separately. This allows for a non-parametric characterization of the preferences distribution.

5.1 Estimates of Preferences for Major Attributes

Table 4 reports the β_i estimates from equation (5), bootstrapped standard errors are reported in parentheses.[12] The first column shows the average estimate for each attribute and tastes across all individual-level estimates. Columns 2 and 3 report the average estimates by gender.

The average estimates have the expected signs: estimates for GPA at graduation and log of earnings are positive, while the estimates for study time are negative. This means that, on average, students prefer majors that pay higher earnings after graduation and have

[11] Probabilities of 0 were replaced with 0.001 and 100 with 99.9.

[12] Sample size is smaller because seniors are not included in the analysis of the hypothetical scenarios data since they are closer to graduation and their preferences for major attributes might be different than those of less senior students. However, all results are qualitatively the same if seniors are included.

on average higher GPA, but lower weekly study time. By gender, the estimates for major attributes present the same qualitative patterns as the average estimates. Additionally, all attributes are statistically different from zero. In terms of tastes, on average, students prefer BEC and STEM majors less than SSH majors (the estimates are relative to SSH), although among men the average BEC and STEM taste estimates are not statistically different from zero.

Table 4: Estimates of Preferences for Major Attributes

	Overall	Female	Male
	(1)	(2)	(3)
GPA at Grad.	0.650***	0.689***	0.574***
	(0.064)	(0.079)	(0.118)
Study time (h/week)	-0.070***	-0.060***	-0.090***
	(0.007)	(0.009)	(0.014)
Log earnings	4.569***	4.058***	5.558***
	(0.154)	(0.182)	(0.291)
Taste for BEC	-0.430***	-0.557***	-0.184
	(0.085)	(0.105)	(0.143)
Taste for STEM	-0.078	-0.244**	0.244
	(0.096)	(0.113)	(0.175)
N	1,192	786	406

Notes: Table reports the average of the coefficientes across the relevant sample. Tastes for BEC and STEM are relative to SSH. Asterisks denote estimates that are statistically different from zero based on bootstrapped standard errors. *Significant at 10%, **5%, ***1%

Given the difficulty of interpreting the magnitudes in these estimates, the next subsection converts the estimates to a willingness-to-pay (WTP) measure in order to quantify the gender gap in grade sensitivity in an easily interpretable way.

5.2 Willingness-To-Pay Measures

In this section, I calculate WTP measures based on the estimated preferences. These estimates translate the differences in utility due to different amounts of a given attribute into the earnings that would make the student indifferent between the two attribute levels.

The thought experiment to compute the WTP is as follows: consider a change in the level of attribute X_k from $X_k = x_k$ to $X_k = x_k + \Delta$ with $\Delta > 0$. Given the linear utility function, it is possible to write the following indifference condition in terms of earnings Y:

$$x_k\beta_{ik} + \beta_{i1}ln\left(Y\right) = \beta_{ik}\left(x_k + \Delta\right) + \beta_{i1}ln\left(Y + WTP_{ik}\left(\Delta\right)\right) \tag{6}$$

Solving (6) for WTP gives the following expression:

$$WTP_{ik}\left(\Delta\right) = \left[exp\left(\frac{-\beta_{ik}}{\beta_{i1}}\Delta\right) - 1\right] \times Y, \tag{7}$$

which is individual i's willingness to pay for a Δ increase in attribute k. Equation (7) depends on the ratio of the student preferences for attribute k, β_{ik}, and preferences for earnings, β_{i1}. Additionally, given the log form in the utility for earnings, the WTP measure depends on the level of earnings Y. For the calculations, Y is the average earnings across all participants across all scenarios ($53,318). The objective of having the same level for all respondents is that any gender differences in WTP discussed later will reflect only differences in preferences, not differences in earnings.

Table 5 shows the average and median WTP measures for one extra unit of the attribute. That is one whole GPA point at graduation (from 2.3 to 3.3 for example) and one extra hour of study time per week. All means and medians reported in Table 5 are statistically different from zero (p-value<0.01). Columns (1)-(3) present the WTP measures in dollars and the last three columns display the WTP as a percentage of average earnings. The stars in the male columns (3) and (6) represent the significance level from a difference in means (or medians)

Table 5: WTP Estimates

	WTP ($)			WTP (as % of average earnings)		
	Overall	Female	Male	Overall	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
GPA at Grad.	8,309	9,089	6,799*	15.58	17.05	12.75*
	(652)	(811)	(1,126)	(1.22)	(1.52)	(2.11)
	[6,608]	[7,790]	[4,882]**	[12.39]	[14.61]	[9.16]**
Study time (h/week)	-1,479	-1,428	-1,579	-2.77	-2.68	-2.96
	(196)	(241)	(355)	(0.37)	(0.45)	(0.67)
	[-638]	[-608]	[-714]	[-1.20]	[-1.14]	[-1.34]
N	1,192	786	406			

Notes: Dropping outliers with WTP for study time or GPA greater than $100,000 or less than -$100,000 (5.5% of the sample). Table reports mean [median] WTP. Bootstrapped standard errors in parentheses. All means and medians are statistically different from zero at 1%. *Significant at 10%, **5%, ***1% from a difference in means and medians test by gender.

test by gender.

On average, students are willing to pay 16% of the average annual earnings for a one-point increase in the average GPA at graduation of a given major but must be compensated with an extra 3% in average annual earnings to study one more hour per week. By gender, women are willing to pay 17% of their annual earnings for the one-point increase in the average GPA at graduation, but men only 13% (p-value<0.1). However, there is no gender difference in the average WTP for weekly study time.

I interpret the WTP for GPA as a measure of students' sensitivity to grades. Since the objective is to understand why women and men value grades differently and how this could impact their major choices, I focus on this measure henceforth.

Table 6 reports the gender gap in WTP for GPA at graduation conditional on background characteristics. In particular, Table 6 reports α_1 from:

$$WTP_{GPAi} = \alpha_0 + \alpha_1 Female_i + \mathbf{C}_i + \xi_i \tag{8}$$

where the outcome variable is participant i's WTP measure for GPA at graduation. $Female_i$ is an indicator equal to one when the participant is female. $\mathbf{C}_i$ includes controls for family income, parents' education, minority status, SAT/ACT scores, school year, and indicators for honors students and majors.

Table 6: Gender Gaps in WTP for GPA

	Overall	STEM/BEC	SSH
	(1)	(2)	(3)
Female	3,057**	3,760**	1,760
	(1,438)	(1,702)	(2,783)
Mean	8,309	9,414	6,307
R2	0.02	0.02	0.02
N	1,192	768	424

Notes: Outcome variable is WTP for an extra point in av. GPA at graduation. All columns control for household income, parents education, SAT/ACT, school year, honors, minority. Additionally, column (1) controls for major. Standard errors reported in parentheses. Columns (2) and (3) split sample by reported major of participants. *Significant at 10%, **5%, ***1%.

Column (1) reports the overall conditional gender gap at $3,057. This gap means that women are willing to forego $3,057 of average annual earnings more than men for an extra GPA point at graduation in a given major. I interpret this difference as the gender gap in grade sensitivity since women are willing to "pay" more for the point increase. In columns (2) and (3) the sample is split by major: STEM/BEC versus SSH.[13] From this, it is clear that the overall gender gap is driven by the gap among STEM/BEC students where the difference in WTP for GPA at graduation between genders reaches $3,760. The gap is smaller ($1,760) and not statistically different from zero among the SSH students. These results are consistent with the administrative data evidence in Figure 1 discussed earlier: women in STEM/BEC majors are more sensitive to grades than men, but this gap is not observed in other majors.

