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COLLEGE MAJORS

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ABSTRACT

This article reviews the recent literature on the determinants of college major choices. We first highlight long-term trends and persistent differences in college major choices by gender, race, and family background. We then review the existing research in six key areas: expected earnings and ability sorting, learning, subjective expectations, non-pecuniary considerations, peer and family effects, and supply side factors. We examine and compare the various approaches employed by previous research and highlight key areas for future research.

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1 Introduction

College major choice and its relationship with labor market outcomes has long been a topic of study for social scientists. For college graduates, major choice is often directly related to occupation choices, particularly in occupations which require a substantial investment in occupation-specific human capital, such as Engineering. A number of studies have demonstrated that the choice of post-secondary field is a key determinant of future earnings, and that the demographic composition of college major choice may be a key factor in explaining earnings differences across demographic groups, such as by gender (Grogger and Eide (1995); Brown and Corcoran (1997); Weinberger (1998); Gemici and Wiswall (2014)).

Beyond individual welfare, the choice of major is important for many reasons. Major choice affects the skill composition of the workforce, making an understanding of how major choices are affected by changes in skill demand important to research on the dynamics in the overall economy. And, as we review below, policymakers have used various supply side policies–tuition, admissions criteria, and targeted aid–to alter the composition of college majors in the economy.

In this article, we review the current literature on college major choice. We begin by documenting long term trends in college major and divergence in these trends by gender and race, in Section 2. We also describe patterns in the relationship between major choice, family background, and labor market outcomes. Motivated by this evidence, we then discuss work on the determinants of college major choice. A vast literature has studied the relationship between expected earnings and human capital investments. Since at least Willis and Rosen (1979), this research has come a long way in understanding the impact of expected earnings on various aspects of college choice. Most of these studies have focused on the decision to enroll in college. However, with increasing educational attainment and specialization of the workforce, the focus has moved towards the *type* of education. As we document below using recent ACS data, and has been noted in several other papers using data from earlier periods (Daymont and Andrisani, 1984; Grogger and Eide, 1995; James et al., 1989; Loury and Garman, 1995; Gemici and Wiswall, 2014), there are large differences in earnings across majors. A natural question then emerges is the extent to which expected future earnings affect major choice. In Section 3, we outline how researchers have used several different approaches to estimate the elasticity of college major choice with respect to earnings.

Much of the earlier work treated college major choice as a static decision with little uncertainty. However, since the early work on major choice, researchers have attempted to incorporate more realistic processes of major selection, incorporating uncertainty about future outcomes (graduation and post-graduation), and learning about own ability and the characteristics of majors. In one of the earliest innovations in this dimension, Altonji (1993) allowed for uncertainty over educational outcomes including major completion, although the completion probability is constant across majors. Montmarquette et al. (2002) further relaxed this assumption by allowing completion probabilities to be individual and major specific. In recent years, a number of studies have shed some light on the dynamics of the choice and how students learn. Improvements in computational methods, the availability of rich and high frequency data on student choices and beliefs, and field experiments that shock students' information sets have enabled substantial progress on these questions. We review this strand of the literature in Section 4. It is worth noting that past reviews by Altonji et al. (2012, 2016) has extensively reviewed the work on this area of research. Altonji et al. (2012) review the literature while providing a dynamic model of education and occupation choice. They emphasize the importance of high school curriculum and its link to college major choice. Adding to this work, Altonji et al. (2016) discusses models of college major choice and the econometric methods used to obtain causal effects of majors on earnings. They highlight graduate school as a new area of research.

One area that has seen explosive growth is the use of subjective expectations in studying major choice. Historically, research on college major choice assumes that expectations are either rational or myopic, and then uses observed choices and earnings to identify parameters (Freeman (1971); Siow (1984); Zarkin (1985); Bamberger (1988); Berger (1988); Flyer (1997); Eide and Waehrer (1998); Montmarquette et al. (2002) ; Arcidiacono (2004)). This approach is limited: observed choices can be consistent with many different combinations of expectations and preferences (Manski (1993)). Moreover, strong assumptions on the structure of expectations can bias inferences about decision rules. For these reasons, a more recent literature uses subjective expectations data, rather than choice data alone, to understand decision-making under uncertainty in the context of schooling choices. We review this nascent but growing literature in Section 5. This body of work has established that students have heterogeneous beliefs about various considerations that can affect their schooling choice. This includes the probability of getting into a selective school, expected earnings after graduating from a major and beliefs about own ability (e.g., Giustinelli (2016); Kaufmann (2014); Ruder and Van Noy (2017); Attanasio and Kaufmann (2017)).

A theme that emerges from much of the recent work, reviewed in Section 3, is that earnings are certainly not the sole determinant of college majors, and there is likely a large role for non-pecuniary considerations. A growing body of research investigates non-pecuniary considerations in the context of major choice. We review this literature in Section 6. This line of work has been facilitated by the availability of subjective data on non-pecuniary factors, that are otherwise hard to quantify using observational data. The standard approach has been to subsume all unobserved factors into a "taste" term. However, in recent years, richer data on non-pecuniary factors (such as work-family balance, parental approval, marriage market considerations) has allowed for considerable progress towards unpacking the black box of tastes.

We also highlight the recent work on supply side considerations in Section 8. And, finally, we discuss work on field of study in graduate degrees other than undergraduate degrees in Section 9. We conclude by highlighting some emerging areas of work that merit further research.

2 Trends and Recent Patterns

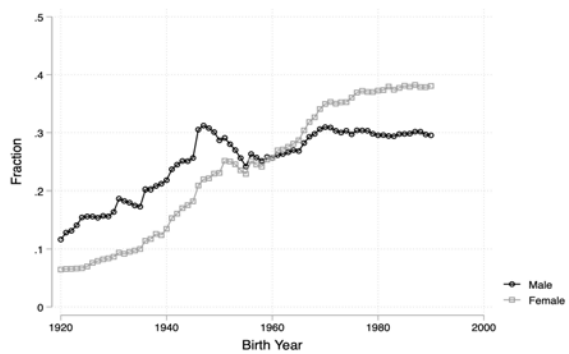
We motivate our review of the existing research by first describing broad patterns in educational attainment and college major choice. We conclude this section by describing recent employment and earnings patterns by major.

2.1 College Attainment

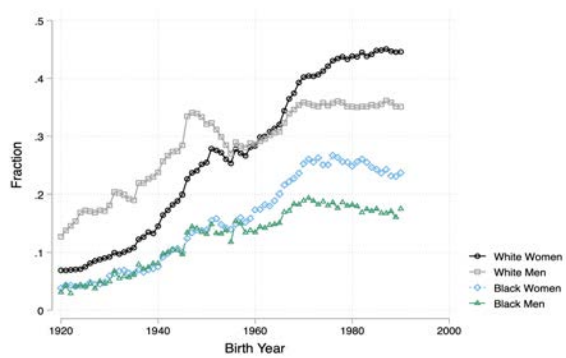
Over the last few decades, the United States has seen a significant increase in educational attainment. Panel A of Figure 1 reports the trend in college degree attainment. As described

Panel A: Overall

Panel B: By Gender



Panel C: By Gender and Race



Source.— American Community Survey (ACS) and Decennial Census.

Note.— This figure reports the fraction of population with 4 or more years of college. The sample includes the population between ages 25 and 49 surveyed in the American Community Survey (ACS) from 2008-2018 and the 1960-2000 Decennial Censuses.

Figure 1: Trends in Schooling Years

in more detail in the Data Appendix, we pool the population surveyed in the American Community Survey (ACS) from 2008-2018 and the 1960-2000 Decennial Censuses, and define college degree as 4 or more years of college, to be consistent across the data sources. Note that to minimize completion and mortality effects, we limit our sample to respondents aged 25 to 49 in each survey year.

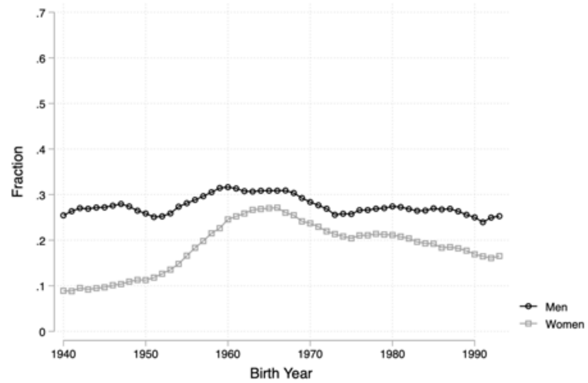
There is a steady increase in the fraction with 16 or more years of schooling, from 10 percent for the 1920 birth cohort to about 34 percent for the population born in 1990 and graduating from college in the 2010s. As is well known, Panel B shows that women overtake men starting with the 1960s birth cohorts (graduating in the 1980s), and for the most recent birth cohorts there is about an 8 percent gap in college attainment between women and men (38 versus 30 percent). Similar gaps between black women and men opened up at the same time, although both black women and men substantially lag white women and men in educational attainment (Panel C).

2.2 College Majors

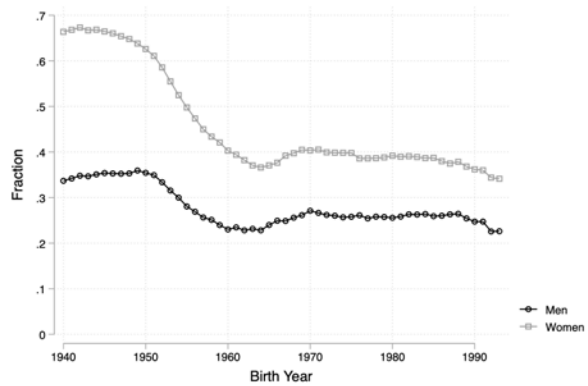
Looking beyond college attainment, we use the more recent ACS data to construct the fraction of undergraduate degrees in various majors by birth cohort. Figure 2 plots the trends in majors for birth cohorts from 1940 to 1993, where we group college/undergraduate majors into three broad categories: (i) Science, Technology, Engineering and Mathematics (STEM), (ii) Business or Economics, and (iii) Humanities, Social Science, and Education. Note that this figure plots undergraduate majors for all college educated respondents, regardless of whether they later complete a graduate degree.

Figure 2 shows substantial change in major composition across birth cohorts. The most substantial change is the reduction in the fraction of degrees in Humanities, Social Science, or Education for women and the concomitant increase in the fraction of other degrees, especially Business and Economics. The fraction of Humanities, Social Science, and Education degrees declined from nearly 70 percent for the 1940s cohorts to about 40 percent for the 1960s cohorts, with much of the increase in Business or Economics degrees, and some in STEM. Changes for men followed the same direction but were smaller in magnitude. The figure shows some notable early convergence in majors by gender, but the male and female trends are largely parallel, and there is still a sizable gap, for the later cohorts.

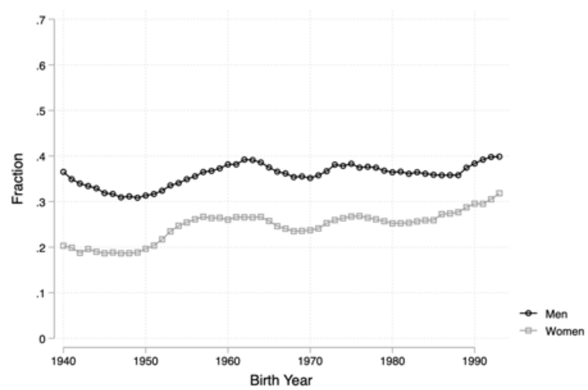
Panel A : Business/ Economics



Panel B : Humanities/ Social Science/ Education



Panel C : STEM



Source.— American Community Survey (ACS)

Note.— This figure reports the trends in major by gender and by birth cohorts. The sample includes all individuals with a bachelors degree or higher for birth cohorts from 1940 to 1993. Major is defined as undergraduate majors for all college educated respondents, regardless of whether they later complete a graduate degree.

Figure 2: Trends in Major by Gender

2.3 Undergraduate and Graduate Degrees by Family Background

An under-explored aspect of major choice is how major choice varies by the socioeconomic status of parents. We use data from National Survey of Graduates (NCSG), a nationally representative survey of college graduates for the years 1993, 2003 and 2010, to examine how undergraduate and graduate degrees vary by the education of the parents (the only measure of family background or parental socioeconomic status (SES) provided). Although college attainment by family background and in particular for first generation students has been extensively studied (Bailey and Dynarski, 2011; Bound and Turner, 2011), less is known about their college major choice. Given the connection between degree field and earnings, the existence of substantial differences by family background may have important implications for inter-generational mobility.

Table 1 shows how major choice varies by parental education. Column I reports the average years of education (averaged across both parents or only the mother if the father's education is missing) by various undergraduate and graduate fields. Columns II and III report the percent chance of graduating with a particular major for first generation students and students with both parents having a college degree, respectively. Columns IV reports the difference between columns II and III as a percent of column II (with column V reporting the p-value). Column VI reports the corresponding percent difference controlling for race, gender, birth year, survey year and birth cohort (with column VII reporting the p-value).

All these measures indicate substantial differences in college major choice by parental education. The first column shows that the majors whose graduates have the highest average parental education are fine arts and physics, and the ones with lowest parental education are Social Work, Business fields, Nursing and Education. Individuals with graduate degrees also tend to have more educated parents than those without, and Law and Medical School graduates have the highest parental years of education. Another way of looking at these differences is the probability of graduating with a major conditional on parental education. Columns (II) and (III) show that there are substantial differences in major choice between students with neither parent having a college degree and those with both parents with college degrees. These gaps are persistent even with a fairly rich set of controls (column VI). Fine

Table 1: Parental Education and Major Choice

		I	II	III	IV	V	VI	VII
	Field	Average Years	First Gen.	Both Parent	No Controls		Controls	
		of Education	Student	College Degree	Percent Diff.	P-Value	Percent Diff.	P-Value
Bachelors	Social Work	14.00	1.30	0.87	-33.17	0.16	-25.40	0.27
	Business	14.20	28.60	18.72	-34.54	0.00	-35.64	0.00
	Accounting	14.27	5.20	3.68	-29.17	0.07	-27.37	0.10
	Education	14.29	13.61	10.76	-20.95	0.03	-20.59	0.03
	Nursing	14.35	2.66	2.26	-15.06	0.21	-19.86	0.13
	Sociology	14.40	2.69	2.49	-7.55	0.51	1.13	0.92
	Math	14.48	3.73	3.07	-17.72	0.08	-15.00	0.16
	STEM	14.48	51.48	44.37	-13.81	0.00	-13.77	0.00
	Psychology	14.62	5.13	5.51	7.35	0.41	7.56	0.40
	Engineering	14.72	5.50	6.45	17.28	0.01	23.05	0.00
	Computer Science	14.73	1.55	1.65	6.23	0.62	1.81	0.88
	Biology	14.73	10.28	11.93	15.99	0.01	14.88	0.02
	Economics	14.84	2.46	2.71	10.25	0.43	20.17	0.14
	Chemistry	14.92	1.15	1.46	26.85	0.16	27.69	0.16
	Political Science	14.99	2.82	3.76	33.20	0.00	41.92	0.00
	History	14.99	2.37	3.55	50.13	0.04	43.04	0.10
	English	15.18	2.80	5.06	80.75	0.00	76.25	0.00
	Fine Arts	15.33	2.10	7.97	280.34	0.00	263.66	0.00
	Physics	15.36	0.28	0.50	82.45	0.00	81.89	0.01
Masters	Any	14.91	20.84	27.20	30.54	0.00	35.49	0.00
	Bus. / Econ.	14.90	4.95	5.88	18.58	0.27	30.41	0.08
	Hum. / So Sci. / Educ.	14.89	11.60	15.20	31.10	0.00	34.82	0.00
	Eng./ Nat. Sc.	15.01	4.33	6.24	43.94	0.00	48.05	0.00
Doc./Prof.	Any	15.53	4.33	9.56	120.95	0.00	132.56	0.00
	STEM	15.47	0.73	1.30	78.60	0.00	90.77	0.00
	Law	15.65	1.84	4.35	136.85	0.00	144.77	0.00
	Medical Degree	15.48	1.29	3.38	161.30	0.00	173.83	0.00

SOURCE.— National Survey of College Graduates (NSCG)

NOTE.— This table reports the gap in major choice by parental education. The estimates are based on the NSCG surveys conducted in the years 1993, 2003 and 2010. Column I reports the average years of education (of both parents) for students graduating in the major. Column II and III report the percent chance of graduating with the major for first generation students and for students with both parents holding a college degree respectively. Columns IV reports the percent difference between the means in columns II and III (as a percent of column II) and Column V reports the P value of the difference. Columns VI reports the corresponding percent difference controlling for race, gender, birth year, survey year and birth cohort and Column VII reports the P value of the difference respectively.

arts stands out with students with college-educated parents almost three times more likely to graduate with this major than their counterparts. We also report the percent of students in a major whose parents have a high school degree, college degree and advanced degree in Appendix Table A-2.

