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The Economics of Higher Education: Interactions Between Gender, College Major Decisions and the Labor Market

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ABSTRACT OF THE DISSERTATION

The Economics of Higher Education: Interactions Between Gender, College Major Decisions and the Labor Market

by

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Dr. Mindy Marks, Chairperson

This dissertation explores topics in the economics of higher education. Its goal is to contribute to further understanding of the factors that influence students' major decisions in college, as well as to evaluate the impact of major decisions on the gender wage gap and the types of work available in the college educated labor market.

The first chapter determines the impact of labor market conditions on student majors and, therefore, the composition of the future labor market. The empirical evidence indicates that students choose higher paying majors when they graduate during times of high unemployment. Estimates suggest that students are 2.8% more likely to choose an occupation that pays twice as much in a recession when the unemployment rate is very high but only 2.6% more likely to choose the higher paying major when the unemployment rate is very low. These effects vary by sex, with women being less sensitive to different pay by major at all levels of unemployment.

The second chapter re-examines the extent to which the gender wage gap can be explained by different major decisions made by male and female graduates. Detailed major data leads to the conclusion that inequality in the distribution of majors by sex has increased in the past decade, whereas previously utilized aggregated major data misses this trend. The result is that major can help explain approximately fourteen percent of the gender wage gap, an increase in explanatory power of thirty-five percent compared to less informative data.

The third chapter explores the labor market response to the changing sex composition of potential workers. As women make up an increasing proportion of graduates in a certain field, the average preferences of that labor market may shift for both employers and employees. The result is that, over the time period studied, a ten percent increase in female graduates in a field led to a seven percent *decrease* in the likelihood that a woman works part-time, and an 8.2% *increase* in the likelihood that a male graduate does.

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Introduction

A significant proportion of the general population holds a college degree. According to the 2010 American Community Survey, nearly a third of workers hold at least a bachelor's. This makes educational attainment an increasingly important factor in any analysis of wages earned. A multitude of literature establishes its importance in determining wages; however, surprisingly less emphasis is given in the literature to the role of college major.

While educational attainment is very important in explaining wage distributions, wage premiums for a college degree are not homogenous across majors. In fact, they vary widely. This is a factor that cannot be overlooked given the significant number of college graduates in the labor force today. For example average wages for men in the 2010 survey graduating from an engineering field are $95,714.98, versus men in education with average wages of $54,996.93. To better contextualize the magnitude of this heterogeneity in wages, note that the difference of $40,718.05 is approximately equal to the difference between average pay for those male workers holding a bachelor's degree and those holding a high school degree ($71,387.37 and $34,223.17, respectively – a difference of $37,164.20).

Since college degree holders make up a significant portion of the labor force, and these workers vary in their field of study, a closer look at the role of major in determining wage distributions is necessary for a more complete understanding of labor force dynamics. Why should we expect major to directly influence an individual's wage, if we indeed expect this at all? Can it help us understand key differences in pay across

demographics? And what relationship does major have with the overall economy and labor market? Understanding major's role in wage distributions, and even some of the determinants of college major distributions, is crucial to our understanding of skill composition of the labor force.

This dissertation will attempt to answer some of these relevant labor market questions regarding the importance of college major. Chapter 1 will work towards understanding some of the factors that influence student major decisions by examining the impact of economic conditions on college majors students graduate in, and how this varies across male and female graduates. The results essentially examine how current labor market wellbeing can impact the future distribution of the skilled labor force.

Chapter 2 will identify major's role in determining wages by studying how much of the gender gap in wages can be explained by major distributions that vary by sex. It will establish the importance of proper categorization of major data in examining field of study impacts on wages. Finally, Chapter 3 examines the impact of an increasingly female body of graduates in a field on the level of flexible employment in the labor market. This is especially relevant as female graduates consistently rank job traits such as flexible hours relatively higher than their male counterparts.

Chapter 1

College Major and the Economy: The Impact of Labor Market Conditions on Field of Study[*]

Abstract

This paper explores the impact of economic conditions on the majors students graduate with. Since college major plays a role in channeling students into their future job market occupations, this relationship has the potential to, in turn, influence the skill set and wages of the next generation of the labor market. Using data from the American Community Survey (ACS), this paper will look at how students decide their majors across the business cycle.

The empirical evidence indicates that students exhibit an increased probability of choosing a higher paying major when the unemployment rate at time of major decision increases. Estimates suggest that students are 2.8% more likely to choose an occupation that pays twice as much when the unemployment rate is very high but only 2.6% more likely to choose the higher paying major when the unemployment rate is very low. These effects vary by sex, with women being less sensitive to different pay by major at all levels of unemployment. The results are attributable to major switching by students as college completion is unaffected by the unemployment rate when deciding a major.

[*] I am sincerely grateful to Mindy Marks, Todd Sorensen, and David Fairris for their continuous guidance throughout this project. This work has also benefitted greatly from comments and suggestions by Aman Ullah, Joseph Cummins, and all those who took the time to offer their advice at conferences and seminars.

1.1 Introduction

The major college students graduate with has a direct effect on the composition of the skilled labor force as the majority of recent graduates are channeled into an occupation related to their major. Changes in the distribution of majors college graduates matriculate in can therefore significantly impact the dynamics of the labor market well into the future. While there are many factors that may influence the majors students pursue, this paper will examine the possibility that the business cycle itself plays a role in the major distribution of college graduates and, in turn, the skill composition and wages of the future labor market.

Economic conditions have the potential to influence decision-making if students pursuing a degree believe that changes in the labor market they are interested in can impact their career trajectory over the course of their lifetime. Such changes may call for a re-evaluation of the preferred field of study as lifetime earnings profiles change. Recent literature in this area suggests that graduating in a recession results in long-term wage penalties over the course of a graduate's career (Oreopoulos et al. 2012, Kahn 2010, Kondo et al. 2010).

The result of these wage penalties is that labor market conditions may alter major decisions through two potential channels - switching majors, or selection into or out of college completion in response to the changing economic conditions. The first channel refers to students who go to college regardless of labor market conditions, but choose a different major during a recession than during a boom. These students decide majors

based on all relevant attributes of the field, recognizing that higher paid majors involve a compensating wage differential since they require more work than lower paid majors. These major specific traits, generally considered 'bads' by most students, result in higher pay. Students must decide how they are willing to trade off major bads for wages, and as they face the prospect of wage penalties due to a recession may become more willing to accept major bads in exchange for higher wages in the future.

Though there is a well-established literature on how students choose majors,[1] little literature exists exploring this first channel on how students switch majors based on labor market conditions. Expected pay has been analyzed as an important factor in students' major decisions, however none of the existing studies explore the potential impact of economic conditions while in college (Blom 2015 is one recent exception). When a recession impacts wages, students are less able to 'afford' good working conditions in college and beyond. This compensating wage differentials channel is the main contribution of this paper. Most of the studies examining how students choose majors also rely on administrative level data sets,[2] which are not as representative as the American Community Survey (ACS) data used in this analysis.

[1] This paper contributes to the literature determining different factors that influence student decision-making regarding major field of study. For example, students choose majors based on the characteristics of a given field that they find desirable (Zafar 2009). These may include whether they believe the required course load will be enjoyable to them or not, the approval of parents, how many units are required for graduation, what level of analytical and math ability is involved, etc. Students also think about the jobs that will result from majoring in a certain field – how enjoyable they may be, what level of interaction with others they involve, how much prestige is associated with the job, and, of course, the pay (Montmarquette 2002). Alongside beliefs about their future earnings from their major and tastes for a certain major, students also emphasize their beliefs about their ability level as a factor in determining what they major in (Altonji et al. 2012, Wiswall and Zafar 2011).

[2] Zafar 2009 utilizes a survey of Northwestern University students while Wiswall and Zafar 2011 take advantage of a survey administered to New York University students.

The second channel involving selection refers to students who may or may not graduate from college depending on the state of the economy. These marginal students either decide to drop out of college (and therefore don't complete a major), or graduate in a major of their choosing. Those students who do graduate in a recession have been found to be more likely to end up in lower level occupations (Kahn 2010), consistent with marginal students choosing lower paying majors. Past literature suggests that college attendance increases when the unemployment rate at time of entrance does (Kahn 2010, Betts and McFarland 1995, Gustman and Steinmeier 1981). However less is known about college completion based on market conditions while in college.

The impact of this retention selection on majors is theoretically unclear. The decreased opportunity cost of taking time out of the labor force for education due to tougher labor markets could lead to stronger retention and increased college completion for students. However the effect of this on the majors students complete depends on which majors experience stronger retention – higher paid fields, lower paid, or a relatively even distribution. Much of the literature on selection deals with enrollment in college rather than completion, which this paper will focus on, and frequently ignores women as their decisions are more complicated. This means that while there is a good amount of literature on selection into college enrollment during recessions, it is not clear what the impact of labor market conditions is on the attainment of college degrees by men and women. This selection retention channel has the potential to alter major composition of college graduates as they either drop out of college from certain majors or remain to complete their degrees.

The two channels, which make up the overall effect of the labor market on college majors, lead to ambiguity as to what this effect actually is. This paper will use the ACS to analyze the potential influence of the economy/labor market conditions on college students' majors. It will show that as the state unemployment rate increases, there is a small but significant change in the majors students graduate with. College graduates gravitate toward majors that on average pay more when they are exposed to a tough labor market. Male students are 2.8% more likely to choose a major that pays twice as much in a recession when the unemployment rate is very high but only 2.6% more likely to choose the higher paying major when the unemployment rate is very low. Women are less sensitive, choosing majors that pay twice as much with an increased likelihood of 0.60% when facing high unemployment but only 0.55% when facing low unemployment. The effect is attributable primarily to student major switching as college completion is unaffected by market conditions while in college for both men and women.

1.2 Theoretical Framework

Students choose their major based on a number of factors, many of which have been established in the literature (as cited). Among these are expected lifetime wages as a result of the degree and the characteristics of the major, everything from the course load to how it is perceived by their parents. So in choosing a major, students maximize the following utility function:

$$U_{ij} = U_i (w_j, t_j)$$

where each student i's utility from a given major j is dependent on the lifetime earnings from that major (w_j) and on the major specific traits 'bad' (t_j), which encompasses all unpleasant characteristics and nonmonetary attributes of a given major. Students then face a tradeoff between wages and major traits, where they require extra expected compensation in exchange for increased effort, less prestige, and other such unpleasant characteristics that make up the bad.[3]

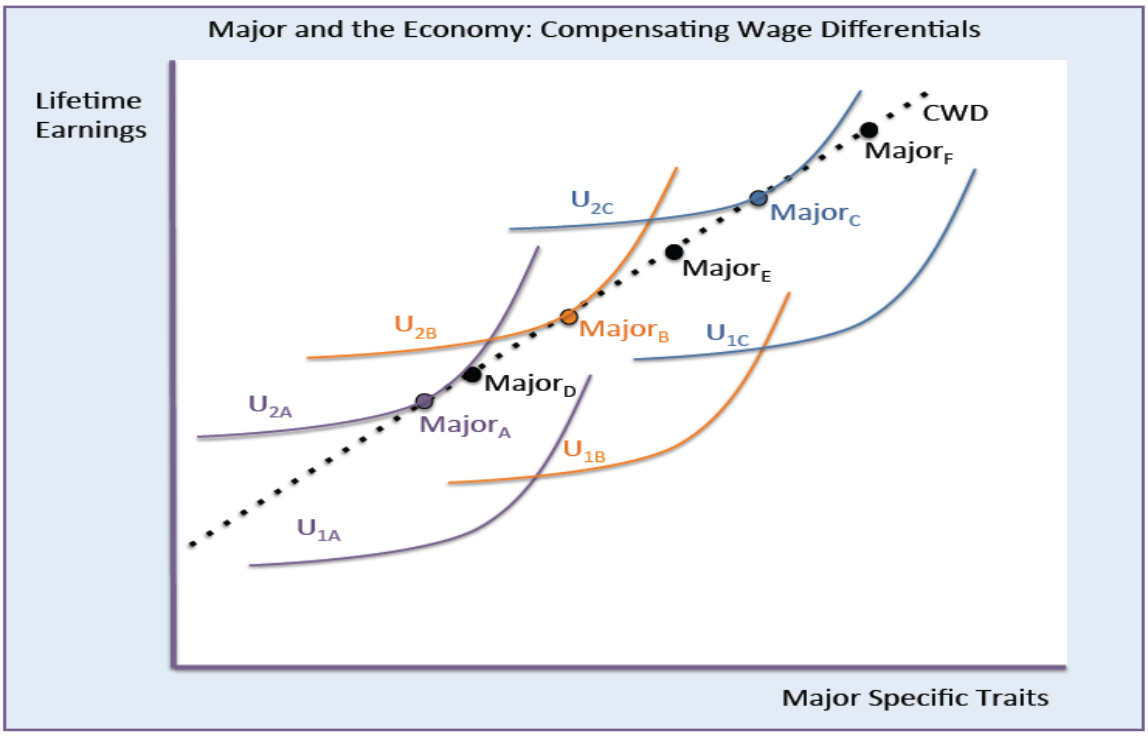
At the same time, each major is characterized by w_j and t_j, its lifetime earnings and specific traits, where the earnings of a major increase as the level of its major specific traits ('bads') do. Different students have different preferences for major traits, and will tradeoff pay accordingly. Past work suggests that male and female students may make different decisions when facing this tradeoff. In the model this is reflected in the way they translate this tradeoff into preferences.[4] The literature suggests that female students rank pleasant working conditions, flexibility, and interacting with others as being more important than prestige and pay, which men rank higher.[5] On average extra pay has less impact for women than it does for men, making them less likely to be willing to take on more major specific bads in exchange for higher wages – especially if these bads involve traits like long hours and extensive travel (items that work against family flexibility).