[13]STEM and BEC majors are pooled together given the similar patterns in grade sensitivity observed in Figure 1.

6 What could be driving the gap?

There could be many potential mechanisms driving the gender differences in grade sensitivity documented in the previous sections. For example, the literature suggests gender differences in risk aversion (Paola and Gioia, 2012), willingness to compete (Buser et al., 2014), self-confidence (Ellis et al., 2016; Moakler and Kim, 2014), and beliefs about what it takes to graduate from a male-dominated major (Owen, 2020).

Another possibility is beliefs about gender discrimination and labor market standards (Steele et al., 2002). There is evidence that women face different standards than men in hiring and promotion decisions, especially in male-dominated areas (Foschi et al., 1994; Goldin and Rouse, 2000; Quintero, 2008; Williams et al., 2014; Funk and Parker, 2018; Alam and Tapia, 2020). Thus, it is reasonable that female students could anticipate facing gender discrimination in the labor market, and even have heterogeneous beliefs about the level of discrimination they could experience in different fields. These beliefs could impact their response to grades and major choices, and help to explain the gender gap in sensitivity for grades documented earlier.

The primary focus of this section is on beliefs about gender discrimination and labor market standards for several reasons. (1) Although there is a substantial amount of research about gender discrimination in the labor market, there is considerably less work on anticipated discrimination and even less on its potential effects on major choices (Steele et al., 2002; Alston, 2019). Therefore, studying this mechanism represents a significant contribution to our knowledge about the effects of gender discrimination in different spheres of life. (2) It is important to investigate mechanisms that do not rest on inherent differences between men and women (risk-aversion, self-confidence, willingness to compete), but instead rest on beliefs about the labor market, like anticipated gender discrimination, because providing evidence of their relevance would suggest different policy implications than other explanations. (3) But I also collect data about self-confidence and beliefs about grades in different fields, they do not seem to be systematically related to grade sensitivity. Therefore, I consider them later in section 7.

First, I present a theoretical model of major choices that incorporates potential discrimination in the labor market against women to develop intuition about the role of beliefs about gender discrimination in decisions about field of study. Second, I provide evidence of the gender gaps in beliefs about gender discrimination and labor market standards using the survey data. Finally, I provide evidence of the importance of those beliefs in explaining the gender differences in grade sensitivity documented earlier.

6.1 Conceptual Framework

In this section, I setup a theoretical framework to formalize the intuition behind how beliefs about gender discrimination in the labor market can lead to gender differences in grade sensitivity and major choices.

I add the employer side from Coate and Loury (1993)'s model of labor market discrimination to a framework of major choices with two stages. In the first stage, students choose between two majors (STEM/BEC vs SSH). In the second stage, after receiving their grades students revise their major decisions. When making or revising their decisions students take into account their study costs, beliefs about their ability, and potential gender discrimination in the labor market.

I incorporate the possibility of gender discrimination by making the utility from each major depend of the probability of finding a job, which could differ by gender given how students believe the labor market works. They believe that as in Coate and Loury (1993), if employers in a given field discriminate against women they impose a more rigorous hiring rule for them. Female students incorporate that differential treatment in their major decision as a lower probability of getting hired in that field.

The goal is show that by allowing major choices to be affected by discrimination in the labor market, women and men that receive the same grades make different decisions about staying in or leaving a given major. The difference arises because they believe they will be treated differently in the labor market based on gender.

6.1.1 Environment

Consider a mass one of female (F) students and a mass one of male (M) students. Gender is denoted by $g \in \{M, F\}$. Students choose between two majors (k): STEM/BEC denoted by S and SSH denoted by N. Students can be high (h) or low (l) ability, but they do not know what their level of ability is. There is a P proportion of high-ability individuals. Additionally, students have a heterogeneous marginal cost for an extra hour of studying $c_i \sim U(0, 1)$.

Throughout college, students receive grades which are noisy signals about their ability. Grades are drawn from $[0, 1]$ according to the pdf $f_h(\theta)$ if the student is high ability or $f_l(\theta)$ if they are low ability. The corresponding CDFs are F_h and F_l, respectively. I assume that $f_h(.)$ and $f_l(.)$ satisfy the Monotone Likelihood Ratio Property (MLRP).[14] Thus, higher grades are more likely if the student is high ability.[15]

Students believe there is a separate labor market for each field, which means that students who graduate with a degree in major k participate in the labor market for field k. Additionally, they believe that employers behave as follows. Employers in a given field have a prior belief π_g^k about the fraction of high ability individuals in the pool of workers. Employers get $x_h^k > 0$ if they hire a high ability student and $x_l^k < 0$ if they hire a low ability student. They observe students GPA (grades) at graduation, θ, which are a noisy signal of the student ability, and update their beliefs about that particular student being high ability following Bayes rule. The posterior probability is denoted by:

$$p(\theta; \pi_g^k) = \frac{\pi_g^k f_h(\theta)}{\pi_g^k f_h(\theta) + (1 - \pi_g^k) f_l(\theta)} \tag{9}$$

[14] $\psi(\theta) = \frac{f_h(\theta)}{f_l(\theta)}$ is strictly increasing and continuous in θ for all $\theta \in [0, 1]$

[15] MLRP implies that F_h FOSD F_l, and that, for a given prior, the probability of being high ability is increasing in the grades (signal).

6.1.2 Hiring Decisions

The firm will optimally choose to hire a student that provides signal θ if and only if

$$p(\theta;\pi_g^k)x_h^k - [1-p(\theta;\pi_g^k)]x_l^k \geq 0 \tag{10}$$

Using (9) in the condition above, a firm hires a student if and only if:

$$\frac{f_h(\theta)}{f_l(\theta)} \geq \frac{1-\pi_g^k}{\pi_g^k}\frac{x_l^k}{x_h^k} \tag{11}$$

The MLRP implies the existence of a unique $\tilde{\theta}_g^k \in (0,1)$ such that (11) holds with equality.[16] This means that the employer follows a cutoff hiring rule. The firm will hire a student if their grade (signal) is higher than the cutoff, i.e. $\theta > \tilde{\theta}_g^k$.

Assume that $\frac{x_l^N}{x_h^N} < \frac{x_l^S}{x_h^S}$, i.e. the ratio of profit to losses is higher in S than in N. This is reasonable since the potential problems of hiring a low-ability worker in a more technological sector like S might be greater than in N. This assumption guarantees that the signal cutoff in the N sector is lower than in the S sector, $\tilde{\theta}_g^N < \tilde{\theta}_g^S$, for both genders. This conclusion is consistent with the average response in the survey about the labor market standards.

