The Contribution of College Majors to Gender and Racial Earnings Differences*

Scott A. Imberman
Michigan State University and NBER

Michael F. Lovenheim
Cornell University, NBER, and Hoover Institution

Patrick Massey
Michigan State University

Kevin Stange
The University of Michigan and NBER

Rodney J. Andrews
Deceased

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ABSTRACT

Gender and racial/ethnic gaps in labor market earnings remain large, even among workers with similar educational attainment. Differences by gender and race in the distribution of college majors and in their returns are potentially important contributors to these gaps. In this paper, we use administrative data from the universe of Texas public high school graduates followed through college and up to 20 years in the labor market to assess gender and racial differences in college major choices and the consequences of these choices. While there are sizable cross-group differences in college major choices, with women, Black, and Hispanic students being under-represented in high-earnings fields such as business, economics, IT, and engineering (while Asian students are over-represented in these fields), we show that these groups also experience much lower returns to these majors (relative to own-group earnings in liberal arts). Differences in major-specific returns are more important than differences in the distribution of college majors for explaining earnings gaps, explaining 26%, 27%, and 25% of the gender, White-Black, and White-Hispanic earnings differences among four-year college students, respectively. This pattern is reversed for White-Asian earnings differences, however, as Asians earn more than Whites but experience lower returns to most majors. The work shines light on the role that college major choice – and returns by gender and race – contributes to inequality.

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* Imberman: imberman@msu.edu. Lovenheim: mfl55@cornell.edu. Massey: pmassey@msu.edu. Stange: kstange@umich.edu. Rodney Andrews tragically and unexpectedly passed away during the analysis for this paper but was a major contributor to the intellectual framing of and analysis that this work builds on, not to mention a dear friend. This paper is dedicated to his memory. We gratefully acknowledge that this research was made possible through data provided by the University of Texas at Dallas Education Research Center. The conclusions of this research do not necessarily reflect the opinions or official positions of the Texas Education Agency, the Texas Higher Education Coordinating Board, the Texas Workforce Commission, or the State of Texas.

I. Introduction

Gender and racial differences in labor market earnings remain substantial, even among workers with four-year degrees (Blau and Kahn 2017; Hirsch and Winters 2014; Sakamoto, Tamborini, and Kim 2018; Bayer and Charles 2018; Chetty et al. 2020). In Texas, our data show that men who attended a four-year college earn 51% more than female college attendees, on average 16-20 years after high school, while White college attendees earn 43% more than Black attendees and 30% more than non-Black Hispanic college enrollees. In contrast, Asians earn about 14% more than Whites. These large cross-group differences in earnings grow over time with potential experience as well. Differences by gender and race/ethnicity in the distribution of college majors and in their returns are potentially important contributors to these labor market disparities. This is a particularly compelling explanation because of the historically-high returns to more technical majors, such as business, economics, engineering, sience, and math (Arcidiacono, 2004; Hamermesh and Donald, 2008; Kirkebøen, Leuven and Mogstad 2016; Andrews et al. forthcoming) as well as the fact that women and under-represented minorities (URMs)[1] are less likely to major in these fields (Turner and Bowen 1999; Kugler, Tinsley, and Ukhaneva 2021; Sloane, Hurst, and Black 2021; Dickson 2010; England and Li 2006; Black et al. 2008; Arcidiacono, Aucejo, and Hotz 2016; Arcidiacono, Aucejo, and Spenner 2012).

College major choice can impact earnings differences across groups through two pathways. First, cross-group differences in the distribution of majors can drive earnings disparities because of the different aggregate returns to majors. Second, there could be differences in group-specific returns to major choice. For example, women may earn less than men because they major in subjects that have a lower average return or because they experience a lower return to majoring in certain areas relative to men. In this paper, we use linked administrative data from Texas that combines K-12 records, higher education records, and quarterly earnings data to examine how major choice varies by gender and race/ethnicity as well as how both differences in the distribution of majors across groups and the returns to major across groups contributes to subsequent earnings disparities. The rich data to which we have access allow us not only to control for a series of pre-collegiate academic characteristics such as test scores and SES, but also allow us to account for the correlation between the type of college

[1] We use the term "under-represented minorities" to refer to non-Hispanic Black and Hispanic students.

attended and college major choice. Prior research studying the contribution of college major choices in the US to gender and racial/ethnic earnings differences have not been able to account for these factors.

We begin by documenting the distribution of college majors by gender (men and women) and racial/ethnic groups (Black, White, Hispanic, and Asian)[2] among those who graduated from a public high school in Texas between 1996 and 2002 and who attended a public, four-year university in Texas within two years of high school graduation. We then examine male-female, White-Black, White-Hispanic, and White-Asian average earnings differences in three periods: 6-10, 11-15, and 16-20 years after high school graduation. By examining how these differences evolve, we provide new evidence on the role of returns to experience in generating labor market disparities. Next, we estimate models that control for a comprehensive set of pre-collegiate characteristics and academic achievement measures as well as college fixed effects that show how much of the unexplained earnings gaps are driven by these pre-market factors.

Our examination of the role of college majors in cross-group earnings differences focuses on the unexplained gaps that are residual to the pre-market controls and college attended fixed effects. We account for 13 broad major groups plus undeclared students[3] as well as more detailed major controls based on 4-digit CIP codes and the interaction of major and postsecondary institution (i.e., program). These estimates provide insight into the contribution of the different distributions of majors across demographic groups.

Next, we extend the literature by assessing the role of differential returns to majors in driving earnings gaps. Prior research generally has assumed that returns are constant across demographic categories, which has led to a focus on the differences in major choices by race/ethnicity and gender as a main contributor to earnings gaps among college graduates. But if under-represented groups face lower returns, especially to majors with high average returns for majority students, then differences in major choices will be less important for explaining earnings differences. We estimate how the return to each major relative to liberal arts (the excluded major in our regression models) varies by gender and race/ethnicity. Our analysis

[2] Black, White, and Asian students are non-Hispanic. Hispanic students can be of any race.

[3] These major groups are liberal arts, agriculture, communications, IT, vocational, engineering, architecture, biology & health, physical sciences & math, social sciences (excluding economics), business, economics, interdisciplinary studies, and undeclared. These are similar major groups to those used to study aggregate returns in Andrews et al. (forthcoming), except that we separate out engineering, business, architecture, and interdisciplinary studies.

focuses both on differences in mean returns as well as how major choice affects the distribution of earnings differentially for each demographic. Hence, we show how the mean returns to major choice differ by potential experience as well as what part of the earnings distributions are most affected. We use the mean returns to conduct a linear Blinder-Oaxaca decomposition that shows how much of the differences in mean earnings can be attributed to differential returns rather than differences in major choice.

Our results show that the distribution of college majors explains relatively little of gender and racial earnings gaps, especially after the early career period that covers 6-10 years after high school graduation (typically 2-6 years after college graduation). During this period, differences in major choices by gender can explain 86% of the earnings gaps that are residual to the controls but can explain only a small amount of the earnings differences across racial/ethnic groups. However, as we examine earnings farther out from high school (and thus college), the explanatory power of college majors falls considerably. By 16-20 years after high school, differences in college major explain just 16% of the earnings gap by gender, 5% of the White-Black earnings gap, and 10% of the White-Hispanic earnings gap. In contrast, college major choice explains 63% of the White-Asian earnings differences 16-20 years after high school.

We document substantial differences in the returns to college major across groups, with differences growing over the lifecycle. Focusing on the period 16-20 years after high school, men experience quarterly returns relative to liberal arts that are $4,046 higher than women in biology & health, $2,474 higher in engineering, $2,608 higher in IT, $4,564 higher in business, $2,860 higher in economics, and $1,109 higher in science & math majors. Using estimates from Wiswall and Zafar (2015) of the elasticity of major choice with respect to earnings expectations, we calculate that under rational expectations these differences in returns can explain a sizable portion of the under-representation of women in these fields.

Similarly, Black and Hispanic students experience far lower returns than White students in many high-earning fields. Relative to White returns, Black student returns 16-20 years after high school are $7,567 lower for engineering, $4,127 lower for IT, $1,099 lower in biology & health, $5,779 lower in business, and $8,816 lower in economics. Hispanic students' returns are $6,278 lower in engineering, $4,4447 lower in business, $6,753 lower in economics, and $2,882 lower in IT relative to White students. These differences in returns can explain nearly all of the

under-representation of Hispanic and Black students in majors associated with high earnings. White-Asian differences in returns are smaller but are sizable in several areas, such as being $3,890 lower in engineering, $3,091 lower in business, $7,116 lower in economics, and $479 lower in IT relative to returns for Whites.

Combining our results on differences in major choice and in the group-specific returns to major, the decomposition analysis shows that differences in major-specific returns are more important than differences in the distribution of college majors. Differences in returns 16-20 years after high school explain 26%, 27%, and 25% of the gender, White-Black, and White-Hispanic earnings differences among four-year college students, respectively. White-Asian differences in returns are in the wrong direction to explain the higher earnings of Asians, however.[4] While the explanatory power of college majors declines with potential experience, the role of differential returns either grows or remains large. Hence, simply equalizing the distribution of majors by gender and race/ethnicity will have only a small impact on cross-group earnings differences in the long run. In order to address gender and racial/ethnic earnings disaparities for those up to their mid-30s, our results show that one must equalize the returns to college major rather than equalizing the distribution of majors.

Together, we show that the combination of different major choices and differential returns to those choices can explain much of the gender and racial/ethnic earnings gaps. In the earliest period, they can explain between 47% and 99% of earnings differences (outside of the White-Asian earnings gap), largely due to the strong explanatory power of major choices. By 16-20 years after high school, major choices and the returns to college major can explain 42% of the gender earnings gap, 31% of the White-Black earnings gap, and 34% of the White-Hispanic earnings difference. They explain only 17% of the White-Asian earnings difference, which is due in part to average earnings and earnings returns differences moving in the opposite direction.

In addition to decomposing earnings differences into the parts due to major choice and differential returns to major, we examine the distributional impacts of major choice on returns by gender and race through the estimation of quantile treatment effects. Our QTE analysis provides an additional explanation for why women and minorities are less likely to enroll in high average

[4] This finding occurs because Asians earn more than Whites on average 16-20 years after college but experience lower group-specific returns to most majors even though they are more highly represented in "high-return" majors like economics and engineering.

return majors. In particular, we show that there is a wide range of returns within demographic group and majors. For certain high average returns majors – specifically business and IT – returns are close to zero for the bottom 50% to 80% of the distribution for women and URMs. At the same time, in these majors along with agriculture, engineering, architecture, the returns for women are lower than for men but converage at the top decile. For URMs, we see similar patterns with respect to Whites but with less the convergence at the top.

Our paper makes several contributions to the literature. We are the first to show gender- and racial/ethnic-specific returns to major choice, how these returns change with potential experience, and the effect the distribution of earnings across groups. Prior research in this area has focused on average effects across gender and racial/ethnic groups (e.g., Arcidiacono 2004; Kirkebøen, Leuven and Mogstad 2016; Bleemer and Mehta 2022).[5] Most closely related to our paper, Andrews et al. (forthcoming) use similar data and methods to estimate the return to college major by potential experience, effects on the distribution of earnings, and lifecycle utility returns. Our relative contribution is to show how these returns vary by race/ethnicity and gender as well as how these differential returns impact earnings differences across groups.

Second, our paper contributes to the large literature on the causes of differential earnings by gender and race/ethnicity in the labor market. Some prior research, discussed in more detail in Section II, shows that college major choices can explain a large portion of the gender wage gap in multiple countries. However, these papers typically are unable to disentangle college major choice from college quality and pre-collegiate academic achievement measures. No prior work examines this question with respect to race/ethnicity. We present new evidence in a setting that allows us to account for these other factors that cross-group differences in major choices, per se, have a small impact on cross-group earnings differences. Our results point to differential *returns* to college major as an important driver of earnings disparities by gender and race/ethnicity. This is a new explanation for earnings differences that prior research has not explored because no previous work has estimated these returns. The results from our paper suggest that differential returns by race/ethnicity and gender can explain a substantial proportion of the cross-group earnings differences among those with a college degree.

[5] See Altonji, Blom, and Meghir (2012), Altonji, Arcidiacono, and Maurel (2016), and Lovenheim and Smith (2023) for reviews of the literature on the returns to field of study.

Third, our results provide a new potential explanation for the persistent under-representation of women and under-represented minorities in fields with high average returns, like engineering and economics. These groups experience lower returns to these fields relative to their other options, which reduces their attractiveness. Assuming rational expectations, differences in earnings returns can explain a sizable portion of the under-representation of women,[6] Black, and Hispanic students in business, economics, IT, science & and math, and engineering.

II. Sources of Gender and Racial/Ethnic Differences in Earnings

a. Gender

Our paper contributes to a sizable body of prior work that explores the sources of differences in earnings by gender and across different racial/ethnic groups. Blau and Kahn (2017) provide a comprehensive review of the gender wage gap. Using data from the Panel Study of Income Dynamics (PSID), they show that by 2010 women earned about 80% as much as men. They further demonstrate that educational attainment and experience can explain little of the gender earnings gap. However, they do not examine the role of college major and instead highlight the importance of gender differences in occupation, gender roles, and the division of labor between men and women as main sources of remaining earnings differences. This conclusion aligns with those of Goldin (2014), who argues that the final convergence of gender earnings gaps is likely to entail increased flexibility of jobs.

Women have higher average educational attainment than men and obtain postsecondary degrees at a higher rate (Goldin, Katz, and Kuziemko 2006), which is why educational attainment cannot explain gender earnings disparities. Beyond attainment, men and women continue to major in different subjects, with men more represented in technical fields that are associated with higher average earnings (Turner and Bowen 1999; Kugler, Tinsley, and Ukhaneva 2021; Sloane, Hurst, and Black 2021; Gemici and Wiswall 2014; Dickson 2010; England and Li 2006; Black et al. 2008). Several papers explore the role of field of study in driving the gender earnings gap. Using data from the American Community Survey (ACS),

[6] Zafar (2013) uses survey data from Northwestern University to show that men and women have different preferences for workplace characteristics, including pay, which can generate differences in major selection. If women care less about the labor market returns to majors than men, we may overstate the role of differential returns in driving college major choice. We note, however, that women do weigh labor market returns when they select majors, just somewhat less than men do.

Sloane, Hurst, and Black (2021) show that major controls account for 32% of the male-female wage gap. McDonald and Thornton (2007) find that college majors explain nearly 95% of differences in starting salary offers after college, while Black et al. (2008) use data from the National Survey of College Graduates to show that controlling for college major explains about 30% of the wage gap over and above what is explained by the highest degree earned.

Similar results have been found in Europe as well. Machin and Puhani (2003) show that college major explains a substantial portion of the gender wage gap in England and Germany. Hägglund (2024) and Francesconi and Parey (2018) find similar results in Germany and Finland, while Humphries, Joensen, and Veramendi (2024) report that college major can explain 50–60 percent of the gender wage gap in Sweden. Furthermore, both Humphries, Joensen, and Veramendi (2024) and Machin and Puhani (2003) present evidence that more detailed major controls explain a larger portion of the gender wage gap.

Our paper extends our understanding of the role of college major choice in driving the gender earnings gap in several ways. First, these papers do not control for pre-collegiate academic achievement levels or the college of attendance. This is problematic because without controlling for selection into majors or the correlation between college quality and major choice, one risks confounding the role of major per se with unobserved labor market productivity. We take a selection on observables approach to addressing selection into field of study. While this method requires assumptions about the controls we use sufficiently accounting for such selection, we have a rich set of pre-collegiate demographic and academic achievement measures that render these assumptions more palatable. Further, we can account for college quality effects, which could be correlated with major choice. Taken together, we are able to provide the first estimates in the US of how major choice affects gender earnings gaps that credibly account for selection into field of study.

We also contribute to this literature by providing the first estimates of how majors affect the time path of earnings inequality between men and women. Our main contribution is to show new evidence on the role played by differential returns to college major in the gender earnings gap. As discussed below, we define returns as the gender-specific effect of majoring in a given area relative to liberal arts. We show that the returns women experience relative to majoring in liberal arts is smaller than this difference for men, especially in fields that have high relative

returns for men such as engineering, IT, business, and economics. These differences in returns can explain 13% of the gender earnings gap right after college, which grows to 26% for workers 16-20 years after high school.[7]

b. Race/Ethnicity

Much research has focused on documenting and understanding trends in earnings disparities between African Americans and Whites as well as between Hispanics and Whites in the US. Existing studies focus either on average earnings differences across groups or on parts of the earnings distribution that are unlikely to be populated by college graduates (Bayer and Charles 2018; Chetty et al. 2020; Antman, Duncan, and Trejo 2023; Hirsch and Winters 2014; Kospentaris and Stratton 2021**).** Using US Tax data, Bayer and Charles (2018) document a median Black-White earnings gap of about 50% in 2014. They also document an earnings difference of 39% at the 90th percentile of the distribution, which is one of the few data points on Black-White earnings differences among those likely to have a college degree. Antman, Duncan, and Trejo (2023) report mean Black-White earnings differences of 47% and 17% among men and women, respectively, and Hispanic-White earnings differences of 30% and 19% for men and women.