The result is that matches are made between students and their ideal major as in Figure 1.1(a). Notice that individual indifference curves tangent to majors in the traits-

[3] See Footnote 1 for a listing of the literature covering characteristics students value when choosing majors.
[4] So in Figure 1.1(a), the average female student will be more likely to express preferences in line with students of the indifference curve U_{2A}, while male students will be more likely to follow U_{2C}.
[5] See Bronson 2013, Wiswall and Zafar 2011, Zafar 2009, and Montmarquette 2002.

earnings space represent matches that occur in this compensating wage differentials framework. These matches determine the number of students in each corresponding major, where certain majors pay more but also require the student to accept more of the

Figure 1.1(a)

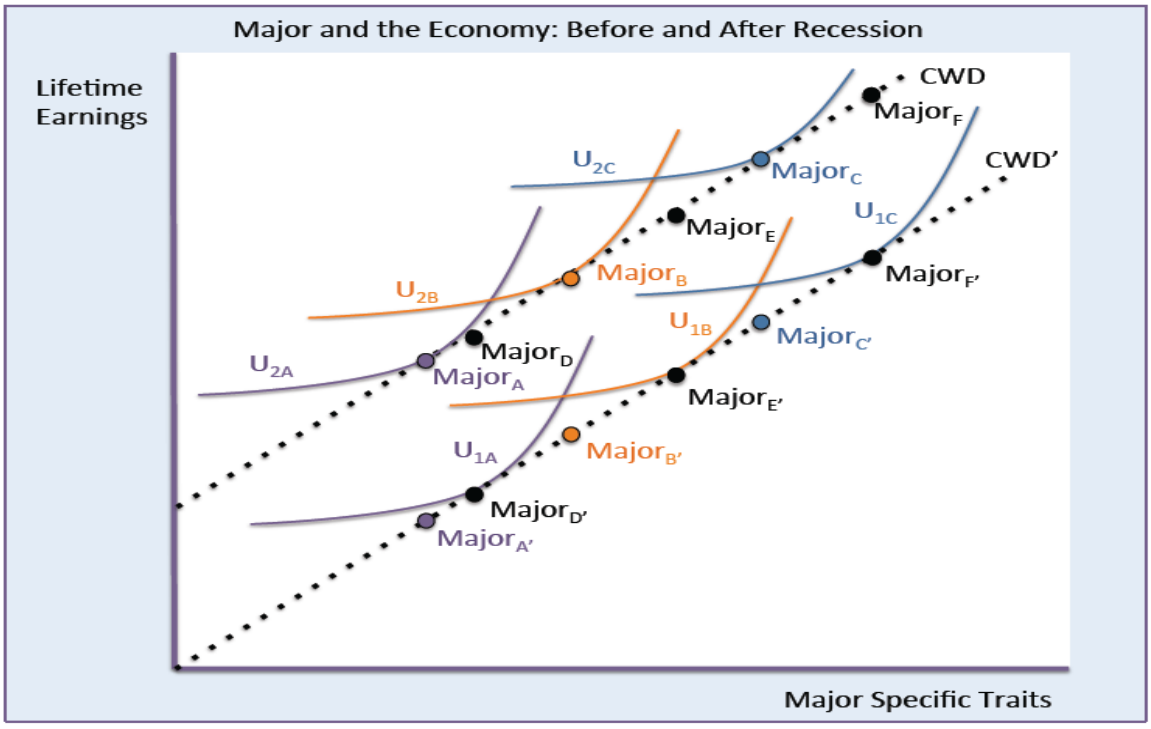


"bad." Higher paying majors such as Engineering, for example, tend to involve longer study hours and require more classes to graduate than a lower paying major such as Education.

In Figure 1.1(a), students expressing preferences for lower paid majors such as Major A are matched with that major and therefore with the corresponding lifetime earnings. Similarly students who accept higher levels of the major bad are rewarded with higher levels of earnings such as with Major C. The relevance of economic conditions in

this framework lies in the impact the economy during college has on the expected lifetime earnings of a major. As recessions occur and adversely impact lifetime wages, the different majors shift downward on this graph. Lifetime earnings are lower while the characteristics of a given major remain the same.

Figure 1.1(b)



The result is a set of new tangency points that shift the CWD locus as in Figure 1.1(b). In this way new matches are made and student's expected lifetime earnings change. The drop in wages leaves students less able to afford 'good' aspects of a major. In Figure 1.1(b), students whose preferences before the recession dictated the choice of a lower paying major switched to a higher paying major with more negative traits as the economy worsened. Notice that those students who before preferred Major A have now

switched to the higher paying Major D. Similarly for those at the relatively higher paying Major C, students have now switched to the even more lucrative Major F.[6] This switch holds for all students, so although the average male and female student may have different preferences they are affected similarly by the changing labor market.

1.3 Analysis and Methods

Following the above utility maximization problem, the probability that individual *i* chooses major *j* from among their set of choices M_i is:

$$P(y_i = j) = P_{ij} = P[\beta_w w_j + \beta_{w*ur} w*ur_{ij} + \varepsilon_{ij} \geq max_{k \in Mi,\, k \neq j}(\beta_w w_k + \beta_{w*ur} w*ur_{ik} + \varepsilon_{ik})]$$

Using the logistic distribution, this probability is expressed as:

$$P_{ij} = \frac{exp\,(\boldsymbol{\beta_w} w_j + \boldsymbol{\beta_{w*ur}} w*ur_{ij})}{\sum_{\boldsymbol{k \in Mi}} exp\,(\boldsymbol{\beta_w} w_k + \boldsymbol{\beta_{w*ur}} w*ur_{ik})}$$

where the independent variables are attributes of the *jth* alternative in the choice set M_i as perceived by the *ith* individual. In this case where the individual is deciding among a range of major choices, these attributes include the lifetime earnings of the major w_j and its interaction with the unemployment rate ur_i. Recall that conditional logit regressions differ from typical logits. The data here is grouped by individuals so the likelihood is determined for each group – hence, a conditional likelihood. For this reason the conditional logistic model is also known as a fixed effect logit model (in this analysis,

[6] Past work indicates that there are heterogeneous effects of a recession on wages, with higher paying majors suffering less of a wage penalty. This would result in a non-parallel shift as majors farther to the upper right quadrant of the graph face less of a drop in lifetime earnings (Oreopoulos et al. 2012). Notice that the overall predictions of the model would remain the same.

individual fixed effects). The conditional logit explains the outcome *for each group* (the individual), so variables that do not vary within the group (ie., the unemployment rate while the individual is in college) will not have a place in the model on their own. The log-likelihood of the conditional fixed-effects logit model used for this analysis can be written as:

$$\boldsymbol{L = \sum_{i=1}^{N} \sum_{j \in Mi} d_{ij} \, ln \, P(y_i = j)}$$

where $\boldsymbol{d_{ij}} = \begin{cases} 1 & if\ individual\ i\ chooses\ alternative\ j \\ 0 & otherwise \end{cases}$

To better interpret the coefficients obtained in the logit model, they can be converted into an elasticity that measures student responsiveness to pay across the business cycle:

$$\eta\,(w) = w_j \frac{\partial P_{ij}}{\partial w_j} = (\beta_w + \beta_{w*ur} * ur_i) * w_j * P_{ij}(1 - P_{ij})$$

Since the dependent probability in this calculation is a number without units between 0 and 1, this elasticity of substitution between majors is a quasi-elasticity. It measures how the wage influences the probability of choosing a given major, and more specifically how a 1% increase in the wage changes the probability of choosing a given major. By recalculating the predicted probabilities at different unemployment rates, it can then be measured in different labor market conditions to visualize how student decisions change.

1.4 Data and Summary Statistics

1.4.1 Data

The Census Bureau recently started collecting data on majors for college graduates. While the American Community Survey (ACS) has had information on educational attainment for many years, it has only gathered information on field of study for those who completed a college degree since 2009. Major data is collected for those respondents who report having completed their bachelor's, not for those in progress or who did not complete their degree. This study will take advantage of this newly available, highly representative data. It will also utilize data on general conditions in the labor market as captured by the state unemployment rate taken from the Bureau of Labor Statistics (BLS).

The ACS major data is ideal for this analysis in that it is nationally representative data. The sample used includes college graduates aged 21 from 1980-2010. These years provide a good amount of variation for the analysis as there are 3 'peaks'/booms and 3 'troughs'/busts (all of which were recessions as classified by the NBER). The majors students report vary widely, from Fine Arts to Business to Biology (see Table 1.3 for more detail**).** There are a total of 38 main major categories in the data classified by the ACS, each of which are strongly represented in the sample with each major containing a significant number of observations. The lowest paid of these is Library Science with average pay for graduates in the sample at $14.29 an hour. The highest paid is Engineering, with average pay of $36.22 an hour. Engineering is also one of the most

popular majors in the sample (5.99% of graduates chose it), along with Psychology (5.44%), Business (21.77%), Social Sciences (7.86%), Medical Sciences (6.47%), Communications (5.11%), and Education (11.34%).

The use of students aged 21 is due to the fact that, despite the availability of major data, degree completion date is not provided in the ACS. Therefore linking students to labor market conditions at the time of their major decision requires the assumption that respondents completed their degrees at approximately age 22. This means they would be making final decisions about their major sometime prior to that point and after the expected completion of high school at age 18. The main assumption in this analysis is that the economy has influenced students' decisions by age 21,[7] making them most susceptible to conditions around that time. Following the theoretical model, observing the ease (or hardship) with which their senior colleagues obtain jobs - and whatever other relevant environmental triggers influence their perceptions about the labor market - should either trigger students to switch majors or influence their decisions about obtaining a bachelor's degree at all. To depict the general conditions the student is exposed to while deciding on their major, rather than just a specific year's labor market, this analysis uses a three year moving average of the state unemployment rate at the expected time of the major decision.[8]

[7] Robustness checks will show that this age can be changed to 19 or 20 without significantly altering the results.

[8] The results are not significantly affected by altering this assumption slightly, robustness check to follow later in the paper.