Additionally, it is the case that $\frac{d\tilde{\theta}_g^k}{d\pi_g^k} < 0$.[17] As the belief about the proportion of high ability workers in the pool of potential employees increases the firm uses a lower threshold for the grades in order to hire them; in other words a less rigorous standard. This property will be relevant later when considering perceived discrimination in the S labor market. Discrimination will be introduced as the belief that the proportion of high-ability (productive) women in the S labor market is lower than men, $\pi_F^S < \pi_M^S$. Therefore, $\tilde{\theta}_F^S > \tilde{\theta}_M^S$, which means that in the presence of perceived gender discrimination women will face a more rigorous standard than men since they need to provide a better signal (higher GPA) in order

[16] If (11) does not hold with equality for any $\theta \in (0,1)$, then $\tilde{\theta}(\pi_g^k) = 0$ if $\frac{f_h(0)}{f_l(0)} = \frac{1-\pi_g^k}{\pi_g^k}\frac{x_l^k}{x_h^k}$ or $\tilde{\theta}(\pi_g^k) = 1$ if $\frac{f_h(1)}{f_l(1)} = \frac{1-\pi_g^k}{\pi_g^k}\frac{x_l^k}{x_h^k}$. See Fang and Moro (2011) for more details.

[17] See Fang and Moro (2011) for proof.

to get hired.

6.1.3 Initial Sorting

Students choose the major with higher utility. The utility of studying each major is given by the expected payoff of a job after graduation in that field minus the cost of studying. The expected payoff depends on the probability of finding a job, which depends on the probability that the GPA at graduation, θ, is above the cutoff in the corresponding field, $\tilde{\theta}_g^k$. This probability is:

$$P[1 - F_h(\tilde{\theta}_g^k)] + (1 - P)[1 - F_l(\tilde{\theta}_g^k)] \tag{12}$$

where P is the prior belief about being high-ability. Notice that the prior belief is equal to the actual proportion of high-ability students, which is the best guess students can make at this stage.

S jobs pay 1 and N jobs pay v with $v < 1$.[18] Utilities for each major are as follows:

$$U_g^N = vP[1 - F_h(\tilde{\theta}_g^N)] + v(1 - P)[1 - F_l(\tilde{\theta}_g^N)] - \delta^N c_i \tag{13}$$

$$U_g^S = P[1 - F_h(\tilde{\theta}_g^S)] + (1 - P)[1 - F_l(\tilde{\theta}_g^S)] - \delta^S c_i \tag{14}$$

where δ^k represents the number of study hours major k requires. Major S requires more study time than N, $\delta^S > \delta^N$.

A student i of gender g compares U_g^S and U_g^N and chooses to enroll in the major with higher utility. There exists $\bar{c}_g \in (0, 1)$ such that[19]

$$\begin{cases} U_g^S \geq U_g^N, & \text{if } c_i \leq \bar{c}_g \\ U_g^S < U_g^N, & \text{otherwise} \end{cases} \tag{15}$$

[18] v must be low enough to avoid a situation where all students pick the same major. See Appendix B.1 for technical details.

[19] See Appendix B.1 for details.

Then, (15) implies that for each gender g, only students with a low enough cost of studying enroll in S.

If the payoff in field N differs by gender such that $v_F > v_M$ or women perceive discrimination in the labor market that corresponds to field S i.e. $\tilde{\theta}_F^S > \tilde{\theta}_M^S$, then $\bar{c}_F < \bar{c}_M$. This inequality means that the proportion of women that enrolled in S is less than the proportion of men, as we observe in the data.

6.1.4 Second Stage

At the end of their first year, students receive their grades, θ_i, drawn from their respective distribution according to ability,$f_h(.)$ or $f_l(.)$. Given this new information, students update their beliefs about being high-ability following Bayes rule and, potentially revise their major choice.

Given grades, θ_i, the posterior belief about being high-ability is

$$P'(\theta_i) = \frac{P f_h(\theta_i)}{P f_h(\theta_i) + (1-P) f_l(\theta_i)} \tag{16}$$

Given the new individual-specific posterior belief, utility for each major is given by:

$$U_g^N(\theta_i) = vP'(\theta_i)[1 - F_h(\tilde{\theta}_g^N)] + v(1 - P'(\theta_i))[1 - F_l(\tilde{\theta}_g^N)] - \delta^N c_i \tag{17}$$

$$U_g^S(\theta_i) = P'(\theta_i)[1 - F_h(\tilde{\theta}_g^S)] + (1 - P'(\theta_i))[1 - F_l(\tilde{\theta}_g^S)] - \delta^S c_i \tag{18}$$

A student i of gender g chooses to stay in (or switch to) S if $U_g^S(\theta_i) \geq U_g^N(\theta_i)$.

Given the new information, student i of gender g once again compares $U_g^S(\theta_i)$ and $U_g^N(\theta_i)$ and chooses to stay in or switch to the major with higher utility. The MLRP implies that a reservation grade $\theta_i^* \in (0,1)$ exists such that[20]

$$\begin{cases} U_g^S(\theta_i) \geq U_g^N(\theta_i), & \text{if } \theta_i \geq \theta_i^* \\ U_g^S(\theta_i) < U_g^N(\theta_i), & \text{otherwise} \end{cases} \tag{19}$$

Thus, a student decides to leave S if their grade is not high enough based on their reservation grade θ_i^*.

It is the case that

$$\frac{\partial \theta_i^*}{\partial \tilde{\theta}_g^S} > 0 \tag{20}$$

which means that the higher the cutoff grade to get a job in S the higher the reservation grade to stay in (or switch into) S.

The reservation grade is a function of both labor market cutoffs, $\tilde{\theta}_g^N$ and $\tilde{\theta}_g^S$, the payoff v in field N, the grade θ_i, the cost of studying c_i, and the study time in both majors δ_S and δ_N.

6.1.5 Anticipated Gender Discrimination in S

Consider the case in which female students expect to face gender discrimination in the labor market for major S. That means that they assume that in the S labor market employers believe that there is a higher proportion of high-ability men than women, $\pi_F^S < \pi_M^S$. Given that employers follow a cutoff hiring rule (See 6.1.2), women believe they will face a higher cutoff than men in S labor market in order to get a full-time job, i.e. $\tilde{\theta}_F^S > \tilde{\theta}_M^S$.

Then, for an identical man and woman (same c_i and ability), and given (20)

$$\theta_i^*(\tilde{\theta}_F^S) > \theta_i^*(\tilde{\theta}_M^S) \tag{21}$$

This means that the woman requires a higher grade than the man to stay in or switch into S. In other words, if they both receive the same grade θ_i, such that $\theta^*(\tilde{\theta}_F^S) > \theta_i > \theta^*(\tilde{\theta}_M^S)$,

[20]See Appendix B.2 for proof.

then the man is going to stay (or switch into) S and the women is going to leave S (or stay in N). Notice that this is consistent with the patterns in grade responsiveness from Figure 1, and the gender difference in grade sensitivity discussed in section 5.2.

6.2 Anticipated Gender Discrimination: Empirical evidence

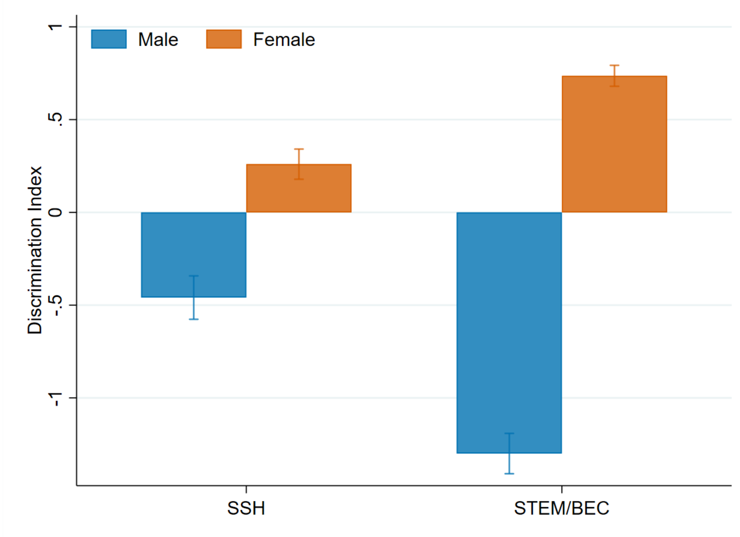
In this section, I document gender differences in students' beliefs about gender discrimination and hiring standards in the labor market using the survey data, and present evidence of the importance of those beliefs to understand the gender differences in grade sensitivity.