Given the large differences in educational outcomes by race/ethnicity, most of the research seeking to explain earnings differences across groups has focused either on educational attainment (Zhou and Pan 2023; Antman, Duncan, and Trejo 2023) or on pre-market educational achievement measures (Neal and Johnson 1996). Despite concerns that URM students are particularly under-represented in technical fields, no research exists on how major choice impacts racial/ethnic earnings differences among college attendees.

Prior research on this question focuses on affirmative action policies and shows that these policies can contribute to under-representation in STEM fields, especially at highly selective universities (Arcidiacono, Aucejo, and Hotz 2016; Arcidiacono, Aucejo, and Spenner 2012). In addition, Bleemer and Mehta (2023) show that restricted major access from major eligibility cutoffs leads to lower representation of Black and Hispanic students in majors that have high

[7] This finding aligns with Sloane, Hurst, and Black (2021), who show that women tend to sort into lower-paying occupations, conditional on major. Importantly, this occupation sorting would not necessarily cause a difference in the gender-specific returns to major choice. If women in every major sort into proportionally lower-paying occupations than men, it would not cause a relative decline in gender-specific returns.

average returns. Their results suggest that these major restrictions have increased racial stratification in the returns to attending a given institution, but they do not examine whether under-represented groups experience the same returns as do majority students. Our findings suggest that because URM students have lower returns to majors with higher returns for White students, differences in major representation have a small impact on racial and ethnic earnings gaps. Instead, our results point to a larger role for differential returns across groups in explaining earnings differences among college attendees.

Finally, we examine differences in earnings between White and Asian workers in Texas. White-Asian earnings differences have not been a focus of prior research, likely because Asian Americans have relatively high levels of educational attainment and earnings. We provide new evidence on differences in earnings between Whites and Asians as well as the role of college choice, pre-collegiate academic achievement, and field of study on these earnings differences after college.

III. Data and Descriptive Statistics

a. Data

We estimate the labor market returns to college majors by sex and gender using administrative data from three sources: the Texas Education Agency (TEA), the Texas Higher Education Coordinating Board (THECB), and quarterly earnings from the Texas Workforce Commission (TWC). These data follow all Texas students from public secondary school through college and into the workforce, provided individuals remain in Texas and attend public colleges and universities.

The construction of our analysis sample closely follows Andrews et al. (forthcoming); the details of the sample are described in Appendix B of that paper. We focus on all public high school graduates in Texas from 1996-2002 who enrolled in a public four-year institution in the state. To capture the most salient postsecondary experience to employers when students end their education, we assign students to major based first on their highest degree earned and then based on their most recent sector of enrollment. Any students who earn a bachelor's degree (BA or BS) at a Texas public institution are included in the sample. Students who earned an associate's degree (AA or AS) but no bachelor's are considered two-year students and are excluded, even if

they enrolled in a four-year institution before or after earning an AA. Our assumption is that students' associate's degree will be more salient to employers than their four-year enrollment that did not lead to a credential. Students who do not earn a bachelor's or associate's degree and whose last sector of enrollment is in the four-year sector are included in our analysis sample. This ensures that we are focusing on the most observable and recent degree or enrollment information that employers may see and that likely determines the skills workers bring to the labor market.

Students' majors are assigned in a similar way as sector, first based on major of their highest degree and then, for non-completers, based on last observed major. We aggregate four-year students into one of 14 major groups based on a combination of their specific 2- and 4-digit CIP codes: liberal arts, agriculture, communications, IT, vocational, engineering, architecture, biology & health, physical sciences & math, social science (excluding economics), business, economics, interdisciplinary studies, and undeclared.[8] The college of attendance is measured as the institution at which the college major is determined using the method described above.

Labor market outcomes are constructed from quarterly earnings records through second quarter of 2018 for each student who works in Texas, except for those who work for the Federal Government, postal service, or are self-employed. These workers are excluded from the earnings data because they are not covered by the state UI system. Thus, we cannot distinguish between those who are unemployed, self-employed, not in the labor force, or working outside of Texas. In general, out-of-state attrition can bias estimates of earnings differences across institutions and fields since migration tends to be correlated with earnings and is differential across programs (Foote and Stange, 2022). In prior work, we do not find such selection to be problematic (Andrews, Li and Lovenheim 2016; Andrews, Imberman and Lovenheim 2020; Andrews et al. forthcoming), and the extent of this bias appears low in Texas specifically due to relatively low out-migration (Foote and Stange, 2022).

In order to reduce bias associated with out-of-state migration, we only include quarterly earnings records that occur during students' in-state employment window, which we define as the time spanning the first non-zero earnings record after leaving college and the last non-zero

[8] During the time period of our study, Texas does not have a four-year education degree. A substantial portion of students who become K-12 teachers major in interdisciplinary studies.

earnings record. This excludes any periods of non-employment immediately after school and at the end of our sample, which would include records from those who have permanently left the state. We also exclude quarters in which students are enrolled in a public postsecondary institution in Texas, which helps to ensure that we are not attributing low earnings during graduate school to a specific major. While we are unable to observe enrollment in graduate schools outside of Texas or in private institutions, this would bias our estimates only to the extent that majors differentially sort to such institutions relative to in-state publics for graduate study. Finally, we only include earnings observations at least 6 years after high school graduation.

Quarters with no earnings records that are within the in-state earnings window and meet our inclusion criteria are imputed to be zero and included in our earnings estimates. This approach is designed to address bias from out-of-state migration while still accounting for the extensive margin. However, we note that if individuals in Texas leave the labor market permanently, we will code them as having left the state rather than not working. Especially for women, we may miss some labor market exit driven by fertility. This should reduce the earnings disparities between men and women, especially in the second two potential experience groups we consider when women are at the age when college graduates are most likely to have children (Livingston 2015).[9] Earnings are converted to real 2016 dollars throughout the analysis.

One of the important contributions we bring to the literature is the ability to control for pre-collegiate academic achievement as well as college type. These controls have not been available in prior research examining the role of major in driving earnings disparities by gender and race/ethnicity. We control for math and reading exam scores that are given to all students in 10^{th} grade in Texas. These are exit exam scores, and students are required to score above a certain threshold to receive a high school diploma. We standardize each score to have a mean of zero and a standard deviation of one in each year the test is given. We also control for whether the student is in the top decile or the 70^{th}-90^{th} percentiles of the within-high school and year distribution. The Texas Top 10 Percent Plan provides automatic admission to any postsecondary

[9] Online Appendix Table A-1 shows the effect of major choice by gender and race/ethnicity on the number of quarters one is in the earnings sample, while Online Appendix Table A-2 shows the effect of major choice by group on the likelihood of leaving the earnings sample. Both tables show that there are not large differences in how major choice relates to the number of quarters one works or whether one remains in the Texas labor market, suggesting that any bias from differential selection into the earnings sample by major and group is likely to be small.

institution for these cohorts for any student in the top 10% of their class GPA distribution. We do not observe high school GPA, but these within-school exam percentiles are strong measures of whether students are admitted under the Top 10 Percent Plan (Andrews, Imberman, and Lovenheim 2020).

We additionally control for whether a student is designed as being "at risk" of high school dropout, which combines information on course performance, grade advancement, test scores, limited English proficiency status, criminal justice system interaction, pregnancy, and homelessness. We control as well for whether a student is economically disadvantaged, defined as whether they are eligible for free or reduced price lunch, whether their family is below the poverty line, or whether they receive TANF or food stamps.

b. Descriptive Statistics

Table 1 provides descriptive statistics for our analysis sample. The first part of the table presents new evidence on major choices by gender and race/ethnicity. Columns (1) and (2) show large differences in major choices between men and women. Women are less likely to major in subjects generally associated with higher earnings: engineering (6.5 pp), science and math (0.8 pp), business (6.0 pp), economics (1.2 pp), and IT (2.5 pp). In contrast, women are 1 percentage point more likely than men to major in liberal arts, 6.7 percentage points more likely to major in social science, and 5.8 percentage points more likely to major in biology and health. There is little gender gap in the likelihood of being undeclared.

There are substantial race/ethnic differences in major choice as well, although they are smaller in magnitude than the gender differences. Relative to White students, Black students are less likely to major in engineering (2.1 pp), science and math (1.0 pp), business (1.8 pp), and economics (0.6 pp). Black students also are less likely to major in liberal arts (4.0 pp) but are more likely to major in vocational (4.5 pp), biology and health (2.8 pp), and social science (1.6 pp). Hispanic students are less likely to major in business (4.3 pp), economics (0.5 pp), and agriculture (3.8 pp) as well as liberal arts (1.9 pp) relative to White students. Hispanic and White students major in IT, engineering, architecture, science & math, and social science at similar rates, while Hispanics are more likely to major in vocational (1.1 pp) and biology and health (2.1 pp). Both Black and Hispanic students are more likely to be undeclared than White students, which in part reflects lower completion rates among these groups.

Asian students have substantially different majors than White, Black, and Hispanic students. Relative to Whites, Asians are less likely to major in liberal arts (6.4 pp), agriculture (4.5 pp), vocational (4.3 pp), communications (1.3 pp), and social science (1.9 pp) and are more likely to major in IT (1.9 pp), engineering (4.3 pp), biology & health (9.8 pp), business (8.8 pp), and economics (1.5 pp). These differences in major choice across gender and racial/ethnic groups are sufficiently large that they could explain much of the earnings gaps between these groups, which we explore directly below.

The remainder of Table 1 shows differences in the observed characteristics of each group as well as mean earnings 6-10, 11-15, and 16-20 years after high school. Men have higher math test scores than women on average but slightly lower reading scores. White and Asian students have higher math and reading scores than Hispanic and Black students, with Asian students having the highest math scores (at 0.81 sd) and White students having the highest reading scores (at 0.63 sd). Gender differences in the likelihood of being at risk or economically disadvantaged are small, while Black and Hispanic college students are much more likely to be at risk of dropout and economically disadvantaged than their White and Asian counterparts. These differences highlight the importance of controlling for pre-collegiate academic achievement in assessing the group-specific returns to college and the role of college majors in explaining earnings gaps.

The bottom of Table 1 shows raw means of earnings by gender and racial/ethnic groups for each time period post-HS, with male-female and each racial/ethnic group difference relative to Whites shown in Table 2. Aligned with the substantial differences in pre-collegiate academic achievement and SES, there are large earnings gaps that grow over time between men and women as well as between White and Black and White and Hispanic students. Recall that these earnings are for those who attend (and mostly complete) a four-year degree, so these large earnings differences are especially notable. As shown in Table 2, men earn about 11% more than women 6-10 years after high school, which grows to 51% by 16-20 years after high school. White earnings are 25% higher than Black earnings and 18% higher than Hispanic earnings in the early post-college period. They grow to 43% and 30% 16-20 years after high school, respectively. Relative to Asians, Whites earn 5% more in the early period right after college but then earn 14% less by their mid-30s. Hence, the White-Asian earnings gap flips sign as people in

the sample gain experience in the labor market, while the other earnings gaps we document get larger in magnitude. We now turn to an examination of the role of college major choice in explaining these patterns.

IV. Empirical Methods

The goal of this paper is to understand how major choice and the differential returns to college major across groups can explain gender and racial/ethnic earnings differences. We approach this question in two ways. First, we estimate how adding controls for college major as well as student background and college controls affects unexplained gender and racial/ethnic earnings gaps by relative experience. We then estimate group-specific returns in order to conduct linear decompositions that allow us to calculate how equalizing college major choices and major returns across groups would affect earnings differences. Last, we estimate quantile treatment effect models to explore what part of earnings distributions are shifted by college major choice by gender and race/ethnicity. Below, we discuss each of these empirical approaches in turn.

a. Unexplained Cross-group Earnings Gaps

We begin by estimating the effect of controlling for major choice on unexplained earnings gaps across groups. We estimate a series of linear regression models of the form:

$$Y_{iscjk} = \beta Male/White_i + \mathbf{\Omega X_i} + \sum_{\mathbf{k=2}}^{\mathbf{12}} \theta_k I(major_i = k) + \delta_{cs} + \gamma_{cj} + \epsilon_{iscjk}, \qquad (1)$$

where Y_{iscjk} is an outcome for individual *i*, from high school *s*, in high school cohort *c*, attending postsecondary institution *j*, and majoring in field *k*. The coefficient of interest in equation (1) is β. When examining gender, β shows the difference in mean earnings between male and female earnings, conditional on the observables. When focusing on race/ethnicity, β shows the difference in mean earnings between White and Black, Hispanic, or Asian college attendees. For the race/ethnicity estimates, we estimate the model separately for each combination of White and focal non-white group in the analysis. All standard errors are clustered at the postsecondary institution-by-major group level, reflecting the correlation of outcomes across students who attend the same college and major in the same subject area. Results are similar if we cluster by high school.

The full version of equation (1) includes the controls for pre-collegiate academic aptitude

and student SES discussed in Section III and shown in Table 1. We also control for high school-by-cohort (δ_{cs}) and college-by-cohort (γ_{cj}) fixed effects. Because of geographic sorting and patterns of segregation by race/ethnicity and SES, one's high school incorporates a substantial amount of information about socioeconomic background. Furthermore, the sorting of students into different colleges leads to smaller differences in unobservables across students within the same college and cohort than across students in different majors and different institutions. Finally, we include college major indicators, with liberal arts (k=1) as the excluded major category. We focus on indicators for the 11 major groups discussed in Section III and shown in Table 1, but we also show how the estimates change when we include dummies for each CIP-4 major and when we interact the major groups with postsecondary institution (i.e., college programs).

To understand how the controls impact the unexplained portion of the earnings gap across groups, we add controls sequentially. We first control for the role of pre-college factors: the X_i variables and the high school by cohort fixed effects. We next add college by cohort fixed effects, followed by our major controls. Hence, we show how much of the unexplained earnings difference can be accounted for by college majors, conditional on pre-collegiate academic achievement, SES, and postsecondary institution. These models are estimated separately for our three different time horizons: 6 to 10 years post-high school, 11 to 15 years post-high school, and 16 to 20 years post-high school.

b. Group-Specific Returns to College Major

The second part of our analysis seeks to estimate group-specific returns to college major choice and then to decompose earnings differences across groups into the portion due to differential major selection and the portion due to differential returns to major. For ease of exposition, we present our approach for gender differences. The analysis of racial/ethnic differences is the same, but replacing *Male* with *White*.

We estimate a version of equation (1) that include interactions between major and *Male*:

$$Y_{iscjk} = \alpha + \beta Male_i + \mathbf{\Omega X_i} + \sum_{k=2}^{12} \theta_k I(major_i = k) + \sum_{k=2}^{12} \phi_k I(major_i = k) * Male_i + \delta_{cs} + \gamma_{cj} + \epsilon_{iscjk}. \quad (2)$$

The coefficients of interest in equation (2) are θ_k and ϕ_k, which show the differential returns, relative to liberal arts (the excluded category), for men and women. That is, θ_k shows the returns for women of a given major relative to women in liberal arts, while $\theta_k + \phi_k$ shows the returns for men of a given major relative to men in liberal arts. These parameters differ from gender-specific earnings differences across majors because they each are relative to gender-specific earnings in liberal arts. If men earn proportionally more than women in every major, then $\phi_k = 0$ for each *k*. To our knowledge, we are the first to estimate gender (and racial/ethnic) specific returns to four-year college majors, relative to an own-group specific baseline major.

We use the estimates from equation (2) to decompose the earnings differences between men and women into the portion due to differential returns (ϕ_k) and the part due to the differences in major choice ($I(major_i = k) * Male_i$). For ease of exposition, define $Z_{iscj} = \boldsymbol{\Omega X_i} + \delta_{cs} + \gamma_{cj}$. These are the non-major controls in the model. Taking expectations, and keeping *i* as the only non-major subscript, we can write the earnings equation for men and women, respectively, as:

$$E(Y|Male) = \alpha + \beta + \boldsymbol{\Psi E}(\boldsymbol{Z_i^m}) + \sum_{\boldsymbol{k=2}}^{\boldsymbol{12}}(\theta_k + \phi_k)P(major = k)^m \quad (3)$$

$$E(Y|Female) = \alpha + \boldsymbol{\Psi E}(\boldsymbol{Z_i^f}) + \sum_{\boldsymbol{k=2}}^{\boldsymbol{12}}(\theta_k)P(major = k)^f \quad (4)$$

Assuming $(E(\epsilon_{iscjk})|\, Male) = E(\epsilon_{iscjk})|\, Female) = 0$, the mean earnings difference between men and women can be written as:

$$\begin{aligned} E(Y|Male) - E(Y|female) &= \beta + \boldsymbol{\Psi}[\boldsymbol{E}(\boldsymbol{Z_i^m}) - \boldsymbol{E}(\boldsymbol{Z_i^f})] + \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k + \phi_k)P(major = k)^m - \\ &\quad \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k)P(major = k)^f \\ &= \beta + \boldsymbol{\Psi}[\boldsymbol{E}(\boldsymbol{Z_i^m}) - \boldsymbol{E}(\boldsymbol{Z_i^f})] + \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k + \phi_k)P(major = k)^m - \\ &\quad \sum_{\boldsymbol{k=2}}^{\boldsymbol{12}}(\theta_k)P(major = k)^f + \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k + \phi_k)P(major = \\ &\quad k)^f - \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k + \phi_k)P(major = k)^f \\ &= \beta + \boldsymbol{\Psi}[\boldsymbol{E}(\boldsymbol{Z_i^m}) - \boldsymbol{E}(\boldsymbol{Z_i^f})] + \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}}(\theta_k + \phi_k)[P(major = k)^m - \\ &\quad P(major = k)^f] + \sum_{\boldsymbol{k=2}}^{\boldsymbol{14}} P(major = k)^f \phi_k \quad (5) \end{aligned}$$

In the last part of equation (5), $\sum_{k=2}^{14}(\theta_k + \phi_k)[P(major = k)^m - P(major = k)^f]$ shows the effect on earnings differences of equalizing the distribution of majors by gender, and $\sum_{k=2}^{14} P(major = k)^f \phi_k$ shows the effect of equalizing the returns to major, relative to gender-specific earnings in liberal arts. The unexplained portion is due to the controls included in **Z** and factors not included in the model. In addition to gender, we conduct these decompositions for each race/ethnicity compared to Whites as well.