2.4 Employment and Earnings by College Major

Next, we examine basic patterns in employment and earnings by undergraduate majors. We do so in part as motivation: if there were limited differences in employment and earnings, one of the key rationale for studying major differences (rather than simply education differences) would be missing. Note that our descriptive analysis does not necessarily reflect the "causal" impact of majors on these labor market outcomes. A rich literature, which we summarize below, has studied this issue, and uses various methods to understand selection into majors.

We use information from the 2016-18 ACS. The Data Appendix provides more detail on sample construction. Table 2 reports the labor force participation rate, the unemployment rate and the earnings by major and age categories. To provide some context, we include statistics for individuals with some college education but no bachelor's degree, including individuals with associates and other two year degrees. This group is labeled as "No Grad" in the table.

In general, we find small differences in labor force participation and unemployment across majors at younger ages. The differences in participation rates and unemployment rates are quite sizable at later ages. We see that among students with a bachelor's degree, starting at age 35, labor force participation rates are lower for those with a major in the Humanities, Social Science or Education and unemployment rates are higher. Notably, we see that individuals without degrees but some college have an unemployment rate about twice as high as that of college graduates.

Next, we explore earnings differences. We focus on the population working full year (50-52 weeks) and full time (at least 35 hours). The mean and median earnings by major and age groups are reported in Table 2, and Figure 3 displays the mean age earnings profile. There are significant differences in earnings across majors and these differences increase with age. Graduates with STEM degrees have the highest average and median earnings, and those with

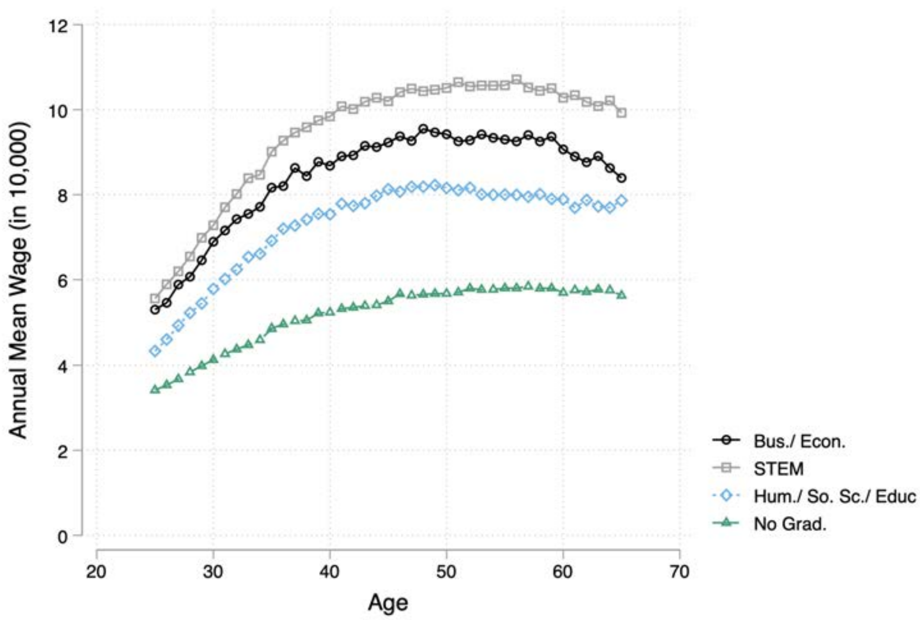
Table 2: Earnings and Employment Status by Major

Major Category	Age Group	I Labor Force Participation	II Unemployment Rate	III Mean Earnings	IV Median Earnings
Bus. / Econ.	25-34	91.51	2.65	6.65	5.84
	35-44	90.16	2.46	8.68	7.68
	45-54	89.86	2.62	9.36	8.37
	55-65	76.32	2.95	9.12	8.10
STEM	25-34	89.69	2.47	7.15	6.49
	35-44	91.92	1.86	9.73	9.00
	45-54	91.58	2.14	10.48	10.00
	55-65	76.53	2.64	10.40	10.00
Hum. / So. Sc./ Educ.	25-34	89.86	2.86	5.62	4.81
	35-44	87.70	2.32	7.50	6.28
	45-54	87.30	2.57	8.13	6.86
	55-65	67.28	2.85	7.88	6.66
No. Grad.	25-34	84.29	5.48	4.02	3.51
	35-44	83.94	4.35	5.17	4.50
	45-54	82.12	3.67	5.68	5.00
	55-65	63.91	3.50	5.77	5.00

Source.— American Community Survey (ACS)

Note.— This table reports the earnings and employment statistics by age and major. The sample includes all individuals with some college, associate's degree, bachelor's degree, master's degree, professional degree beyond bachelor's and doctoral degree. The sample pools data from 2016 to 2018. Column I reports the labor force participation rate by age group and major. Column II reports the unemployment rate (unemployed as a fraction of the total labor force). Columns III and IV report the mean and median earnings by major and age group in $ 10,000. The sample for earnings estimates includes all full time and full year workers. Full time workers are defined as the sample for whom usual hours worked last week is at least 35 hours and full year is calculated as 50-52 weeks worked last year. No Grad. refers to individuals with some college education but no bachelor's degree, including individuals with associates and other two year degrees. Earnings are bottom coded at $ 12,293 and top coded at $ 190,000. All earnings values are in 2018 $ 10,000.

Humanities, Social Science, or Education degrees the lowest. Average earnings for STEM degree holders are about 25-30 percent higher than for Humanities, Social Science, and Education majors; the difference in median earnings is even larger. Business and Economics majors are in between these two major groups. These differences in earnings among college graduates by major are substantial, compared to about 40-45 percent difference in average earnings between the some college group and the lower earning Humanities, Social Science, and Education college graduates.[1]



SOURCE.— American Community Survey (ACS)

NOTE.— This figure reports the mean wage earnings by age and major. The sample includes all full time, full year workers. Full time is the sample for whom usual hours worked last week is at least 35 hours and full year is 50-52 weeks worked last year. No Grad. refers to individuals with some college education but no bachelor's degree, including individuals with associates and other two year degrees. Earnings are bottom coded at $ 12,293 and top coded at $ 190,000. All values are in 2018 $ 10,000. The figure pools data from 2016 to 2018. The sample includes all individuals with at least some college, and all individuals are classified according to their undergraduate major, regardless of whether they have completed a graduate degree.

Figure 3: Mean Age Earnings Profiles by Major

Given these large differences in earnings by major as well as demographic differences

[1] Note that these statistics are for all college graduates, including those with advanced degrees; individuals are classified according to their undergraduate major. See Appendix A for additional tabulations.

in college major choice, a rich literature has carefully studied the extent to which these differences reflect sorting into majors, as opposed to higher returns to certain fields. We describe this literature in the following sections.

3 Labor Market Earnings

We begin our overview of the existing research on the determinants of college major choices with labor market earnings.

3.1 Early Work

Although there was some earlier related work by Freeman (1971, 1999); Siow (1984); Zarkin (1985) on selection into particular college educated occupations (lawyers, engineers, teachers), which we briefly review below, Berger (1988) was one of the first papers to study this question specifically in regard to college majors. Using a rational expectations approach, Berger (1988) assumes that utility from each major is a function of the discounted value of lifetime expected earnings and a non-pecuniary major specific component. Identification comes from some key assumptions. First, he assumes that agents have rational expectations. Second, agents are uncertain about future earnings streams but there is no uncertainty regarding college completion. Third, all time variation in college major choice across cohorts is coming from variation in the monetary returns. Berger (1988) finds that students are influenced by the future flow of earnings rather than just the initial earnings when they are choosing their college major. Subsequent research has gradually relaxed these assumptions, and generalized the model of major choice. We discuss these innovations below. First, we review an area of research that has received a lot of attention, the role of pre-college ability in earnings determination and college major decisions.

3.2 Ability

It is likely that a key determinant of college major choice and its consequent labor market returns is student ability established prior to college. Past work has established that there are large differences in ability at college entrance across majors (measured with test scores such as SAT math and verbal scores) (Turner and Bowen, 1999).

Motivated by large earnings and ability differences across major as well as the complimentarities between them, researchers have been trying to understand the extent to which earnings differentials are driven by sorting by ability. For example, does the wage premium for an Engineering degree remain if students were identical in their ability across majors. Sorting on ability is an issue that has been foundational to research on schooling decisions, and early papers by Altonji (1993) and Keane and Wolpin (1997) have used dynamic structural models of schooling to address selection, allowing for heterogeneity along various dimensions. Altonji (1993) in particular was the first to incorporate college major choice in this context. Since then, a number of papers have used a similar methodology to develop and study dynamic models of college major choice (Arcidiacono, 2004; Beffy et al., 2012; Stinebrickner and Stinebrickner, 2012). According to the estimates of Arcidiacono (2004), most of the ability sorting occurs due to preferences for majors and the workplace rather than differences in pecuniary returns. Further, the earnings differences persist even after controlling for selection. An additional advantage of dynamic structural models is the ability to model detailed aspects of the decision of choosing major by school year. This is particularly important since major switching in college is fairly common in the US (Arcidiacono, 2004; Stinebrickner and Stinebrickner, 2012, 2014a,b).

Related to this body of work, several studies have explored another measure of pre-college ability, namely high school preparedness. These studies have studied the role of high school curriculum in college major choice, particularly in explaining gender differences in STEM majors. Aucejo and James (2019) study the role of high school preparation in the gender gap in STEM majors. Specifically, they estimate a dynamic production function of math and verbal skills and their role in explaining gender differences in college education and major choice. They implement this method on a rich panel database in the UK that follows students from elementary school to university. They find that verbal skills play a greater role in university enrollment than math skills, and that women have a comparative advantage in verbal skills. This has implications for the gender gap in STEM majors. Similarly, using rich administrative data from high school students in Ontario along with data from the province's university admission system, Card and Payne (2017) find that the main source of the gender gap in STEM major choice is the lower overall rate of university attendance by men. Differences in high school course-taking patterns and preferences for STEM, conditional on readiness, explain part of the gender gap in major choice. Humphries et al. (2019) use rich Swedish administrative data to study the role of multidimensional ability and secondary school track choice on college preparedness and labor market outcomes. They find strong complementarities between high school decisions and college and post-college outcomes.[2]

3.3 Earnings Uncertainty

Although a large literature has looked at how the *level* of earnings is related to college major choice, less is known about its relationship to the *uncertainty* in earnings. Several decades of research has emphasized the importance of earnings risk and life-cycle earnings growth in understanding human capital investment choices. One strand of this past work suggests that lifetime earnings risk varies significantly across education and occupations, and that these differences are an important driver of choices (Flyer (1997); Nielsen and Vissing-Jorgensen (2006); Bonin et al. (2007); De Paola and Gioia (2012); Belzil and Leonardi (2013); Fouarge et al. (2014); Barth et al. (2017); Dillon (2018)). Educational investment can be viewed as a risky investment and therefore agents may demand a higher premium for careers with more risk. Using this framework, Saks and Shore (2005)) focus on the relationship between earnings risk and major choice and find that Education, Health and Engineering are "safe" investments whereas Business, Sales and Entertainment related majors are more risky. Additionally, they find evidence of sorting by wealth into these high-risk majors, particularly Business.

3.4 Identifying the Labor Market Returns to Major Choice

A related literature focuses on methods of identifying the labor market returns to college major choice. The key econometric problem is that college majors are self-selected, and

[2] Jain et al. (2018) study STEM high school track choice and its relationship to earnings in India. They show that studying Science in high school is associated with 22 percent higher earnings than studying Business or Humanities.

there can be sorting into majors based on factors that affect the labor market return. For example, there could be sorting on *comparative* advantage whereby students who choose to study Engineering tend to be good at Engineering relative to teaching, and therefore have a higher labor market return to an Engineering degree relative to a degree in teaching. For this reason, the observed earnings differences by major (as we show above) would be a biased estimate of the labor market return. There can also be sorting on *absolute* advantage as potential labor market earnings could be correlated with unobserved skills or non-pecuniary tastes which affect major choices. For example, if students with greater overall labor market ability have preferences for non-pecuniary characteristics of Business majors, they would sort by *absolute* advantage into Business. Once again, this would result in biased estimates of the returns to a Business major.

Several recent papers have used variation in demand side driven labor market returns to study the responsiveness of college major choices to earnings. Beffy et al. (2012) estimate the earnings elasticity using a sequential model of schooling. They exploit variation in the French business cycle to identify earnings elasticities. More recently, Long et al. (2015), using descriptive analysis, find a significant relationship between lagged occupation-specific wages and college major choice in related fields. This relationship is stronger for fields that are closely connected to specific occupations. There is also evidence that exposure to higher unemployment rates makes students choose majors with higher earnings (Blom et al., 2019; Bedard and Herman, 2008). Similarly, in a recent paper, Abramitzky et al. (2019) take advantage of a unique setting in traditional Israeli communities, where Israeli kibbutzim shifted from their traditional policy of equal sharing to productivity-based wages. In this setting of very low initial returns to education, they find that the large increase in the rate of return and its sharp variation across fields of study led to a large increase in the probability of receiving a Bachelor's degree (by 3.3 percentage points), especially in fields of study with high financial returns, such as STEM (3.8 percentage point increase).