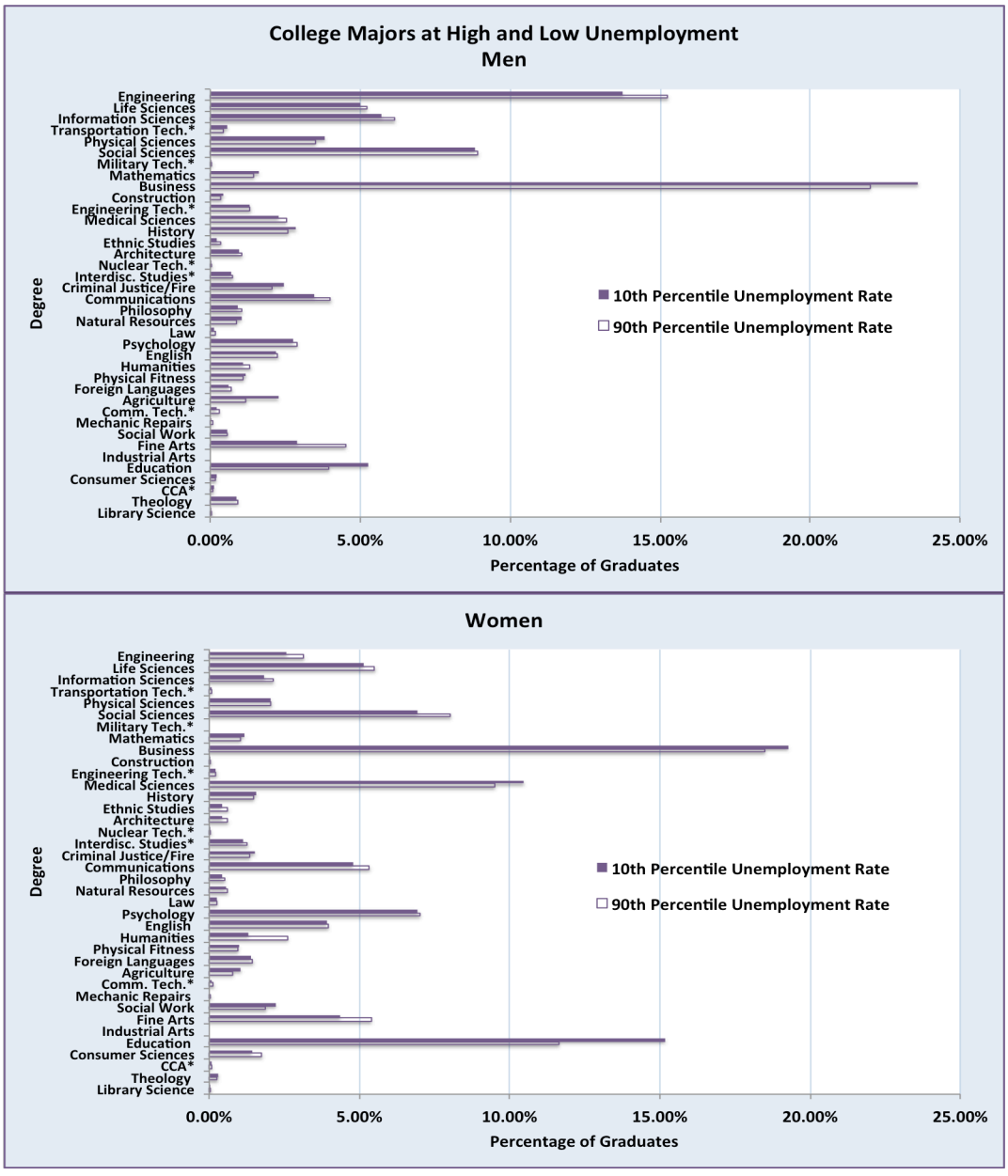
1.4.2 Major and the Business Cycle

There are changes in the majors students pursue as labor market conditions fluctuate. Figure 1.2 shows the distribution of majors across economic conditions. Notice that as students are exposed to high unemployment rates at age 21 the majors they graduate in are different from the students who were exposed to lower unemployment rates as they were making their major decisions.[9] The figure compares students who went to college and got jobs in states that fell into the ninetieth percentile and above in their unemployment rate for that year to those who were in states in the tenth percentile or below. According to the selection and compensating wage differentials channels in the model, the effect of the change in labor market conditions is ambiguous. It is possible to observe more students in higher paying majors, or lower paying majors, when the unemployment rate increases. In Figure 1.2, majors are ordered by average hourly pay with the highest paying major at the top to observe which, if either, of these trends holds.

The data seems to indicate that among some of the more popular majors (with higher proportions of graduates), students switch to more lucrative fields when facing high unemployment rates. However this trend doesn't always hold, and its magnitude varies for male and female graduates. For example, among both men and women, the highest paying field of Engineering becomes more popular when facing higher unemployment. In better labor market conditions 13.76% of male and 2.58% of female college graduates finish a degree in Engineering. However when unemployment rates are

[9] Recall that major decisions are assumed to be made by age 21, so Figure 1.2 plots the majors students graduated with after being exposed to high vs. low unemployment at that age.

Figure 1.2



Note: Data is taken from the 2010 American Community Surveys (ACS), with a sample including those aged 21 from 1980-2010 as in the analysis. The majors here are ordered by increasing average pay. The ninetieth percentile refers to states with unemployment rates above that percentile in a given year (on average for all years above 8.6%) and the tenth percentile includes rates below that percentile in a given year (on average for all years below 4.2%). A similar figure can be made for majors studied above and below the median unemployment rate of 5.9%.

* "Tech." abbreviates Technologies in the major names. CCA refers to the major Cosmetology and Culinary Arts. "Comm." abbreviates Communications, "Interdisc." Interdisciplinary.

highest 15.24% of males and 3.13% of females graduate in the field, increases of approximately 10.7 and 21.3 percent respectively.

The same trend holds for Social Sciences, with increases of 1 percent for men and 15.7 percent for women. However in Business, another popular field among college graduates, students actually chose the field less when encountering higher unemployment despite its position as a relatively high paying field. In a good labor market 23.6% of men and 19.26% of women graduate in Business, but when in hard economic times only 21.99% of men and 18.48% of women make this decision. This represents a drop of 6.8 percent in the likelihood of male graduates to study Business when times are hard, and a drop of 4.0 percent for females.

On the opposite side of the spectrum, students pursue relatively lower paying majors less in tougher labor markets. For example Education, one of the lowest paying majors on the spectrum, graduates fewer students in harsher economies. Only 3.95% of men are in Education when unemployment is high, and 11.63% of women, but this rises to 5.25% of men and 15.17% of women when unemployment is low. This translates to a drop of 24.8 percent during hard times for men and a drop of 23.3 percent for women.[10]

Extremely similar trends emerge when plotting the differences in majors at levels of unemployment above and below the yearly median as well. The significance of these changes in the distribution of majors over time is that each of these majors yield different lifetime earnings on average (in Figure 1.2, higher earning majors are on the top of the

[10] All statistics are for the college graduate sample analyzed in this paper, aged 21 from 1980-2010.

scale). If the economy can help explain any part of these changes, it is then also responsible for influencing potential earnings of the college-educated workforce.

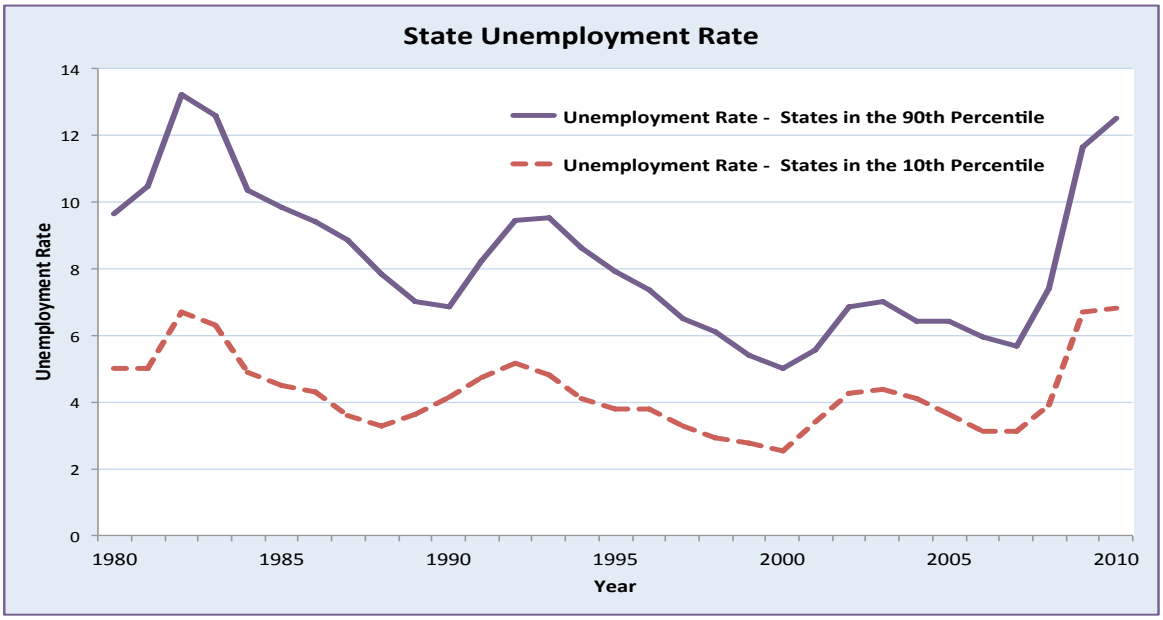
The correlation here between college major and labor market conditions leaves open the potential role for both the retention channel, where students base decisions regarding completion of their degree on the business cycle, and the compensating wage differential channel, where the tradeoff between wages from a major and the traits it is characterized by changes as market conditions fluctuate. This analysis will pursue the overall combined impact of these two channels, since both are relevant to answering the question of how labor market conditions impact major decisions.

In this analysis general labor market conditions are captured by the state unemployment rate as reported by the BLS. State rates are more informative than federal ones as they capture more variation in labor market conditions that students are exposed to as they make decisions about their education. More variation beyond state is difficult to attain since precise locations for the students' graduation and working career are not available. This makes any unemployment rate more specific than state hard to accurately match to an individual in the data. Ideally these state unemployment rates capture the most concise picture of what students are using to form beliefs about their prospects in a more informative way than just federal rates, since state unemployment varies widely compared to the national level.

In fact, the yearly state unemployment rates range from 2.3% (Connecticut and Virginia in 2000, Nebraska in 1990, and New Hampshire in 1987) to 17.4% (West

Virginia in 1983) over the time period studied.[11] The 1980-2010 time frame provides a significant amount of variation for identification of the model since it includes both boom times and the Great Recession. Figure 1.3 illustrates the fluctuations in the economy during this time. In any given year there is a significant difference between states at the

Figure 1.3



Note: Data is taken from the Bureau of Labor Statistics. The ninetieth percentile refers to states with unemployment rates above that percentile in a given year (on average for all years above 8.6%) and the tenth percentile includes rates below that percentile in a given year (on average for all years below 4.2%).

highest level of unemployment (in the ninetieth percentile or above for that year) and states at the lowest level (in the tenth percentile or below). In fact there is consistently at least a two percent gap between the states with high levels of unemployment and those with low levels of unemployment throughout this time period. As with Figure 1.2, a similar figure can be made for states above and below the median unemployment rate in a given year.

[11] The 3-year moving average as used in the analysis ranges from 2.4% to 15.5% accordingly.

This analysis matches students with the appropriate state unemployment rate[12] while they were choosing their major. Those students who migrated at some point during their working career are dropped from the analysis. The data does not provide a listing of where students completed their bachelor's degrees, so it is difficult to match migrants with the unemployment rate that is likely to influence their decision-making. Students who had plans when in college to move states upon completion would in all likelihood incorporate the destination state's unemployment rate into their decisions rather than the rate in their state of college attendance.

The data is also missing information about the precise year in which the student graduated. For this reason the model matches students with the best approximation of the relevant unemployment rate based on the "typical" college students' path of completion. Since students decide on their major at some point while attending school, but may change it at any point up until graduation, it is difficult (and probably inaccurate) to pinpoint a specific year during which the economy will impact this decision specifically. For this reason, the unemployment rate refers to a three-year moving-average of the unemployment rate when the student is 21 years old. Using a three-year average[13] better captures the general economic conditions the student is exposed to when making this decision.

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[12] Alternatively, the unemployment rate for just those with a bachelor's degree could be used by aggregating individual data in the ACS. Since this results in an unemployment rate that is highly correlated with the reported BLS state unemployment rates (correlation above 0.7), this analysis will employ the reported BLS numbers as the Bureau of Labor Statistics is responsible for reporting the correct statistics.

[13] Robustness checks will also evaluate without the moving average since the moving average smooths out a lot of variation. The moving average as defined here is the simple moving average. Alternatively the centered moving average could be used, which changes only the way the unemployment rates used are framed. For example, when using the moving average at age 21 this incorporates unemployment at 19, 20, and 21. The centered average would be the same, stated as the centered moving average at age 20.