In order to measure beliefs about anticipated gender discrimination in the labor market, participants responded to a gender discrimination panel in the survey. They were asked, how likely (on a 5-point Likert scale) it would be that: (1) it is harder to find a job because of their gender, (2) their supervisor/boss would treat them differently because of their gender, and (3) their peers/coworkers would treat them differently because of their gender.[21] Given that beliefs about discrimination can be different for different majors or fields, the questions were asked for each major separately. Their responses for each major were combined using Principal Components Analysis (PCA) to create a major-specific index of anticipated gender discrimination.

Figure 3 shows the average gender discrimination index by major and gender. By construction, each index has a mean of zero (and standard deviation of one), therefore negative (positive) numbers imply anticipated gender discrimination that is lower (higher) than average. Men anticipate facing less discrimination due to their gender in both fields than the average participant. The story is different for the female students. Female participants foresee facing more gender discrimination than average in both fields. However, women anticipate that they will face more gender discrimination in the STEM/BEC labor market than in the SSH labor market (p-value<0.01). This result is consistent with evidence of higher difficulties in the labor market for women in male-dominated fields (Foschi et al.,

[21]Given the leading nature of these questions they were asked at the end of the survey.

Figure 3: Gender Discrimination Index by Gender



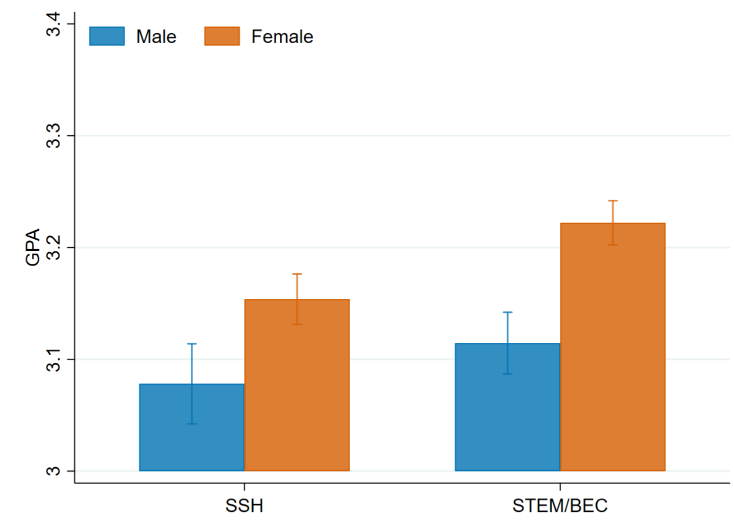
Notes: Average gender discrimination index for each major by gender. The index calculated using PCA and the responses to how likely (on a 5-point Likert scale) it would be that: (1) it is harder to find a job because of their gender, (2) their supervisor/boss would treat them differently because of their gender, and (3) their peers/coworkers would treat them differently because of their gender. Spikes represent 95% CI.

1994; Goldin and Rouse, 2000; Funk and Parker, 2018; Alam and Tapia, 2020).

As the theoretical framework shows, a way in which discrimination could affect women's decisions is through beliefs that they need to provide more or better evidence of competence than men in order to be hired, especially in male-dominated fields. Therefore, participants were asked to report what they think is the minimum GPA at graduation that they will require to secure a full-time job in STEM/BEC (SSH) if they were to graduate with a degree in STEM/BEC (SSH). Each participant answered the question for each major, regardless of the major they report to be enrolled in.

Figure 4 shows the average GPA threshold for each major by gender. In general, participants believe they would need a lower GPA to secure a job in SSH than in STEM/BEC. For instance, on average women believe they would need a GPA 0.068 higher to get a job in STEM/BEC than in SSH (p-value$<$0.01). On average men believe they would need 0.036 extra GPA points at graduation to secure a job in STEM/BEC instead of SSH (p-value=0.014). Moreover, on average, women believe they need a higher GPA than men to secure a full-time job, regardless of the major they graduate from. The gender gaps in beliefs about the

Figure 4: Average Beliefs about Min. GPA Necessary for Full-Time Job in Given Field



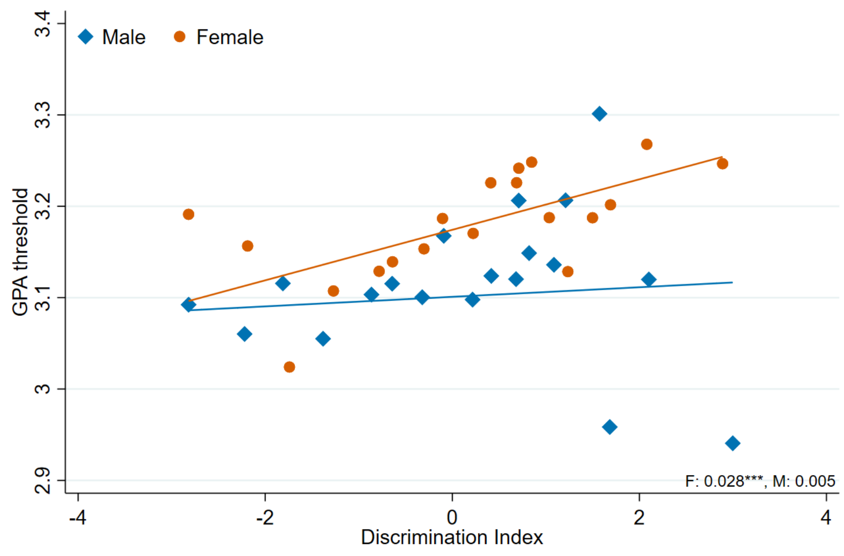
Notes: Average belief about the minimum cumulative GPA at graduation required to secure a full-time job in each field by gender. Spikes represent 95% CI.

GPA necessary to get an SSH or STEM job are 0.075 and 0.11, respectively (p-value$<$0.01 for both). In summary, women believe they will need to provide a better signal of their competence in the labor market in the form of a higher GPA than their male counterparts, especially in order to secure a job in the STEM/BEC field.

The binned scatter plot in Figure 5 shows the relationship between beliefs about anticipated gender discrimination in the labor market and beliefs about the GPA required to secure a job. There is a positive and significant relationship (p-value$<$ 0.01) between the level of discrimination that a woman believes she is going to face and her beliefs about the minimum GPA at graduation required to secure a full-time job. However, this positive relationship is weaker for men, which is not surprising since men expect to experience less gender discrimination. Therefore, their beliefs about the GPA required to get a full-time job are not as strongly related to discrimination as they are for women.