Other studies have tried to address the selection issue using rich measures of otherwise unobserved determinants. Many studies use various measures and correlates of ability, including demographic characteristics, test scores, high school GPA, parental income and education. Additionally, some research includes measures of college quality (Loury and Garman, 1995;

Rumberger and Thomas, 1993), high school curriculum (Altonji, 1993; James et al., 1989), personality traits (Webber, 2014), and course content (Hamermesh and Donald, 2008). The methods used range from regressions with rich sets of control variables, to more sophisticated methods correcting for selection, including Webber (2014) who implements the approach by Altonji et al. (2005) and control function approaches (Berger, 1988). However, as is typical, crucial to a credible identification strategy is the presence of an exclusion restriction. In practice, variables that affect the choice of major but do not affect wages are hard to come by.

A branch of the literature has exploited eligibility requirements in various countries to implement a Regression Discontinuity (RD) design (Bertrand et al., 2010; Hastings et al., 2013; Kirkeboen et al., 2016; Andrews et al., 2017). Many countries allocate students to majors competitively based on various admissions criteria. Students provide a ranking of the programs, and a centralized system allocates students to their most preferred choice conditional on qualifying for the program. RD designs compare students who were just above the admissions threshold to those who were just below the threshold, provided there are sufficient number of observations around the cutoff. A challenge for implementing this design in the context of major choices is that choices are multiple and unordered. For this reason, the treatment effect of choosing a major is relative to a mixture of students who chose all other majors. In order to identify the treatment effect of choosing a major relative to a second major, studies make further assumptions (Hastings et al., 2013) or use additional information on rankings (Kirkeboen et al., 2016).

The post-secondary system in Chile has score-based admissions rules which allows Hastings et al. (2013) to estimate the returns to various degree programs using an RD approach. They parameterize earnings as a linear function of comparative advantage in each major and absolute advantage. Their RD design eliminates selection on absolute advantage. They then express the comparative advantage as a function of observables and assume that there is no selection into fields based on unobservables that influence earnings for those near the cutoff. This allows them to calculate the field specific premia for those near the threshold for particular values of the observables. They find heterogeneous returns and particularly high returns to selective degrees such as Health, Science and Social Science.

Kirkeboen et al. (2016) use data from Norway where a similar centralized process for admission into most universities exists. They use information on course rankings and discontinuity in cutoffs to implement a *next-best alternative* identification strategy. This approach identifies the returns to a chosen field *relative* to a next best alternative, allowing for heterogeneity in returns along this dimension. They find that different fields have widely different payoffs depending on alternatives. For example, by choosing Science *instead* of Humanities, individuals vastly increase their earnings early in their working career, whereas if they choose Science *instead* of Engineering, they have a low return to their major.

Eckardt (2020) is one of the first papers to estimate the returns to various combinations of college majors and occupations, in a particular context of apprenticeships in Germany. She takes advantage of detailed administrative data on German apprentices, which links training and occupations. She links this database to historical data on occupation specific vacancies, which serve as close proxies for occupation specific labor demand. She then uses expected vacancies in occupations other than the chosen training occupation as instruments for a particular training choice. Similarly, she uses shocks to these expectations in occupations other than the chosen one as instruments for a particular occupation choice. Eckardt (2020) finds that workers employed in occupations related to their training earn 10 to 12 percent more than those who are employed in occupations different from their training. This suggests that there are positive returns to specialization in such a system.

The choice of occupation closely mediates this relationship between earnings and major choice and so, researchers have been looking at various methods of understanding this mapping.

3.5 Majors and Occupations

There is an emerging literature that studies the relationship between college major choice and occupations. Several papers have shown the degree to which majors are concentrated in certain occupations (Ransom et al., 2014; Black et al., 2003; Altonji et al., 2012; Lemieux, 2014; Ransom, 2016). In a recent paper, Sloane et al. (2019) document these mappings and substantial gender differences in these choices. Even conditional on major, women systematically choose lower potential wage and lower potential hours-worked occupations than men. There is also research that has examined the extent to which workers report that their work activities are unrelated to the college major (Robst, 2007).

Past work has modified structural models of human capital investment to account for the specificity of skill gained by specialization in college. Kinsler and Pavan (2015) , in their structural model of human capital, allow for both skill uncertainty and differential accumulation of human capital across majors. The model is a dynamic Roy Model where workers select into their major, and then their job type. Both the math and verbal human capital evolve and students observe noisy signals about their human capital during college but learn about their true human capital in the labor market when they choose a job. Their findings indicate that the average returns to obtaining a Business or Science degree, although quite large, are smaller than the raw gaps would indicate. The combination of skill uncertainty and the specificity of the return appear to make majoring in a Science related field less attractive.

Related work by Arcidiacono et al. (2017) has used extensive data on subjective expectations, especially on outcomes from counterfactual choices and choice probabilities of majors and *occupations*. By explicitly eliciting beliefs about probabilities and expected returns to particular majors and occupations from Duke University undergraduate students, they are able to identify a model of occupational choice with minimal assumptions on beliefs and preferences. They find large differences in expected earnings across occupations, and complementarities between majors and occupations. They find that sorting is largely driven by non-monetary factors. Recognizing the multidimensional nature of skills (Heckman et al., 1998; Keane and Wolpin, 1997), an alternative "task-based" approach has been employed by Stinebrickner et al. (2020) to study the role of differences in task-specific skill accumulation for explaining the gender wage gap. Importantly, by collecting longitudinal job-level task information as well as explicit time allocation information to circumvent issues typically faced by the literature, they find that (1) majors are strongly related to current period tasks. For example, business majors spend over 33 percent more time in high skilled tasks that interact with information than Humanities majors; (2) there is also substantial variation in these task specific measures by gender, *within* major. For example, women in Social Science majors spend 21 percent less time on high skilled tasks that interact with information than men.

These task measures, in turn, account for a considerable fraction of the gender wage gap. This emphasizes the need for more research on understanding the determinants of major and occupation choice, and the role of pecuniary and non-pecuniary factors in the decision process.

4 Learning and Dynamics

A stream of research has tried to rationalize major switching by modeling the *process* by which a student chooses her college major. The choice of major can be viewed as the outcome of a learning process through which an individual gradually learns his or her "match quality" with the major. This approach is in the spirit of learning models used in the context of other educational outcomes (Manski, 1989; Altonji, 1993), where students learn not only about their own ability in school but also about their labor market returns from graduating with the majors.

Arcidiacono (2004) incorporates learning in a dynamic model of college major choice where the uncertainty emerges from imperfect information about ability. He finds that this is particularly important in the context of major switches and drop out decisions. For example, students who perform poorly may find it beneficial to switch into a less difficult major or to drop out altogether. Related to this, Stange (2012) studies the option value of college attendance using a dynamic structural model. He models the decision to enroll in two-year or four-year college as well as enrollment and grade outcomes. Enrollment, in his model, has value because it resolves uncertainty along various dimensions: collegiate aptitude, non-persistent shocks to the relative cost of college, and finally uncertainty related to wage outcomes. Arcidiacono et al. (2016a) build on the previous work and allows for imperfect information about schooling ability as well as labor market productivity. Their innovation is to allow for correlated learning through college grades and wages, whereby individuals may leave or re-enter college as a result of the arrival of new information on their ability and productivity. Their findings stress the importance of informational frictions.

A body of work collects panel data from currently enrolled college students about their expectations regarding completing various majors and outcomes (such as earnings). Stinebrickner and Stinebrickner (2012, 2014a,b) use data from their Berea Panel Study and find that students are over-optimistic about attaining a Science degree, and a large number of those students eventually switch out of those majors. The over-optimism can be attributed to biased beliefs about own ability to perform well in Science courses. Similarly, in a different paper, Stinebrickner and Stinebrickner (2014a) find that 45 percent of dropouts that occur in the first two years of college can be attributed to what students learn about their academic performance, but that this type of learning becomes a less important determinant of dropout after the midpoint of college. In their unique setting in Berea College, students receive a full tuition subsidy (and a large room and board subsidy). This allows them to focus on non-financial explanations for dropping out, namely learning about academic performance. Finally, Gong et al. (2019b) investigate how uncertainty about future income is resolved in college. They find that roughly a third of the income uncertainty present at the time of entrance is resolved by the end of college, primarily through factors such as college GPA and major.

Zafar (2011) studies expectations formation using a sample of sophomore students in Northwestern University and finds that students do have biased beliefs about their *own* major specific ability. Students are likely to overestimate their own future academic performance. However, he finds that students revise their expectations in a way that is consistent with Bayesian updating. Other work using subjective expectations surveys such as Arcidiacono et al. (2012a) at Duke University also finds a similar overestimation of self ability.

Similarly, Wiswall and Zafar (2015) conduct an information experiment on undergraduate students at New York University and collect beliefs about their own earnings at various points in the life cycle as well as population earnings (that is, the students' beliefs about the earnings of current college graduates). Using this rich panel of beliefs, they study the extent to which students are biased in their beliefs about population earnings as well as their responsiveness to information about these earnings. Their findings indicate that students have biased beliefs about earnings and there is considerable heterogeneity in errors, which is uncorrelated with observable characteristics. Unique to their study, they are able to study how students revise their *self* beliefs, and find substantial heterogeneity in the students' updating heuristics.

The importance of information frictions has also been studied by complementing experimental variation with large scale surveys by Hastings et al. (2015). Information on earnings and cost outcomes by major, provided to college applicants in Chile, caused low income students to reduce their demand for low return degrees. They find that these interventions are important for reducing uncertainty about college outcomes.

Finally, Conlon (2019), in a field experiment at a flagship state university, finds that students, on average, underestimate mean salaries by majors. However, he finds large heterogeneity in beliefs across students, similar to other research. Importantly, he finds that students who are treated with earnings information about a given field are significantly more likely to major in that field. Thus, existing evidence shows that information frictions are important in this context, and that simple information interventions can have meaningful impacts on beliefs and major choice.

Looking beyond earnings information, there are now several papers that explore other interventions or natural variation to investigate student-major mismatch. Fricke et al. (2018) exploit a natural experiment in a Swiss university that allows them to test whether exposure to a field (in the form of a research term paper in the first year of studies) influences major choice. They find compelling evidence that writing in the field increases share of students in that major. Likewise, Patterson et al. (2019) find that students at the United States Military Academy who are randomly assigned to take certain courses during (as opposed to after) the semester when they have to select a major are more likely to choose a major that corresponds to the course. Given the low switching costs, this is a puzzle and suggests that timing of exposure to subject content can be a crucial aspect of major choice—something that is not very well understood. Arcidiacono et al. (2016b) studies the implications of better matching for minority Science graduation rates at University of California campuses. Less prepared minorities at higher ranked campuses had lower persistence rates in Science and took longer to graduate. Additionally, they stress the importance of information and better matching of students to courses and universities for improving persistence rates.

Relatedly, Bordon and Fu (2015) study the possibilities of student-major mismatches using college-major-specific admissions policies in post-secondary education in Chile. They study the *equilibrium* effects of postponing student choice of major using a model that allows for match uncertainty and peer effects. Their estimates indicate that allowing students to postpone their major choice leads to an increase in average student welfare. In a complimentary paper, Malamud (2011) also examines the effects of changes in the timing of specialization, exploiting variation in the British system of specialization in England and Scotland. The outcome of interest in his setting is whether students switch to an occupation unrelated to their specialization. Interestingly, he finds that individuals in England who specialize early are more likely to switch to an unrelated occupation. However, higher wage growth among those who switch eliminates the wage differences between Scotland and England after several years.

5 Subjective Expectations

The studies that we have reviewed in Section 3 use revealed preference data to understand the drivers of major choice. The goal for the researcher is to recover parameters of the utility function from actual observed data. In general, this requires three additional layers of assumptions: i) an assumed mapping between revealed or actual post-graduation earnings to beliefs about earnings (or any other elements of post-graduation utility) for the major that is chosen, ii) an assumed model for counterfactual beliefs about earnings (or any other elements of post-graduation utility) in majors not chosen, and iii) an assumed distribution of tastes for all majors. The prior literature makes various types of (implicit or explicit) assumptions along these dimensions. This approach overlooks the fact that subjective expectations may be different from objective measures, assumes that formation of expectations is homogeneous (conditional on some observables), and uses choice data to infer decision rules conditional on maintained assumptions on expectations. This can be problematic since observed choices might be consistent with several combinations of expectations and preferences, and the list of underlying assumptions may not be valid. This identification challenge has been outlined by (Manski (1993)), and has spurred a large literature on the direct elicitation of subjective expectations (see Manski (2004) for a review of earlier work in this space.

In order to understand the determinants of college major choice, a growing body of research has incorporated subjective expectations and, in some cases, exploited information experiments. These studies use information about expectations about earnings (as well as other outcomes) conditional on graduating with a major and the probability of pursuing each of these majors. Importantly, to estimate choice models, the researcher needs to elicit expectations not only for the chosen major but also the *counterfactual* majors. This approach requires the researcher to collect their own data and is typically restricted to one academic institution.

The earliest attempt that we are aware of that collects subjective expectations data in the context of college majors is the Berea Panel Study (BPS). The BPS, starting in the early 2000s, collected detailed information from Berea College students, every semester, regarding their expectations over outcomes, such as college major choice, as well as potential determinants of these outcomes. These data, for example, are useful in understanding how students learn and resolve uncertainty about major choice over the course of their studies (Stinebrickner and Stinebrickner, 2014b). Other papers that have used this dataset include Stinebrickner and Stinebrickner (2008, 2012, 2014b). This high-frequency data is valuable in characterizing uncertainty at various stages in college, that might be important for determining the timing of information interventions.

Zafar (2013) is the first effort that uses subjective expectations data, collected from Northwestern University undergraduate students, to directly estimate a model of college major choice.[3] His results point to low earnings elasticities, as is the case with previous papers (Arcidiacono, 2004). Arcidiacono et al. (2012b) collect similar data from Duke undergraduate male students, and similarly find that both expected earnings and ability are important drivers of major choice. They also document substantial errors in students' perceptions of major-specific earnings in the population. Their simulations show that a non-trivial proportion of students would switch majors if they had accurate perceptions. Wiswall and Zafar (2015) further use an information experiment and a panel of beliefs to *difference* out major-specific tastes, that may be correlated with expected earnings. The argument being that students who have positive tastes for a given major may also expect to earn more in that major. Accounting for this, they find that earnings elasticities are even smaller. The

[3]Beyond the choice of college majors, Delavande (2008) is the first paper that estimates a random utility choice model using solely subjective expectations data. Their application is the choice of birth control.

methodological innovation in this approach is to elicit a panel of choice probabilities as well beliefs about the potential determinants of these choices before and after an experimental intervention. By creating this panel over a short time period, this approach creates a setting where there are minimal changes in the environment and therefore any changes in choices can be credibly attributed to the intervention. This approach has spurred a literature that has increasingly employed information interventions to understand the formation of expectations and the link with behavior, in other contexts (for example, see Armona et al. (2019) in the context of home price expectations and Coibion et al. (2020) in the context of inflation expectations.

Most of the papers on college major choice do not elicit beliefs regarding occupation characteristics after graduating from a particular major. However, as mentioned earlier, Arcidiacono et al. (2017) elicits additional beliefs on *occupation-specific* probabilities conditional on pursuing a major as well as expected earnings for each of those major-occupation pairs. The study finds a large role of non-pecuniary factors in occupation choice.