1.4.3 Summary Statistics

For this sample of college graduates, students report 2010 average wages of approximately $55,935 as they are at the peak of their earnings profile with an average age of 37. There are of course differences for men and women here, with the males in the sample earning on average $31,839.63 more. These numbers compare all college graduates in the sample, including those who are not working and all types of

Table 1.1: Summary Statistics

	All	Men	Women
State Unemployment Rate	6.13% (1.92%)	6.16% (1.93%)	6.10% (1.92%)
2010 Wage	$55,935.02 ($62,539.22)	$73,602.96 ($75,820.01)	$41,763.33 ($44,564.94)
Age	37.19 (8.50)	37.63 (8.45)	36.84 (8.53)
Graduate Education	30.91%	30.04%	31.61%
White	87.95%	89.31%	86.86%
Married	62.73%	63.77%	61.91%
Employed Full Time	76.93%	87.63%	68.34%
Observations	302,164	134,492	167,672

Note: Data is taken from the 2010 ACS. Sample includes 302,164 college graduates aged 21 in 1980-2010. Standard deviation in parentheses, where applicable. Full time means at least thirty-five hours per week.

occupations, levels of work intensity, ages, etc. Almost a third of the sample has a graduate education and that is even for both men and women – 30.04% of men and 31.61% of women in the sample. The overwhelming majority of the students are white,

married, and work full time (see Table 1.1). However 87.63% of the men work full time while only 68.34% of the women do. This includes 302,164 graduates reporting in the current ACS, who were deciding on their college majors over the three decades covered in this analysis.

1.5 College Major in the Data

1.5.1 Reliability of the Data

Major is self-reported in the ACS. Therefore measurement error in the variable is a potential concern as students may experience recall bias or for any number of reasons incorrectly state their major. Such error may be the basis for issues with identification so it is important to know how reliable this variable is in the data, especially as it is relatively new to the ACS and is a central focus of this study. Fortunately, comparison to the National Center for Education Statistics major data yields very similar distributions of majors during this time period, lending support to the reliability of the data.[14] Additionally, major distributions over time, race, and sex do not display erratic changes, consistent with the measure being reliably reported in the survey. Looking at the distributions of college major present in the sample over the five years of data available shows that they remain consistent over time. This lends credence to the reliability of the data as it would be unusual to observe erratic behavior or drastic changes in majors

[14] Comparison of the two data sets yields similar distributions for recent college graduates as measured by the Duncan Dissimilarity Index. Survey used is the NCES' B&B: 08/12 Baccalaureate and Beyond. The Duncan enumerates major distributions by assigning a number between 0 and 1 indicating what percentage of women (or men) would need to switch their major in order for the relative distribution of majors for both men and women to be the same. A zero value implies parity between male and female graduates, while one implies complete separation.

graduated in across such a short window of time. Major distribution by race and sex also stays relatively consistent over the five survey years.

More convincingly, comparison of the ACS data to other currently available data on major fields of study yields similar distributions of major by sex. The National Center for Education Statistics (NCES) B&B: 08/12 Baccalaureate and Beyond Longitudinal Study follows students after they complete their bachelor's degree in order to study their education and work experiences. The 2009 study interviewed graduates of 2007-08 and has just followed up with these graduates for another interview. It is the third such wave

Table 1.2: Comparison of ACS and NCES Data

Major	**Percent of Graduates B&B**	**Percent of Graduates ACS**
Computer and information sciences	2.9%	2.4%
Engineering and engineering technology	6.2%	7.0%
Bio/physical science/science tech/math/agriculture	7.3%	14.4%
General Studies and other	2.9%	1.1%
Social sciences	15.0%	15.0%
Humanities	11.8%	15.3%
Health care fields	7.5%	6.2%
Business	23.1%	20.0%
Education	8.3%	8.9%
Other applied	14.9%	10.0%

Note: Majors in the 2010 ACS are aggregated here to approximate the B&B:08/12 classification of major. Figures presented represent the percentage of recent college graduates who graduated in each major.

of the study. All studies use a "nationally representative sample of postsecondary students and institutions," according to the NCES website, just like the ACS data. It is the closest source for comparison to the ACS data as they are both nationally

representative datasets and cover approximately the same cohort of college graduates. However the NCES is not being utilized here since it does not include nearly as many years of students.

When the ACS data is categorized into roughly the same ten major groups as the NCES, the major distribution by sex is approximately the same across both sources. The Duncan Index quantifying this distribution by sex is 0.34 for the NCES data, while for the ACS data it is 0.35. Each of the major categories are also similar in their breakdown in the sample, as shown in Table 1.2. These figures aggregate the ACS data into approximately the same classifications as the B&B study for recent graduates up to age 25 (for comparison, since the B&B only includes recent graduates). Since the aggregation is an attempt at imitating the B&B classifications as closely as possible, the distribution of majors is similar but not identical. For example, Business graduated 23.1% of students according to the B&B, and 20.0% according to the ACS.

1.5.2 Calculation of Major Premiums

To evaluate student decision making over the business cycle when faced with a pool of potential college majors, this analysis looks at how different levels of pay by major impact the likelihood of graduating in a given field as the unemployment rate fluctuates.[15] In short, it analyzes whether students are more likely to choose higher or lower paying fields when faced with increased levels of unemployment. Average pay by major fails to account for a number of factors including self-selection into a given major, perhaps by

[15] Recall that the theoretical model emphasizes the link from unemployment to major decisions through pay as students make different wage-traits tradeoffs when faced with higher unemployment.

innate ability of the individual. It also omits the fact that in the labor force graduates with some majors may have different characteristics than others, such as more experience on average. For these reasons the major pay variable does not just measure average pay. A simple measure of average pay groups together all graduates in a given major, of all ages and experience levels, and so may be misleading when ranking the choice of majors by pay from a graduate's perspective.[16]

In the theoretical framework, majors differ by their specific traits and wages. In fact wage profiles by major vary widely, with (for example) male graduates in Engineering earning on average more than $40,000 extra in wages than their counterparts in Education. This is approximately equal to the difference in earnings between the average high school and college graduates. To construct an accurate ranking of majors, the major premium variable is derived by determining the wage premium or penalty associated with a given major relative to others, after controlling for relevant variables such as potential experience, intensity of work, and demographic traits. Since major information is only available as of 2009 in the data, all pay information by major is from that point on. However it will be covariate adjusted, including the age-wage profile, for use in the analysis. Because of this, however, wage profiles are being accounted for using currently reported pay for all age/experience levels. This assumes that today's Business majors will be compensated in a similar pattern/at the same relative level

[16] This is assuming that students consider factors such as experience and don't just evaluate a major's pay potential using the average. Robustness checks using the 'naïve' average pay will show similar general results.

compared to other majors as yesterday's graduates, at least in the minds of current students forming decisions about their major.

A basic fixed effects regression of the following form determines the covariate adjusted wage premiums:

$$wage_{jst} = \beta_1 * age_{jt} + \beta_2 * age^2_{jt} + \beta_3 * married_{jt} + \beta_4 * race_{js} + \alpha_j + \mu_s + \gamma_t + \varepsilon_{jst}$$

where the hourly income for a given major *j* in state *s* at time *t* is explained by its age wage profile/potential experience, the race (an indicator for minority) and marital status composition of the major.[17] State and time fixed effects are included. More importantly, the coefficients on the major fixed effects (α_m) represent the wage premium (or penalty) associated with a given major after controlling for the fact that some majors consist of more experienced people and therefore higher pay, etc. The coefficients on each of these major indicators make up the major premium variable.

Included in these premium calculations are all graduates reporting a given major, whether they are currently working or not. Relative employability of a given major is an important consideration for students considering a field when facing tough labor markets. Including students with zero wage allows for the incorporation of information about relative major employability as well as pay.[18] Similarly some majors, such as Biology and Life Sciences, Physical Sciences, History, and Psychology (to name a few) end up

[17] Hourly wage is computed by taking the annual wage reported in the ACS, divided by hours worked (hours worked per week times weeks worked per year). Hours worked per week range from 0-99 and weeks worked per year are in bins of: 0, 1-13, 14-26, 27-39, 40-47, 48-49, and 50-52 weeks, each used in this calculation as their respective midpoints.

[18] To test the importance of employability in major decisions, robustness checks will re-evaluate the major premium excluding graduates who don't report wages. Those premiums will be calculated using the same regression as these premiums, excluding non-workers from the sample.

with a larger proportion of their graduates with graduate degrees than other majors (see Table 1.3). The increased education leads to higher pay, and makes the likelihood of attending graduate school a possible consideration for students thinking about their major and its long term potential. For this reason graduate education is an important endogenous variable that acts as a mechanism through which students make major decisions and is therefore not added as a control in this regression.[19]

The major premiums are evaluated using the 2009-13 ACS to determine the most accurate ranking of major pay possible. The calculation includes college graduates of working age from 21 to 65. Since male and female earnings are different on average (see Table 1.1), there is reason to believe their major premiums will be different as well. For this reason the premiums are calculated separately for male and female graduates, hence there is no control for sex in the equation. In fact notice in Table 1.3 that the premiums for male and female graduates are not only significantly different, but the resulting relative ranking of majors by these pay premiums is different as well. Majors such as Consumer Sciences, Fine Arts, Mechanic Repairs, and Humanities for example have premiums that are positive for men and negative for women (relative to the comparison Library Science major), placing them at completely different relative rankings for the sexes. It would be inaccurate, then, to utilize the combined[20] major premium in analysis.

[19] However the main results do not change significantly when graduate education is added as a control. In the sample 33.67% of students hold a graduate degree.

[20] Evaluating major premiums together (including a gender control) results in slightly different premiums and ranking of majors. However in robustness checks evaluating men and women's premiums together rather than separately does yield similar overall results.

1.3: Covariate Adjusted Major Premiums

Major	Percent of Sample	Percent with Graduate Degree	Average Hourly Wage	Male Major Premium	Female Major Premium	Combined Major Premium
Library Science	0.02%	76.92%	$14.29	$0.00	$0.00	$0.00
Theology	0.54%	32.99%	$16.21	-$6.04	-$5.24	-$8.29
CCA[1]	0.08%	11.24%	$16.94	-$1.84	-$5.60	-$5.62
Consumer Sciences	0.91%	23.81%	$17.58	$4.62	-$0.89	$0.38
Education	11.34%	41.36%	$18.41	$2.25	$0.73	-$0.80
Industrial Arts	0.01%	14.11%	$19.90	-$0.30	-$8.62	-$4.90
Fine Arts	4.39%	21.31%	$20.18	$1.36	-$1.69	-$1.43
Social Work	1.41%	39.34%	$20.52	$3.10	-$0.03	$1.15
Mechanic Repairs	0.03%	13.64%	$21.32	$0.34	-$2.94	-$4.16
Comm. Tech.[1]	0.17%	11.09%	$21.38	$3.73	$0.04	-$0.62
Agriculture	1.26%	21.45%	$21.49	$0.19	$0.52	$1.66
Foreign Languages	0.92%	40.98%	$21.89	$7.49	$1.19	$2.57
Physical Fitness	1.17%	24.38%	$22.28	$3.99	$2.26	$1.50
Humanities	1.42%	25.13%	$22.58	$5.59	-$0.36	$1.06
English	3.27%	39.48%	$23.60	$8.17	$1.47	$3.16
Psychology	5.44%	42.13%	$24.04	$4.02	$1.42	$3.20
Law	0.20%	26.55%	$24.15	$6.28	$2.22	$3.27
Natural Resources	0.76%	23.45%	$24.52	$4.23	$1.26	$1.02
Philosophy	0.72%	45.43%	$24.53	$4.16	$1.63	$0.65
Communications	5.11%	18.26%	$24.78	$6.34	$2.32	$3.14
Criminal Justice/Fire	2.06%	17.86%	$25.05	$4.02	$2.45	$1.68
Interdisc. Studies[1]	0.78%	32.39%	$25.36	$9.68	$2.07	$4.27
Nuclear Tech.[1]	0.03%	16.67%	$26.31	$8.22	$5.29	$5.51
Architecture	0.67%	28.59%	$26.96	$5.39	$0.85	$1.58
Ethnic Studies	0.37%	43.15%	$27.05	$12.55	$2.66	$5.87
History	2.20%	41.42%	$27.14	$8.41	$3.46	$4.34
Medical Sciences	6.47%	31.27%	$29.08	$17.46	$9.48	$11.11
Engineering Tech.[1]	0.70%	14.84%	$29.31	$7.31	$3.53	$3.39
Construction	0.20%	7.03%	$29.47	$8.32	$2.24	$3.63
Business	21.77%	19.33%	$29.82	$11.47	$4.16	$6.49
Mathematics	1.19%	41.94%	$30.78	$15.98	$6.86	$10.00
Military Tech.[1]	0.01%	10.00%	$30.80	$5.25	$11.56	$1.75
Social Sciences	7.86%	38.07%	$30.90	$13.95	$3.99	$7.72
Physical Sciences	2.56%	44.30%	$32.84	$16.78	$7.25	$11.27
Transportation Tech.[1]	0.30%	15.83%	$32.87	$11.76	$5.03	$7.48
Information Sciences	2.87%	19.33%	$34.64	$13.96	$6.45	$8.71
Life Sciences	4.81%	51.28%	$35.08	$20.00	$8.87	$13.20
Engineering	5.99%	33.38%	$36.22	$16.96	$10.18	$12.64

Note: Data taken from the 2009-13 American Community Surveys (ACS). Notice that all majors are being compared to Library Science as the omitted category in this design.