The assumptions of this Blinder-Oaxaca decomposition are that the controls in the model are sufficient to account for selection of different groups into different majors. Put another way, conditional on the controls the unobserved earnings capacity of each group is the same within each major. This is a somewhat strong assumption, however we emphasize that we have a larger set of controls for pre-collegiate academic achievement than has been used in most of the returns to college major literature and most certainly in prior work that has sought to estimate the contribution of college majors to cross-group earnings differences. These assumptions also are similar to those invoked in Andrews et al. (forthcoming) in their analysis of the returns to college major choice averaged over all students in Texas.

c. Quantile Treatment Effects

In addition to examining how mean earnings returns vary across groups, we estimate how major choice affects the cross-sectional distribution of earnings differentially by gender and race/ethnicity using unconditional quantile treatment effect models (DiNardo, Fortin, and Lemieux 1996; Firpo 2007). We first take each major pair, where a major pair consists of one of the major groups listed above and liberal arts. Letting *k* index the non-liberal arts major, we estimate a logit model of the likelihood of majoring in *k* relative to liberal arts:

$$\Pr(Maj_i = k) = \frac{e^{(\zeta + \mathbf{T}\boldsymbol{X_i} + \omega_{cs} + \phi_{cj} + \nu_{icsj})}}{1 + e^{(\zeta + \mathbf{T}\boldsymbol{X_i} + \omega_{cs} + \phi_{cj} + \nu_{icsj})}}. \quad (6)$$

For each non-liberal arts major, we estimate a separate version of equation (6), and the predicted values from these logit models are used to construct weights:

$$\psi(x) = \frac{\Pr\,(\widehat{Maj_i} = k)}{1 - \Pr\,(\widehat{Maj_i} = k)}. (7)$$

Equation (7) is the odds ratio of the conditional likelihood of individual *i* choosing major *k*

(relative to liberal arts), and we apply the weights, $\psi(x)$, to the distribution of earnings among those with a liberal arts major. This generates a counterfactual distribution of earnings that would have been expected if the observed characteristics of students in a given group with a liberal arts major were distributed the same as the observed characteristics of those in that group with major *k*. The quantile treatment effect is the vertical difference between the inverse CDFs of the group-specific major *k* earnings distribution and the reweighted group-specific liberal arts earnings distribution at each quantile. We estimate equations (6) and (7) separately by gender and race/ethnicity for each major pairing with liberal arts.

The assumptions underlying this approach are very similar to the linear selection on observables methods discussed above. Both methods ultimately are identified from the assumption that the observed characteristics are sufficient to account for the selection of students with different potential earnings into different majors. The QTE model estimates the effect of college major *k* relative to liberal arts on the distribution of earnings for a given gender or racial/ethnic group. This differs from the distribution of treatment effects, which requires a rank invariance assumption that the treatment does not alter one's rank in the major-specific earnings distribution. This is a stronger assumption that is not possible to test and that we do not invoke.

V. Results

a. Unexplained Cross-group Earnings Gaps

Tables 3-6 present the β estimates from equation (1) sequentially for male-female, White-Black, White-Hispanic, and White-Asian earnings differences. In each table, we first show the raw earnings differences in column (1), after which we add controls for observed characteristics and high school-cohort fixed effects in column (2) and then college-cohort fixed effects in column (3). Column (4) includes indicators for college majors, using the 14 college major groups on which we focus. We then explore the role of more finely controlling for major and college type by including interactions between college major group and college fixed effects in column (5) and then also including CIP4 major fixed effect in column (6). Panel A of the tables presents estimates for earnings 6-10 years after high school, Panel B shows estimates for earnings 11-15 years after high school, and Panel C presents results for earnings 16-20 years post high school. In Panel D we present results for log(earnings) 16-20 years post high school, which expresses the

gap in approximately percentage terms.

Table 3 reports a raw earnings gap of $808 in Panel A, $3,688 in Panel B, and $6,954 in Panel C. As shown in Table 2, the gender earnings differences grow with potential experience. Including the vector of controls, including high school by cohort fixed effects (column 2) diminishes this gap by 27% in the early period but only by 12%-13% in the later two periods. Adding college-cohort fixed effects has only a slight effect on the explaining the residual earnings differences, reducing the unexplained gender earnings gap by 29% in the early period and by 14% and 13% in Panels B and C, respectively. Pre-collegiate academic achievement, SES, and college type thus explain almost a third of the early-career earnings differences between men and women but explain less than 15% of the gender gap as workers gain experience in the labor market.

Prior work has focused on differences in the distribution of majors across genders as a major contributor to the gender earnings gap, since women are underrepresented in higher-paying fields of engineering, IT, business, and economics. Including major fixed effects in column (4) explains 78% of the gap in earnings 6-10 years after high school, which is an increase of 49% of the explained percentage relative to the other controls. This is aligned with prior evidence that college major differences can explain most of the gender gap in starting salaries (McDonald and Thornton 2007). After this early career period, however, major choice becomes less important for explaining gender earnings differences: majors account for an additional 17% of the earnings gap 11-15 years post-HS and 11.6% 16-20 years after high school, above and beyond what is explained by controls and institution. Hence, differences in majors by gender are a decreasingly important explanation for gender differences in earnings as workers age. In Panels B and C, major choice has less explanatory power for gender earnings gaps than has been found in the prior literature, which likely is due to the ages at which prior researchers have observed earnings and the lack of academic achievement, SES, and college type controls in prior analyses. Using log(earnings) rather than levels demonstrates a very similar pattern, qualitatively and quantitatively.

Including controls for college major program more flexibly – with institution by major fixed effects or additionally controlling for the specific 4-digit CIP major code – does not explain much more of the residual gender earning gap. The latter model controls for differences in the

specialization within broad field, for instance between marketing and finance within business, which could differ by gender. The 14 major groups on which we focus contain the relevant differences across students in terms of labor market outcomes. Allowing the effect of majors to vary by institution or further disaggregating majors does not explain more of the earnings differences between men and women in any time period.

Table 4 provides a similar analysis of White-Black earnings differences. There is a large raw earnings gap in each period: $1,673 6-10 years after high school, $3,237 11-15 years after high school, and $5,423 16-20 years after high school. As discussed in Section III, these gaps grow in percentage terms as well as in levels. Aligned with the findings in Neal and Johnson (1997), controlling for pre-collegiate academic achievement explains 55%-62% of the earnings gap between Blacks and Whites who attended college. Adding in college fixed effects explains 74% of earnings differences in Panel A, 74% in Panel B, and 76% in Panel C. Most of the Black-White earnings differences thus can be explained by where students attend college, pre-collegiate academic achievement, and SES measures.

Adding in major controls has no additional explanatory power for any relative experience group. Indeed, the explained portion declines when we add in major controls and does not change when we more flexibly control for major. This result occurs because Black students, on average, major in higher earning areas than White students. For example, the proportion of Black students majoring in liberal arts is lower and the proportion majoring in biology and health and vocational is higher.[10] These findings are novel in showing that while Black-White earnings differences are strongly related to academic achievement and college quality, field of study actually pushes earnings in the opposite direction of lowering the earnings gaps. This is an important finding in particular in light of concerns about affirmative action inducing Black students to major in less technical subjects (Arcidiacono, Aucejo, and Hotz 2016; Arcidiacono, Aucejo, and Spenner 2012; Arcidiacono and Lovenheim 2016). On average, these results suggest that Black students are not majoring in lower-earnings subjects, at least in Texas public institutions.

Table 5 presents results for White-Hispanic earnings differences. Hispanic college attendees earn less than White college attendees in each period: $1,285 6-10 years after high

[10] See Andrews et al. (forthcoming) for evidence on the average return to these different majors.

school, $2,414 11-15 years after high school, and $4,179 16-20 years after high school. These differences grow with potential experience, both in levels in proportionally in relation to mean White earnings. The pre-collegiate controls explain a large proportion of these earnings differences, at 82% in Panel A, 72% in Panel B, and 69% in Panel C. Adding in college fixed effects explains more of the earnings gaps, such that in column (3) the non-major controls account for 97% of the raw earnings gap in the earliest post-college period, 84% in the second period, and 77% in the latest period. These variables explain even more of the Hispanic-White earnings differences as they do the Black-White earnings differences. The importance of college fixed effects speaks to the large differences in earnings effects across colleges coupled with inequitable access to these colleges, particularly along racial and socioeconomic lines (Bleemer, 2022; Chetty et al, 2020).

Controlling for college major has little impact on the unexplained portion of the White-Hispanic earnings gap in any of the relative experience periods. In the earliest period the explained percentage increases slightly, but it declines in the other two periods. As in Table 4, more flexible major controls do not have any impact on the residual gaps. Overall, conditional on the controls, college major differences do not explain any of the Hispanic-White earnings differences residual to the college, academic achievement, and SES controls.

We report results for White-Asian earnings differences in Table 6. Raw White-Asian earnings differences are positive 6-10 years after high school at $361 and then turn negative at -$1,184 and -$2,972 11-15 and 16-20 years after high school, respectively. Because Asian students on average have higher pre-collegiate academic achievement than Whites (Table 2), controlling for pre-collegiate observables exacerbates the positive earnings difference in Panel A and explains 80% and 51% of the negative earnings differences in Panels B and Panel C, respectively. Adding in college fixed effects predicts a similar positive gap in Panel A, column (3) and modestly reduces the negative differences for the second two experience groups. This result is driven by the fact that Asian students attend colleges that are associated with higher earnings than do White students, on average. Taken together, these results show that Whites earn more than Asian students right after college despite having worse pre-collegiate academic achievement and attending lower-return colleges, while these factors explain most of the higher earnings among Asians in 11-15 and 16-20 years after high school.

Asian students major in subjects that are higher earnings relative to their White counterparts, and thus controlling for college major induces all of the White-Asian earnings differences to be positive. Hence, for the 11-15 and 16-20 years post-HS groups, major choice more than fully explains the remaining earnings differences, while for the 6-10 years post-HS group it suggests an even larger positive earnings disparity in favor of White workers. As with the prior results for Black and Hispanic workers, more flexibly controlling for major has little impact on the results and conclusions. The controls in our model combined with college major fully explain the fact that White students earn less than Asian students 11+ years after high school. Differences in major choice account for a non-trivial part of these earnings differences, which indicates that college majors are far more important in explaining White-Asian earnings gaps than they are for White-Hispanic and White-Black differences. In the earliest career period, our data show that White students earn more than Asian students despite the fact that they have lower pre-collegiate academic achievement, attend lower-earnings colleges, and major in lower-earning subjects on average. Why White students earn more than Asian students early in their career as well as conditional on all of these controls in each time period studied is in an important question that is due to factors beyond the scope of this study and that deserve more attention in subsequent research.

From this analysis, one might conclude that college major only plays a modest role in explaining longer-run earnings gaps among college attendees between men and women and between race/ethnic categories. These models, however, impose that the earnings return to college major is the same for men and women and by race/ethnicity. We now turn to an examination of differential returns by gender and race/ethnicity and assessment of how much these differences may matter for observed earnings gaps.

b. Gender and Racial/Ethnic Differences in Returns to College Major

Figures 1 and 2 show estimates of the θ_k and $\theta_k + \phi_k$ from equation (2) by gender. These estimates are gender-specific returns, meaning they show the return for men (women) of majoring in field *k* relative to earnings in liberal arts for men (women). They thus measure the gender-specific earnings differences between field *k* and liberal arts (the excluded category). Note that this is different from earnings gaps by major, since the estimates are relative to own-gender earnings in liberal arts. If, for example, women earn proportionally less in every major

than men, these returns will not differ by gender. No prior work has shown how returns to major choice vary by gender or race/ethnicity, which highlights the novelty of these findings. Importantly, gender-specific returns, rather than earnings gaps, are the key factor in students' choice of major.

Throughout this section, we show estimates separately for the 6 higher-earnings majors (Biology and Health, Business, Economics, Engineering, IT, and Science and Math) and the 6 lower-earnings majors (Agriculture, Communications, Architecture, Social Sciences, Interdisciplinary Studies, and Vocational).[11] All estimates are relative to liberal arts, and we exclude undeclared majors as they all are college non-completers.

Figure 1 shows differences in returns for the high earnings majors and Figure 2 presents the same estimates for the lower-earnings majors. The estimates in Figure 1 show that men and women experience different returns to many majors (relative to liberal arts) that are associated with high overall earnings. Also, the disparities in returns tend to grow with potential experience, such that 16-20 years post-HS the returns differences are particularly large in most of these areas. The differences are large outside of science and math. Relative returns in each of these areas are positive and large for both genders, but over time gender gaps grow to be substantial. By 16-20 years post-HS, male relative returns are $4,564 higher in business, $2,859 higher in economics, $4,046 higher in biology & health, $2,608 higher in IT, and $2,474 higher in engineering. The return gap also is positive for science and math, at $1,108, but it is smaller than in these other fields. Right after college, these gaps are much smaller and are in the opposite direction for biology & health and science & math. In the 11-15 year post-HS period, returns for men become larger than for women in business, economics, and IT, but they are much smaller than in the 16-20 year period. Hence, women experience lower long-run returns than men to these fields of study, but these gaps are not present in the period directly after college.

Substantial gender gaps in returns also are evident for lower-earnings majors, as shown in Figure 2. For agriculture, architecture, social sciences, interdisciplinary studies, and vocational, female returns are substantially below those for men 16-20 years after high school. Overall returns for these majors are lower than those in Figure 1, but the gender gaps still are sizable: 16-20 years post-HS, returns for women are $4,410 lower in agriculture, $839 lower in architecture,

[11] We use the estimates from Andrews et al. (forthcoming) to split majors in this way.

$1,368 lower in social science, and $1,765 lower in interdisciplinary studies relative to men. The only major in which the return for women is higher than for men is communications, which is characterized by low overall returns. Unlike in Figure 1, the return gap tends to open up earlier for these majors, especially for vocational and agriculture. As a result, the conclusions one can draw about differential returns to majors by gender depends to some extent on when earnings are measured. Shorter-run earnings estimates tell a different story from those measured farther out from college.[12]

Can these differential returns explain the under-representation of women in high aggregate return fields like business and economics? To address this question, we use the elasticity of major choice with respect to earnings expectations from Wiswall and Zafar (2015). They report an elasticity of 0.07. Under rational expectations, how much do the lower expected earnings for women because of these differential returns reduce the likelihood that they declare a major in a given area? Using the 16-20 post-HS estimates, we calculate that these differential returns reduce the likelihood that women major in business by 3.2 percentage points (off of a 6.0 pp gap), economics by 2.6 percentage points (off of a 1.2 pp gap), engineering by 1.5 percentage points (off of a 6.5 pp gap), IT by 2.7 percentage points (off of a 2.5 pp gap), and science & math by 1.7 percentage points (off of a 0.8 pp gap). These estimates highlight that the differences in returns experienced by men and women can explain substantial proportions of the under-representation of women in many fields. Nonetheless, it remains possible, and in fact likely, that elasticities differ for men and women, which Wiswall and Zafar (2015) do not separately calculate.

Similar estimates by racial/ethnic groups are shown in Figures 3 and 4 in levels and in Online Appendix Figures A-3 and A-4 in logs. Large differences in returns across racial ethnic groups are apparent. Focusing on White vs. Black returns, Figures 3 and 4 show that Black students experience far lower returns than White students in biology & health, business, economics, engineering, IT, agriculture, communications, and vocational. As with gender, these differences tend to be small in the earliest period right after college but then expand substantially over time. Relative to White returns, Black student returns 16-20 years after high school are

[12] These estimates in Figures 1 and 2 are in levels. When we use logs to examine proportional differences in Online Appendix Figures A-1 and A-2 we see a more stable pattern of male returns being substantially higher than female returns by a similar proportion in each period (outside of communications).

$7,567 lower for engineering, $4,126 lower for IT, $1,099 lower for biology & health, $5,779 lower for business, $8,816 lower for economics, $3,080 lower for agriculture, and $2,493 lower for vocational 16-20 years after high school. These differences are large relative to mean quarterly earnings for Black college attendees of $12,457 during this period. For several majors, such as business, economics, engineering, IT, agriculture, and vocational, sizable returns differences are evident 6-10 and 11-15 years after high school as well. For interdisciplinary studies and social sciences, returns experienced by Black students are higher than those for White students.