Another advantage of collecting subjective expectations data directly from individuals at a stage prior to their major choice is that the data can be used to directly recover ex ante treatment effects, that is, how the student believes the college major will affect their future outcomes. This concept is distinct from ex post treatment effects of majors. It is, after all, the ex ante beliefs, and not ex post outcomes, that are relevant for understanding behavior. Data on ex-ante expectations also allow the researcher to characterize the nature of sorting. Both Wiswall and Zafar (2019) and Arcidiacono et al. (2017) show evidence of students sorting based on ex ante returns into majors and occupations, respectively.

It is also worth noting that several papers in this growing literature have followed these students over time, and validated that subjective expectations are indeed predictive of future outcomes (Arcidiacono et al. (2017); Wiswall and Zafar (2019); Gong et al. (2019a); Stinebrickner and Stinebrickner (2014b)).

Finally, many papers in this area have employed the estimates from these choice models to understand gender differences in college major choice. They find that most of the differences in college major choice by gender can be attributed to differences in "tastes" (Zafar, 2013; Wiswall and Zafar, 2018). Zafar (2013) finds that even though enjoying coursework and gaining parental approval are the most important determinants of major choice for both genders, the two genders differ in various other preferences. Men care about pecuniary outcomes to a much larger degree than women. Several consequent studies have tried to understand this "taste" component (Wiswall and Zafar, 2019, 2018). We explore these explanations in more detail in the next few sections.

Although recent advances allow researchers more flexibility to estimate models without making strong assumptions about students' expectations at the time of the decision, the data available to researchers typically do not allow them to incorporate individual-specific risk and discounting components into utility. And, as a consequence, past research instead typically assumes particular functional forms for utility and imposes homogeneity. This is despite the well-documented heterogeneity of risk aversion and discounting across individuals (see Niederle (2014) for a review) and the evidence suggesting that these measures are related to educational sorting.

Some recent progress in this area is Patnaik et al. (2020), who use a unique dataset of beliefs of NYU students with three key features: a) individual beliefs about the level of earnings, earnings growth, and earnings uncertainty for a set of possible college major choices, b) survey-based individual measures of risk tolerance and patience, and c) an experimental component. This is the same dataset used by Wiswall and Zafar (2015). Consistent with prior literature, they find that women, on average, are more risk averse and patient than men and that there is substantial heterogeneity in these measures *within* gender. The paper's methodological innovation is to use these individual-specific measures on time and risk preferences in a life-cycle model of college major choice, while imposing limited structure on the choice problem. They find that models which assume standard, homogeneous levels of discounting and risk aversion are likely to overestimate how sensitive students' college major choices are to expected earnings.

Additionally, some recent work has explored the role of other traits in explaining gender differences in major choice. Buser et al. (2014), for example, find that secondary school boys in the Netherlands are substantially more competitive than girls. Their experimental measure of competitiveness is positively correlated with choosing a more prestigious high school academic track. Importantly, it can explain nearly a fifth of the gender gap in track choice.

Similarly , Reuben et al. (2017) use an experiment to measure competitiveness and overconfidence among NYU undergraduate students, and link these measures to expectations about earnings and major choice. They find gender differences in competitiveness and overconfidence. Notably, they find that both overconfidence and competitiveness are systematically related to earnings expectations, but neither seems to explain college major choice.

6 Non-Wage Considerations

The existing major choice literature has found that while choices are responsive to expected future earnings, the choice elasticity is relatively low, suggestive of non-pecuniary considerations potentially being quite important. In college, these non-pecuniary concerns may include the enjoyability of courses, something that has been found to be important for major choice (Zafar, 2013), as well as for explaining socioeconomic gaps in college attendance (Boneva and Rauh, 2019).

The non-pecuniary concerns *post* college can include how major choice affects job amenities and various family domains (marriage, spouses, children). Several studies have documented the relationship between educational attainment and marriage market prospects and the implications for inter-generational mobility. For example, Eika et al. (2019) show descriptive evidence on assortative mating from Denmark, Germany, Norway, the United Kingdom, and the United States to document the degree of educational assortative mating. Recent papers have analyzed the role of marriage market returns in human capital investment (Iyigun and Walsh, 2007; Ge, 2011; Attanasio and Kaufmann, 2017; Kaufmann, 2014; Lafortune, 2013; Chiappori et al., 2009, 2017). Studies have further looked at the returns to the *quality* of human capital investment: Kaufmann et al. (2013) focuses on estimating the marriage market return of attending an elite university. In an RD design which exploits the centralized admission system in Chile, they find that attending a higher ranked university program has positive returns in terms of partner quality (as measured by the partner's test scores and socioeconomic background), and in terms of children's test scores. Similarly, a different line of research studies the role of job amenities associated with careers and the implications for human capital decisions (Bertrand et al., 2010; Goldin and Katz, 2011; Flabbi and Moro, 2012; Goldin, 2014; Kleven et al., 2019). This concern is particularly relevant for studying gender gaps in career choices and labor market outcomes, where we might expect that certain job amenities such as workplace hours flexibility is particularly important to women who anticipate labor market disruptions due to childcare.

Wiswall and Zafar (2019) and Gong et al. (2019a) study the relationship between major choice and expectations about marriage and labor supply by directly collecting subjective expectations data from college students. In their sample of NYU students, Wiswall and Zafar (2019) find that both men and women in their sample anticipate that the choice of major would have a large impact on marriage timing, spousal quality, fertility timing, as well as the number of children. For example, both men and women perceive a positive return in the marriage market from completing their degree, with men on average perceiving their chance of being married to be over 35 percent higher, and women perceiving it to be 13 percent higher. Additionally, female students perceive a marriage penalty to completing a degree in Science and Business, believing that if they complete these degrees it would delay marriage. Overall, they find that "family" considerations – marriage, spousal earnings, and fertility – are economically and statistically significant correlates of major choice, but primarily for women. They also show that omission of these variables biases upwards the importance of earnings in major choice.

A growing body of research uses observational data to investigate non-pecuniary considerations in the context of major choice. Bronson (2014) shows the importance of work hours flexibility and changes in divorce laws and divorce risk in explaining longer term trends in major choices. She provides reduced-form evidence that higher earning degrees provide insurance for women, especially in the case of divorce. Additionally, majors differ substantially in the degree of "work-family flexibility they offer, such as the size of wage penalties for temporary reductions in labor supply. She then uses a structural model to test the effects of educational and work-family flexibility policies on educational choices, and finds that some "family-friendly" policies, such as extended maternity leaves, increase the gender gap in majors further, while part-time work entitlements and child care subsidies have the potential to reduce the gap. Similarly, Wasserman (2015) uses data on US medical school graduates to study the relationship between workplace characteristics and women's fertility choices. The author investigates this question by studying a 2003 policy that capped the average work week for medical residents at 80 hours. She finds that when a specialty reduces its weekly hours, more women enter the specialty. More recently, Artmann et al. (2018) estimate the causal effects of field of study on a variety of family outcomes such as having a partner, own earnings, partner and household earnings, and number and "quality" of children. They exploit admissions lotteries for 16 cohorts in universities in the Netherlands and compare students who won the lottery and majored in their preferred field with students who did not win and entered their next best field. Their evidence supports the hypothesis that field of study matters for partner choice, although they do not find any effect on fertility.

Finally, Wiswall and Zafar (2018) use a hypothetical choice methodology to estimate preferences for workplace attributes from their sample of high-ability undergraduates attending NYU. They estimate that women on average have a higher willingness-to-pay (WTP) for jobs with greater work flexibility and job stability, and men have a higher WTP for jobs with higher earnings growth. In their sample, students perceive jobs to differ along these dimensions. And because students anticipate that majors are linked to certain jobs, these job preferences affect college major choices. Providing some validation of the data collection, they also show that these preferences elicited in college are related with characteristics of actual workplaces reported in a follow-up survey four years after graduation. They conclude that in this sample, gender differences in preferences for non-wage amenities explain at least a quarter of the early career gender wage gap.

7 Family, Peers, and Role Models

A sizable literature has examined the impact of family, peers, and role models on major choice. This literature often finds important effects, and can provide a partial explanation for the (gender, race, and SES) gaps observed in major choice. In this section, we review this strand of the literature.

7.1 Decision Making within the Family

Some work has explored the role of family in college major choice. Although most of the literature has looked at college major choice as an individual choice problem, the choice of major can also be viewed as an outcome of interactive decision making within the family, including the student's parents or siblings. There is some innovative work that has studied group decision making under uncertainty in the context of education (Giustinelli, 2016; Attanasio and Kaufmann, 2014). Zafar (2012, 2013) uses unique data on subjective expectations gathered from undergraduate students in Northwestern University and finds that that parental approval is an important factor for choosing majors, particularly in the context of double majors. Students believe that their parents are more likely to approve of majors associated with high social status and high returns in the labor market. Xia (2016) shows that students learn about earnings in different majors through the wages of their parents and older siblings. In addition, she shows that the probability of a student choosing a major related to the occupation of a close family member is strongly correlated with the family member's wages at the time the student is choosing the major. This suggests a family-based wage information channel. Oguzoglu and Ozbeklik (2016) show that, in families with a father in a STEM occupation, the likelihood of a woman choosing a STEM major is significantly lower if she has brothers. This points to some interesting transmission of information and/or preferences within the family that depends on household composition. More recently, Neilson et al. (2020) shows causal evidence from Chile, Croatia, and Sweden that the college and major choice of younger siblings is significantly affected by their older siblings' choices. Using a regression discontinuity design that exploits the centralized admissions systems in these countries, they show that younger siblings in each country are significantly more likely to apply and enroll in the same college and major that their older sibling was assigned to.

These papers suggest that dynamics within the family matter in the choice of major. Evidence indicates that this is, partly, due to inter- and intra- generational transfer of information and preferences. However, we have a limited understanding of the underlying mechanisms. Similar conclusions are reached by Giustinelli and Manski (2018) in their review of family decision-making in the context of secondary schooling.

7.2 Peers

In recent years, a large literature has emerged that investigates the role of peers in major choice. Sacerdote (2001) exploits the random assignment of freshman year roommates at Dartmouth College to study the effects of peers in student outcomes. While he finds evidence of peers affecting grade point averages and social activities of students, he finds no evidence of major choice being impacted by peers. De Giorgi et al. (2010), exploiting the random assignment of students to sections in mandatory courses in the initial semesters at Bocconi University, finds that students are more likely to choose a major that their peers choose.

Peer effects have also been explored as a possible explanation for the gender gap in major choice. Feld and Zölitz (2018), using an identification strategy similar to De Giorgi et al. (2010), find that high-achieving male peers increase (decrease) the likelihood of male (female) students taking Math courses. Similarly, Zölitz and Feld (2019) look at peer effects for women in Business school. Interestingly, they find that women who are randomly assigned to teaching sections with more female peers are less likely to choose majors such as finance, which have a large proportion of men. Additionally, having more female peers also causes women to choose lower paying jobs with fewer hours. Likewise, Griffith and Main (2019) use data on first year Engineering students in a large selective Engineering school to show that both race and gender of peers affects grades and persistence in Engineering. They find that having more peers from minorities improves grades of minorities.

7.3 Professors and Role Models

There is also a literature that has focused on understanding the effects of role models and professors in major choice, in particular the choice of STEM majors. There is a body of work that has explored the effect of professor gender or race on various academic outcomes in college (Canes and Rosen, 1995; Canaan and Mouganie, 2019; Bettinger and Long, 2005; Hoffman and Oreopoulos, 2007; Fairlie et al., 2014; Kato and Song, 2018; Kofoed et al., 2019).

Carrell et al. (2010) studies the role of instructor gender in explaining the gender gap in STEM majors. They exploit the random assignment of students to professors in mandatory courses at the U.S. Air Force Academy, and find that professor gender has a significant effect on female students' performance , their likelihood of taking STEM courses as well as graduating with a STEM degree. In a recent paper, Mansour et al. (2020) also use data from the US Air Force Academy and exploit the random assignment of students in their mandatory freshman Math and Science courses to study the effects of professor gender on *post-graduation outcomes* such as post-graduate education and the choice of occupation. Using a panel that tracks students for at least 8 years after graduation, they find that for high ability female students, exposure to female Math and Science professors is associated with increases in the probability of graduating with a STEM degree, working in a STEM occupation, and receiving a STEM masters degree.

Some recent work has focused on understanding the absence of role models as a possible explanation for the gender gap in Economics majors.[4] Porter and Serra (2019) use a field experiment where they randomly expose introductory Economics students to role models, who they characterize as charismatic and successful women alumni. They find that exposure to successful role models has large effects on interest in pursuing Economics, increasing enrollment in Economics for female students by 8 percentage points. Similarly, Li (2018) examines whether mentoring, the provision of additional information, and nudges help reduce the gender gap in economics majors via a randomized controlled experiment conducted in introductory economics classes at a large, public, four-year institution. The treatments substantially increase female students' probability of majoring in economics. The results show that the treatment effects are heterogeneous and have the most significant impact on female students with grades above the median.

8 Supply Considerations

So far our discussion of the determinants of college major choice has focused on student level factors that can influence the demand for majors. However, the choice of major also depends on various supply side factors determined by universities. We consider three factors that have

[4]In other work, Bayer et al. (2020) have recently analyzed the pedagogical approach and coursework in the introductory courses in Economics.

been the focus of recent research: major specific costs/pricing, differences in grading policies across majors and, finally, local variation in course offerings.

8.1 Pricing

Motivated by the increase in field-specific surcharges levied in a number of public universities in response to cuts in state funding, a recent body of research considers the effects of major specific costs on college major choice. Most of these policies have been implemented in high return majors such as Engineering, Business and Nursing. Some of these differences may simply be reflecting field specific teaching costs. Using detailed administrative data from the Florida public university system, Altonji and Zimmerman (2017) report that the costs of producing graduates in Engineering is almost double of that of producing Business graduates (a low-cost major).

The literature, as of now, has found mixed effects of these differential pricing policies on major choice. Using the staggered adoption of these policies across universities, Stange (2015) finds a significant decline in the shares of students declaring Engineering in response to higher costs, and a similar (although noisy) decline in share of students declaring Business.

One might be inclined to think that most of this effect may be coming from the higher price responsiveness of the choices of low-income students. However, Evans (2017) finds that financial aid geared towards STEM majors, in the form of Science and Mathematics Access to Retain Talent (SMART) grants in the state of Ohio, has a small effect on increasing the likelihood of students declaring STEM majors. In a recent paper, Andrews and Stange (2019) studies a major price deregulation policy introduced in Texas in 2003, and finds that poor students are *more* likely to major in these high sticker price-high return majors. They explain these results due to the increased price discrimination which translated to higher grant aid for poor students. If we believe that low income students are the most price sensitive students, it is interesting that increased grant aid would increase the likelihood of majoring in STEM in one setting and have a negligible effect on the other. There is clearly more to be learned about these policies and the importance of the institutional setting.

8.2 Grading and Difficulty

Next, we delve into grading policies and the difficulty of course material, another supply side consideration that could influences the choice of major. There is evidence that points to both the existence of differences in grading standards (Dickson, 1984; Freeman, 1999; Johnson, 2006) and the responsiveness of students to these differences (Butcher et al., 2014). Majors that have high returns (and have a high demand) such as Engineering also have lower grades (Sabot and Wakeman-Linn, 1991). Studies have pointed to several possible explanations for the differences in average grades. On the one hand, faculty may provide higher grades to increase the demand for courses, particularly in low return majors such as Humanities majors. On the other hand, instructors in STEM courses (that are often high demand courses) also demand higher workloads from students (Arcidiacono et al., 2012a).