[1] "Tech." abbreviates Technologies in the major names. CCA refers to the major Cosmetology and Culinary Arts. "Comm." abbreviates Communications, "Interdisc." Interdisciplinary.

For this reason the logit coefficients and the corresponding elasticities will be obtained in analysis for men and women separately.

The different major premiums are listed in Table 1.3. The premiums are calculated compared to the major "Library Science," a relatively low paying major in the sample. This means that more lucrative majors, such as Engineering, boast premiums as high as $16.96 per hour above graduates in the Library Sciences for male graduates, while Humanities yield only $5.59. There are differences by sex as the premiums when calculated for women are in general lower than the male major premiums. For example, the premiums for Engineering and Humanities are $10.18 and -$0.36, respectively, for female graduates. When the premiums are calculated for both men and women together (using the above fixed effects regression with the addition of an indicator for sex) the premiums lose variation, with Engineering majors overall earning $12.64 more than the base and Liberal Arts & Humanities earning $1.06. Following this result, the analysis will evaluate men and women separately and will therefore use the male and female major premiums separately. However to check robustness, and to acknowledge the fact that college students may not utilize separate premiums when evaluating payoffs to a major, the combined major premium will be used as well.

Since no major information is collected before 2009, pay for older, more experienced graduates is taken from current pay information. In other words, students who graduated in Education Administration and Teaching in 1985 at the age of 22 (for example), making them 47 in the 2010 survey, are responsible for the pay associated with that major and experience level in the calculation of the premiums. Since this analysis

spans a number of years, it is important that the relative ranking of major premiums, if not the absolute level of the premiums themselves, stays approximately the same across the time period studied. Using the years of data that are available, this does seem to be the case.[21] Incorporating as many years of data as possible into the calculation makes this assumption and the reliability of the major premiums calculated stronger since it allows for changes across time in pay reported during different surveys. The result is the most accurate premiums possible given the lack of major data alongside income prior to 2009.

Table 1.3 presents the major premiums by sex and combined for both men and women alongside information on what portion of the sample each major comprises. For comparison (and to provide a base to compare the premiums to) average wages are also presented. Notice how the ranking of majors by average wage (as they are ordered in Table 1.3) does not necessarily line up with the ranking of majors by their pay premium since the premium measure controls for a number of important factors that average pay does not.

1.6 Results and Channels

1.6.1 Main Results

The results suggest that students are relatively inelastic to different major premiums as the unemployment rate fluctuates. Students are more likely to choose a higher paying major as conditions worsen, but this effect is small. The overall impact is that on average a major that pays twice as much increases the likelihood of choosing the field by only

[21] Calculating the premiums for each year of the survey data does indeed yield similar major pay premiums for each year available.

2.7% for male graduates - an elasticity of 0.027. For female graduates the likelihood increases by even less, just 0.57%, an elasticity of 0.0057 (see Table 1.4). The relatively lower elasticity for female graduates concurs with past literature suggesting that women place less importance on higher pay. In this specific case, women emphasize pay less when choosing majors compared to their male colleagues.[22]

Table 1.4: Estimation Results by Sex

	(1) Men	**(2) Women**
Major Premium	0.0904*** (0.0015)	0.0580*** (0.0017)
Unemployment Rate* Major Premium	0.0018*** (0.0002)	0.0013*** (0.0003)
Observations	134,492	167,672
Elasticity	0.027	0.0057

Note: Major premium measured hourly. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

In the model, the coefficient on the major pay premium variable represents student response to higher paying majors, and the coefficient on the interaction of market conditions and the premium represents any extra response when the unemployment rate changes. So a positive coefficient on the major premium indicates that students prefer higher paying majors, and a positive coefficient on the interaction term indicates that they

[22] The effect is robust to changing the time frame studied, for example from 1990-2010 or even 2000-2010. The 2010 ACS is used here since the computational requirements of conditional logits make difficult the use of multiple surveys at once. Robustness checks have shown that similar results are achieved using other available ACS data.

prefer higher paying majors even more as the unemployment rate increases.[23] This second coefficient is positive for both men and women, indicating that a higher unemployment rate when deciding on major does increase the likelihood of choosing a major that pays more. Since logit coefficients are not directly interpretable on their own, they are presented here for understanding, as they are used to calculate the elasticity, and to observe their signs.[24] The elasticity is the most important number for interpretation of this model.

It is simplest to interpret elasticities across different potential unemployment rates. Each of the major elasticity of substitution values calculated in Table 1.4 represents the elasticity when unemployment is at average levels. To better answer the question of how students respond to labor market conditions when choosing their major, it is also useful to see the potential range of elasticity values students may exhibit at different unemployment levels. Table 1.5 shows these values for potential unemployment rates of zero through fifteen.[25] The increase in the elasticity as the unemployment rate rises suggests that men are 2.8% more likely to choose a major that pays twice as much in a recession when the unemployment rate is very high (fifteen percent) but only 2.6% more likely when the unemployment rate is very low (one percent). The difference is subtle.

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[23] Recall from the methods section that conditional logits are fixed effects models, in this case individual fixed effects, and so only include variables that define characteristics of the choice being made – in other words, variables that define aspects of a given major and therefore vary within individual groups. As a result unemployment rate during college, which doesn't vary by individual/across majors, is not in the regression except as an interaction.

[24] Alternatively marginal effects are useful for interpretation. However since the elasticity is the most relevant number for interpretation in this model, actual coefficients are presented to understand the calculation of this number better.

[25] The elasticities here are being calculated by holding unemployment constant at each rate 0-15%.

Women will also choose higher paying majors when facing high unemployment. They are 0.60% more likely to choose the higher paying major when unemployment is high, but only 0.55% more likely when unemployment is low. In general women are less

Table 1.5: Elasticity of Substitution Across the Business Cycle

Unemployment Rate	(1) Men	(2) Women
0	0.0262	0.00544
1	0.0264	0.00548
2	0.0265	0.00552
3	0.0267	0.00555
4	0.0268	0.00559
5	0.0269	0.00562
6	0.0271	0.00566
7	0.0272	0.00570
8	0.0274	0.00573
9	0.0275	0.00577
10	0.0277	0.00580
11	0.0278	0.00584
12	0.0279	0.00588
13	0.0281	0.00591
14	0.0282	0.00595
15	0.0284	0.00598
Average	0.0271	0.00566

sensitive to pay premiums but exhibit the same pattern of changing majors when facing higher unemployment. This is in line with average female students preferences regarding pleasant major traits rather than pay.[26]

In Figure 1.2, there was movement in and out of majors when students faced relatively high or low unemployment. For example, a number of women left the

[26] See Bronson 2013, Wiswall and Zafar 2011, Zafar 2009, and Montmarquette 2002.

Business major when facing high unemployment rates, while others joined Engineering. A similar trend held for men. Whether this happens through selection or switching as students re-optimize their pay versus major traits tradeoff (recall the theoretical compensating wage differentials framework), the countervailing forces potentially balance each other out. This may result in the seemingly small effects observed here despite hypothetically large underlying changes. In fact these results may be a lower bound as many students do not follow the traditional college career path. According to the National Center for Education Statistics,[27] as many as 12% of public 4-year institutions are students aged 25 and over. This number is drastically higher – 71% - at for-profit universities. For these students, analyzing the economy around the typical college student's major decision period would result in no effect, and hence result in downward attenuation bias. Since they graduate later in life, labor market conditions at the time they were approximately 21 may have minimal or no impact on their major decisions.

The literature also suggests that beliefs about returns to schooling probably matter more for its accumulation rather than actual returns – whether these beliefs are correct or not (Jensen 2010, Nguyen 2008, Kaufmann 2008, Manski 1993, Betts 1996). Students are often wrong in their assumed beliefs about potential expected earnings and other major specific outcomes (Wiswall and Zafar 2011). It is therefore entirely possible that the effects of the economy measured here are small due to people's reliance on potentially faulty beliefs about the prospects a given major holds rather than actual

[27] Taken from the NCES Integrated Postsecondary Education Data System (IPEDS), enrollment component.

analysis of how it is impacted by the economy.[28] These beliefs could range from general consensus on how lucrative a major is to how 'employable' a given major is seen as being by students.

Additionally, if a marginal student is indifferent between earning in the labor market and attaining higher education, the decreased opportunity cost of college due to a recession will lead to a preference for education. These students will not be those with relatively high earnings potential, as those high earners would choose to remain in college regardless of the circumstances, but rather those in relatively lower paying fields. As the unemployment rate rises this will result in an increasing number of students in the lower paying majors, making it appear as though tough economies push students toward lower paying majors rather than higher paying ones. This potential retention could therefore also help to explain why reaction to labor market conditions is small in the analysis, as the response in college graduation rates may be pushing the results downward. However this will only be true if retention is a relevant factor in major decisions for men and women in the sample.

1.6.2 Retention Channel

Both male and female college major decisions across the business cycle involve an element of potential selection since individuals may also make decisions about whether to continue their college degree based on economic conditions. If attainment of higher education is influenced by the economy, then estimates of how the economy affects

[28] Robustness checks will attempt to understand some aspects of student thinking by, for example, using a naïve average pay by major measure rather than covariate adjusted major premiums.

major decisions include this potential channel through which graduates' fields of study are changed. In fact previous work suggests that this may indeed be the case – that as the economy worsens, students turn to higher education as a means of increasing human capital in their field or gaining training in a new one (Kahn 2010, Betts and McFarland 1995, Gustman and Steinmeier 1981). Betts and McFarland (1995) found that a one percent increase in unemployment led to a four percent increase in full time college enrollment in the 80s, while Gustman and Steinmeier (1981) also found that higher unemployment stimulates less choice for work versus school enrollment. Analysis of the effect of graduating under bad economic conditions, besides finding long-term wage penalties, also notes that cohorts who graduate in worse economies have higher levels of educational attainment especially as students pursue graduate education (Kahn 2010).

To determine whether retention is a potential channel through which major decisions are being made when students are exposed to varying economic conditions, tests following the literature on college attendance selection can be performed to determine whether a recession really does increase college completion in the data. A key point is that previous papers looked at college attendance rather than completion (Gustman and Steinmeier noted that better conditions reduce probability of *enrollment*, while Betts and McFarland noticed effects on community college enrollment) or involve only selection into education beyond a bachelor's degree (Kahn 2010). The sample used in this paper is those students who *completed* (not just enrolled in) a certain major. The possibility that many of the marginal students who attend school during a recession may

drop out before completion, perhaps since they may not have gone to college under other circumstances, could mean that selection plays a different role in this sample.

To test for the presence of retention selection, it is necessary to see whether labor market conditions have a direct impact on the likelihood of completion of a bachelor's degree given that one has a high school education for both men and women:

$$bach_{ist} = \beta_1 * ur_{st} + \beta_2 * age_{it} + \beta_3 * age^2_{it} + \beta_4 * race_{is} + \mu_s + \gamma_t + \varepsilon_{ist}$$

where the outcome variable *bach* indicates whether the individual completed a bachelor's degree or not, given that they started college. A significant value for β_1 (using logit) indicates that there is some selection into completion of a degree based on economic conditions – the same conditions used in regression, a three year moving average of the unemployment rate while deciding on major at age 21. Just as in the fixed effects calculations of the major premiums, there is no control for sex here since the retention selection test will be run for men and women separately.