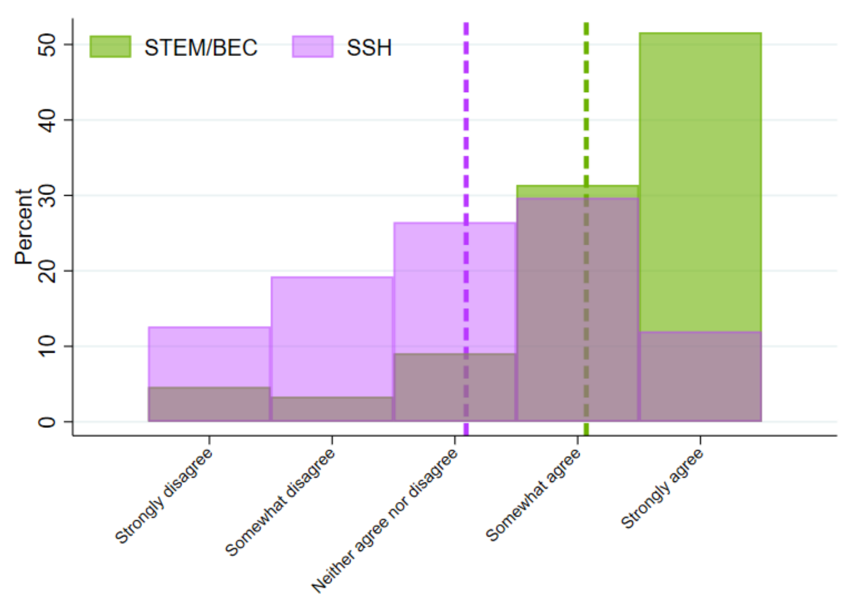
The fields where women expect to face more discrimination due to their gender are the fields in which they foresee they will need to provide a really strong signal about their ability in order to be competitive. In fact, I asked female participants how much they agree (on a 5-point scale) with the idea that a woman applying for a job after graduation in a given

Figure 5: Discrimination and Thresholds Relationship



Notes: Markers are from a binned scatter plot between GPA thresholds to get a full-time job and the anticipated discrimination index. Lines are fitted values from a regression of the GPA threshold on the discrimination index separately by gender and standard errors are clustered at individual level. Coefficients at the bottom left corner are the slopes of each line. *Significant at 10%, **5%, ***1%.

Figure 6: Female Participants Agreement with "Women need a higher GPA to compete against similar man", by major



Notes: For each major, histogram of female participants responses to "How much you agree with: A woman competing for a job in this field would need a higher GPA than an otherwise similar man to be competitive." Dashed lines represent the average level of agreement by major.

field would need a higher GPA than an otherwise similar man to be competitive. Figure 6 summarizes the responses. The dashed lines represent the average response per major. On average, the level of agreement with the idea of women requiring a higher GPA in order to be competitive is higher if applying for a STEM/BEC job than an SSH job (p-value$<$0.01). Moreover, almost 83% of the female participants somewhat agree or strongly agree with the statement in the case of a STEM/BEC job, whereas only 42% agree to the same extent in the case of an SSH job. These results reinforce the previous conclusions, women believe they will have a harder time in the STEM/BEC labor market.

Table 7 analyzes the role of anticipated discrimination and beliefs about GPA thresholds to secure a full-time job in explaining the gender gap in grade sensitivity. The first column duplicates column (1) in Table 6, which reports the conditional average gender gap in WTP for GPA at graduation, \$3,057. Column (2) controls for beliefs about the necessary GPA to get a full-time job in STEM/BEC and SSH fields. Although the gender gap is still statistically different from zero, the point estimate decreases by 13% (\$2,671). Therefore, beliefs about facing different standards in the labor market seem important to understand why women and men value grades differently.

Discrimination also plays a role in explaining the gender gap in WTP aside from its effects through the GPA thresholds as can be seen in column (3), which controls directly for the anticipated discrimination indexes in STEM/BEC and SSH. In this case, the gender gap is no longer statistically different from zero and the point estimate decreases by 36% to \$1,965. This reduction suggests that anticipated discrimination is relevant for understanding the gender gap in grade sensitivity. Finally, column (4) includes controls for both discrimination indexes and GPA thresholds. In this case, the point estimated decreases to \$1,600, a 48% reduction, and it is not statistically significant. An Oaxaca-Blinder decomposition indicates that anticipated discrimination indexes and GPA standards explain 55% of the gender gap in WTP.

These results suggest that beliefs about anticipated gender discrimination and labor

Table 7: Importance of Anticipated Discrimination and GPA Thresholds for the Gender Gaps in WTP for GPA

	(1)	(2)	(3)	(4)
Female	3,057**	2,671*	1,965	1,600
	(1,438)	(1,427)	(2,047)	(2,036)
Belief GPA Threshold STEM/BEC		5,548**		5,533**
		(2,426)		(2,423)
Belief GPA Threshold SSH		-499		-487
		(2,057)		(2,064)
Anticipated Discrimination STEM/BEC			620	613
			(728)	(730)
Anticipated Discrimination SSH			-261	-270
			(536)	(532)
Mean	8,309	8,309	8,309	8,309
R2	0.018	0.024	0.019	0.025
N	1,192	1,192	1,192	1,192

Notes: Outcome variable is WTP for an extra point in av. GPA at graduation. All columns control for household income, parents education, SAT/ACT, school year, honors, minority, and major. Standard errors reported in parentheses. *Significant at 10%, **5%, ***1%.

market standards are important to understand why women and men value grades differently. Additionally, they support the intuition formalized in the conceptual framework that highlights the role of beliefs about anticipated discrimination in women's major choices.

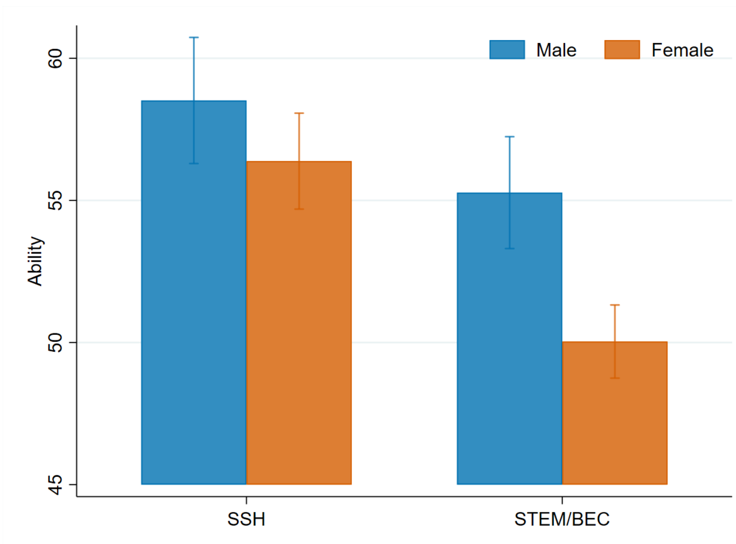
7 Other Explanations

Aside from beliefs about gender discrimination and labor market standards, there could be other mechanisms that contribute to explaining the gender gap in sensitivity to grades. The literature suggests that gender differences in self-confidence, and beliefs about the grade distribution in different fields could play a role in this context. In this section, I discuss the empirical evidence of their contribution to explaining why women and men react differently to grades using the survey data.