Do these grading policies affect major choices? Recent work by Ahn et al. (2019) studies the relationship between study effort, grading policies, and female interest in STEM majors. To do this, they build and estimate a structural model of student effort and course choice. Ahn et al. (2019) shows that these strict grading policies in STEM disproportionately affect women, contributing to the gender gap in STEM majors.[5]

8.3 Admissions and Capacity Constraints

Finally, universities often have capacity constraints that limit the number of courses or majors that they can offer. These capacity constraints can operate through faculty-student ratios, or constraints on the infrastructure. For example, courses in Engineering often require lab equipment. Similarly, high demand courses such as Business are constrained by the number of faculty who are available to teach courses. Universities often employ rationing devices such as eligibility rules and GPA cutoffs to allot students to majors. There has been considerable policy debate about how universities should allocate students across majors and how important the timing of specialization is.

Researchers have exploited different settings of the post-secondary system to study the

[5]There is related work on study effort and college outcomes, including a series of papers by Stinebrickner and Stinebrickner (2003, 2004, 2006, 2008).

implications of admissions policies and capacity constraints in programs. In countries such as Chile, India and Norway, where majors are decided at the time of admission, there are cutoffs based on a national exam for admission into programs (combinations of college and majors). Several studies have exploited these cutoffs as an exogenous variation in the access to the major to determine the returns to various majors. Bertrand et al. (2010); Hastings et al. (2013); Kirkeboen et al. (2016) have implemented Regression Discontinuity designs using this approach in India, Chile and Norway, respectively. Some of these papers have been discussed in Section 3.

In countries like the United States, students usually do not choose majors at the time of admission. In majors with high demand, such as Business, there are typically university GPA cutoffs to determine entry. Andrews et al. (2017) uses these GPA cutoffs in the state of Texas to implement an RD design. They find that 60 percent of marginal Business students would have otherwise majored in STEM fields. They also find that earnings twelve years after college graduation are higher by 80-120 percent for those induced by the GPA cutoff rules to major in Business. Similarly, in a more recent paper, Bleemer and Mehta (2020) take advantage of GPA eligibility requirements in introductory Economics courses for declaring Economics major in University of California- Santa Cruz. They implement a similar RD design to estimate the returns to an Economics major and find that for students near the threshold, declaring a major in Economics increased their annual earnings by $ 22,000 (58 percent).

In contrast to highly selective universities, some regional universities are unwilling to offer certain courses, particularly for low-demand courses such as Humanities, as was the case at the University of Wisconsin- Stevens Point [6]. There has been an emerging literature that studies such supply side constraints. Bianchi (2019) uses an educational expansion of Italian STEM course offerings and exploits the selective eligibility of this expansion to understand how changes in the access to education can change peer effects, school quality, and the returns to skill.

Finally, Cook (2020) studies these supply-side constraints in the context of an equilibrium

[6] https://www.washingtonpost.com/news/answer-sheet/wp/2018/03/21/university-of-wisconsin-campus-pushes-plan-to-drop-13-majors-including-english-history-and-philosophy/

model of the college market. Universities compete on prices, admissions criteria, as well as the *number of majors* offered. Students choose where to apply as well as where to enroll conditional on receiving an offer. She finds that student willingness-to-pay (WTP) is over $100 per year for each major offered, although this WTP differs depending on the type of major.

9 Beyond Undergraduate Degrees

Although most of the work studying specialization in college considers four-year bachelor's degrees, there is a line of research that focuses on community college and associates degrees and the returns to those degrees, as well as work on graduate degrees.

9.1 Associates Degrees and Community Colleges

Community college degrees are becoming increasingly common in the US with community college students comprising 40 percent of the total undergraduate enrollment (Ma and Baum, 2016). The labor market outcomes become even more important in the context of associates and community college degrees since many of these courses are geared towards training students for a specific career. Further, a large proportion of these students are likely to be first generation students and from disadvantaged populations. Understanding labor market outcomes for these degrees is therefore likely important for understanding social mobility.

Recent work on the returns to community college programs report strong positive returns (see Belfield and Bailey (2017) for a detailed review article). Jepsen et al. (2014) uses administrative data from the state of Kentucky and provides estimates of the labor-market returns (in terms of quarterly earnings) to community college certificates and diplomas, as well as estimates of the returns to the more commonly studied associate's degrees. They use a student fixed effects model that exploits within-student variation (and hence requires data on earnings from individuals both prior to and after enrolling in a community college – something that is typically not readily available), and compare the outcomes of students who received a community college degree to those who dropped out. The implicit assumption being that the time-invariant fixed effect adequately controls for selection into who completes the degree. They find that associates degrees and diplomas have quarterly earnings returns of nearly $2,400 for women and $1,500 for men, compared with much smaller returns for certificates. There is substantial heterogeneity in returns across fields of study. Similarly, Liu et al. (2015) examine the relative labor market gains for first-time college students who entered the North Carolina Community College System. They also find that associate and bachelor's degrees yield high returns compared to the returns to certificates and diplomas. Interestingly, they find that even small accumulations of some college credits have returns in the labor market. Bahr et al. (2015) relaxes the assumption of constant returns over time to find that the returns to associate degrees are the most durable over time, while returns to short- and long-term certificates and low-credit awards are strong initially but begin to flatten or decline by seven years after the award. They find evidence for the need to distinguish returns after a credential is awarded from returns after a student has finished (or otherwise left) post-secondary education.

Community colleges have long been centers for retraining displaced workers. Jacobson et al. (2005) focuses on the effectiveness of community college training for these workers and finds large effects. The equivalent of an academic year of community college schooling raises the long-term earnings of displaced workers by an average of about 9 percent for men and about 13 percent for women with substantial heterogeneity depending on the course.

Although subjective expectations have long been studied in the context of four-year bachelor's degrees (see section 4 for a review of this literature), there is very little evidence about the extent of bias in perceptions about earnings of community college students. In a recent paper, Baker et al. (2018) studies students' subjective expectations over earnings after graduating with a community college degree and use an information experiment along the lines of Wiswall and Zafar (2015). They find evidence of over-optimism: students believe that salaries are 13 percent higher than they actually are, on average, and students underestimate the probability of being employed by almost 25 percent. They also show that a 10 percent increase in salary leads to a 14 to 18 percent increase in the probability of choosing a major, which is a much larger elasticity than the estimates for four year undergraduate students.

9.2 Graduate Degrees

There is a great deal of interest in the choice to enroll in a graduate degree and the returns to various graduate degrees, particularly with the rise in the number of graduate degree holders over the past few years. Altonji et al. (2016) discusses the increase in the number of graduate degree holders as well as the importance of studying the returns to these degrees. We discuss some of their key findings here. Interested readers are referred to Altonji et al. (2016) for an in-depth discussion of graduate degrees. They report that the share of individuals getting a master's degree, for the population of US citizens and residents, has increased dramatically by 240 percent between 1985 and 2013, and this is not entirely due to the increase in the number of undergraduate degree holders over the same time period. Graduate degrees are quite heterogeneous in their duration as well as returns. Among students who graduate with a master's degree, Education and Business are the most popular majors. They collectively account for 50 percent of the master's degrees over the same time period. Although less common, Ph.D. degrees have also been increasing in number over the same time period.

There have been studies that have focused on a particular field. For example, the return to MBA degrees has been studied by Arcidiacono et al. (2008), using panel data from the pool of students registered to take the Graduate Management Admissions Test (GMAT) in 1990. They find that controlling for individual fixed effects substantially reduced the returns to an MBA, particularly for schools in the top 25. Similarly, there has been research on the return to medical degrees (Bhattacharya, 2005; Chen and Chevalier, 2012; Ketel et al., 2016; Wasserman, 2015). Bhattacharya (2005) finds that there are large returns to specialization of medical school. Similarly, Chen and Chevalier (2012) study the penalty of long work hours for women in high income specialties. They find that women would have higher lifetime earnings if they were physician assistants than family practitioners because they would have spent less time in medical school and residency programs and would not have faced the penalty for working fewer hours than their male counterparts.

Altonji and Zhong (2019) are the first to study a broad set of graduate degrees and provide estimates for the returns to these degrees. In order to estimate returns to specific graduate degrees, they use an approach that they call $FE - cg$ approach, which is fixed effects for whether an individual has obtained a particular combination of college major c and graduate field g. While this approach allows the authors to use all individuals with earnings observed before the advanced degree and all individuals observed with earnings after the advanced degree (without imposing that an individual appear both before and after, as would be required for an individual FE approach), the approach requires that the ability and preference distributions do not depend on the timing of labor force participation (whether the individual is observed in the labor market only before, only after, or both before and after graduate study). They find that the estimated return for law and medicine is 52 percent and 77.5 percent, respectively. The return to an MBA is only 10.1 percent.

Graduate degrees have been studied to some degree in the context of immigration policy (Ganguli et al., 2020). Amuedo-Dorantes et al. (2019) examine whether a 2008 policy extending the Optional Practical Training (OPT) period for STEM graduates affected international students' propensities to major in a STEM field. They find that foreign born students are in fact highly responsive in terms of their major choice to immigration policy that improves their job finding rates in the United States.

10 Conclusion

Given the choice of major is an important determinant of future earnings and welfare, and a factor in influencing the overall economy, a growing literature has examined factors that affect college major choice. We highlight key findings that emerge from this literature. One, earnings differentials remain even after controlling for selection, although the responsiveness of students to earnings is very low. This is consistent across various studies and institutional settings. Two, there is a role of learning about one's own ability in determining the *final* major choice. Three, sorting in majors is primarily driven by non-pecuniary components, often interpreted as "tastes" for majors. This has spurred a recent literature that studies several non-pecuniary considerations that can demystify the "taste" component. This includes marriage and fertility considerations as well as workplace characteristics, particularly in the context of understanding gender gaps in major choice. Researchers have also explored differences in risk and time preferences, the lack of role models as well as differences in confidence and optimism to study these gaps. Fourth, researchers have stressed the importance of not assuming full information or rational expectations, as subjective expectations data has revealed substantial bias in students' beliefs and that students logically update their beliefs in response to experimentally provided information. Finally, an emerging literature studies several supply side factors that can affect major choice and serve as some policy levers to change the major composition.

Several avenues emerge for future research, and we list here a few key areas. First, there is still important work to be done in understanding the role of college majors in the labor market. This relates to an understudied area: the relationship between majors and occupations. Although there is some recent work on mapping majors to occupations, there is surprisingly scarce evidence on how firms value students with different majors for a particular occupation and the extent to which the major serves as a productive type of human capital versus a signal of ability. For example, why do firms often hire engineer undergraduates for management consultancy jobs? This relates to specificity of skills in majors and its mapping to occupations.

Another area we foresee as an important area of future research is how family background induces sorting into college majors, since that has the potential to have important implications for inter-generational mobility. Although a large literature has studied the role of family income on college attendance and completion, there is little work (descriptive or otherwise) on how family income affects major choice. As we show, there is a systematic relationship between parental education and college major choice, and this correlational pattern is consistent with Ma (2009), who finds that lower-SES children are more likely to major in lucrative college majors. However, we do not know the mechanisms through which family background influences major choice. Recent work on patterns of major switching by minorities and the effect of programs like the Texas Top Ten Percent program on major choice (Arcidiacono et al., 2016b; Baird et al., 2016; Black et al., 2020) suggest that this will be an important area for future work.

Understanding how the choice of major may be impacted by the increasing cost of a college education (hence increasing student debt) is another important area for future research. This is partly because the rise in student debt is a relatively recent phenomenon: student debt has more than tripled since 2006.[7] Rothstein and Rouse (2011) find that a policy that replaced loans in financial aid packages with grants at a highly selective university had an impact on the kinds of jobs students chose after graduation, but had no meaningful impact on major choice (though their estimate is quite imprecise). Likewise, students with debt are increasingly enrolling in income-driven repayment (IDR) plans, which set monthly payments to a fixed proportion of the borrower's income and forgive the remaining balance after a certain number of years. Such plans have been shown to increase the financial health of student loan borrowers (Herbst, 2020). But, at this stage, we do not know how such plans may affect the choice of major of students. In addition, in recent years, a number of universities have implemented income-share agreements (ISA) with terms of repayment that depend on college major. ISA is essentially a "human capital" contract in which the student agrees to pay a fixed percentage of future earnings for a fixed time period in exchange for payment of college tuition today. In this way, the university provides insurance against future income risk. Mumford (2018) uses administrative data from Purdue University to estimate the extent of selection into ISA. He finds that selection into ISA is mostly a function of parental characteristics, salary differences across majors, and location preferences and so far, there is no evidence of adverse selection on ability. These programs are quite new and much more research is needed to understand the impact of these programs on college major choice and the optimal design and implementation of such income share agreements.

Finally, the gender gap in major choice remains a dynamic area of research. We know that gender differences in college preparedness cannot explain this gap: girls perform at least as well, if not better, than boys in school in both math and non-math fields (Goldin et al., 2006). Gender differences in preferences for non-pecuniary factors and tastes remains the main explanation for gender gaps in major choice. In this review article, we have mentioned studies that try to unpack the black box of tastes. Work that makes further progress on this front will be valuable.

We do not yet know the answers to arguably first-order questions. For example, students who intend to major in Business and Economics majors tend to have higher risk tolerance, whereas students who major in Engineering and Natural Sciences are less risk averse (Pat-

[7] https://www.stlouisfed.org/on-the-economy/2020/january/rising-student-debt-great-recession

naik et al., 2020). However, the extent to which this reflects sorting into majors along this dimension versus a causal impact of training in these fields onto these traits is not known. Likewise, STEM jobs have been argued to require higher cognitive skills but not necessarily higher social skills or creativity, which seem to be more important for later-life career trajectories (Deming and Noray, 2019). Again, the extent to which different majors foster soft skills remains unknown. Given the socioeconomic patterns of sorting into majors that we have described earlier – with students from higher SES backgrounds being more likely to sort into the liberal arts majors – the extent to which this pattern is driven by selection is unclear. Thus, given the sequential nature of educational choices, data collection efforts that start at earlier ages of children (and collect data on soft skills, behavioral traits, and cognitive measures) and then follow them over time would be particularly valuable.

In short, as this review shows, research on college major choice has been increasing rapidly in the last decade or so. However, there are a lot of questions that remain unanswered and we hope that researchers continue their work on this exciting area of research.

References

R. Abramitzky, V. Lavy, and M. Segev. The effect of changes in the skill premium on college degree attainment and the choice of major. Technical report, National Bureau of Economic Research, 2019.

T. Ahn, P. Arcidiacono, A. Hopson, and J. R. Thomas. Equilibrium grade inflation with implications for female interest in stem majors. Technical report, National Bureau of Economic Research, 2019.

J. G. Altonji. The Demand for and Return to Education When Education Outcomes are Uncertain. *Journal of Labor Economics*, 11(1, Part 1):48–83, jan 1993. ISSN 0734-306X. doi: 10.1086/298317. URL https://www.journals.uchicago.edu/doi/10.1086/298317.