Using these selection checks, it appears that retention in college is unaffected by the unemployment rate (see Table 1.6). These results are robust to the possibility that this selection is driven by timing. Students may, for example, be 21 in 2008 but take longer than the typical schedule to obtain their degrees so that in the 2010 Census they have yet to obtain their bachelor's. It is possible that they will not, but they also may not show in the data as having a degree simply because they have not yet completed rather than due to labor market conditions. However robustness checks of the selection test using only years up until 2005, as well as up until 2000, (to include only individuals who,

if they are going to graduate, already have) result in similar conclusions. Student retention is unaffected by the unemployment rate. This indicates that the main results found are reflective of a pure major switching compensating wage differentials channel.

This is a different selection test than the previously cited past literature, which in many cases suggests that students select into college when facing bad labor market conditions. Those studies test selection based on the unemployment at age 18, after high

Table 1.6: Retention Channel

Dependent Variable: Bachelor's Degree	**(1) Men**	**(2) Women**
Unemployment Rate	0.0004 (0.0013)	0.0004 (0.0012)
Age	0.9318*** (0.0715)	0.9964*** (0.0442)
Age^2	-0.0126*** (0.0010)	-0.0136*** (0.0006)
White	0.0508*** (0.0030)	0.0577*** (0.0033)
State and Year FE	YES	YES
Observations	305,621	368,824

Note: Marginal effects shown. Robust standard errors, clustered by state and year, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

school, and this is a test of the effect of unemployment while in college deciding on a major. Those studies also focus on enrollment, while these results capture completion of a degree. While enrollment may increase as marginal students (who might not have gone to school when its opportunity costs were higher) now attend college, this does not mean

that they will complete the degree. The effect of the unemployment rate *at age 21 on completion of a bachelor's degree* is therefore insignificant for men and women.

1.7 Alternative Specifications and Robustness Checks

1.7.1 Major Premiums

The results are robust to a number of specifications, including alternate versions of each of the three main parts of this analysis: computation of the major specific wage premium, the unemployment rate used, and timing of student major decisions. For example,

Table 1.7: Results with Combined Sample and Major Premiums

	Men & Women		**Men**	**Women**	
	(1) Combined Premiums	**(2) Sex Specific Premiums**	**(3) Combined Premiums**	**(4) Combined Premiums**	**(5) Male Premiums**
Major Premium	0.0005*** (0.0012)	0.0770*** (0.0012)	0.1152*** (0.0019)	0.0754*** (0.0016)	0.0572*** (0.0014)
Unemployment Rate* Major Premium	0.0019*** (0.0002)	0.0018*** (0.0002)	0.0024*** (0.0003)	0.0009** (0.0003)	0.0007** (0.0002)
Observations	302,164	302,164	134,492	167,672	167,672
Elasticity	0.014	0.015	0.020	0.010	0.014

Note: Major premium measured hourly. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

evaluating the model with combined rather than sex specific major premiums as well as the combined (male and female) sample leads to similar results, where students are more

likely to choose higher paying majors when unemployment is elevated. Table 1.7 shows that if covariate adjusted major premiums are calculated for men and women together, with an indicator for sex included in the regression, the results for men and women are similar to the results obtained when evaluating men and women separately.

The main difference is that male and female graduates' range of elasticities converge due to the combined analysis. Recall that the elasticity at average unemployment levels was 0.027 for men and 0.0057 for women in the main specification. Here those elasticity values are 0.020 and 0.010, respectively. Table 1.7 also shows what happens when the results are obtained for men and women as a combined sample, both using joint premiums and sex specific ones. This yields similar results, with even more convergence and an average elasticity of 0.014.

Exploiting combined premiums accounts for the fact that it is entirely possible that students do not form beliefs about the payoffs to a certain major using specific premiums but rather more general ones. For this reason Table 1.7 also shows the results using not just the combined premiums, but the male premiums as the default payoffs in decision making. Notice that this gives a similar result in female student decision-making, although women who use male payoffs in their decision-making become slightly more sensitive to major pay with an elasticity of 0.014 at average unemployment levels.

It is also possible that students don't covariate adjust when analyzing relative pay by major as in this model. Table 1.8 shows what happens when students use a naïve measure of relative major pay – a simple average hourly pay by major metric. Notice

that similar results are obtained as in the main specification but students exhibit heightened sensitivity to measures of average pay compared to the covariate-adjusted premium. Men now have an elasticity of 0.085 at average levels of unemployment, while women's elasticity is also noticeably higher at 0.016. These are increases of 215 and 186 percent, respectively, as compared to the preferred specification in Table 1.4.[29] The

Table 1.8: Results with Alternate Major Premiums

	Men		**Women**	
	(1) Average Pay	**(2) Short Term Premium**	**(3) Average Pay**	**(4) Short Term Premium**
Major Premium	0.1044*** (0.0019)	0.1603*** (0.0031)	0.0196*** (0.0016)	0.1071*** (0.0022)
Unemployment Rate* Major Premium	0.0022*** (0.0003)	0.0050*** (0.0005)	0.0008*** (0.0003)	0.0046*** (0.0004)
Observations	134,492	134,492	167,672	167,672
Elasticity	0.085	0.013	0.016	0.018

Note: Major premium measured hourly. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

drastic increases in major elasticity of substitution suggest that students utilize average pay by major in their decision making rather than covariate adjusting their analysis.

If students don't covariate adjust, they may also fail to account for the entire life cycle of major pay. This equates to a short-term outlook of the relative payoffs a major

[29] Average pay by major here is calculated for men and women together to reflect lack of covariate adjustment. Applying average pay by major by gender also yields similar results.

entails. For this reason Table 1.8 also shows how student decisions change when major premiums are calculated using just recent graduates (aged 22-30).[30] The results are consistent with the preferred specification, but also seem to indicate that male graduates are less responsive to short term pay outcomes while female graduates are more responsive to them in their decision-making. The difference is not as large as the change when evaluating average pay by major. The male elasticity decreases by 51.9 percent while the female elasticity increases by 181 percent.

There are also endogenous variables that students may or may not consider when analyzing pay by major, namely the employability of a given major and its likelihood of leading to graduate school. Both of these are relevant to the lifetime earnings expected by students of a given major and should therefore be relevant mechanisms through which market conditions impact major decisions. However considering employability or graduate school adds an additional layer to major decisions that involves long term planning by students. For this reason Table 1.9 examines how the results change when students do not incorporate these elements into their decisions. When students who are not working are excluded from the major premium calculation (columns 1 and 3), reflecting premiums given that students are working and therefore excluding information about relative employability of a major, the results are again similar but both men and women are slightly less responsive to these premiums. The elasticity at average unemployment decreases by 7.4 percent for men and 38.6 percent for women, indicating that students are more likely to incorporate employability by major into their decision.

[30] Similar results are obtained using graduates aged 22-35, or even 22-40.

Student major decisions may also be impacted by decisions about graduate school completion. Since the likelihood of holding a graduate degree varies by major (see Table 1.3), decisions about which major to choose when facing different labor market conditions may involve long term outlooks about pursuing graduate school (and ideally higher pay). In Table 1.9 (columns 2 and 4) when premiums are calculated while controlling for graduate school attainment, student response actually increases slightly.

Table 1.9: Results without Endogenous Variables

	Men		**Women**	
	(1) Employability	**(2) Graduate School**	**(3) Employability**	**(4) Graduate School**
Major Premium	0.0853*** (0.0015)	0.1075 *** (0.0020)	0.0440 *** (0.0015)	0.0502 *** (0.0020)
Unemployment Rate* Major Premium	0.0018 *** (0.0002)	0.0025 *** (0.0003)	0.0009 ** (0.0002)	0.0027 *** (0.0003)
Observations	134,492	134,492	167,672	167,672
Elasticity	0.025	0.045	0.0035	0.0092

Note: Major premium measured hourly. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

This indicates that students respond more to major premiums on average when they do not incorporate potential returns to graduate school. In other words, students do not tend to include information about the likelihood of attending graduate school when evaluating major decisions across the business cycle. This time the calculated elasticity at average unemployment increases by 66.7 percent for men and 61.4 percent for women.

Overall, the general results remain robust – students are relatively inelastic to different major pay premiums but this sensitivity does increase as the labor market worsens.[31]

1.7.2 Unemployment Rate

The results are also robust to different specifications of the unemployment rate used. For example, Table 1.10 shows how using only the year specific state unemployment rate[32]

Table 1.10: Results with Different Unemployment Rates

	Men		**Women**	
	(1) No Moving Average	**(2) Recession Indicator**	**(3) No Moving Average**	**(4) Recession Indicator**
Major Premium	0.0914*** (0.0014)	0.0999*** (0.0005)	0.0610*** (0.0016)	0.0652*** (0.0005)
Unemployment Rate* Major Premium	0.0016*** (0.0002)	0.0058*** (0.0010)	0.0008** (0.0002)	0.0030*** (0.0011)
Observations	134,492	134,492	167,672	167,672
Elasticity	0.027	0.027	0.0057	0.0057

Note: Major premium measured hourly. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

rather than the three year moving average results in similar measures for both men and women. In fact the elasticities here are identical to the elasticities at average

[31] Elasticity values across the business cycle are not shown here for all alternative specifications and robustness checks, although they follow the same pattern as Table 1.5. The average elasticities shown in each table are relatively inelastic as in the main specification, but sensitivity does increase as the unemployment rate goes up.

[32] The state unemployment rate at age 21, robustness check to follow.

unemployment for the preferred specification. Additionally, since it is possible that students don't assess their prospects based on a specific measure like the state unemployment rate, columns two and five evaluate the impact of making major decisions during a year classified by the NBER as a recession year.[33] Using an indicator for whether or not a given year's labor market was classified by recession conditions, the results indicate that both men and women respond similarly to general recessions as they do to specific state unemployment rates. In fact the elasticities are once again identical to the preferred specification. Students seem to classify labor market conditions generally rather than responding primarily to a specific indicator.

1.7.3 Timing

Finally, the results are robust to variations on timing of major decisions. The preferred specification assumes major decisions are most influenced by labor market conditions when the student is in college and uses a moving average of the unemployment rate at age 21. However changing this assumption slightly does not alter the results. Table 1.11 shows how students respond in a similar manner to three year moving averages of the unemployment rate at ages 19 and 20. This suggests that major decisions may be the accumulation of a number of years of exposure to general conditions rather than the result of a specific time period. In fact since the nature of the data makes it difficult to precisely pinpoint the age at which a student graduated there may be effects at a number of different ages since some students finish their schooling later than others.

[33] These years include: 1980-82, 1990, 2001, and 2008-09. Each of these had at least six months of the year classified as a recession by the NBER.

The results do seem to indicate that general labor market conditions around the time of their major decision matter more for the decision than some strict turning point year. Not only does it not matter which measure of the unemployment rate is used (3-year versus single year), but also evaluating at different timing of impact still results in a similar measure of how student decision-making is impacted by the business cycle. The general state of the economy as the student is thinking about college matters, perhaps

Table 1.11: Results at Different Age of Major Choice

	Men		**Women**	
	(1) At Age 19	**(2) At Age 20**	**(3) At Age 19**	**(4) At Age 20**
Major Premium	0.0899*** (0.0016)	0.0906*** (0.0016)	0.0557*** (0.0017)	0.0563*** (0.0017)
Unemployment Rate* Major Premium	0.0018*** (0.0002)	0.0017*** (0.0002)	0.0017*** (0.0003)	0.0016*** (0.0003)
Observations	134,492	134,492	167,672	167,672
Elasticity	0.027	0.027	0.0057	0.0057

Note: Major premium in thousands of dollars. Robust standard errors, clustered by individual, in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Data is taken from the 2010 ACS. Unemployment rate data is from the BLS and is used here as the state 3-year moving average.

suggesting that the economy impacts decision making through a general 'feeling' about the state of the economy around the time the student is considering attaining a degree. This is also supported by the previously identified robustness of utilizing a specific yearly unemployment rate versus a moving average. Even the robustness of utilizing average

major pay instead of premiums indicates that students conduct more generalized analysis rather than specific.

1.8 Conclusion

Using the new ACS data collected on college majors, this paper finds that students choose higher paying majors when the unemployment rate increases. Estimating an elasticity of substitution between majors suggests that students are 2.8% more likely to choose a major paying twice as much in a recession when the unemployment rate is very high but only 2.6% more likely when the unemployment rate is very low. This effect varies by sex, with women less sensitive to measures of pay. Female graduates are only 0.60% more likely to choose a major paying twice as much in a recession when the unemployment rate is very high and 0.55% more likely when it is very low.