These differential returns can explain much of the White-Black differences in the distribution of majors. Using the 0.07 elasticity with respect to expected earnings (Wiswall and Zafar 2015), differences in returns (under rational expectations) 16-20 years after high school reduce the likelihood Black students major in business by 4.5 percentage points (off of a 1.8 pp gap), economics by 7.0 percentage points (off of a 0.6 pp gap), engineering by 4.2 percentage points (off of a base of 2.1 pp), IT by 4.4 percentage points (off of a base of 0.20 pp), and science and math by less than 0.1 percentage points (off of a base of 1.0 pp). These differences in earnings returns therefore can almost fully explain Black-White differences in major choices in these areas using the Wiswall and Zafar (2015) elasticity estimate.

A similar pattern emerges for Hispanic students relative to White students, although the Hispanic-White return differences are somewhat smaller than are the Black-White differences. Hispanic students experience returns relative to Whites that are $4,4447 lower in business, $6,753 lower in economics, $2,882 lower in IT, $6,278 lower in engineering, $1,722 lower in science & math, $1,788 lower in agriculture, and $807 lower in biology & health 16-20 years after high school. As with prior comparisons, these gaps tend to open up in the later period, with the exception of business, economics, engineering, IT, and agriculture, which exhibit substantial differences in the shorter run as well. Taken together, the evidence in Figures 2 and 3 point to large differences in the returns to college major between these two under-represented minority groups and Whites, especially in subjects that have high average returns for White students. Black and Hispanic students do not experience as much of the earnings premiums conventionally associated with “high return” fields.

As with Black students, the lower returns experienced by Hispanic students can explain

much of the under-representation in several fields. Lower returns 16-20 years after high school reduce the likelihood Hispanic students major in business by 3.5 percentage points (off of a 4.3 pp gap), economics by 5.4 percentage points (off of a 0.5 pp gap), engineering by 3.5 percentage points (off of a base of 0.5 pp), IT by 3.1 percentage points (off of a base of 0.4 pp), and science & math by 3.0 percentage points (off of a base of 0.3 pp). As with Black students, the lower returns experienced by Hispanic relative to White students can explain virtually all the differences in major distributions across groups.

Relative returns to college majors are more mixed for Asian students relative to White students. For biology & health and sciences & math, Asian students have higher returns than White students, at $1,850 and $1,553 16-20 years post-HS, respectively. Relative returns in IT are similar for Asian and White students, while for other majors there is a sizable return gap 16-20 years post-HS favoring Whites: $3,091 in business, $7,116 in economics, $3,890 in engineering, $3,260 in agriculture, $2,314 in architecture, and $3,920 in communications. Because Asian students are more likely to major in engineering, business, IT, and economics than are White students, these differential returns do not contribute to relative White students' under-representation in these areas.

c. Decomposition: How Much of the Gap is Explained by Differences in Returns to Major?

Given the differences in returns to major across groups, we now decompose the residual gender and racial earnings gaps into the part that is due to differences in the distribution of majors versus differences in the group-specific returns to different majors. We compute how much of the gender (race) earnings difference at different ages would change if women (non-whites) had the same distribution of majors as men (whites) and, separately, if women (non-whites) had the same returns relative to liberal arts as men (whites). We use the raw gap presented in specification (1) of Tables 3 to 6 as the baseline gap that we seek to explain using the distribution of and returns to college major.[13] Table 7 reports these decomposition results, with Panel A showing results for gender and Panels B-D reporting for race/ethnicity.

[13] We also could perform the same decomposition on the residual earnings gap presented in specification (3) and would reach a similar qualitative conclusion though the share explained by both the distribution and returns would be higher since the residual gap is smaller than the raw gap.

Panel A first shows that, combined, the distribution of majors and differences in returns explain 99% of the gap in years 6-10 after high school. This indicates that if women had the same returns to majors and the same distribution as men, the gender gap would be eliminated in the years right after college. However, this pattern changes dramatically as we look further into individuals' careers, driven by a reduction in the role of major choice. By 16-20 years after high school, the distribution of majors explains 15.9% of the earnings gap. In contrast, the explanatory power of differences in returns to major choice grows over time. By 11-15 years post-HS gender differences in the returns to major explains 19.7% of the gender gap in earnings, which grows to 26.2% by 16-20 years after high school. In the later period, gender differences in returns is a more important component of the gender earnings gap than is major choice. The importance of gender differences in the *returns* to major in explaining the gender earnings gap has not been acknowledged, especially in relation to the voluminous research on gender differences in the distribution of majors. Taken together, major choice and the returns to major explain 46% of the raw gender earnings gap 11-15 years post-HS and 42% 16-20 years after high school. That the explanatory power of majors declines as workers gain potential experience suggests that other factors uncorrelated with college major choice are driving the increasing gender earnings gap over time.

Panel B shows that the distribution of college majors explains little of the White-Black earnings gap, especially 16-20 years after high school. Differences in majors most affect early-career earnings differences, but the explained proportion is small, at 16%. By 16-20 years after high school, differences in major explain less than 5% of Black-White earnings differences. This is perhaps not surprising given the similar distribution of majors between Black and White college students shown in Table 1 and the insensitivity of the White-Black earnings gap to controlling for majors (conditional on the other controls) in Table 4. In contrast, race-specific differences in the returns to college major relative to liberal arts can account for more than half of the earnings gap between Black and White students. This effect remains relatively stable as workers age, explaining 30% of the gap 6-10 years after high school, 23% 11-15 years after high school, and 27% 16-20 years after high school. If Black students had the relative returns of White students, the earnings gap would close by about a quarter. Simply put, Black college students do not benefit as much from studying "high return" majors such as business, economics,

IT, and engineering. Just equalizing the distribution of majors by race would do little the alter the Black-White earnings gap. The much larger source of earnings differences lies in the differential returns to college major by race. These two dimensions of differences in college major explain 31% to 47% of Black-White earnings differences among college attendees.[14]

Panel C tells a similar story for White-Hispanic earnings differences. Differences in college major choice explain little of the earnings differences, which declines from 25% in the earliest period to 10% in the latest period. As in Panel B, differential returns to college major have much larger explanatory power, explaining 53% of the Hispanic-White earnings gap 6-10 years after high school, 37% 11-15 years after, and 25% 16-20 years post-HS. The impact of equalizing major distributions across White and Hispanic students would do little to alter later earnings differences without equalizing the returns these students experience. Together, differences in majors and differences in the returns to major explain 34%-78% of the Hispanic-White earnings gap across periods.

The decomposition results thus far in Table 6 have several similarities across groups that are important to highlight. First, the percent explained by differences in major choice are largest right after college in the early career period. This finding suggests that the conclusions about the role of college major choice, per se, in driving cross-group earnings differences is sensitive to when earnings are measured. Second, starting in the 11-15 years after high school period, differences in the returns to college major become a more empirically relevant explanation for cross-group earnings differences. Third, the explanatory power of differential returns tends to grow with potential experience. These results thus point to group-specific relative returns as a key factor in understanding racial/ethnic and gender earnings disparities among college attendees in the long run.

The results for Asian-White earnings differences in Panel D differ from those for the other groups because Asians are the only group who major in subjects with higher earnings than Whites on average, and their average earnings are higher than Whites in the second two periods.

[14] Online Appendix Table A-3 shows decomposition estimates that switch the base category, using women instead of men and each non-White group instead of Whites. The pattern of results are qualitatively similar, with some differences in magnitudes. Differences in returns to major have more explanatory power for Black and Hispanic groups, and the role of major choice has less explanatory power. The role of returns among Asians is reduced somewhat in the first two earnings periods, while for gender the main difference is in the first earnings period where the role of returns is lower and the role of major choice is larger.

The results in Panel D show that both the distribution of majors and the returns to major are important for explaining White-Asian earnings differences, but they move in different directions in different time periods. In the early period, differences in major choices move in the "wrong" direction for explaining earnings differences, as Whites earn more on average than Asians but Asian students major in higher-earning subjects. In the subsequent two periods, differences in major choices explain about 100% and 63% of the earnings differences, since Asian students earn on average more than White students. The role of differences in returns to majors is opposite in sign to the effect of major choice in each period. This occurs because Asian students receive lower returns to majors than Whites, leading to a positive effect of return differences in the first period (when the gap is positive) and a negative effect in the second two periods (when the gap is negative). Put differently, if we equalized the return to majors between Whites and Asians, Asians would earn even more than Whites than they already do by about 50% in the 11-15 and 16-20 post-HS periods.[15]

d. The Effect of Major Choices on the Distribution of Earnings

Up to now, we have shown large differences in mean returns to college major across group: on average, men benefit more from certain "high return" majors than women do, as do White students compared to Black and Hispanic students. These mean earnings differences may be a poor reflection of the patterns experienced by the typical student, however. Majors with small mean earnings gaps across groups could exhibit larger gaps at different parts of the earnings distribution. For instance, a major with moderate female relative earnings could reflect a few women having very high earnings with most having lower earnings, or it can reflect most women experiencing modestly higher earnings. Examining the effect of major choice on the distribution of earnings separately by race/ethnicity provides insight into why the earnings returns differ across groups and for whom. Is it because of a few high earners or is it a more ubiquitous effect across the distribution?

Differences in earnings returns across the distribution also creates ex-ante risk in terms of the likelihood of a randomly chosen student receiving the average return. Risk differences may magnify mean earnings differences if students are risk averse, and there may be differences in

[15] Online Appendix Table A-4 shows decomposition estimates using log earnings rather than earnings levels. The patterns are similar to those shown in Table 7, with the largest differences occurring in the 6-10 years after high school.

risk preferences by gender or race/ethnicity that further alter the effective returns to different majors experienced by those in each group. Prior work has shown that distributional effects are important across majors (Andrews et al, forthcoming) and institutions (Andrews, Li, Lovenheim, 2016) but has not examined differences by gender and race/ethnicity.

Figures 5 and 6 report quantile treatment effect estimates of the return to major (relative to liberal arts) separately by gender, as described in Section IVc. Figure 5 presents estimates for the high-earnings majors, while Figure 6 presents estimates for the lower-earnings majors. The outcome is average person-level mean quarterly earnings across all years and experience levels in our sample. The solid curves in each panel presents the QTE estimates separately for male and female students, and the shaded regions shows the 95% confidence intervals that are calculated using a block bootstrap at the institution-by-major level.

The mean gender earnings differences in Figures 1 and 2 can provide a misleading picture of the relative returns for many students. For IT, and architecture, the differences in mean returns for men and women are driven by the lower part of the earnings distribution. There is convergence at the top, and the gender gaps are largest below the 80^{th} percentile. By contrast, business, economics, engineering, agriculture, and vocational majors shift out the male earnings distribution by more than the female earnings distribution at all percentiles. For biology & health, science & math, social sciences, and interdisciplinary studies, the earnings differences only are evident at the top of the distribution.

It also is notable that for business, IT, and agriculture, the returns for women are especially low in the bottom half of the distributions, while for architecture, vocational, and social sciences they are close to zero throughout the distribution. For a large portion of women in these fields, the relative returns are effectively zero.

Figures 7 and 8 show quantile treatment effect estimates by race/ethnicity. Here the patterns are even more striking: the returns to many majors – IT, business, economics, science & math, biology & health, and vocational – are close to zero below the median for Black and Hispanic students. Yet these majors shift out the earnings distribution (in varying magnitudes) at all percentiles for White and Asian students. IT, business, and economics are particularly noteworthy for having high returns for most White and Asian students but low returns for most Black and Hispanic students. Engineering shifts out the earnings distributions throughout for all

groups, but the shift is larger for White and Asian students than for Black and Hispanic students across most of the distribution.

We also highlight that for many of the highest-return majors – business, economics, engineering, and biology & health – the earnings returns at the top of the distribution for Asians is lower than for Whites and in several cases than for Black and Hispanic students. The differences in earnings returns (relative to Whites) in these fields is driven by those at the top of the distribution. In contrast, the earnings differences between Whites and both Hispanics and Blacks is due to those lower in the earnings distribution in these majors. Overall, our results show that the mean differences in earnings returns by race are not simply due to high earners. Discussions of the sources of earnings differences by race/ethnicity can focus on what is happening with top earnings. Our results show that one must examine a wider range of workers to fully understand these differences in returns to major choice and racial/ethnic earnings gaps.

We interpret the QTE estimates as providing evidence of ex-ante risk differences across majors. Generally, the gender and racial/ethnic gaps in mean returns to major shown in Figures 1-4 will understate the welfare gap to each field given that the returns to different majors for female, Black, and Hispanic students accrue to specific parts of the earnings distribution rather than being spread out evenly across the distribution. Thus, differences in the returns to college major may explain even more of the *welfare* gap than is suggested by our decomposition of earnings.

VI. Conclusion

Using administrative data on K-12 public school students linked with public higher education students and the near-universe of quarterly earnings for workers in Texas, we present new evidence on how major choices differ between men and women as well as between White, Black, Hispanic, and Asian racial/ethnic groups. We then examine the consequences of these differences for explaining earnings cross-group earnings gaps in three periods of post-college working life: 6-10, 11-15, and 16-20 years after high school. We thus document how these earnings gaps evolve in our data among those who attend a four-year college in Texas and how major choices impact earnings disparities as workers age.

We focus on two dimensions along which major choices can impact earnings differences

across groups: the role of differences in major choices per se and differences in returns experienced by different groups. The latter refers to the group-specific returns to a given major relative to liberal arts (the excluded category), which prior work has not examined. We present evidence that women experience much lower relative returns to high-earnings majors than do men, such as IT, engineering, business, economics, and biology & health. A similar story emerges for racial/ethnic earnings differences: Black and Hispanic students experience lower returns relative to White students to these majors that have high average returns. Using an elasticity estimate from the literature (Wiswall and Zafar 2015), we show that these differences in earnings returns can explain much of the under-representation of women and URMs in these majors.

We then present evidence from a linear decomposition that differences in earnings returns are a more important determinant of cross-group earnings differences than are major choices. Differences in majors are most important in the early career period, but once students reach their late 20s differences in the returns to major are the more dominant explanation for gender and racial/ethnic earnings gaps. For workers attending college in Texas 16-20 years after high school, differences in earnings returns explain 26% of the gender earnings gap, 27% of the White-Black earnings gap, 25% of White-Hispanic earnings disparities, and move in the wrong direction to explain earnings differences between Whites and Asians. Major choices and differential returns together explain 42% of the gender earnings gap, 31% of the White-Black earnings gap, 34% of the White-Hispanic earnings difference, and 17% of the White-Asian earnings difference. Hence, college majors are an important determinant of earnings inequality by gender and race/ethnicity in the labor market, with differential returns to major playing a large role especially as workers age.

Our results have important implications for policies that can address racial and gender/ethnic labor market outcomes. They suggest that simply equalizing the distribution of majors between groups will have only a minor effect on earnings differences, particularly in the longer-run. Rather, what is needed is policies to equalize returns. Indeed, our results suggest that equalizing returns could eliminate or significantly reduce cross-group differences in major choice. One important source of differential earnings returns is occupational choices that may vary by gender and race/ethnicity conditional on college major. Policies to make high-earning

occupations more inclusive also could reduce differences in returns across groups, though our results also show that differences in returns occur throughout the earnings distribution and are not just driven by high earners. Future work that further examines the sources of these gender and racial/ethnic disparities in returns is important to more fully understand what policies can be used to reduce gender and racial/ethnic stratification in earnings.

References

Altonji, Joseph G., Erica Blom, and Costas Meghir. 2012. "Heterogeneity in Human Capital Investments: High School Curriculum, College Major, and Careers." *Annual Review of Economics* 4(1): 185-223.

Altonji, Joseph G., Peter Arcidiacono, and Arnaud Maurel. 2016. "The Analysis of Field Choice in College and Graduate School: Determinants and Wage Effects." In *Handbook of the Economics of Education*, vol. 5, pp. 305-396. Elsevier.

Andrews, Rodney J., Scott A. Imberman, and Michael F. Lovenheim. 2020. "Recruiting and Supporting Low-income, High-achieving Students at Flagship Universities." *Economics of Education Review* 74: 101923.

Andrews, Rodney J., Scott A. Imberman, Michael F. Lovenheim, and Kevin M. Stange. Forthcoming. "The Returns to College Major Choice: Average and Distributional Effects, Career Trajectories, and Earnings Variability." *Review of Economics and Statistics*.

Andrews, Rodney J., Jing Li, and Michael F. Lovenheim. 2016. "Quantile Treatment Effects of College Quality on Earnings." *Journal of Human Resources* 51(1): 200-238.

Antman, Francisca M., Brian Duncan, and Stephen J. Trejo. 2023. "Hispanic Americans in the Labor Market: Patterns Over Time and Across Generations." *Journal of Economic Perspectives* 37(1): 169-198.

Arcidiacono, Peter. 2004. "Ability Sorting and the Returns to College Major." *Journal of Econometrics* 121(1): 343-375.