J. G. Altonji and L. Zhong. The labor market returns to advanced degrees. Technical report, mimeo, 2019.

J. G. Altonji and S. D. Zimmerman. The costs of and net returns to college major. Technical report, National Bureau of Economic Research, 2017.

J. G. Altonji, T. E. Elder, and C. R. Taber. Selection on observed and unobserved variables: Assessing the effectiveness of catholic schools. *Journal of political economy*, 113(1):151–184, 2005.

J. G. Altonji, E. Blom, and C. Meghir. Heterogeneity in human capital investments: High school curriculum, college major, and careers. *Annu. Rev. Econ.*, 4(1):185–223, 2012.

J. G. Altonji, P. Arcidiacono, and A. Maurel. The analysis of field choice in college and graduate school: Determinants and wage effects. In *Handbook of the Economics of Education*, volume 5, pages 305–396. Elsevier, 2016.

C. Amuedo-Dorantes, D. Furtado, and H. Xu. Opt policy changes and foreign born stem talent in the us. *Labour Economics*, 61:101752, 2019.

R. J. Andrews and K. M. Stange. Price regulation, price discrimination, and equality of opportunity in higher education: Evidence from texas. *American Economic Journal: Economic Policy*, 11(4):31–65, 2019.

R. J. Andrews, S. A. Imberman, and M. F. Lovenheim. Risky business? the effect of majoring in business on earnings and educational attainment. Technical report, National Bureau of Economic Research, 2017.

P. Arcidiacono. Ability sorting and the returns to college major. *Journal of Econometrics*, 121(1-2):343–375, 2004. URL https://ideas.repec.org/a/eee/econom/v121y2004i1-2p343-375.html.

P. Arcidiacono, J. Cooley, and A. Hussey. The economic returns to an mba. *International Economic Review*, 49(3):873–899, 2008.

P. Arcidiacono, E. M. Aucejo, and K. Spenner. What happens after enrollment? An analysis of the time path of racial differences in GPA and major choice. *IZA Journal of Labor Economics*, 1(1):5, dec 2012a. ISSN 2193-8997. doi: 10.1186/2193-8997-1-5. URL http://izajole.springeropen.com/articles/10.1186/2193-8997-1-5.

P. Arcidiacono, V. J. Hotz, and S. Kang. Modeling college major choices using elicited measures of expectations and counterfactuals. *Journal of Econometrics*, 166(1):3–16, jan 2012b. ISSN 03044076. doi: 10.1016/j.jeconom.2011.06.002. URL https://linkinghub.elsevier.com/retrieve/pii/S0304407611001151.

P. Arcidiacono, E. Aucejo, A. Maurel, and T. Ransom. College attrition and the dynamics of information revelation. Working Paper 22325, National Bureau of Economic Research, June 2016a. URL http://www.nber.org/papers/w22325.

P. Arcidiacono, E. M. Aucejo, and V. J. Hotz. University differences in the graduation of minorities in stem fields: Evidence from california. *American Economic Review*, 106(3): 525–62, 2016b.

P. Arcidiacono, V. J. Hotz, A. Maurel, and T. Romano. Recovering ex ante returns and preferences for occupations using subjective expectations data. Technical report, unpublishedmanuscript, 2017.

L. Armona, A. Fuster, and B. Zafar. Home price expectations and behaviour: Evidence from a randomized information experiment. *The Review of Economic Studies*, 86(4):1371–1410, 2019.

E. Artmann, N. Ketel, H. Oosterbeek, and B. Klaauw. Field of study and family outcomes. 2018.

O. P. Attanasio and K. M. Kaufmann. Education choices and returns to schooling: Mothers' and youths' subjective expectations and their role by gender. *Journal of Development Economics*, 109:203–216, 2014.

O. P. Attanasio and K. M. Kaufmann. Education choices and returns on the labor and marriage markets: Evidence from data on subjective expectations. *Journal of Economic Behavior & Organization*, 140:35–55, 2017.

E. M. Aucejo and J. James. The path to college education: The role of math and verbal skills, 2019.

P. R. Bahr, S. Dynarski, B. Jacob, D. Kreisman, A. Sosa, and M. Wiederspan. Labor market returns to community college awards: Evidence from michigan. a capsee working paper. *Center for Analysis of Postsecondary Education and Employment*, 2015.

M. J. Bailey and S. M. Dynarski. Gains and gaps: Changing inequality in us college entry and completion. Technical report, National Bureau of Economic Research, 2011.

M. Baird, M. Buchinsky, and V. Sovero. Decomposing the racial gap in stem major attrition: A course-level investigation. 2016.

R. Baker, E. Bettinger, B. Jacob, and I. Marinescu. The effect of labor market information on community college students' major choice. *Economics of Education Review*, 65:18–30, 2018.

G. Bamberger. Occupational choice: The role of undergraduate education. 1988.

D. Barth, S. H. Shore, and S. T. Jensen. Identifying idiosyncratic career taste and skill with income risk. *Quantitative Economics*, 8(2):553–587, jul 2017. ISSN 17597323. doi: 10.3982/QE424. URL http://doi.wiley.com/10.3982/QE424.

A. Bayer, G. Bruich, R. Chetty, and A. Housiaux. Expanding and diversifying the pool of undergraduates who study economics: Insights from a new introductory course at harvard. Working Paper 26961, National Bureau of Economic Research, April 2020. URL http://www.nber.org/papers/w26961.

K. Bedard and D. A. Herman. Who goes to graduate/professional school? the importance of economic fluctuations, undergraduate field, and ability. *Economics of Education Review*, 27(2):197–210, 2008.

M. Beffy, D. Fougère, and A. Maurel. Choosing the Field of Study in Postsecondary Education: Do Expected Earnings Matter? *Review of Economics and Statistics*, 94 (1):334–347, feb 2012. ISSN 0034-6535. doi: 10.1162/REST_a_00212. URL http://www.mitpressjournals.org/doi/10.1162/REST{_}a{_}00212.

C. Belfield and T. Bailey. Model specifications for estimating labor market returns to associate degrees: How robust are fixed effects estimates? a capsee working paper. *Center for Analysis of Postsecondary Education and Employment*, 2017.

C. Belzil and M. Leonardi. Risk Aversion and Schooling Decisions. *Annals of Economics and Statistics*, No.111/112 Special Issue on Education:35–70, 2013. doi: 10.2307/23646326.

M. C. Berger. Predicted Future Earnings and Choice of College Major. *ILR Review*, 41 (3):418–429, apr 1988. ISSN 0019-7939. doi: 10.1177/001979398804100306. URL http://journals.sagepub.com/doi/10.1177/001979398804100306.

M. Bertrand, C. Goldin, and L. F. Katz. Dynamics of the gender gap for young professionals in the financial and corporate sectors. *American economic journal: applied economics*, 2 (3):228–55, 2010.

E. P. Bettinger and B. T. Long. Do faculty serve as role models? the impact of instructor gender on female students. *American Economic Review*, 95(2):152–157, May 2005. doi:

10.1257/000282805774670149. URL https://www.aeaweb.org/articles?id=10.1257/000282805774670149.

J. Bhattacharya. Specialty selection and lifetime returns to specialization within medicine. *Journal of Human Resources*, 40(1):115–143, 2005.

N. Bianchi. The indirect effects of educational expansions: Evidence from a large enrollment increase in university majors. 2019.

D. A. Black, S. Sanders, and L. Taylor. The economic reward for studying economics. *Economic Inquiry*, 41(3):365–377, 2003.

S. E. Black, J. T. Denning, and J. Rothstein. Winners and losers? the effect of gaining and losing access to selective colleges on education and labor market outcomes. Working Paper 26821, National Bureau of Economic Research, March 2020. URL http://www.nber.org/papers/w26821.

Z. Bleemer and A. Mehta. Will studying economics make you rich? a regression discontinuity analysis of the returns to college major. *A Regression Discontinuity Analysis of the Returns to College Major (April 2020)*, 2020.

E. Blom, B. C. Cadena, and B. J. Keys. Investment over the business cycle: Insights from college major choice. 2019.

T. Boneva and C. Rauh. Socio-economic gaps in university enrollment: The role of perceived pecuniary and non-pecuniary returns. 2019.

H. Bonin, T. Dohmen, A. Falk, D. Huffman, and U. Sunde. Cross-sectional earnings risk and occupational sorting: The role of risk attitudes. *Labour Economics*, 14 (6):926–937, dec 2007. URL https://www.sciencedirect.com/science/article/pii/S0927537107000462.

P. Bordon and C. Fu. College-major choice to college-then-major choice. *The Review of economic studies*, 82(4):1247–1288, 2015.

J. Bound and S. Turner. Chapter 8 - dropouts and diplomas: The divergence in collegiate outcomes. In E. A. Hanushek, S. Machin, and L. Woessmann, editors, *Handbook of The Economics of Education*, volume 4 of *Handbook of the Economics of Education*, pages 573 – 613. Elsevier, 2011. doi: https://doi.org/10.1016/B978-0-444-53444-6.00008-0. URL http://www.sciencedirect.com/science/article/pii/B9780444534446000080.

M. A. Bronson. Degrees are forever: Marriage, educational investment, and lifecycle labor decisions of men and women. *Unpublished manuscript*, 2, 2014.

C. Brown and M. Corcoran. Sex-based differences in school content and the male-female wage gap. *Journal of Labor Economics*, 15(3):431–65, 1997. URL https://EconPapers.repec.org/RePEc:ucp:jlabec:v:15:y:1997:i:3:p:431-65.

T. Buser, M. Niederle, and H. Oosterbeek. Gender, competitiveness, and career choices. *The Quarterly Journal of Economics*, 129(3):1409–1447, 2014.

K. F. Butcher, P. J. McEwan, and A. Weerapana. The effects of an anti-grade-inflation policy at wellesley college. *Journal of Economic Perspectives*, 28(3):189–204, 2014.

S. Canaan and P. Mouganie. Female science advisors and the stem gender gap. *Available at SSRN 3396119*, 2019.

B. J. Canes and H. S. Rosen. Following in her footsteps? faculty gender composition and women's choices of college majors. *ILR Review*, 48(3):486–504, 1995.

D. Card and A. A. Payne. High school choices and the gender gap in stem. Working Paper 23769, National Bureau of Economic Research, September 2017. URL http://www.nber.org/papers/w23769.

S. E. Carrell, M. E. Page, and J. E. West. Sex and science: How professor gender perpetuates the gender gap. *The Quarterly Journal of Economics*, 125(3):1101–1144, 2010.

M. K. Chen and J. A. Chevalier. Are women overinvesting in education? evidence from the medical profession. *Journal of Human Capital*, 6(2):124–149, 2012.

P.-A. Chiappori, M. Iyigun, and Y. Weiss. Investment in schooling and the marriage market. *American Economic Review*, 99(5):1689–1713, 2009.

P.-A. Chiappori, B. Salanié, and Y. Weiss. Partner choice, investment in children, and the marital college premium. *American Economic Review*, 107(8):2109–67, August 2017. doi: 10.1257/aer.20150154. URL http://www.aeaweb.org/articles?id=10.1257/aer.20150154.

O. Coibion, Y. Gorodnichenko, and T. Ropele. Inflation expectations and firm decisions: New causal evidence. *The Quarterly Journal of Economics*, 135(1):165–219, 2020.

J. J. Conlon. Major malfunction: A field experiment correcting undergraduates' beliefs about salaries. *Journal of Human Resources*, pages 0317–8599R2, 2019.

E. E. Cook. Competing campuses: An equilibrium model of the us higher education market. 2020.

T. N. Daymont and P. J. Andrisani. Job preferences, college major, and the gender gap in earnings. *Journal of Human Resources*, pages 408–428, 1984.

G. De Giorgi, M. Pellizzari, and S. Redaelli. Identification of social interactions through partially overlapping peer groups. *American Economic Journal: Applied Economics*, 2(2): 241–75, April 2010. doi: 10.1257/app.2.2.241. URL http://www.aeaweb.org/articles?id=10.1257/app.2.2.241.

M. De Paola and F. Gioia. Risk aversion and field of study choice: The role of individual ability. *Bulletin of Economic Research*, 64:s193–s209, dec 2012. URL https://doi.org/10.1111/j.1467-8586.2012.00445.x.

A. Delavande. Pill, patch, or shot? subjective expectations and birth control choice. *International Economic Review*, 49(3):999–1042, 2008.

D. J. Deming and K. L. Noray. Stem careers and the changing skill requirements of work. Technical report, National Bureau of Economic Research, 2019.

V. A. Dickson. An economic model of faculty grading practices. *The Journal of Economic Education*, 15(3):197–203, 1984.

E. W. Dillon. Risk and Return Trade-Offs in Lifetime Earnings. *Journal of Labor Economics*, 36(4):981–1021, oct 2018. ISSN 0734-306X. doi: 10.1086/697475. URL https://www.journals.uchicago.edu/doi/10.1086/697475.

D. Eckardt. *Training, occupations, and the specificity of human capital*. PhD thesis, The London School of Economics and Political Science (LSE), 2020.

E. Eide and G. Waehrer. The role of the option value of college attendance in college major choice. *Economics of Education Review*, 17(1):73–82, 1998. URL https://EconPapers.repec.org/RePEc:eee:ecoedu:v:17:y:1998:i:1:p:73-82.

L. Eika, M. Mogstad, and B. Zafar. Educational assortative mating and household income inequality. *Journal of Political Economy*, 127(6):2795–2835, 2019.

B. J. Evans. Smart money: Do financial incentives encourage college students to study science? *Education Finance and Policy*, 12(3):342–368, 2017.

R. W. Fairlie, F. Hoffmann, and P. Oreopoulos. A community college instructor like me: Race and ethnicity interactions in the classroom. *American Economic Review*, 104(8): 2567–91, August 2014. doi: 10.1257/aer.104.8.2567. URL https://www.aeaweb.org/articles?id=10.1257/aer.104.8.2567.

J. Feld and U. Zölitz. Peers from venus and mars–higher-achieving men foster gender gaps in major choice and labor market outcomes. 2018.

L. Flabbi and A. Moro. The effect of job flexibility on female labor market outcomes: Estimates from a search and bargaining model. *Journal of Econometrics*, 168(1):81–95, 2012.

F. A. Flyer. The Influence of Higher Moments of Earnings Distributions on Career Decisions. *Journal of Labor Economics*, 15(4):689–713, oct 1997. ISSN 0734-306X. doi: 10.1086/209842. URL https://www.journals.uchicago.edu/doi/10.1086/209842.

D. Fouarge, B. Kriechel, and T. Dohmen. Occupational sorting of school graduates: The role of economic preferences. *Journal of Economic Behavior & Organization*, 106:335–351, oct 2014. ISSN 0167-2681. URL https://www.sciencedirect.com/science/article/pii/S016726811400208X.

D. G. Freeman. Grade divergence as a market outcome. *The Journal of Economic Education*, 30(4):344–351, 1999.

R. Freeman. The market for college trained manpower. 1971.

H. Fricke, J. Grogger, and A. Steinmayr. Exposure to academic fields and college major choice. *Economics of education review*, 64:199–213, 2018.