The results use a measure of pay by major that is covariate adjusted for relevant factors that influence lifetime earnings of a college graduate in a given field, such as age profiles. Though small, these effects are robust to different specifications of the major pay metric, unemployment rate used, and timing of major decisions.

These conditional logit estimates may be a lower bound estimate of how the economy impacts major decisions as the data does not provide information on college graduation date or age. The significant number of students who finished their degrees later in life are not affected by the economy during the same time as their traditional counterparts. The impact of the economy on their major decisions during the typical college attendance period should therefore be zero, biasing the results downward.

Additionally many students move to higher paying majors such as Engineering when facing a recession, but majors such as the relatively high paying Business major are more popular when in a good economy. The opposing effects may counteract each other in the analysis. The literature also suggests that student beliefs about returns to schooling matter more for their decision-making than actual returns do. The effects of labor market conditions on major found here may be small due to, as in much of the literature, student use of faulty beliefs about the relative lifetime earnings a major pays.

In general students appear to be most sensitive to measures of average pay, rather than a covariate adjusted major premium, and respond more to rankings of major that incorporate information about their relative employability than to those that do not. This indicates a tendency to evaluate prospects using general measures rather than more specific ones, something that is furthered by the observation that students evaluate major decisions using general labor market conditions for a number of years.

Changes in major composition as a result of the business cycle come about through enrolled students switching majors. In this analysis both men and women are unaffected by the business cycle in their decisions about whether to attain a bachelor's degree. The effects found here are therefore primarily attributable to student major switching as they reevaluate their willingness to accept major bads in exchange for increased lifetime earnings. Therefore through a compensating wage differential channel, students are responsive to different pay by major and the level of this sensitivity increases across the business cycle.

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Chapter 2

College Major and the Gender Gap:

A Closer Look*

Abstract

This paper takes a closer look at the impact of college major on the gender wage gap by utilizing detailed data to detect trends in college major that were previously unobservable. Newly available, detailed major data from the American Community Survey reveals different levels of inequality in the distributions of major by sex than past surveys and other more generalized major data and, for the past decade, even a different trend. These observations warrant a re-examination of the role major now plays in the gender wage gap, especially as detailed major data reveals increasingly polarized majors for male and female graduates in recent years, while more generalized data would seem to indicate convergence among graduates.

This analysis will also evaluate major's impact on the wage gap by assessing some of the potential mechanisms, such as graduate education, through which we might expect major to impact wages. Overall, when using major to help explain the gender wage gap, the ACS data can help us to understand approximately 14% of the difference in pay, a jump in explanatory power of 35% when compared to less informative data.

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2.1 Introduction

In college today male and female graduates finish their degrees in a wide variety of majors. Despite a complete reversal in the gender graduation gap, where in the 1950s approximately 42% of college graduates were female but 58% are today, a significant gap in the majors men and women pursue while studying for their degree remains. If it were to mirror the trend in overall graduation rates, the difference in male-female college majors would be eliminated or significantly diminished. Instead there is a pattern of continuing divergence that has led to increasing disparity in the distributions of major by sex over the past decade. Women and men continue to graduate in different college majors - despite both being well represented in the university environment. The divergence in field of study distributions by sex contributes to the ever-present gender gap in wages observed in the labor market for college graduates.

This paper will focus on the impact of major on the gender gap. It will take a closer look at why college major matters for the graduate wage gap by evaluating some of the potential mechanisms through which we might expect major to influence wages. More specifically, through the use of a more expansive data set than was previously available, it will note that college major plays a significant role in determining an individual's wages beyond just the expected channeling of a given major into certain occupations associated with different levels of pay, or even beyond the channeling of certain majors into education beyond the bachelors' degree. This paper will broaden the discussion to better answer the question: if major matters for an individual's wages, how

much of the gender gap in wages can be explained by college major distributions that vary by sex? If the answer is nonzero, as in similar earlier studies, then analysis of the gender gap that does not take college major into account may be misleading.

Crucially, this paper will note that using newly available detailed American Community Survey data reveals different levels of inequality in major distributions by sex than other more generalized major data. For the past decade the ACS data even detects a different trend than less detailed data, warranting a re-examination of the role major now plays in the gender wage gap. In fact detailed major data reveals increasingly polarized majors for male and female graduates in recent years, while more generalized data would seem to indicate convergence among graduates. Overall, when using major to help explain the gender wage gap, the ACS data can help us to understand approximately 14% of the difference, a jump in explanatory power of 35% when compared to less informative data.

2.2 College Major and the Gender Gap

This paper contributes to existing literature that analyzes the relationship between college major and the gender gap. This is in turn a part of a broader literature dissecting the components of education, beyond attainment, that matter for wages. To dissect the gender wage gap, studies have found that many components of education matter for wages outside of just quantity – classes taken and mathematical content of schooling (Brown and Corcoran 1997, Weinberger 1999), composition of classrooms (Anelli and Peri 2013), grades and scholastic achievement (Fuller and Schoenberger 1991, Loury

1997), and college major (Daymont and Andrisani 1984, Eide 1994, O'Neill 2003), to name a few.

The literature analyzing the role of major on the gender wage gap has been limited by data restrictions in the level of detail available and the extent of representation the data is able to achieve. For example, Daymont and Andrisani (1984) use the National Longitudinal Studies of the High School Class of 1972 (from the National Center for Education Statistics NCES) to find that different majors pursued by men and women can account for somewhere between one-third and two-thirds of the gender gap, so that discrimination is overestimated if this is not included in the analysis. However this survey is limited by the fact that it classifies majors into only 15-20 categories, depending on the question in the survey, and so analysis in the paper is conducted at an aggregate level containing only ten majors (nine common categories plus a general "other major" one). As we will see in this paper such aggregation leads to less precise, and sometimes completely misleading, (see Figures 2.1(a) through 2.2(b)) results.

In Eide (1994), the same data is used to analyze the changing gender gap as convergence in major distributions by sex leads to a decline in the gap. Since the paper uses the NCES data, it focuses on the period before convergence stagnated and inequality increased despite a turnaround in the graduation gap. It also faces the same data issues as the previous paper. In fact this analysis groups major into only five main categories plus "other."

Brown and Corcoran (1997) again use the same data in combination with the Survey of Income and Program Participation (SIPP) to examine the relationship between high school courses, college majors, and adult labor market wages. Again the same issue with data limitations is a limiting factor, although the SIPP does allow for a bit more in depth major analysis, with nineteen main major categories plus "other."

O'Neill (2003) uses the National Longitudinal Survey of Youth (NLSY79) in one of its later waves to discover that occupational characteristics (which include college major in the paper) account for a significant amount of the gender wage gap. Though specific details are not given on the use of the major variable in this analysis – it is not the focus of the analysis and so the variable is lumped into "other occupational characteristics" – the NLSY has more majors than the NCES data, but few observations in each, so that generally studies using the NLSY must aggregate majors for a useful analysis.

This paper contributes to the existing literature through use of a newly available, much more extensive dataset that allows for a clearer analysis of the impact of major on wages. The data contains a thorough breakdown of 172 majors and, more importantly, each major contains a significant number of observations so that aggregation is completely unnecessary for analysis. In a college field of study analysis, this means that instead of indicator variables for the field of "Science," for example, we can see the impact on wages of "Physics," "Biology," "Chemistry," etc., separately. As physical sciences are generally different from biological sciences the ability to separate them in an analysis of the relationship between field of study and wages results in a much more in

depth understanding of the role of major in the labor market. The same can be said of many such majors in the data. In some cases use of aggregated major data actually yields misleading conclusions regarding the extent of inequality in the labor market (again see Figures 2.1(a) through 2.2(b) and the associated discussion). The detailed data also allows us to see to what extent major matters for wages above and beyond some of its primary channeling mechanisms.

2.3 Distributions of Major By Sex

2.3.1 Duncan Dissimilarity Index

This analysis aims to obtain a more detailed and complete understanding of the role of college major in explaining gender wage gaps. For this purpose it takes advantage of recently available data from the U.S. Census American Community Survey (ACS) for the years 2009-12. The ACS is a relatively large, representative[1] dataset with information on educational attainment and field of study that began being collected as of the 2009 survey. The sample used includes individuals who completed a bachelor's degree and therefore list a field of study in the data.[2] These majors range from Fine Arts to Biology to Business, for a total of 172 possibilities, each of which are generously represented in the sample. See the Appendix for a breakdown of the major variable used in analysis. The ACS field of study data is very detailed, with each major containing a significant

[1] Sampling weights will be utilized in this analysis.

[2] Major field of study is only collected in this survey if the respondent reported having completed their bachelor's degree.

number of observations, leading to a perhaps more informative analysis than previous studies.

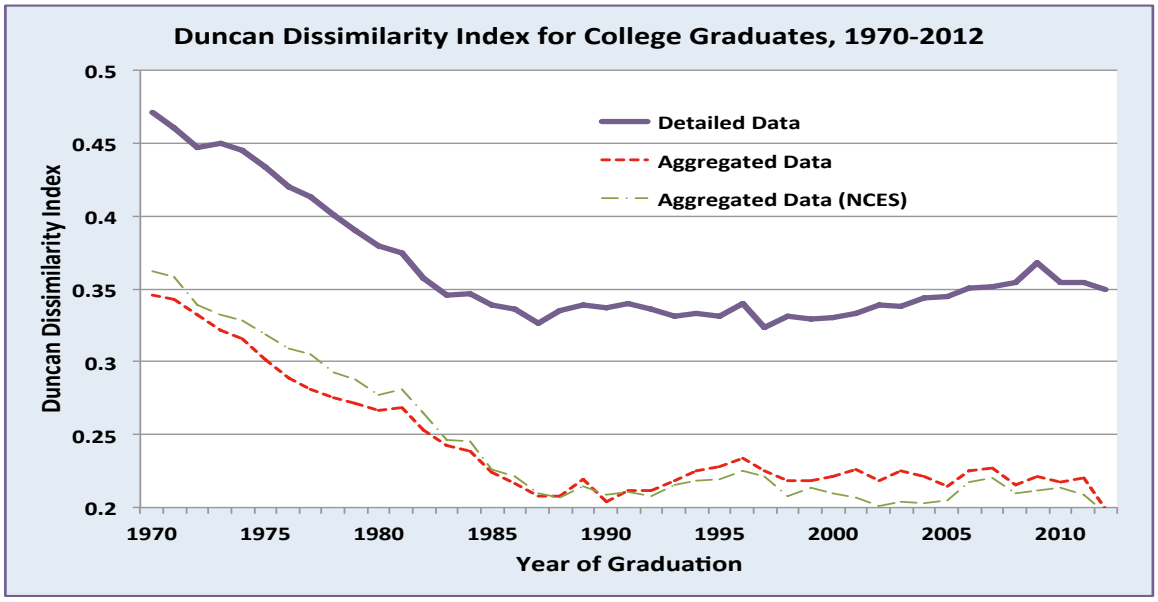
For major to help explain any portion of the gender gap, there must be variation in the field of study decisions made by male and female graduates. Both past and present data confirm this persistent trend. Women overwhelmingly enter fields such as Education, while men dominate fields such as Engineering (see Figure 2.2(a)). In fact Business is the most common field for men of all ages, with about 23% of male college graduates matriculating in this field, while Education is the most common for female graduates, at about 22% of female college graduates choosing this field. This pattern has held over time though it has become less stark. In recent years more women have entered 'male' fields such as Business, for example, even moving this field to one of the most frequently chosen by women. For recent graduates aged 25-30 in the sample, about 17% of women chose majors in the Business field, surpassing the 13% who chose more typical majors in the field of Education. The overall trend in persistent 'male' versus 'female' majors has held over time. Its magnitude, however, has changed. These changes in major decisions have the potential to alter analysis of the role of major in explaining the current gender gap as compared to previous similar studies.