Arcidiacono, Peter, Esteban M. Aucejo, and V. Joseph Hotz. 2016. "University Differences in the Graduation of Minorities in STEM Fields: Evidence from California." *American Economic Review* 106(3): 525-562.

Arcidiacono, Peter, Esteban M. Aucejo, and Ken Spenner. 2012. "What Happens After Enrollment? An Analysis of the Time Path of Racial Differences in GPA and Major Choice." *IZA Journal of Labor Economics* 1: 1-24.

Arcidiacono, Peter, and Michael Lovenheim. 2016. "Affirmative Action and the Quality–fit Trade-off." *Journal of Economic Literature* 54(1): 3-51.

Astorne-Figari, Carmen and Jamin D. Speer. 2019. "Are Changes of Major Major Changes? The Roles of Grades, Gender, and Preferences in College Major Switching." *Economics of Education Review* 70: 75-93.

Bayer, Patrick and Kerwin Kofi Charles. 2018. "Divergent Paths: A New Perspective on Earnings Differences Between Black and White Men Since 1940." *Quarterly Journal of Economics* 133(3): 1459-1501.

Black, Dan A., Amelia M. Haviland, Seth G. Sanders, and Lowell J. Taylor. 2008. "Gender Wage Disparities Among the Highly Educated." *Journal of Human Resources* 43(3): 630-659.

Blau, Francine D. and Lawrence M. Kahn. 2017. "The Gender Wage Gap: Extent, Trends, and Explanations." *Journal of Economic Literature* 55(3): 789-865.

Bleemer, Zachary and Aashish Mehta. 2022. "Will Studying Economics Make You Rich? A Regression Discontinuity Analysis of the Returns to College Major." *American Economic Journal: Applied Economics* 14(2): 1-22.

Bleemer, Zachary and Aashish Mehta. 2023. "College Major Restrictions and Student Stratification." Working Paper.

Chetty, Raj, Nathaniel Hendren, Maggie R. Jones, and Sonya R. Porter. 2020. "Race and Economic Opportunity in the United States: An Intergenerational Perspective." *Quarterly Journal of Economics* 135(2): 711-783.

Dickson, Lisa. 2010. "Race and Gender Differences in College Major Choice." *The Annals of the American Academy of Political and Social Science* 627(1): 108-124.

DiNardo, John, Nicole M. Fortin, and Thomas Lemieux. 1996. "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach." *Econometrica* 64(5): 1001-1044.

England, Paula and Su Li. 2006. "Desegregation Stalled: The Changing Gender Composition of College Majors, 1971-2002." *Gender & Society* 20(5): 657-677.

Firpo, Sergio. 2007. "Efficient Semiparametric Estimation of Quantile Treatment Effects."

Econometrica 75(1): 259-276.

Foote, Andrew and Kevin M. Stange. 2022. "Attrition from Administrative Data: Problems and Solutions With an Application to Postsecondary Education." NBER Working Paper No. w30232.

Francesconi, Marco and Matthias Parey. 2018. "Early Gender Gaps Among University Graduates." *European Economic Review* 109: 63-82.

Gemici, Ahu and Matthew Wiswall. 2014. "Evolution of Gender Differences in Post-secondary Human Capital Investments: College Majors." *International Economic Review* 55(1): 23-56.

Goldin, Claudia, Lawrence F. Katz, and Ilyana Kuziemko. 2006. "The Homecoming of American College Women: The Reversal of the College Gender Gap." *Journal of Economic perspectives* 20(4): 133-156.

Hägglund, Anna Erika. 2024. "Same Degrees, Different Outcomes? Fields of Study Choices and Gender Wage Inequality in Finland and Germany." *Social Science Research* 122: 103029.

Hamermesh, Daniel S. and Stephen G. Donald, 2008. "The Effect of College Curriculum on Earnings: An Affinity Identifier for Non-ignorable Non-response Bias." *Journal of Econometrics* 144(2): 479-491.

Hirsch, Barry T. and John V. Winters. 2014. "An Anatomy of Racial and Ethnic Trends in Male Earnings in the US." *Review of Income and Wealth* 60(4): 930-947.

Humphries, John Eric, Juanna Schrøter Joensen, and Gregory F. Veramendi. 2024. "The Gender Wage Gap: Skills, Sorting, and Returns." *AEA Papers and Proceedings* 114: 259-264.

Kirkebøen, Lars, Edwin Leuven, and Magne Mogstad, 2016. "Field of Study, Earnings, and Self-Selection," *The Quarterly Journal of Economics* 131(3): 1057-1111.

Kospentaris, Ioannis and Leslie S. Stratton. 2021. "The Evolution of Labor Market Disparities Between Black, Hispanic, and White Men: 1968-2019." Life Course Centre Working Paper 2021-08.

Kugler, Adriana D., Catherine H. Tinsley, and Olga Ukhaneva. 2021. “Choice of Majors: Are Women Really Different from Men?” *Economics of Education Review* 81: 102079.

Lovenheim, Michael and Jonathan Smith. 2023. “Returns to Different Postsecondary Investments: Institution Type, Academic Programs, and Credentials.” *Handbook of the Economics of Education* Vol 6: 187-318.

Machin, Stephen and Patrick A. Puhani. 2003. “Subject of Degree and the Gender Wage Differential: Evidence from the UK and Germany.” *Economics Letters* 79(3): 393-400.

McDonald, Judith A. and Robert J. Thornton. 2007. “Do New Male and Female College Graduates Receive Unequal Pay?" *Journal of Human Resources* 42(1): 32-48.

Neal, Derek A. and William R. Johnson. 1996. “The Role of Premarket Factors in Black-white Wage Differences.” *Journal of political Economy* 104(5): 869-895.

Sakamoto, Arthur, Christopher R. Tamborini, and ChangHwan Kim. 2018. “Long-term Earnings Differentials Between African American and White Men by Educational Level.” *Population Research and Policy Review* 37: 91-116.

Saltiel, Fernando. 2023. “Multi-dimensional Skills and Gender Differences in Stem Majors.” *The Economic Journal* 133(651): 1217-1247.

Sloane, Carolyn M., Erik G. Hurst, and Dan A. Black. 2021. “College Majors, Occupations, and the Gender Wage Gap.” *Journal of Economic Perspectives* 35(4): 223-248.

Turner, Sarah E. and William G. Bowen. 1999. “Choice of Major: The Changing (Unchanging) Gender Gap.” *Industrial and Labor Relations Review* 52(2): 289-313.

Wiswall, Matthew and Basit Zafar. 2015. “Determinants of College Major Choice: Identification Using an Information Experiment.” *Review of Economic Studies* 82(2): 791-824.

Zafar, Basit. 2013. “College Major Choice and the Gender Gap.” *Journal of Human Resources* 48(3): 545-595.

Zhou, Xiang, and Guanghui Pan. 2023. “Higher Education and the Black-white Earnings Gap.” *American Sociological Review* 88(1): 154-188.

Table 1: Means of Analysis Variables

Variable	(1) Male	(2) Female	(3) White	(4) Black	(5) Hispanic	(6) Asian
Liberal Arts	0.125	0.135	0.142	0.102	0.123	0.078
Agriculture	0.046	0.023	0.048	0.008	0.010	0.003
Communications	0.040	0.055	0.051	0.053	0.040	0.038
IT	0.029	0.004	0.015	0.013	0.011	0.034
Vocational	0.109	0.053	0.073	0.118	0.084	0.030
Engineering	0.079	0.014	0.043	0.022	0.038	0.086
Architecture	0.012	0.009	0.012	0.007	0.008	0.009
Biology & Health	0.060	0.118	0.080	0.108	0.101	0.178
Science & Math	0.023	0.015	0.020	0.010	0.017	0.023
Social Science	0.074	0.141	0.112	0.128	0.107	0.093
Business	0.220	0.160	0.193	0.175	0.150	0.281
Economics	0.016	0.004	0.010	0.004	0.005	0.025
Interdisciplinary Studies	0.020	0.125	0.082	0.062	0.090	0.028
Undeclared	0.156	0.150	0.125	0.194	0.222	0.115
Double Major	0.007	0.008	0.007	0.004	0.006	0.021
Male	1.000		0.452	0.390	0.413	0.487
Female		1.000	0.548	0.610	0.587	0.513
White	0.647	0.613	1.000			
Black	0.088	0.107		1.000		
Hispanic	0.207	0.230			1.000	
Asian	0.058	0.048				1.000
Math Exam Score	0.651	0.495	0.683	0.067	0.382	0.812
	(0.667)	(0.704)	(0.604)	(0.818)	(0.741)	(0.603)
Reading Exam Score	0.507	0.527	0.630	0.195	0.353	0.475
	(0.599)	(0.576)	(0.494)	(0.707)	(0.651)	(0.682)
Top Ten Percent Math	0.288	0.21	0.283	0.084	0.170	0.393
	(0.453)	(0.407)	(0.450)	(0.278)	(0.376)	(0.489)
70th-90th Percentile Math	0.317	0.291	0.331	0.194	0.264	0.314
	(0.465)	(0.454)	(0.471)	(0.396)	(0.441)	(0.464)
Top Ten Percent Reading	0.253	0.261	0.308	0.117	0.173	0.265
	(0.435)	(0.439)	(0.462)	(0.322)	(0.378)	(0.441)
70th-90th Percentile Reading	0.303	0.302	0.329	0.224	0.266	0.290
	(0.460)	(0.459)	(0.470)	(0.417)	(0.442)	(0.454)
At Risk	0.172	0.167	0.108	0.310	0.287	0.153
	(0.377)	(0.373)	(0.310)	(0.463)	(0.452)	(0.360)
Limited English Profiency	0.005	0.005	0	0.001	0.017	0.022
	(0.070)	(0.073)	(0.016)	(0.031)	(0.129)	(0.148)
Economically Disadvantaged	0.147	0.173	0.036	0.296	0.460	0.184
	(0.355)	(0.378)	(0.186)	(0.457)	(0.498)	(0.388)
Earnings 6-10 Years Post-HS	8,351.08	7,542.64	8,365.45	6,692.78	7,080.45	8,004.07
	(7407.63)	(5840.25)	(6878.10)	(6504.13)	(5389.54)	(7114.77)
Earnings 11-15 Years Post-HS	14,283.30	10,594.92	13,023.62	9,786.93	10,609.97	14,208.00
	(13494.23)	(12647.42)	(14907.54)	10165.40	(8095.91)	12238.99
Earnings 16-20 Years Post-HS	20,475.56	13,521.19	17,962.23	12,539.09	13,782.83	20,934.35
	(22617.08)	(11797.48)	(19926.70)	(9537.73)	(12113.46)	(20945.65)
Observations	218,276	275,889	310,922	48,671	107,445	26,061

Notes: Standard Deviations in parentheses.

Table 2: Gender and Racial/Ethnic Differences in Earnings over Time

	(1)	(2)	(3)	(4)	(5)	(6)
Earnings Period	Male	Female	White	Black	Hispanic	Asian
Earnings 6-10 Years Post-HS	8,351	7,543	8,365	6,693	7,080	8,004
		(808)		(1,673)	(1,285)	(361)
		10.7%		25.0%	18.1%	4.5%
Earnings 11-15 Years Post-HS	14,283	10,595	13,024	9,787	10,610	14,208
		(3,688)		(3,237)	(2,414)	(-1,184)
		34.8%		33.1%	22.7%	-8.3%
Earnings 16-20 Years Post-HS	20,476	13,521	17,962	12,539	13,783	20,934
		(6,954)		(5,423)	(4,179)	(-2,972)
		51.4%		43.2%	30.3%	-14.2%

Notes: The table displays mean earnings in each period from Table 1. The difference between male-female and between white and each racial/ethnic group is in parentheses, with the percent difference in earnings relative to the non-male/non-white mean shown in each third row.

Table 3: Male-Female Earnings Differences

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Earnings 6-10 Years Post-HS						
Male	808	588	573	176	203	201
	(201)	(153)	(133)	(83)	(84)	(62)
% Explained		27.2%	29.1%	78.2%	74.9%	75.1%
Panel B: Earnings 11-15 Years Post-HS						
Male	3,688	3,228	3,180	2,545	2,569	2,410
	(349)	(270)	(244)	(190)	(198)	(184)
% Explained		12.5%	13.8%	31.0%	30.3%	34.7%
Panel C: Earnings 16-20 Years Post-HS						
Male	6,954	6,142	6,062	5,254	5,299	5,013
	(555)	(434)	(409)	(365)	(379)	(362)
% Explained		11.7%	12.8%	24.4%	23.8%	27.9%
Panel D: Log(Earnings) 16-20 Years Post-HS						
Male	0.400	0.359	0.356	0.312	0.313	0.298
	(0.024)	(0.020)	(0.018)	(0.015)	(0.014)	(0.013)
% Explained		10.3%	11.0%	22.0%	21.8%	25.5%
Controls + HS FE		X	X	X	X	X
College FE			X	X		
Major Group FE				X		
College - Major Group FE					X	X
CIP4 FE						X

Notes: Standard errors clustered at the institution-major level are in parentheses. % Explained is the percent of the raw earnings difference across groups explained by the covariates.

Table 4: White-Black Earnings Differences

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Earnings 6-10 Years Post-HS						
White	1,673	762	442	508	498	498
	(250)	(131)	(93)	(85)	(85)	(82)
% Explained		54.5%	73.6%	69.6%	70.2%	70.2%
Panel B: Earnings 11-15 Years Post-HS						
White	3,237	1,338	839	1,053	1,038	1,067
	(421)	(200)	(131)	(125)	(130)	(132)
% Explained		58.7%	74.1%	67.5%	67.9%	67.0%
Panel C: Earnings 16-20 Years Post-HS						
White	5,423	2,058	1,309	1,656	1,638	1,722
	(634)	(286)	(194)	(181)	(188)	(192)
% Explained		62.1%	75.9%	69.5%	69.8%	68.2%
Controls + HS FE		X	X	X	X	X
College FE			X	X		
Major Group FE				X		
College - Major Group FE					X	X
CIP4 FE						X

Notes: Standard errors clustered at the institution-major level are in parentheses. % Explained is the percent of the raw earnings difference across groups explained by the covariates.

Table 5: White-Hispanic Earnings Differences

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Earnings 6-10 Years Post-HS						
White	1,285	233	36	13	-5	-26
	(242)	(93)	(55)	(53)	(53)	(50)
% Explained		81.9%	97.2%	99.0%	100.4%	102.0%
Panel B: Earnings 11-15 Years Post-HS						
White	2,414	668	396	422	402	406
	(390)	(157)	(103)	(102)	(101)	(100)
% Explained		72.3%	83.6%	82.5%	83.3%	83.2%
Panel C: Earnings 16-20 Years Post-HS						
White	4,179	1,293	971	1,061	1,032	1,065
	(578)	(239)	(177)	(168)	(165)	(166)
% Explained		69.1%	76.8%	74.6%	75.3%	74.5%
Controls + HS FE		X	X	X	X	X
College FE			X	X		
Major Group FE				X		
College - Major Group FE					X	X
CIP4 FE						X

Notes: Standard errors clustered at the institution-major level are in parentheses. % Explained is the percent of the raw earnings difference across groups explained by the covariates.