I. Ganguli, S. Kahn, and M. MacGarvie. *The Roles of Immigrants and Foreign Students in US Science, Innovation, and Entrepreneurship.* University of Chicago Press, 2020.

S. Ge. Women's college decisions: how much does marriage matter? *Journal of Labor Economics*, 29(4):773–818, 2011.

A. Gemici and M. Wiswall. Evolution of gender differences in post-secondary human capital investments: College majors. *International Economic Review*, 55(1):23–56, 2 2014. ISSN 0020-6598. doi: 10.1111/iere.12040.

P. Giustinelli. Group Decision Making with Uncertain Outcomes: Unpacking Child-Parent Choice of the High School Track *. *International Economic Review*, 57(2), May 2016. URL https://economics.wustl.edu/files/economics/imce/vrptrackchoicepaper{_}sept13{_}pgiusti.pdf.

P. Giustinelli and C. F. Manski. Survey measures of family decision processes for econometric analysis of schooling decisions. *Economic Inquiry*, 56(1):81–99, 2018.

C. Goldin. A grand gender convergence: Its last chapter. *American Economic Review*, 104 (4):1091–1119, 2014.

C. Goldin and L. F. Katz. The cost of workplace flexibility for high-powered professionals. *The Annals of the American Academy of Political and Social Science*, 638(1):45–67, 2011.

C. Goldin, L. F. Katz, and I. Kuziemko. The homecoming of american college women: The reversal of the college gender gap. *Journal of Economic perspectives*, 20(4):133–156, 2006.

Y. Gong, R. Stinebrickner, and T. R. Stinebrickner. Marriage, children, and labor supply: Beliefs and outcomes. Technical report, National Bureau of Economic Research, 2019a.

Y. Gong, T. Stinebrickner, and R. Stinebrickner. Uncertainty about future income: Initial beliefs and resolution during college. *Quantitative Economics*, 10(2):607–641, 2019b.

A. L. Griffith and J. B. Main. First impressions in the classroom: How do class characteristics affect student grades and majors? *Economics of Education Review*, 69:125–137, 2019.

J. Grogger and E. Eide. Changes in college skills and the rise in the college wage premium. *Journal of Human Resources*, 30(2):280–310, 1995. URL https://EconPapers.repec.org/RePEc:uwp:jhriss:v:30:y:1995:i:2:p:280-310.

D. S. Hamermesh and S. G. Donald. The effect of college curriculum on earnings: An affinity identifier for non-ignorable non-response bias. *Journal of Econometrics*, 144(2):479–491, 2008.

J. Hastings, C. A. Neilson, and S. D. Zimmerman. The effects of earnings disclosure on college enrollment decisions. Technical report, National Bureau of Economic Research, 2015.

J. S. Hastings, C. A. Neilson, and S. D. Zimmerman. Are some degrees worth more than others? evidence from college admission cutoffs in chile. Technical report, National Bureau of Economic Research, 2013.

J. J. Heckman, L. Lochner, and C. Taber. Explaining rising wage inequality: Explorations with a dynamic general equilibrium model of labor earnings with heterogeneous agents. *Review of economic dynamics*, 1(1):1–58, 1998.

D. Herbst. Liquidity and insurance in student loan contracts: The effects of income-driven repayment on borrower outcomes, 2020.

F. Hoffman and P. Oreopoulos. A professor like me: The influence of instructor gender on college achievement. Working Paper 13182, National Bureau of Economic Research, June 2007. URL http://www.nber.org/papers/w13182.

J. E. Humphries, J. S. Joensen, and G. F. Veramendi. Complementarities in high school and college investments. 2019.

M. Iyigun and R. Walsh. Endogenous gender power, household labor supply and the demographic transition. *Journal of Development Economics*, 82(1):138–155, 2007. URL https://EconPapers.repec.org/RePEc:eee:deveco:v:82:y:2007:i:1:p:138-155.

L. Jacobson, R. LaLonde, and D. G. Sullivan. Estimating the returns to community college schooling for displaced workers. *Journal of Econometrics*, 125(1-2):271–304, 2005.

T. Jain, A. Mukhopadhyay, N. Prakash, and R. Rakesh. Labor Market Effects of High School Science Majors in a High STEM Economy. IZA Discussion Papers 11908, Institute of Labor Economics (IZA), Oct. 2018. URL https://ideas.repec.org/p/iza/izadps/dp11908.html.

E. James, N. Alsalam, J. C. Conaty, and D.-L. To. College quality and future earnings: Where should you send your child to college? *The American Economic Review*, 79(2): 247–252, 1989.

C. Jepsen, K. Troske, and P. Coomes. The labor-market returns to community college degrees, diplomas, and certificates. *Journal of Labor Economics*, 32(1):95–121, 2014.

V. E. Johnson. *Grade inflation: A crisis in college education*. Springer Science & Business Media, 2006.

T. Kato and Y. Song. An Advisor like Me: Does Gender Matter? IZA Discussion Papers 11575, Institute of Labor Economics (IZA), May 2018. URL https://ideas.repec.org/p/iza/izadps/dp11575.html.

K. M. Kaufmann. Understanding the income gradient in college attendance in Mexico: The role of heterogeneity in expected returns. *Quantitative Economics*, 5(3):583–630, nov 2014. ISSN 17597323. doi: 10.3982/QE259. URL http://doi.wiley.com/10.3982/QE259.

K. M. Kaufmann, M. Messner, and A. Solis. Returns to elite higher education in the marriage market: Evidence from chile. *Available at SSRN 2313369*, 2013.

M. P. Keane and K. I. Wolpin. The career decisions of young men. *Journal of political Economy*, 105(3):473–522, 1997.

N. Ketel, E. Leuven, H. Oosterbeek, and B. van der Klaauw. The returns to medical school: Evidence from admission lotteries. *American Economic Journal: Applied Economics*, 8 (2):225–54, 2016.

J. Kinsler and R. Pavan. The specificity of general human capital: Evidence from college major choice. *Journal of Labor Economics*, 33(4):933 – 972, 2015. URL https://EconPapers.repec.org/RePEc:ucp:jlabec:doi:10.1086/681206.

L. J. Kirkeboen, E. Leuven, and M. Mogstad. Field of study, earnings, and self-selection. *The Quarterly Journal of Economics*, 131(3):1057–1111, 2016.

H. Kleven, C. Landais, and J. E. Søgaard. Children and gender inequality: Evidence from denmark. *American Economic Journal: Applied Economics*, 11(4):181–209, 2019.

M. S. Kofoed et al. The effect of same-gender or same-race role models on occupation choice evidence from randomly assigned mentors at west point. *Journal of Human Resources*, 54 (2):430–467, 2019.

J. Lafortune. Making yourself attractive: Pre-marital investments and the returns to education in the marriage market. *American Economic Journal: Applied Economics*, 5(2): 151–78, 2013.

T. Lemieux. Occupations, fields of study and returns to education. *Canadian Journal of Economics/Revue canadienne d'économique*, 47(4):1047–1077, 2014.

H.-H. Li. Do mentoring, information, and nudge reduce the gender gap in economics majors? *Economics of Education Review*, 64(C):165–183, 2018. doi: 10.1016/j.econedurev.2018. URL https://ideas.repec.org/a/eee/ecoedu/v64y2018icp165-183.html.

V. Y. Liu, C. R. Belfield, and M. J. Trimble. The medium-term labor market returns to community college awards: Evidence from north carolina. *Economics of Education Review*, 44:42–55, 2015.

M. C. Long, D. Goldhaber, and N. Huntington-Klein. Do completed college majors respond to changes in wages? *Economics of Education Review*, 49:1–14, 2015.

L. D. Loury and D. Garman. College selectivity and earnings. *Journal of labor Economics*, 13(2):289–308, 1995.

J. Ma and S. Baum. Trends in community colleges: Enrollment, prices, student debt, and completion. *College Board Research Brief*, 4:1–23, 2016.

Y. Ma. Family socioeconomic status, parental involvement, and college major choices—gender, race/ethnic, and nativity patterns. *Sociological Perspectives*, 52(2):211–234, 2009.

O. Malamud. Discovering one's talent: learning from academic specialization. *ILR Review*, 64(2):375–405, 2011.

C. F. Manski. Schooling as experimentation: a reappraisal of the postsecondary dropout phenomenon. *Economics of Education review*, 8(4):305–312, 1989.

C. F. Manski. Adolescent econometricians: How do youth infer the returns to schooling? In *Studies of supply and demand in higher education*, pages 43–60. University of Chicago Press, 1993.

C. F. Manski. Measuring expectations. *Econometrica*, 72(5):1329–1376, 2004.

H. Mansour, D. I. Rees, B. M. Rintala, and N. N. Wozny. The effects of professor gender on the post-graduation outcomes of female students. Working Paper 26822, National Bureau of Economic Research, March 2020. URL http://www.nber.org/papers/w26822.

C. Montmarquette, K. Cannings, and S. Mahseredjian. How do young people choose college majors? Technical report, 2002. URL www.elsevier.com/locate/econedurev.

K. J. Mumford. Student selection into an income share agreement. *Purdue University Krannet School of Management*, 2018.

C. Neilson, A. Altmejd, A. Barrios-Fernandez, M. Drlje, D. Kovac, et al. Siblings' effects on college and major choices: Evidence from chile, croatia and sweden. Technical report, 2020.

M. Niederle. Gender. Working Paper 20788, National Bureau of Economic Research, December 2014. URL http://www.nber.org/papers/w20788.

H. S. Nielsen and A. Vissing-Jorgensen. The Impact of Labor Income Risk on Educational Choices: Estimates and Implied Risk Aversion *. Technical report, 2006. URL https://pdfs.semanticscholar.org/2a43/c98022c53b654566e129079a5c975d79a977.pdf?{_}ga=2.117443657.1364505584.1552779231-1306858675.1552779231.

U. Oguzoglu and S. Ozbeklik. Like father, like daughter (unless there is a son): Sibling sex composition and women's stem major choice in college. 2016.

A. Patnaik, J. Venator, M. Wiswall, and B. Zafar. The role of heterogeneous risk preferences, discount rates, and earnings expectations in college major choice. Technical report, National Bureau of Economic Research, 2020.

R. Patterson, N. Pope, and A. Feudo. Timing is everything: Evidence from college major decisons. 2019.

C. Porter and D. Serra. Gender differences in the choice of major: The importance of female role models. *American Economic Journal: Applied Economics*, 2019.

M. R. Ransom, A. Phipps, et al. The changing occupational distribution by college major. 2014.

T. Ransom. Selective migration, occupational choice, and the wage returns to college majors. *Duke University*, 2016.

E. Reuben, M. Wiswall, and B. Zafar. Preferences and biases in educational choices and labour market expectations: Shrinking the black box of gender. *The Economic Journal*, 127(604):2153–2186, 2017.

J. Robst. Education and job match: The relatedness of college major and work. *Economics of Education Review*, 26(4):397–407, 2007.

J. Rothstein and C. E. Rouse. Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics*, 95(1-2):149–163, 2011.

A. I. Ruder and M. Van Noy. Knowledge of earnings risk and major choice: Evidence from an information experiment. *Economics of Education Review*, 57:80–90, apr 2017. doi: https://doi.org/10.1016/j.econedurev.2017.02.001.

R. W. Rumberger and S. L. Thomas. The economic returns to college major, quality and performance: A multilevel analysis of recent graduates. *Economics of Education Review*, 12(1):1–19, 1993.

R. Sabot and J. Wakeman-Linn. Grade inflation and course choice. *Journal of Economic Perspectives*, 5(1):159–170, 1991.

B. Sacerdote. Peer effects with random assignment: Results for dartmouth roommates. *The Quarterly journal of economics*, 116(2):681–704, 2001.

R. E. Saks and S. H. Shore. Risk and Career Choice. *The B.E. Journal of Economic Analysis & Policy*, 5(1), jan 2005. ISSN 1935-1682. doi: 10.1515/1538-0637.1414. URL https://www.degruyter.com/view/j/bejeap.2005.5.issue-1/bejeap.2005.5.1.1414/bejeap.2005.5.1.1414.xml.

A. Siow. Occupational Choice under Uncertainty. *Econometrica*, 52(3):631–645, May 1984. URL https://ideas.repec.org/a/ecm/emetrp/v52y1984i3p631-45.html.

C. Sloane, E. Hurst, and D. Black. A cross-cohort analysis of human capital specialization and the college gender wage gap. Technical report, National Bureau of Economic Research, 2019.

K. Stange. Differential pricing in undergraduate education: Effects on degree production by field. *Journal of Policy Analysis and Management*, 34(1):107–135, 2015.

K. M. Stange. An empirical investigation of the option value of college enrollment. *American Economic Journal: Applied Economics*, 4(1):49–84, 2012.

R. Stinebrickner and T. Stinebrickner. Academic performance and college dropout: Using longitudinal expectations data to estimate a learning model. *Journal of Labor Economics*, 32(3):601–644, 2014a.

R. Stinebrickner and T. R. Stinebrickner. Working during school and academic performance. *Journal of Labor Economics*, 21(2):473–491, 2003. ISSN 0734306X, 15375307. URL http://www.jstor.org/stable/10.1086/345565.

R. Stinebrickner and T. R. Stinebrickner. Time-use and college outcomes. *Journal of Econometrics*, 121(1-2):243–269, 2004.

R. Stinebrickner and T. R. Stinebrickner. What can be learned about peer effects using college roommates? evidence from new survey data and students from disadvantaged backgrounds. *Journal of public Economics*, 90(8-9):1435–1454, 2006.

R. Stinebrickner and T. R. Stinebrickner. The causal effect of studying on academic performance. *The BE Journal of Economic Analysis & Policy*, 8(1), 2008.

R. Stinebrickner and T. R. Stinebrickner. A major in science? initial beliefs and final outcomes for college major and dropout. *Review of Economic Studies*, 81(1):426–472, 2014b.

T. Stinebrickner and R. Stinebrickner. Learning about Academic Ability and the College Dropout Decision. *Journal of Labor Economics*, 30(4):707–748, oct 2012. ISSN 0734-306X. doi: 10.1086/666525. URL https://www.journals.uchicago.edu/doi/10.1086/666525.

T. Stinebrickner, R. Stinebrickner, and P. Sullivan. Job tasks, task-specific work experience, and the gender wage gap. 2020.

S. E. Turner and W. G. Bowen. Choice of major: The changing (unchanging) gender gap. *ILR Review*, 52(2):289–313, 1999.

M. Wasserman. Hours constraints, occupational choice and fertility: Evidence from medical residents, 2015.

D. A. Webber. The lifetime earnings premia of different majors: Correcting for selection based on cognitive, noncognitive, and unobserved factors. *Labour economics*, 28:14–23, 2014.

C. J. Weinberger. Race and gender wage gaps in the market for recent college graduates. *Industrial Relations: a journal of economy and society*, 37(1):67–84, 1998.

R. J. Willis and S. Rosen. Education and self-selection. *Journal of political Economy*, 87(5, Part 2):S7–S36, 1979.

M. Wiswall and B. Zafar. Determinants of College Major Choice: Identification using an Information Experiment. *The Review of Economic Studies*, 82(2):791–824, apr 2015. ISSN 0034-6527. doi: 10.1093/restud/rdu044. URL https://academic.oup.com/restud/article-lookup/doi/10.1093/restud/rdu044.