7.1 Self-Confidence

There is evidence that women are less confident in their quantitative abilities than men. For example, Ellis et al. (2016) finds that women that take Calculus I start and end the term with less confidence in their mathematical abilities than men. Similarly, Moakler and Kim (2014) finds that women report lower academic and mathematics confidence than men, and this is related to their lower chances of choosing a STEM major. Therefore, women could interpret less-than-stellar grades in STEM and BEC majors as confirmation of their lack of ability and subsequently switch out of them.

Figure 7: Average Beliefs about Ability in Each Major

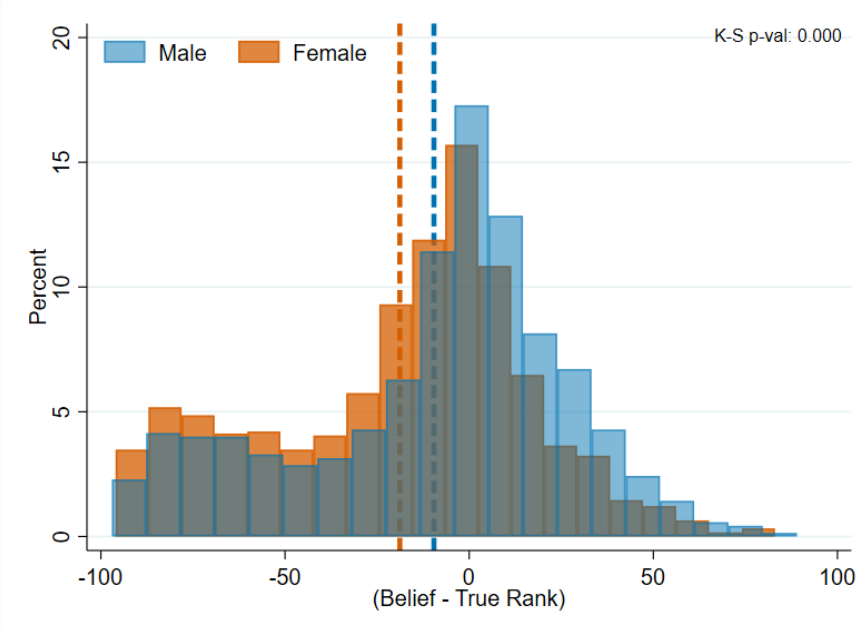


Notes: Average ability ranking in each major by gender. Rank is on a 1-100 scale where higher numbers represent higher ability. Spikes represent 95% CI.

In the survey, participants report beliefs about their SSH and STEM/BEC ability as their rank relative to peers on a 1-100 scale.[22] Figure 7 reports the average rank by gender and major. Students report higher beliefs about their ability in SSH than in STEM/BEC: on average women (men) report rankings 6.35 (3.24) points higher in SSH than in STEM/BEC (p-value<0.01 for both genders). On average, men report higher beliefs about both their SSH and STEM/BEC ability than women. However, only the gender gap in beliefs about STEM/BEC ability is statistically different from zero (p-value <0.01).

[22]The higher the number the better the ability relative to peers.

Figure 8: Ability Over/Under Confidence, by Majors



Notes: Histogram, by gender, of the difference between participants' beliefs about their rank in their reported major and their "true" rank in that major based on reported cumulative GPA. Dashed lines represent the mean of each respective distribution. K-S p-val: p-value from a Kolmogorov-Smirnov test for the equality of the distributions.

Figure 8 plots the distribution of the difference between participants' beliefs about their rank in their reported major and their "true" rank in that major (Belief - True Rank). True rank is calculated using the administrative data of students registered in each of the majors during the Spring of 2021. Specifically, in the administrative data, all students in a major cohort are ranked based on their cumulative GPA and this ranking is used to assign the true rank to the survey participants based on the cumulative GPA they provided. Then, this difference (Belief - True Rank) is the error in participants' beliefs about their ability. If the error is positive (negative) participants are over (under) confident in their ability.

In Figure 8, the vertical dashed lines represent the mean of the distribution by gender and show that on average participants are under-confident in their ability. In other words, participants report a worse rank than their actual position based on their GPA. However, women are more under-confident than men as illustrated by the lower mean (p-value <0.01), and the extra mass below zero in the female histogram.[23,24]

Table 8: Importance of the Errors in Beliefs about Ability for the Gender Gaps in WTP for GPA

	(1)	(2)
Female	3,057**	2,905**
	(1,438)	(1,443)
Error in Beliefs about Ability		-18
		(20)
Mean	8,309	8,309
R2	0.018	0.019
N	1,192	1,192

Notes: Outcome variable is WTP for an extra point in av. GPA at graduation. All columns control for household income, parents education, SAT/ACT, school year, honors, minority, and major. Standard errors reported in parentheses. *Significant at 10%, **5%, ***1%.

Table 8 examines the role of over/under confidence in the gender differences in grade sensitivity. Column (1) reproduces the first column from Table 6, which reports the conditional average gender gap in WTP for GPA at graduation, $3,057. Column (2) controls for the error in beliefs about ability as described before: belief - true rank. This error reduces the gender gap slightly (5%), but it remains statistically significant.

Despite the fact that the gender differences in self confidence have the expected patterns, theses results do not support the role of self-confidence as an important driver of the gender differences in sensitivity to grades.

7.2 Beliefs about Grade Distribution in Different Fields

Academic performance is one of the main reasons for changing majors (Wright, 2018). However, there is evidence that students sometimes hold erroneous beliefs about the grade distributions in different fields. For example, Owen (2020) finds that men are more likely to underestimate the median grade of students enrolled in STEM majors, while women

[23] Based on the Kolmogorov-Smirnov test, female and male distributions are statistically different from each other in both panels of Figure 8 (p-value$<$0.01).

[24] Results are qualitatively the same if the distributions are analyzed separately for students enrolled in SSH and STEM/BEC. See Figure A1 in the Appendix.

overestimate it. If women overestimate the grades of the students graduating from STEM or BEC majors, they might believe that their less-than-stellar grades in the introductory classes are not good enough to succeed in those majors, and they might switch out. Therefore, erroneous beliefs about the grades at graduation in different majors seem like a potential explanation for the gender gap in grade sensitivity.

Table 9: Average Beliefs about GPA at Graduation by Gender and Major

	Female	Male	p-value
	(1)	(2)	(3)
SSH	3.46	3.36	0.000
STEM/BEC	3.37	3.23	0.000

Notes: Column (3) is the p-val of a difference in means test across genders within major.

In the survey participants are asked to report what they believe is the average GPA of students who graduate from each major. Table 9 reports the average response for each major by gender. The third column reports the p-value from a difference in means test between genders. Regardless of major, women believe that the average GPA at graduation is higher than what men believe. All participants believe that the average GPA at graduation is lower among STEM/BEC students.