Table 6: White-Asian Earnings Differences

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Earnings 6-10 Years Post-HS						
White	361	793	709	1,201	1,242	1,203
	(404)	(309)	(194)	(125)	(106)	(72)
% Explained		-119.7%	-96.4%	-232.7%	-244.0%	-233.2%
Panel B: Earnings 11-15 Years Post-HS						
White	-1,184	-228	-137	732	842	1,005
	(495)	(322)	(198)	(193)	(234)	(237)
% Explained		80.7%	88.4%	161.8%	171.1%	184.9%
Panel C: Earnings 16-20 Years Post-HS						
White	-2,972	-1,451	-1,041	268	537	1,011
	(832)	(557)	(436)	(428)	(489)	(490)
% Explained		51.2%	65.0%	109.0%	118.1%	134.0%
Controls + HS FE		X	X	X	X	X
College FE			X	X		
Major Group FE				X		
College - Major Group FE					X	X
CIP4 FE						X

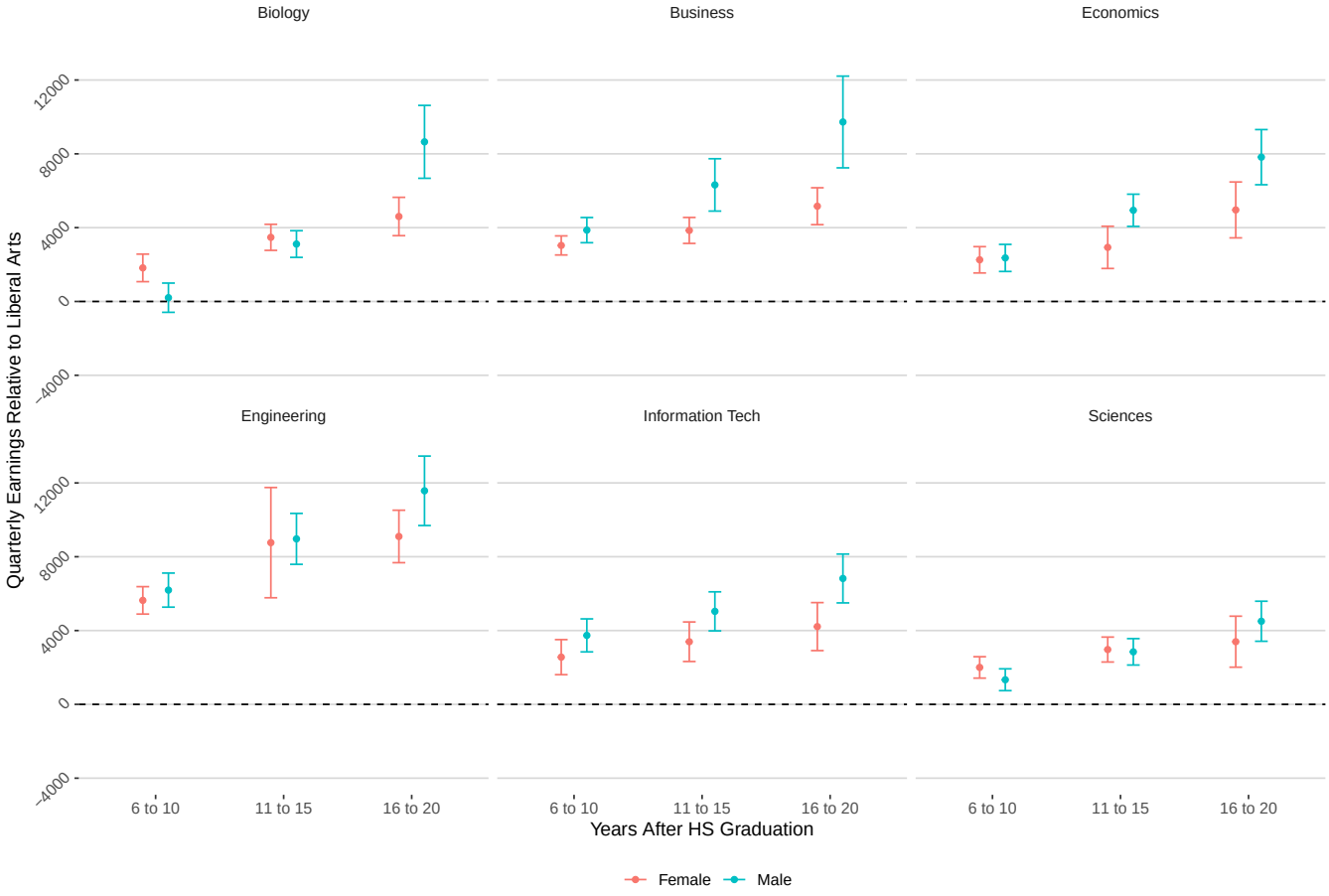
Notes: Standard errors clustered at the institution-major level are in parentheses. % Explained is the percent of the raw earnings difference across groups explained by the covariates.

Table 7: Blinder-Oaxaca Decompositions of Earnings Differences Due to Major Choice and Returns to Major Choice

	Years after High School		
Panel A: Male-Female	6-10	11-15	16-20
Percent Explained by Major Choice	86.1%	26.0%	15.9%
Percent Explained by Major Returns	12.9%	19.7%	26.2%
Panel B: White-Black			
Percent Explained by Major Choice	16.2%	8.6%	4.5%
Percent Explained by Major Returns	30.4%	22.8%	26.8%
Panel C: White-Hispanic			
Percent Explained by Major Choice	25.4%	16.4%	10.0%
Percent Explained by Major Returns	53.0%	36.6%	24.5%
Panel D: White-Asian			
Percent Explained by Major Choice	-176.7%	101.6%	63.1%
Percent Explained by Major Returns	43.5%	-41.6%	-46.2%

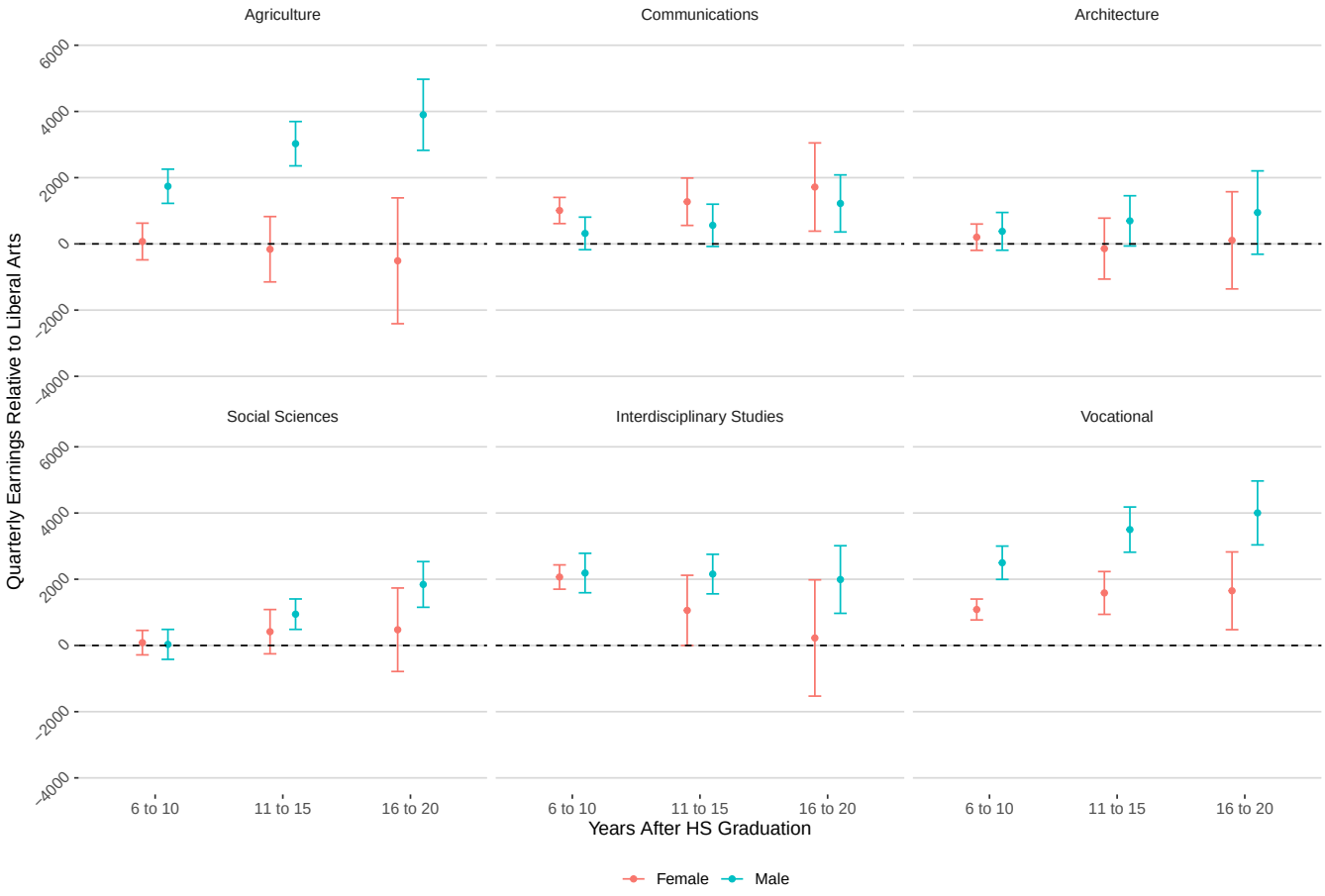
Notes: Percent Explained by Major Choice shows how much of the difference in earnings across groups would change if women (non-Whites) had the same distribution of majors as men (Whites). Percent Explained by Major Returns shows how much of the difference in earnings across groups would change if women (non-Whites) had the same returns relative to liberal arts as men (Whites).

Figure 1: Earnings Returns Over Time Relative to Liberal Arts, by Field and Gender – High Average Earnings Majors



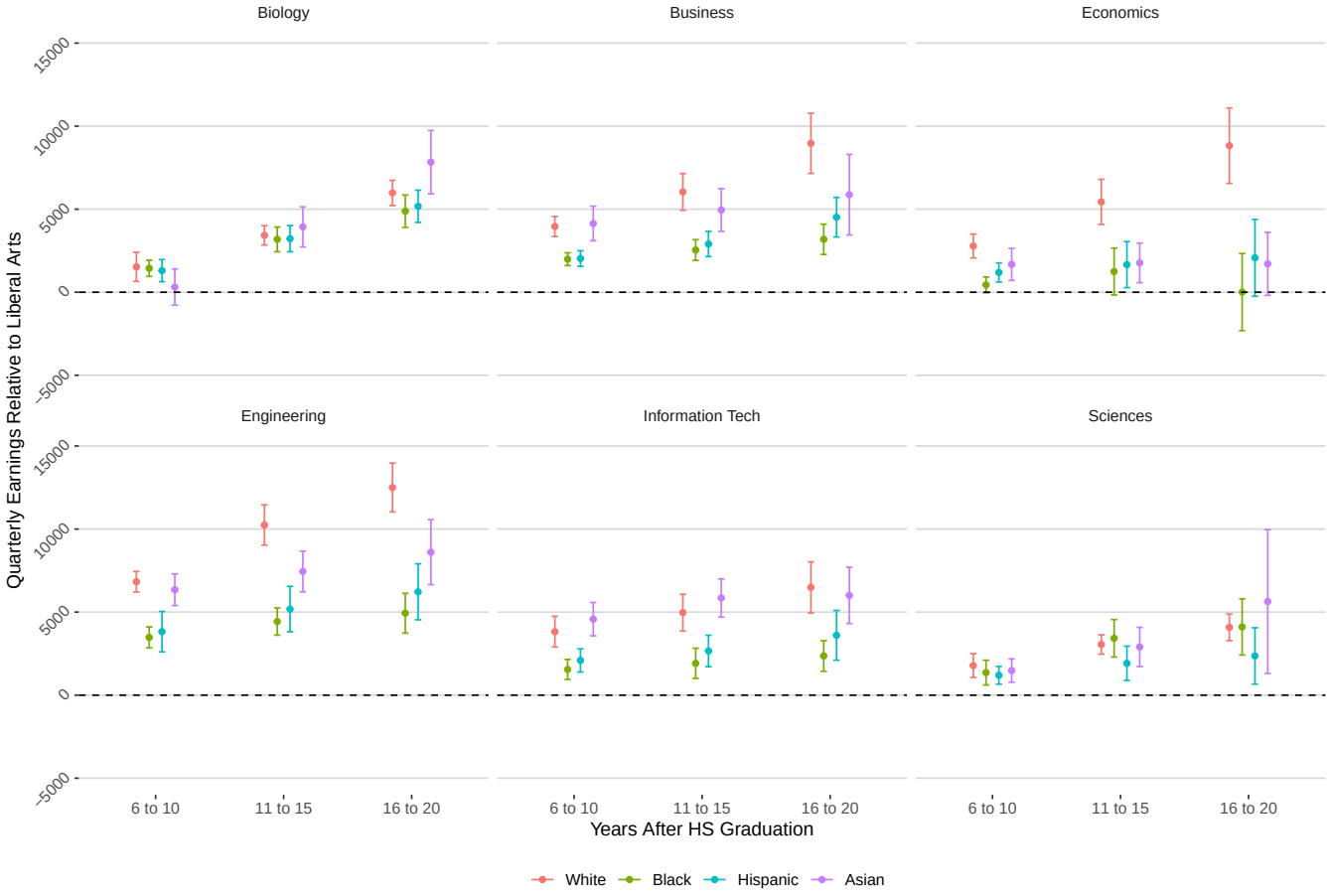
Error bars represent the 95% confidence interval

Figure 2: Earnings Returns Over Time Relative to Liberal Arts, by Field and Gender – Low Average Earnings Majors



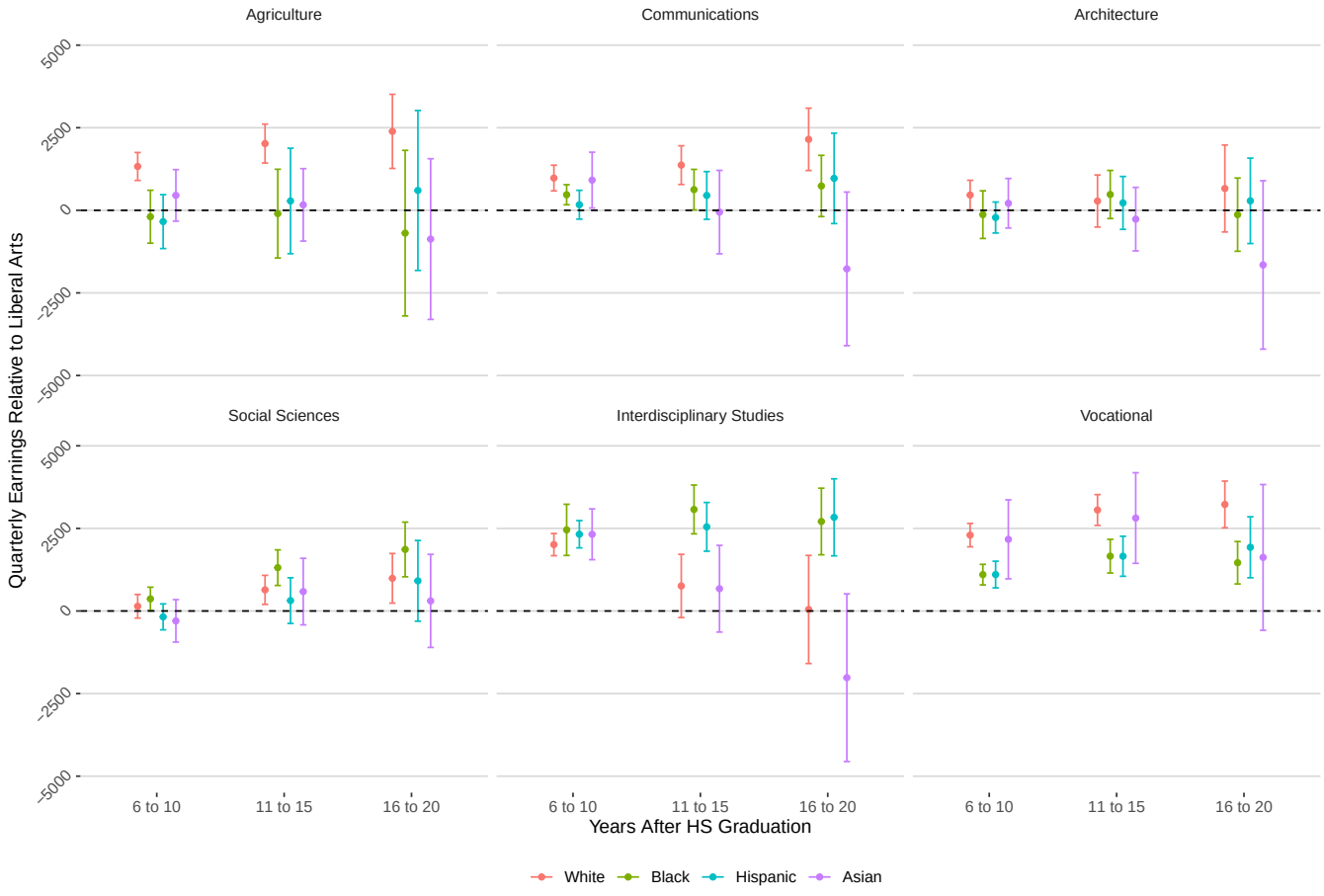
Error bars represent the 95% confidence interval

Figure 3: Earnings Returns Over Time Relative to Liberal Arts, by Field and Race – High Average Earnings Majors



Error bars represent the 95% confidence interval

Figure 4: Earnings Returns Over Time Relative to Liberal Arts, by Field and Race – Low Average Earnings Majors



Error bars represent the 95% confidence interval

Figure 5: Quantile Treatment Effects, by Field and Gender – High Average Earnings Majors