M. Wiswall and B. Zafar. Preference for the workplace, investment in human capital, and gender. *The Quarterly Journal of Economics*, 133(1):457–507, 2018.

M. Wiswall and B. Zafar. Human capital investments and expectations about career and family. Technical report, National Bureau of Economic Research, 2019.

X. Xia. Forming wage expectations through learning: Evidence from college major choices. *Journal of Economic Behavior & Organization*, 132(PA):176–196, 2016. doi: 10.1016/j.jebo.2016.10.01. URL https://ideas.repec.org/a/eee/jeborg/v132y2016ipap176-196.html.

B. Zafar. How do college students form expectations? *Journal of Labor Economics*, 29(2): 301–348, 2011.

B. Zafar. Double majors: One for me, one for the parents? *Economic Inquiry*, 50(2):287–308, 2012.

B. Zafar. College Major Choice and the Gender Gap. *Journal of Human Resources*, 48 (3):545–595, jul 2013. ISSN 0022-166X. doi: 10.3368/jhr.48.3.545. URL http://jhr.uwpress.org/lookup/doi/10.3368/jhr.48.3.545.

G. A. Zarkin. Occupational Choice: An Application to the Market for Public School Teachers. *The Quarterly Journal of Economics*, 100(2):409–446, 1985. URL https://ideas.repec.org/a/oup/qjecon/v100y1985i2p409-446..html.

U. Zölitz and J. Feld. The effect of peer gender on major choice in business school. *University of Zurich Department of Economics Working Paper*, (270), 2019.

Appendices

A Data Description

This appendix provides an overview of the data and the sample construction. We use 3 data sources: decennial Census, American Community Survey (ACS), and the National Survey of College Graduates (NSCG). All data sources were accessed from the IPUMS database.

A.1 Decennial Census

To compute college attainment by birth cohort, we use data from decennial Census for years 1960-2000. To minimize completion effects at earlier ages and mortality effects at later ages, we limit the sample to respondents aged 25-49 in each data sample. We define college attainment consistently across years by defining college as 4 or more years of college (16 or more years of schooling). This sample includes respondents with a bachelor's degree, a master's degree, a professional degree beyond a bachelor's degree or a doctoral degree. This sample would necessarily also include individuals with 4 years of college but did not complete a college degree.

A.2 American Community Survey

We use annual ACS data from 2008 to 2018. We form 3 samples for specific purposes.

We form two samples from the ACS to track educational attainment by birth cohort. The first ACS sample is used to compute college attainment. We follow our construction of the Census sample and restrict this sample to those aged 25-49 in each survey year. We define college attainment following the Census sample, and this sample necessarily includes some respondents with 4 years of college but no degree.

The second ACS sample is used to compute undergraduate majors. We restrict this sample to those who hold a bachelors degree or higher, including those holding a masters degree, a professional degree beyond a bachelor's degree, or a doctoral degree. Because mortality differences by major within the college educated population are likely minimal, we include all respondents aged 25-90 in each survey year.

The ACS contains rich information on the field in which the person received a Bachelor's degree. We pool data from the ACS for the samples from 2009 to 2018 for which the field of study was collected. The data contains a very fine categorization of majors upto four digit CIP codes. For some purposes, we group these majors to three broad categories:

- Humanities / Social Science / Education
- STEM (Excluding Business and Economics)
- Business / Economics

Table A-1 provides a detailed list of the majors included in these categories.

We form a third ACS sample to examine recent patterns in employment and earnings by major. We limit this sample to the population aged 25 to 65 who report having at least some college. We then define a "no degree" or "No Grad" group as having some college but no bachelor or higher degree. The major fields are for the bachelor's degree.

We focus on annualized wage earnings of full-time and full-year workers. Full time is defined as working at least 35 hours a week and full year as working between 50-52 weeks a year. We pool ACS data for 2016, 17, and 18. All earnings values are deflated to 2018$. Earnings are bottom coded at $ 12,293 and top coded at $ 190,000.

A.3 National Survey of College Graduates

The NSCG is a nationally representative survey of college graduates currently residing in the United States. The NSCG contains detailed classification of the field of study, both at the undergraduate and graduate levels that allows us to observe parental education gradients in major choice by detailed major categories.

We pool the sample of cohorts surveyed in 1993, 2003 and 2010. We restrict the sample to individuals born in 1970 or later, and older than age 25 at the time of the survey. We also restrict the sample to college graduates who attended high school in the United States and those for whom mother's education or field of degree is not missing.

A Additional Tables and Figures

Table A-1: Major Categorisation

Major Category	Major Included	CIP Classification
So. Sc. / Hum.	Education Administration and Teaching	23
	English Language, Literature, and Composition	33
	Family and Consumer Sciences	29
	Fine Arts	60
	History	64
	Law	32
	Liberal Arts and Humanities	34
	Library Science	35
	Linguistics and Foreign Languages	26
	Public Affairs, Policy, and Social Work	54
	Social Sciences	55
Business/ Economics	Business	62
	Economics	5501
STEM	Biology and Life Sciences	36
	Communication Technologies	20
	Computer and Information Sciences	21
	Electrical and Mechanic Repairs and Technologies	57
	Engineering	24
	Engineering Technologies	25
	Environment and Natural Resources	13
	Mathematics and Statistics	37
	Medical and Health Sciences and Services	61
	Military Technologies	38
	Nuclear, Industrial Radiology, and Biological Technologies	51
	Physical Sciences	50
	Precision Production and Industrial Arts	58
	Transportation Sciences and Technologies	59

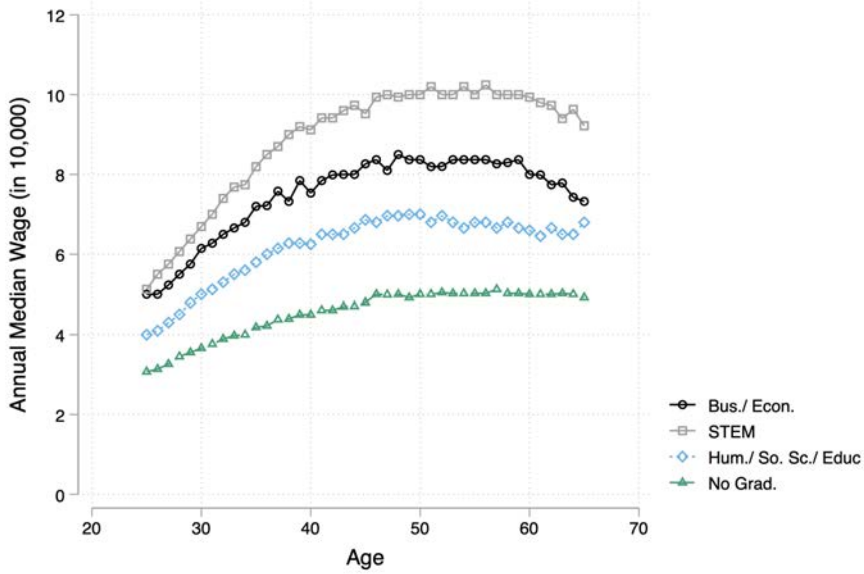
Table A-2: Parental Education and Major

	Field	I	II	III	IV	V	VI	VII
		At Least High School Grad.		At Least College Grad.			Advanced Degree Grad.	
		Mother	Father	Mother	Father	Both	Mother	Father
Bachelors Degree	Accounting	93.50	92.25	37.54	45.11	28.35	12.82	17.02
	Biology	94.99	95.01	44.17	51.54	34.11	18.00	27.13
	Business	93.96	94.05	35.40	41.93	26.10	12.76	16.65
	Chemistry	96.35	95.24	46.03	58.09	37.99	18.34	32.23
	Computer Science	94.32	95.03	42.42	53.73	34.38	17.53	29.04
	Economics	94.23	93.59	45.73	59.06	38.30	19.76	29.20
	Education	94.20	93.73	35.19	44.17	25.15	13.09	18.26
	Engineering	95.31	94.74	44.26	53.43	35.00	17.47	24.22
	English	93.65	96.53	49.23	62.67	43.59	23.44	35.84
	Fine Arts	98.80	95.40	57.10	61.77	42.03	22.52	34.44
	History	97.30	94.84	50.86	54.16	37.90	23.52	28.43
	Math	94.43	91.08	38.93	48.39	30.96	16.64	23.75
	Nursing	96.10	94.37	34.16	45.74	25.36	10.22	21.80
	Physics	98.35	96.87	49.15	65.88	42.44	25.13	40.64
	Political Science	95.75	94.44	46.55	57.11	38.74	23.02	33.80
	Psychology	94.16	93.93	41.54	48.88	31.69	15.89	27.28
	Sociology	95.26	91.42	37.69	45.87	27.68	13.47	21.25
	Social Work	94.67	92.05	28.97	32.32	18.39	13.03	16.74
	STEM	94.53	94.33	39.93	47.78	30.71	15.49	22.15
Masters Degree	Any	95.36	94.62	46.57	55.36	22.88	30.33	36.14
	Bus. / Econ.	94.85	94.63	50.15	56.96	23.42	30.14	39.05
	Hum. / So Sci. / Educ.	95.09	94.45	44.78	54.30	23.25	30.27	34.70
	Eng./ Nat. Sc.	96.38	95.06	48.48	57.52	22.53	32.21	38.28
Doc./Prof.	Any	96.73	96.32	58.56	66.65	29.15	44.41	50.44
	STEM	97.56	96.50	57.92	66.37	51.15	30.87	41.15
	Law	96.97	96.48	60.07	68.44	51.48	32.40	46.13
	Medical Degree	96.15	97.05	57.49	66.10	49.50	26.43	43.99

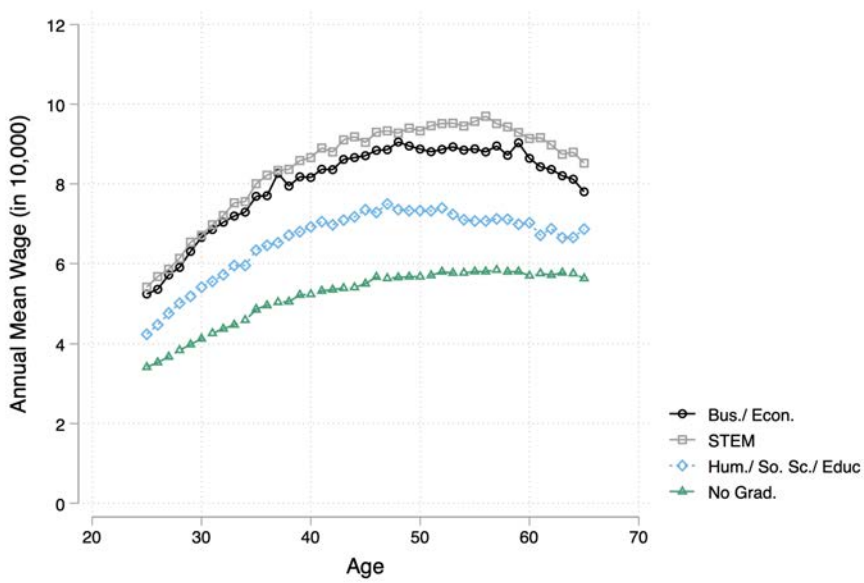
Source.— National Survey of College Graduates (NSCG)

Note.— This table reports the parental education of students for each educational level and each major category. The estimates are based on the NSCG surveys conducted in the years 1993, 2003 and 2010. Columns I and II report the percent of students whose mother and father are at least high school graduates respectively. Columns III, IV and V reports the percent of students whose mother, father and both parents are at least college graduates respectively. Columns VI and VII reports the percent of students whose mother and father hold advanced degrees respectively .

Panel A: Median Earnings



Panel B: Exclude Advanced Degrees

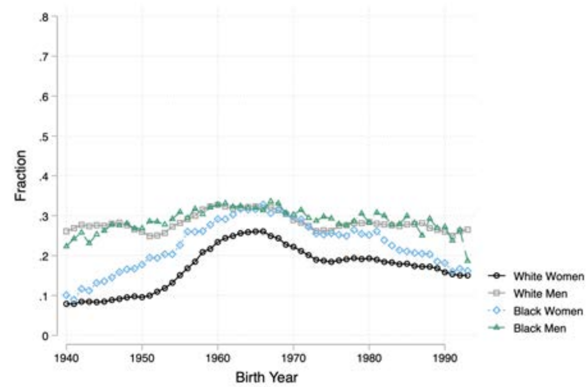


SOURCE.— American Community Survey (ACS)

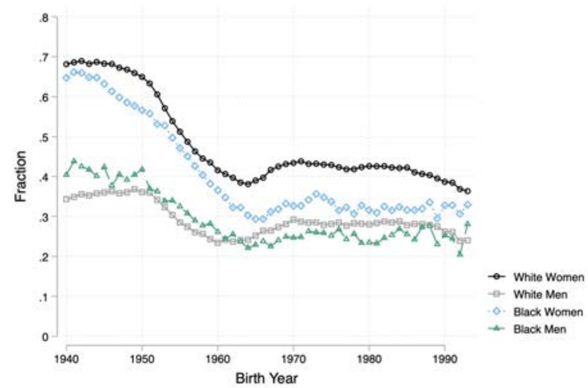
NOTE.— This figure reports the wage earnings by age and major. Panel A reports the median age earnings profiles whereas Panel B reports the age - mean earnings profiles excluding advanced degrees. The sample includes all full time, full year workers. Full time is the sample for whom usual hours worked last week is at least 35 hours and full year is 50-52 weeks worked last year. No Grad. refers to individuals with some college education but no bachelor's degree, including individuals with associates and other two year degrees. Earnings are bottom coded at $ 12,293 and top coded at $ 190,000. All values are in 2018 $ 10,000. The figure pools data from 2016 to 2018. The sample includes all individuals with at least some college, and all individuals are classified according to their undergraduate major, regardless of whether they have completed a graduate degree.

Figure A-1: Age Earnings Profiles by Major

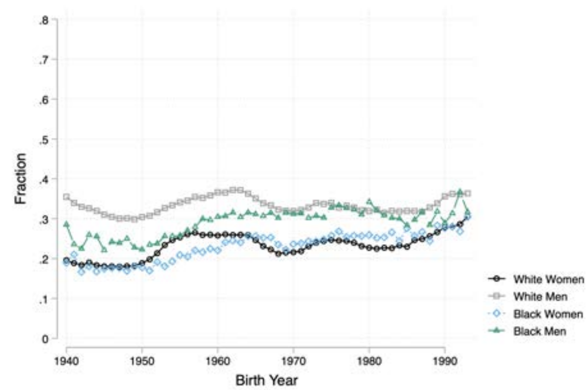
Panel A : Business/ Economics



Panel B : Humanities/ Social Sciences/ Education



Panel C : STEM



Source.— American Community Survey (ACS)

Note.— This figure reports the trends in major by gender, race and by birth cohorts. The sample includes all individuals with a bachelors degree or higher for birth cohorts from 1940 to 1993. Major is defined as undergraduate majors for all college educated respondents, regardless of whether they later complete a graduate degree.

Figure A-2: Trends in Major by Gender and Race