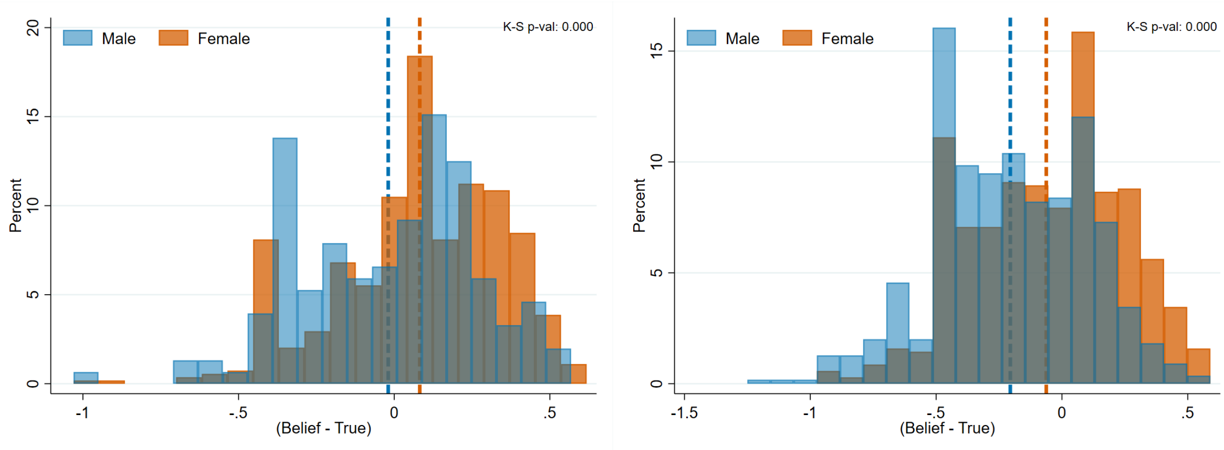
It is important to learn how close these beliefs are to the actual GPA of people graduating from each major. To do so, I use the administrative data described in section 2. Specifically, I calculated the average GPA among the students that graduate from each major during the Spring of 2019.[25] Based on these data, the average GPA at graduation in STEM/BEC majors is slightly higher than in SSH majors (3.38 in SSH, 3.41 in BEC, and 3.44 in STEM), which is the opposite of what participants believe.

Figure 9 shows the distribution of the difference (error) between a participant's belief about the GPA at graduation for the major they report to be enrolled in and the corre-

[25] I use Spring 2019 instead of Spring 2020 or Spring 2021 because those are semesters affected by different grading policies implemented as a response to the COVID-19 pandemic. However, results are qualitatively the same if any of those semesters is used instead.

Figure 9: Error in Beliefs about Av. GPA at Graduation, by Majors

(a) SSH (b) STEM/BEC



Notes: Histogram, by gender, of the difference (error) between a participant's belief about the GPA at graduation for the major they report to be enrolled in and the corresponding average GPA at graduation from the administrative data (Spring 2019). Dashed lines represent the mean of each respective distribution. K-S p-val: p-value from a Kolmogorov-Smirnov test for the equality of the distributions.

sponding average GPA at graduation from the administrative data (Spring 2019). Negative (positive) numbers indicate that participants underestimate (overestimate) the GPA at graduation. The dashed lines represent the mean of each distribution.

On average, men in SSH majors tend to underestimate the grades of their graduating peers. However, on average, women in SSH hold correct beliefs about the GPA of their graduating peers.[26] In STEM/BEC, both women and men underestimate the GPA of the students graduating from those majors. Nonetheless, on average, women underestimate the grades of their graduating peers less than men (p-value$<$0.01 from a one-sided test). This means that women's beliefs are closer to the actual GPA of the Spring 2019 graduating class than men's.

Additionally, the distributions in each panel of Figure 9 are statistically different across genders as the p-value from the Kolmogorov-Smirnov test shows. Regardless of major, a higher share of women tends to overestimate the GPA of their graduating peers, as illustrated by the extra mass above zero in the female distributions relative to men's.

Table 10 evaluates the role that over or underestimation of the GPA at graduation plays

[26]The mean for women is statistically not different from zero, p-value=0.4540

Table 10: Importance of the Errors in Beliefs about GPA at Graduation for the Gender Gaps in WTP for GPA

	(1)	(2)
Female	3,057**	2,796*
	(1,438)	(1,448)
Error in Beliefs about GPA at Graduation		1,871
		(2,397)
Mean	8,309	8,309
R2	0.018	0.019
N	1,192	1,192

Notes: Outcome variable is WTP for an extra point in av. GPA at graduation. All columns control for household income, parents education, SAT/ACT, school year, honors, minority, and major. Standard errors reported in parentheses. *Significant at 10%, **5%, ***1%.

in explaining the gender gap in grade sensitivity. Column (1) reproduces the first column in Table 6, which reports the conditional average gender gap in WTP for GPA, $3,057. Column (2) controls for the errors in beliefs about the GPA at graduation (the errors plotted in Figure 9). In this case, the gender gap estimate decreases by about 9% to $2,796.

These results do not provide strong support in favor of the hypothesis that holding erroneous beliefs about what is required to graduate from a given major is an important driver of the gender differences in grade sensitivity.

8 Conclusion

The probability of women continuing their studies in or switching out of male-dominated fields like STEM and Economics depends more on their performance in relevant courses at the beginning of their college career relative to men. This paper studies why women and men react differently to grades during college and how this behavior impacts their decision to persist or switch out of a given major. Understanding why talented women with the potential to succeed in male-dominated fields drop out because of less-than-stellar grades in an introductory class is important for closing the gender gap in these areas, improving the labor market outcomes of highly skilled women, and achieving an efficient allocation of resources across fields of study and occupations.

Using administrative data from Arizona State University, I document gender differences in reaction to grades among undergraduate students. I find that among STEM and business students, the gender gap in the probability of persisting in those majors is negatively related to first year GPA.

The limited ability of the administrative data to shed light on the reasons that lead to those patterns, I use novel data from an online survey to quantify students' sensitivity to grades, and investigate the reasons why women and men react differently to grades. I estimate students' grade sensitivity using the hypothetical scenarios methodology. I find that, conditional on background characteristics, women are willing to pay about $3,000 more of average annual earnings than men for a one-point increase in the average GPA at graduation in a given major. This gender gap is primarily concentrated among STEM and business students.

I provide evidence that anticipated discrimination in the labor market of male-dominated fields is important to understand this gender gap in grade sensitivity. I find that women believe that they are more likely to experience gender discrimination in the labor market than men, particularly in STEM and business fields. Additionally, I find that women believe that they will face a higher standard in the labor market in terms of GPA in order to get a full-time job. I provide evidence that the beliefs about higher standards are related to beliefs about gender discrimination in the labor market. Furthermore, my results show that beliefs about gender discrimination in the labor market account for 48% of the gender gap in sensitivity to grades.

Also, I propose a theoretical framework that formalizes the intuition about how these beliefs can lead to the gender differences in persistence observed in STEM and business majors. I show that by allowing major choices to be affected by discrimination in the labor market, women and men that receive the same grades make different decisions about staying in or leaving a given major. The difference arises because they believe they will be treated differently in the labor market based on gender.

I acknowledge that there are other mechanisms that could contribute to explaining the gender differences in grade sensitivity that I document. However, anticipated discrimination represents an explanation not often considered, and my results provide evidence of its importance in this context. In fact, considering the role of such beliefs is crucial to designing policies that effectively encourage the participation of women in traditionally male-dominated fields. For example, if students' beliefs about gender discrimination are close to the reality of the labor market, then policymakers should aim to solve the discrimination issues in the labor market. On the other hand, if students hold inaccurate beliefs about the labor market, information interventions could be a valuable tool. Therefore, assessing the accuracy of these beliefs represent an important avenue for future research.