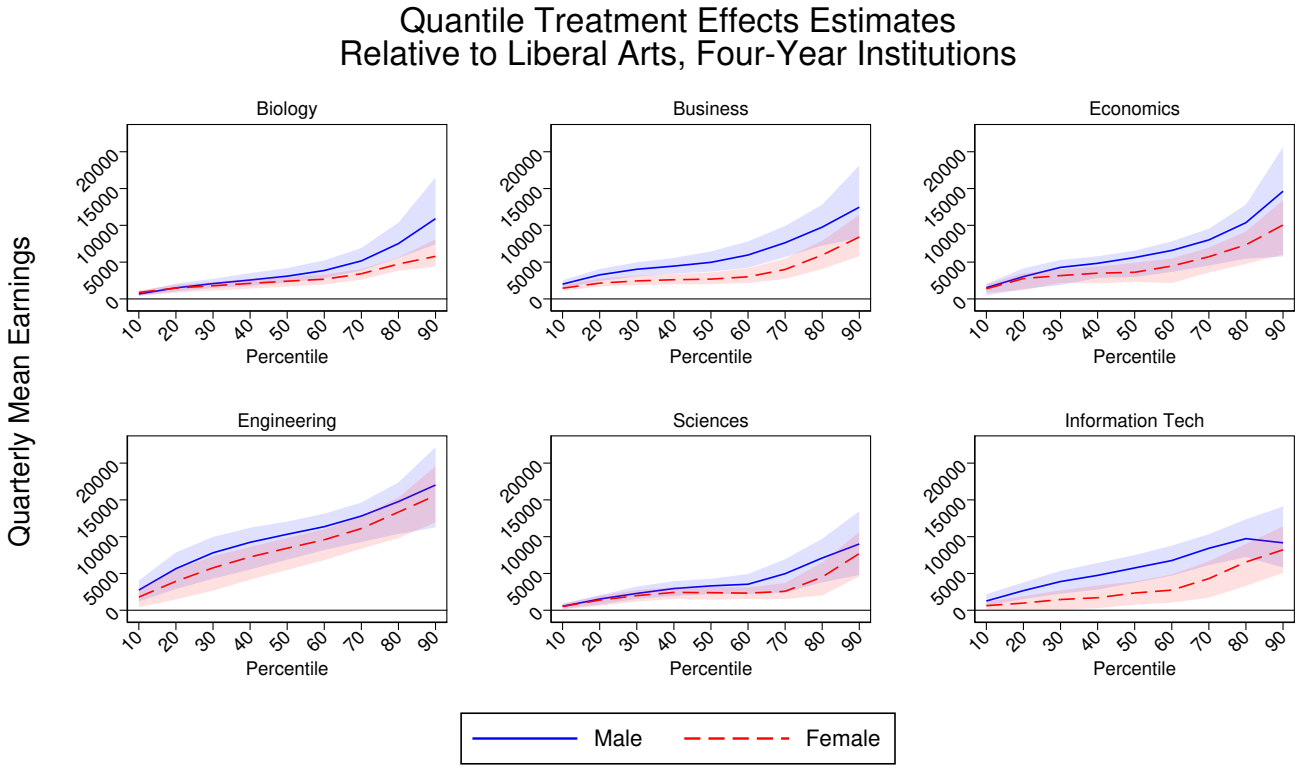


Figure 6: Quantile Treatment Effects, by Field and Gender – Low Average Earnings Majors

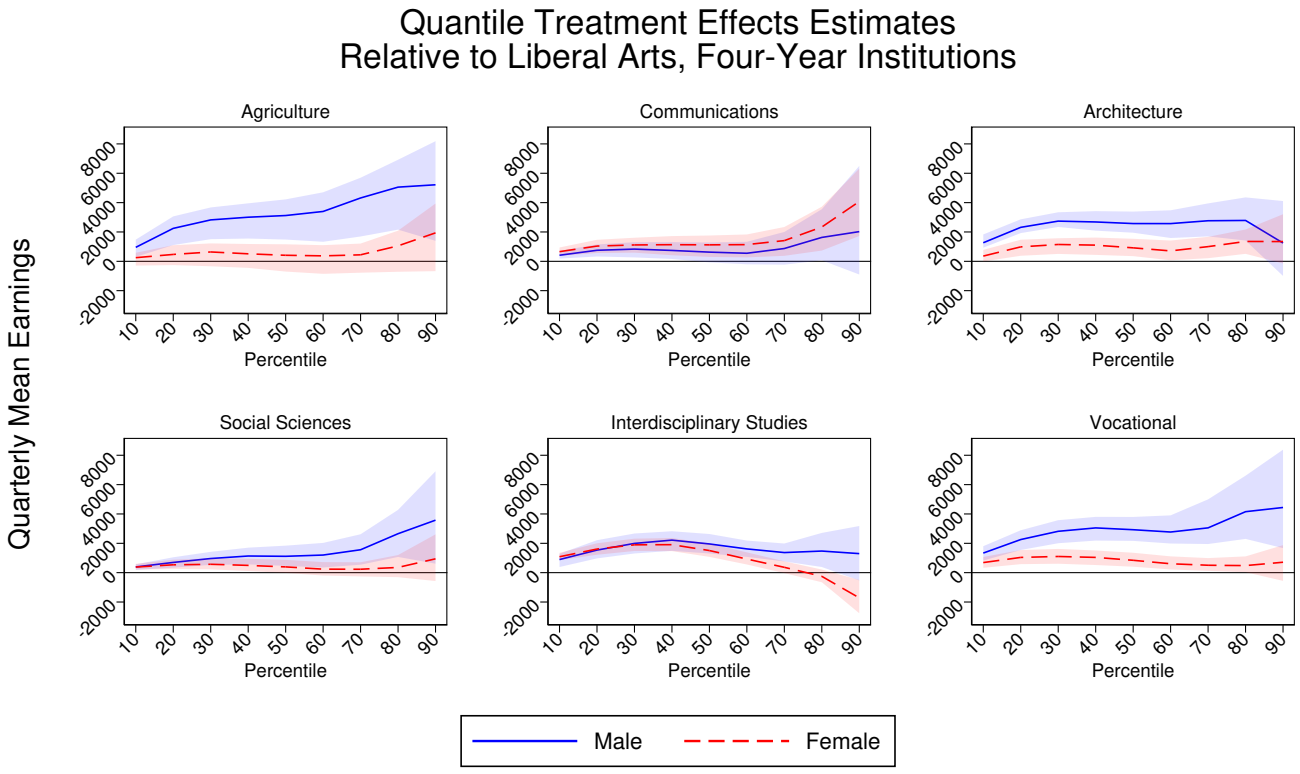


Figure 7: Quantile Treatment Effects, by Field and Race – High Average Earnings Majors

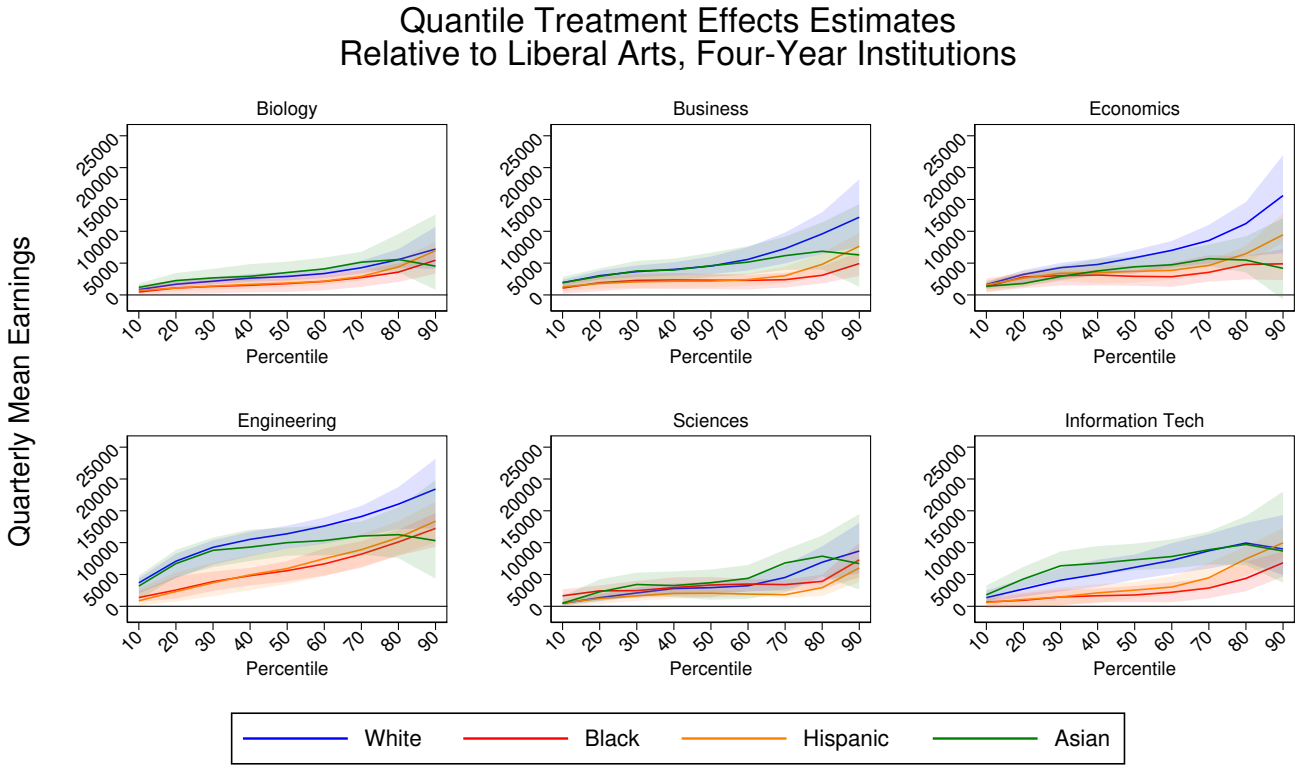
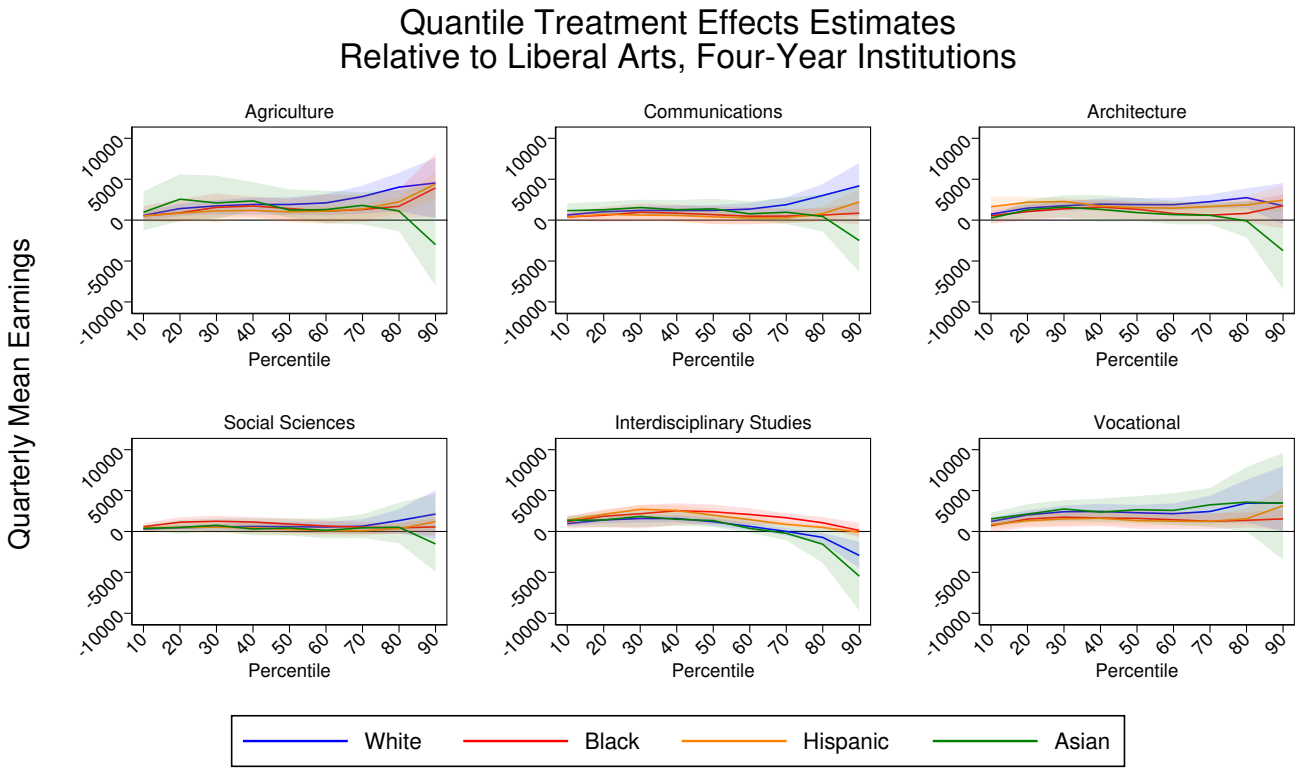
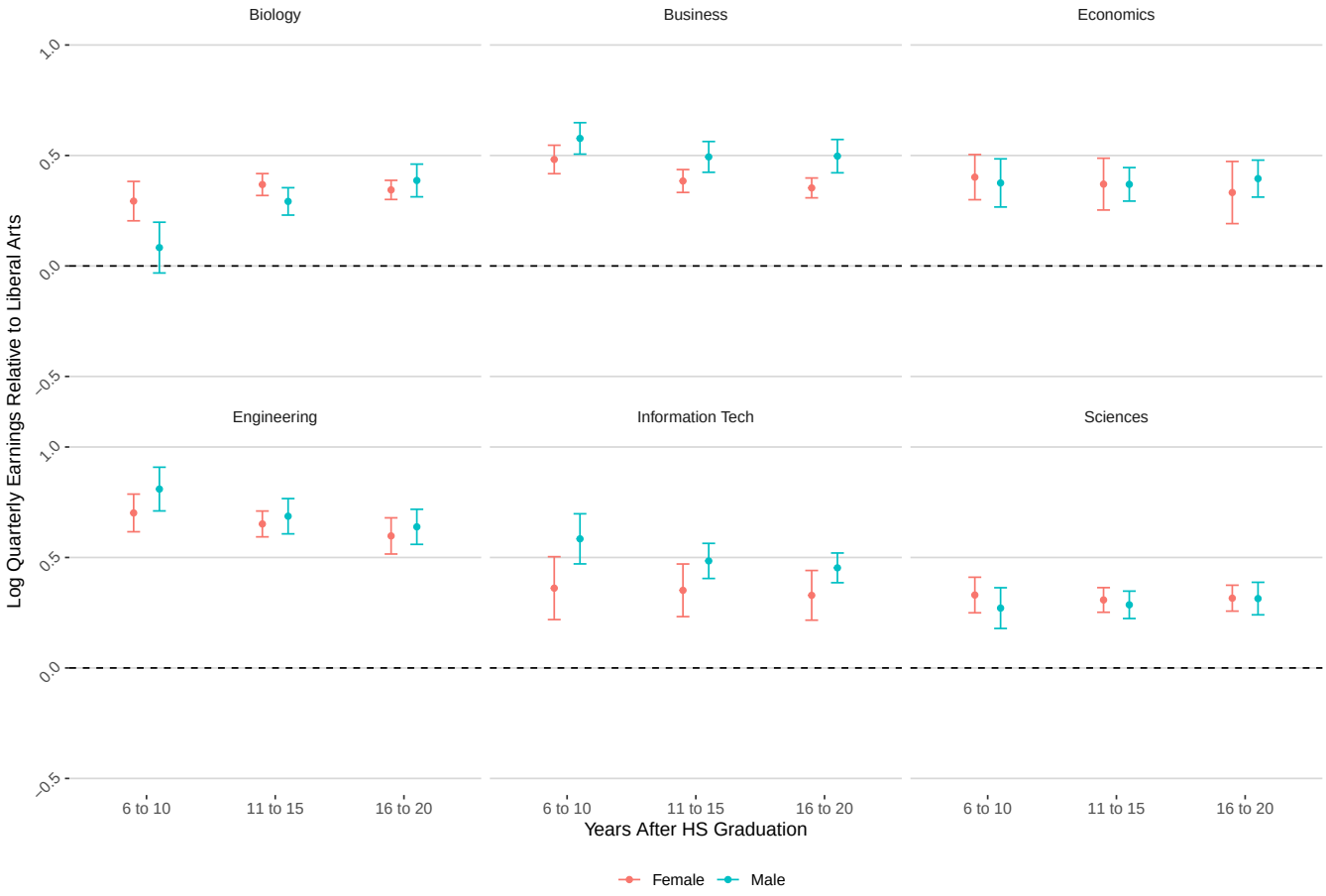


Figure 8: Quantile Treatment Effects, by Field and Race – Low Average Earnings Majors



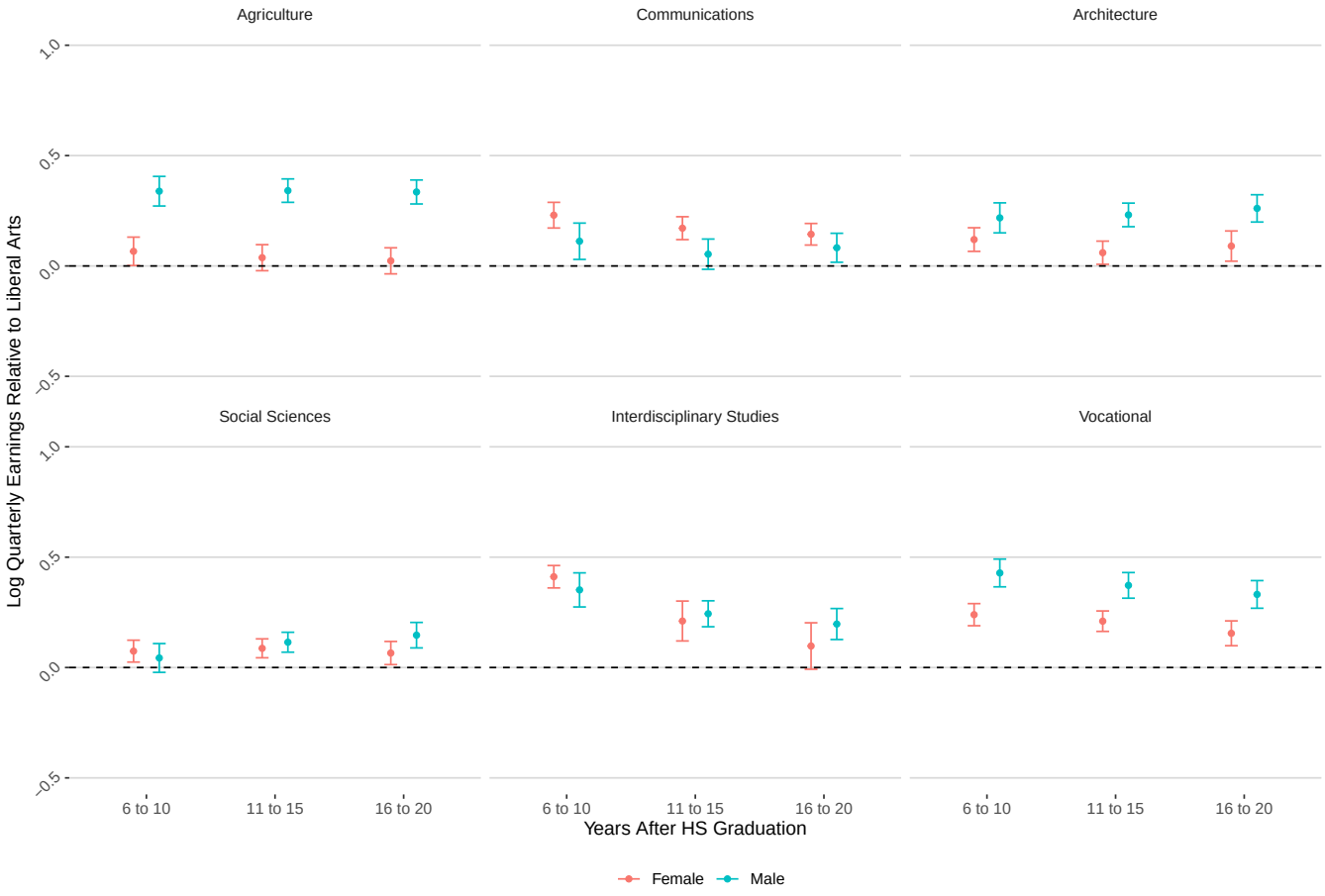
Online Appendix: Not for Publication

Figure A-1: Mean Log Earnings Over Time, by Field and Gender – High Average Earnings Majors



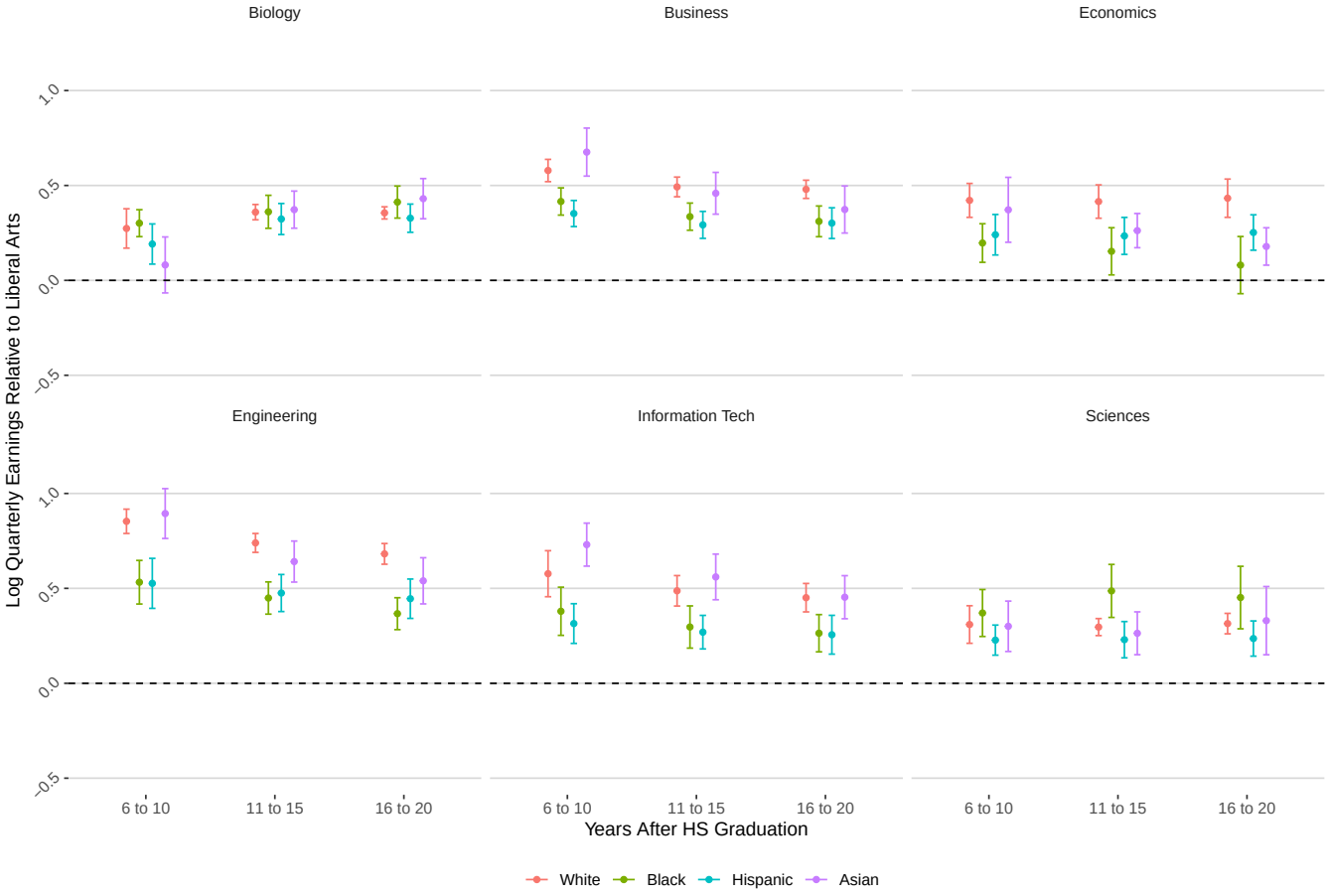
Error bars represent the 95% confidence interval

Figure A-2: Mean Log Earnings Over Time, by Field and Gender – Low Average Earnings Majors



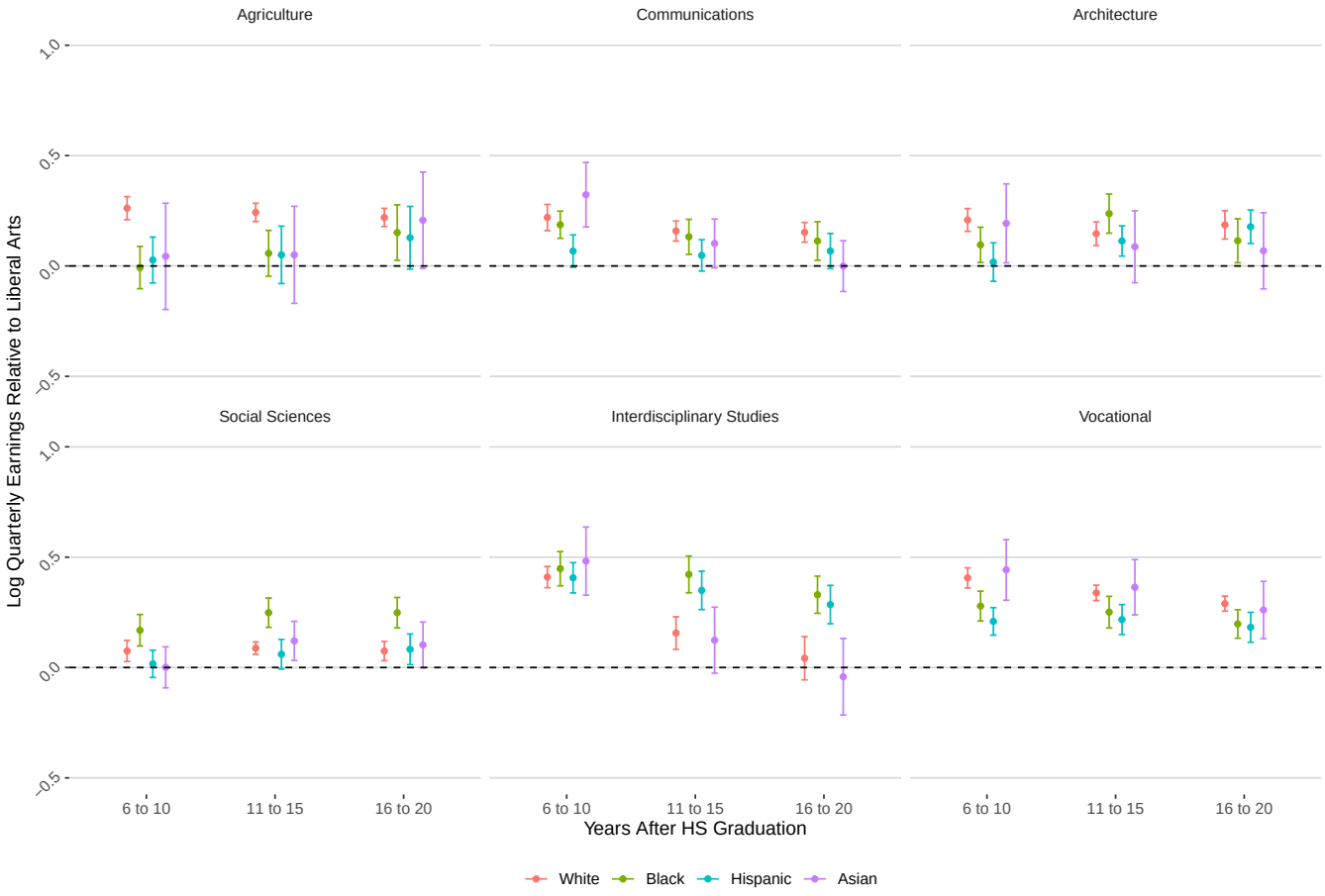
Error bars represent the 95% confidence interval

Figure A-3: Mean Log Earnings Over Time, by Field and Race – High Average Earnings Majors



Error bars represent the 95% confidence interval

Figure A-4: Mean Log Earnings Over Time, by Field and Race – Low Average Earnings Majors



Error bars represent the 95% confidence interval

Table A-1: The Effect of Major Choice on the Number of Positive Earnings Quarters, by Gender and Race

	(1)	(2)	(3)	(4)	(5)	(6)
Major	Male	Female	White	Black	Hispanic	Asian
Agriculture	-2.83	-2.23	-2.24	-3.44	-4.25	-3.59
	(0.63)	(0.86)	(0.59)	(1.76)	(0.89)	(1.74)
Communications	-2.96	-1.78	-2.24	-1.52	-2.74	-1.77
	(0.67)	(0.71)	(0.49)	(1.57)	(0.86)	(1.25)
IT	-1.25	-1.77	-0.75	-0.03	-2.73	1.89
	(0.60)	(0.83)	(0.62)	(1.72)	(1.01)	(1.27)
Vocational	-1.21	-0.95	-0.50	0.05	-2.58	0.24
	(0.55)	(0.71)	(0.48)	(1.56)	(0.81)	(1.41)
Engineering	-0.89	-2.05	-0.29	-2.03	-2.88	1.43
	(0.59)	(0.85)	(0.53)	(1.68)	(0.99)	(1.28)
Architecture	-3.62	-4.73	-4.12	-1.46	-4.31	-4.65
	(0.68)	(0.81)	(0.64)	(1.99)	(0.89)	(1.58)
Biology & Health	-5.10	-1.65	-2.66	-0.86	-2.91	-4.31
	(0.64)	(0.68)	(0.50)	(1.56)	(0.83)	(1.25)
Science & Math	-3.74	-1.32	-2.96	-0.37	-2.47	-2.05
	(0.61)	(0.74)	(0.60)	(1.75)	(0.85)	(1.22)
Social Science	-4.26	-2.67	-3.70	-0.82	-3.05	-3.47
	(0.56)	(0.70)	(0.46)	(1.60)	(0.82)	(1.28)
Business & Economics	-0.37	0.02	0.00	0.42	-1.14	1.01
	(0.56)	(0.70)	(0.46)	(1.53)	(0.79)	(1.28)
Undeclared	-8.92	-8.86	-9.03	-6.93	-9.64	-6.43
	(0.65)	(0.74)	(0.54)	(1.60)	(0.87)	(1.29)
Constant	35.90	33.36	35.60	35.78	35.92	31.75
	(0.91)	(1.04)	(0.46)	(1.55)	(0.81)	(1.29)

Notes: Each column comes from a separate regression of the number of positive earnings quarters in the earnings sample on major choice, controlling for observed characteristics used in equation (1) as well as high school-by-cohort and college-by-cohort fixed effects. Liberal arts is the excluded category. Standard errors clustered at the college-major level are shown in parentheses.

Table A-2: The Effect of Major Choice on Exiting the Earnings Sample, by Gender and Race

Major	Male	Female	White	Black	Hispanic	Asian
Agriculture	0.07	0.09	0.09	0.01	0.08	0.06
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.05)
Communications	0.05	0.05	0.07	-0.04	0.04	0.01
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
IT	-0.01	0.01	0.01	-0.07	-0.01	-0.07
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.03)
Vocational	0.02	0.07	0.06	-0.04	0.02	0.00
	(0.02)	(0.02)	(0.02)	(0.05)	(0.04)	(0.02)
Engineering	0.00	0.02	0.01	-0.03	0.05	-0.07
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Architecture	0.12	0.12	0.14	0.01	0.14	0.08
	(0.03)	(0.02)	(0.02)	(0.06)	(0.04)	(0.03)
Biology & Health	0.12	0.10	0.13	-0.03	0.09	0.10
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Science & Math	0.06	0.03	0.08	-0.04	0.02	-0.01
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Social Science	0.11	0.11	0.13	0.00	0.09	0.10
	(0.02)	(0.02)	(0.02)	(0.05)	(0.04)	(0.02)
Business & Economics	0.00	-0.01	0.01	-0.07	-0.01	-0.03
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Undeclared	0.13	0.16	0.19	0.02	0.13	0.08
	(0.02)	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Constant	0.60	0.59	0.54	0.70	0.59	0.66
	(0.03)	(0.03)	(0.02)	(0.06)	(0.04)	(0.02)

Notes: Each column comes from a separate linear probability model regression of whether an individual leaves the earnings sample on major choice, controlling for observed characteristics used in equation (1) as well as high school-by-cohort and college-by-cohort fixed effects. Liberal arts is the excluded category. Standard errors clustered at the college-major level are shown in parentheses.

Table A-3: Blinder-Oaxaca Decompositions of Earnings Differences Due to Major Choice and Returns to Major Choice, Reversing the Base Group in the Decomposition

	Years after High School		
Panel A: Male-Female	6-10	11-15	16-20
Percent Explained by Major Choice	45.6%	18.1%	12.0%
Percent Explained by Major Returns	53.4%	27.6%	30.1%
Panel B: White-Black			
Percent Explained by Major Choice	6.5%	2.0%	-0.8%
Percent Explained by Major Returns	69.6%	77.2%	73.2%
Panel C: White-Hispanic			
Percent Explained by Major Choice	13.6%	7.0%	1.7%
Percent Explained by Major Returns	64.8%	45.9%	32.7%
Panel D: White-Asian			
Percent Explained by Major Choice	-149.4%	93.6%	64.0%
Percent Explained by Major Returns	16.2%	-3.5%	-47.2%

Notes: Percent Explained by Major Choice shows how much of the difference in earnings across groups would change if men (non-Whites) had the same distribution of majors as men (Whites). Percent Explained by Major Returns shows how much of the difference in earnings across groups would change if women (non-Whites) had the same returns relative to liberal arts as men (Whites).

Table A-4: Blinder-Oaxaca Decompositions of Log Earnings Differences Due to Major Choice and Returns to Major Choice

Panel A: Male-Female

	Years after High School		
	6-10	11-15	16-20
Percent Explained by Major Choice	228.6%	27.0%	16.2%
Percent Explained by Major Returns	-19.0%	14.9%	17.6%

Panel B: White-Black

	Years after High School		
	6-10	11-15	16-20
Percent Explained by Major Choice	287.1%	126.0%	39.9%
Percent Explained by Major Returns	90.6%	37.9%	44.4%

Panel C: White-Hispanic

	Years after High School		
	6-10	11-15	16-20
Percent Explained by Major Choice	59.6%	35.2%	13.9%
Percent Explained by Major Returns	78.4%	49.9%	23.4%

Panel D: White-Asian

	Years after High School		
	6-10	11-15	16-20
Percent Explained by Major Choice	-84.9%	84.2%	51.8%
Percent Explained by Major Returns	-31.7%	4.1%	-19.1%

Notes: Percent Explained by Major Choice shows how much of the difference in log earnings across groups would change if women (non-Whites) had the same distribution of majors as men (Whites). Percent Explained by Major Returns shows how much of the difference in log earnings across groups would change if women (non-Whites) had the same returns relative to liberal arts as men (Whites).