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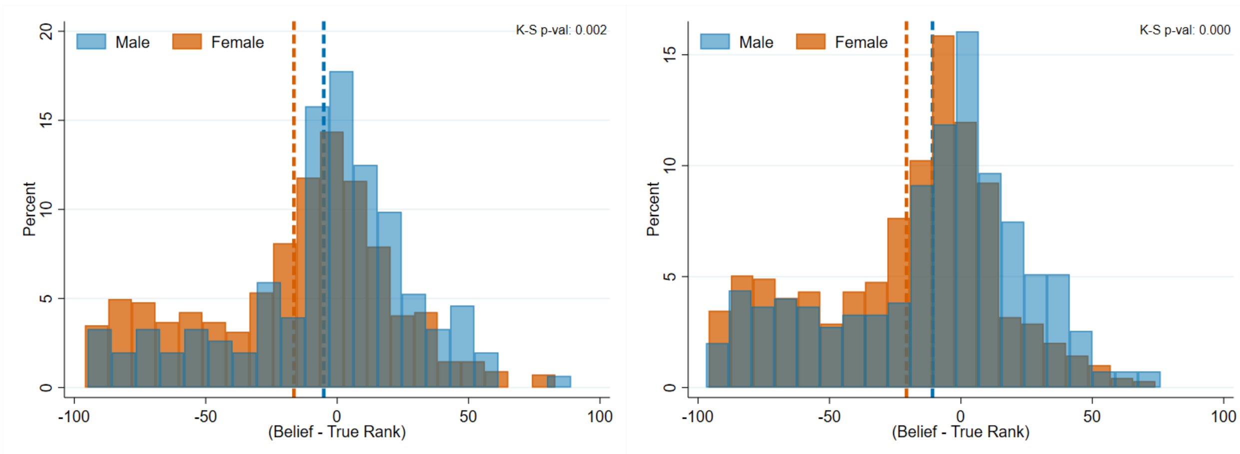
A Appendix

Figure A1: Ability Over/Under Confidence, by Majors

(a) SSH (b) STEM/BEC



Notes: Histogram, by gender and major, of the difference between participants' beliefs about their rank in their reported major and their "true" rank in that major based on reported cumulative GPA. Dashed lines represent the mean of each respective distribution. K-S p-val: p-value from a Kolmogorov-Smirnov test for the equality of the distributions.

B Appendix

B.1 Existence of $\bar{\mathbf{c}}_{\mathbf{g}}$

Student i chooses major S iff

$$
\begin{aligned}
&U_g^S(\theta_i) \geq U_g^N(\theta_i) \\
&\iff P[1-F_h(\tilde{\theta}_g^S)] + (1-P)[1-F_l(\tilde{\theta}_g^S)] - \delta^S c_i \geq vP[1-F_h(\tilde{\theta}_g^N)] + v(1-P)[1-F_l(\tilde{\theta}_g^N)] - \delta^N c_i \\
&\iff (\delta^N - \delta^S)c_i \geq vP[1-F_h(\tilde{\theta}_g^N)] + v(1-P)[1-F_l(\tilde{\theta}_g^N)] - P[1-F_h(\tilde{\theta}_g^S)] - (1-P)[1-F_l(\tilde{\theta}_g^S)] \\
&\iff c_i \leq \frac{vP[1-F_h(\tilde{\theta}_g^N)] + v(1-P)[1-F_l(\tilde{\theta}_g^N)] - P[1-F_h(\tilde{\theta}_g^S)] - (1-P)[1-F_l(\tilde{\theta}_g^S)]}{(\delta^N - \delta^S)}
\end{aligned}
$$

Let $\bar{c}_g = \frac{vP[1-F_h(\tilde{\theta}_g^N)] + v(1-P)[1-F_l(\tilde{\theta}_g^N)] - P[1-F_h(\tilde{\theta}_g^S)] - (1-P)[1-F_l(\tilde{\theta}_g^S)]}{(\delta^N - \delta^S)}$

- $\bar{c}_g > 0$ if

$$
v < \frac{P[1-F_h(\tilde{\theta}_g^N)] + (1-P)[1-F_l(\tilde{\theta}_g^N)]}{P[1-F_h(\tilde{\theta}_g^S)] + (1-P)[1-F_l(\tilde{\theta}_g^S)]} \tag{22}
$$

- $\bar{c}_g < 1$ if

$$
v < \frac{(\delta^N - \delta^S) + P[1-F_h(\tilde{\theta}_g^N)] + (1-P)[1-F_l(\tilde{\theta}_g^N)]}{P[1-F_h(\tilde{\theta}_g^S)] + (1-P)[1-F_l(\tilde{\theta}_g^S)]} \tag{23}
$$

Then, as long as v is small enough such that (23) holds, $\exists \bar{c}_g \in (0,1)$ such that

$$
\begin{cases}
U_g^S \geq U_g^N, & \text{if } c_i \leq \bar{c}_g \\
U_g^S < U_g^N, & \text{otherwise}
\end{cases} \tag{24}
$$

B.2 Existence of θ_i^*

Student i chooses major S iff

$$\begin{aligned}
& U_g^S \geq U_g^N \\
\iff & P'(\theta_i)[1 - F_h(\tilde{\theta}_g^S)] + (1 - P'(\theta_i))[1 - F_l(\tilde{\theta}_g^S)] - \delta^S c_i \\
& \geq vP'(\theta_i)[1 - F_h(\tilde{\theta}_g^N)] + v(1 - P'(\theta_i))[1 - F_l(\tilde{\theta}_g^N)] - \delta^N c_i \\
\iff & P'(\theta_i) \geq \frac{c_i(\delta^N - \delta^S) + [F_l(\tilde{\theta}_g^N) - F_l(\tilde{\theta}_g^S)]}{v[F_l(\tilde{\theta}_g^N) - F_h(\tilde{\theta}_g^N)] - [F_l(\tilde{\theta}_g^S) - F_h(\tilde{\theta}_g^S)]}
\end{aligned}$$

Let $\Xi_i = \frac{c_i(\delta^N - \delta^S) + [F_l(\tilde{\theta}^N) - F_l(\tilde{\theta}^S)]}{v[F_l(\tilde{\theta}^N) - F_h(\tilde{\theta}^N)] - [F_l(\tilde{\theta}^S) - F_h(\tilde{\theta}^S)]}$

By MLRP $P'(\theta_i)$ is continuous and increasing in $[0, 1]$, then $P'(\theta_i) \geq \Xi_i$ holds if and only if $\theta_i \geq \theta_i^*$, where the threshold θ_i^* is determined as follows.

- If $P'(0) \geq \Xi_i$ then $\theta_i^* = 0$
- If $P'(1) \leq \Xi_i$ then $\theta_i^* = 1$
- If $P'(0) < \Xi_i$ and $P'(1) > \Xi_i$, by the Intermediate Value Theorem $\exists \theta_i^* \in (0, 1)$ s.t.

$$P'(\theta_i^*) = \Xi_i \tag{25}$$

The first two cases imply the everyone stays or changes to S, or stays or changes to N, respectively. The third case is more intuitive,

- if $\theta_i \geq \theta_i^* \Rightarrow P'(\theta_i) \geq \Xi_i \Rightarrow U_g^S(\theta_i) \geq U_g^N(\theta_i)$, individual i stays (or changes to) in S
- if $\theta_i < \theta_i^* \Rightarrow P'(\theta_i) < \Xi_i \Rightarrow U_g^S(\theta_i) < U_g^N(\theta_i)$, individual i stays (or changes to) in N