The Duncan Dissimilarity Index can be used to analyze numerically the pronounced difference between male and female college majors over time in order to effectively highlight changes in major distributions by sex. It enumerates the major distribution by assigning a number between zero and one indicating what percentage of

women (or men, for that matter) would need to switch their major in order for the relative distribution of majors for the two sexes to be the same.[3]

Figure 2.1(a) plots these values over time, demonstrating changing trends in the majors men and women graduate in. Differences in majors have persisted over time, but the distributions are not nearly as different as they were for older cohorts. In fact, past

Figure 2.1(a)



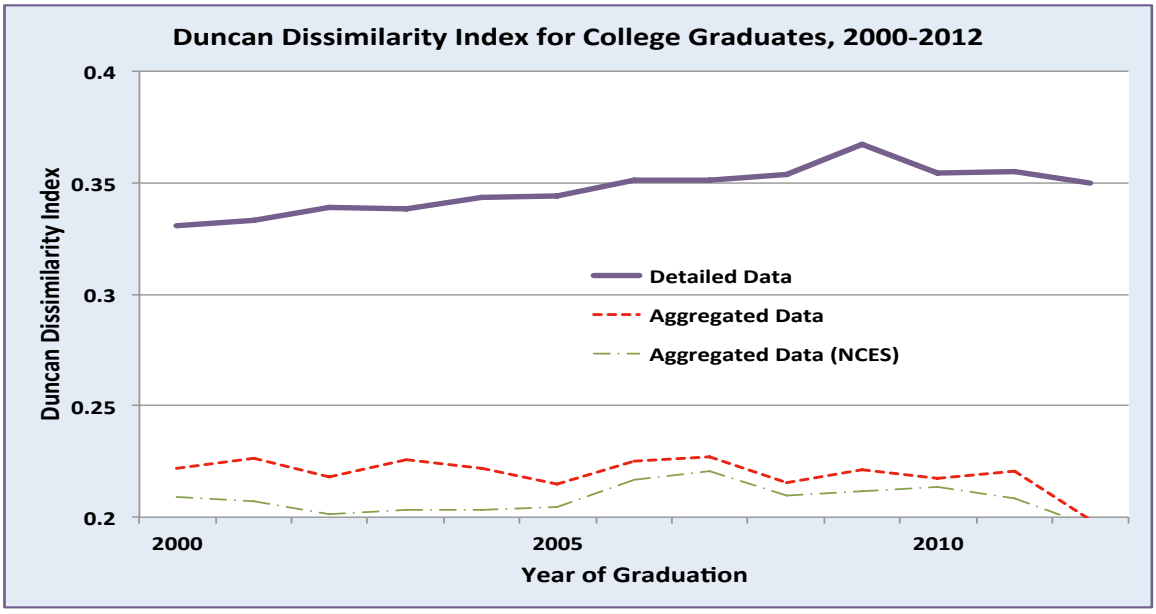
Note: Based on 2009-12 American Community Survey Data. Detailed major field of study variable used in dissimilarity index calculation includes 172 possible major categories. Aggregated Data aggregates major into eleven major categories similar to previously available data. Aggregated Data (NCES) approximates the ten major categories used in the NCES 2009 Baccalaureate and Beyond Longitudinal Study.

cohorts who graduated in the 1950's faced Duncans above 0.5 (implying that more than half of male graduates needed to change their major for uniformity across sexes) whereas cohorts graduating in the 60s and 70s experienced significant levels of convergence in

[3] So a Duncan of 0.2 implies that twenty percent of women (men) need to switch majors in order to demonstrate the same distribution of majors as men (women) do. A Duncan of 0 implies parity in major distributions between male and female college graduates, while 1 implies men and women pursue entirely different fields of study.

male-female college graduates that eventually brought the dissimilarity index down to the 0.35 range. Over the past few decades there has not been as much noticeable movement in the index. Some majors, such as Education and Business discussed earlier, have experienced significant shifts in student composition responsible for the historic downward trend. Other majors, such as Engineering, have stayed static (with a constant percentage of women - less than three percent - choosing to enter the field over time) and have therefore created a sort of bottleneck for any more downward movement in the index.

Figure 2.1(b)



Note: Based on 2009-12 American Community Survey Data. The most recent years in Figure 2.1(a) are shown in more detail here.

More importantly, the detailed ACS data on major plays a crucial role in a complete understanding of the dynamics of college major here. The bottom, dashed line in Figure 2.1(a) plots the Duncan over time using eleven aggregated major categories.

These are meant to approximate coarse major groupings as utilized in past studies, whereas the detailed data line uses the newly available, in depth, ACS major data. While the overall trend remains approximately the same, in the past decade the aggregated data fails to pick up the slight upward turnaround the index has experienced.[4] It also consistently underestimates the level of inequality present among college graduates, as the index is constantly lower when using the aggregated major variable.

The index as calculated using the detailed major variable depicts an increase in the level of inequality over the last decade, yet the aggregated data seems to suggest that inequality is continuing to decrease. The turnaround in the index makes the role of major in male-female wages an interesting topic to revisit. In Figure 2.1(b), where the last decade has been highlighted, use of the aggregated data actually results in a sense of convergence in male-female majors. Using aggregated data as in past studies therefore leads to an understatement of the role major plays in inequality among graduates.

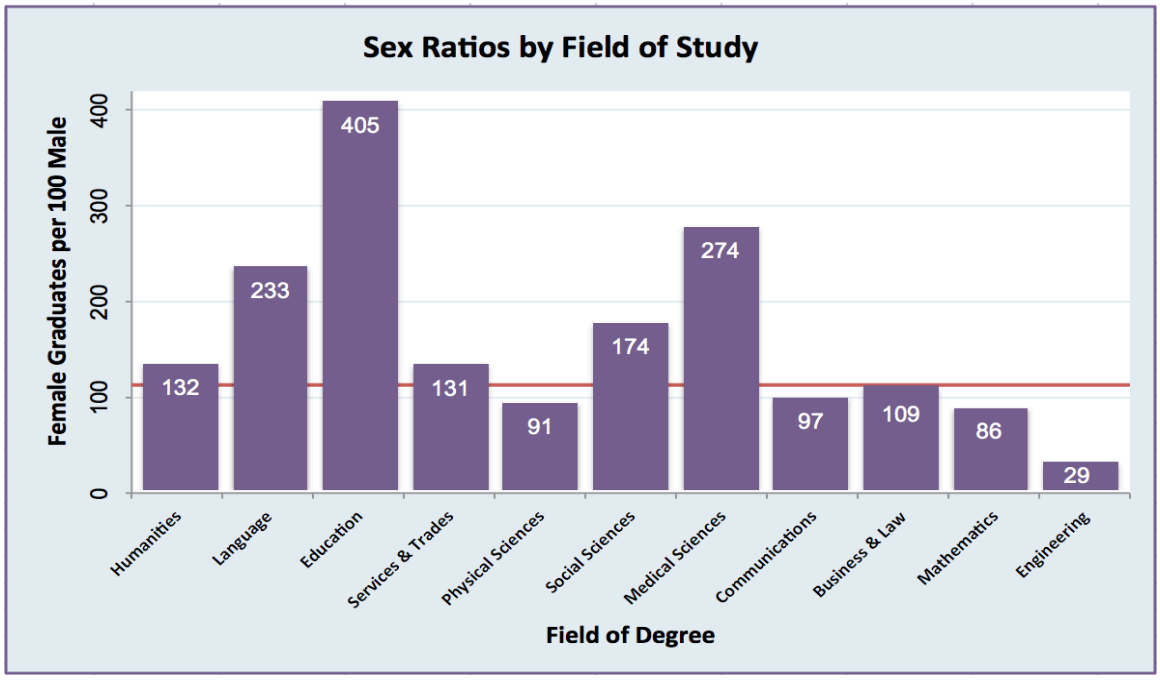
2.3.2 Detailed or Aggregated Major Data?

The ACS aggregates the detailed major variable, with 172 different majors, into a less detailed variable containing 38 different majors. These were then aggregated further, (see Appendix), into the eleven major categories used for illustration in the figures and tables in this paper. The basis for aggregation was primarily similar fields of study, but how prevalent the field was among college graduates was also considered. The resulting

[4] This is consistent with Turner and Bowen (1999) who noted that differences in college major distributions hadn't lessened in the 80s and 90s. Now with this improved data it seems that after 2000 inequality has actually started to increase again.

categories represent the whole spectrum of majors in terms of average wages, area of study, and sex distribution.

Figure 2.2(a)

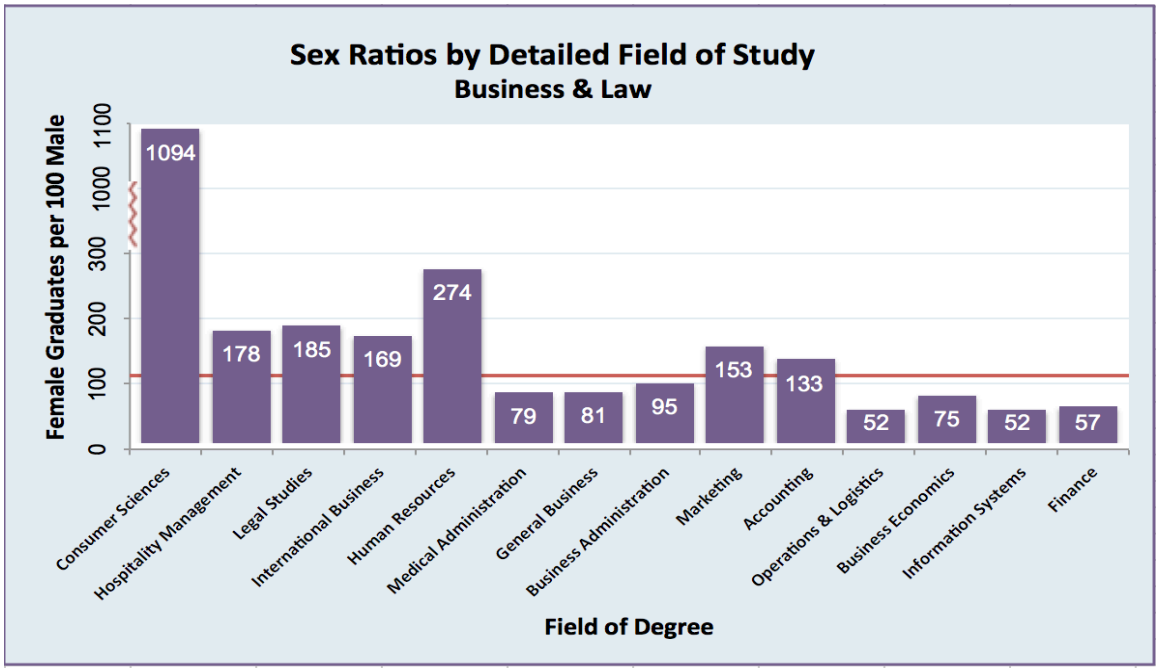


Note: Based on 2009-12 American Community Survey Data. Majors reported for all individuals with at least a Bachelor's degree and ordered here by increasing average wages. Sample includes 239,928 recent college graduates aged 25-30. Since sample is 56.5% female, red line at 113 indicates the ratio at which the major is balanced in its male-female composition.

To be clear, aggregation is used in this paper for the sake of illustration only. It would be difficult to convey meaning in Figure 2.2(a) or Table 2.1, for example, with 172 majors. The lack of information available from aggregated versus detailed data applies when using any reasonably aggregated data - not just the aggregation used. In this paper, eleven major categories are employed but notice also that the dash-dot line in Figures 2.1(a) and 2.1(b) demonstrates that the same issue arises from the data when aggregated in different ways. The alternate aggregation here approximates the National Center for

Education Statistics (NCES) Baccalaureate and Beyond Study major classifications, which break major down into ten different categories. Notice that, if the ACS data is aggregated in the same way as the NCES data, the Duncan graphs shown using Aggregated Data (NCES) are again misleading in the information they convey compared to the detailed data.

Figure 2.2(b)



Note: Based on 2009-12 American Community Survey Data. Since sample is 56.5% female, red line at 113 indicates the ratio at which the major is balanced in its male-female composition. Here the Business & Law major is broken down into more detailed majors, ordered by increasing average wages as in Figure 2.2(a). Note the broken y-axis so as to reduce distortion of the smaller bars due to the large number of females in Consumer Sciences.

For recent graduates, women still overwhelmingly dominate the Education field (see Figure 2.2(a)), as there are 405 female graduates for every 100 male. The majors in Figure 2.2(a) are ordered by increasing average wage in order to highlight the relationship between sex and wage. It is interesting that the most male dominated fields

are on the right hand side of the scale where wages are highest. Also notice the importance of the detailed ACS data in a thorough analysis of the gender gap and major as shown in Figure 2.2(b). Figure 2.2(a), where majors are aggregated into eleven categories for the sake of illustration, suggests that Business & Law is a major category that is approximately balanced in its male-female distribution (although it tilts slightly male). However when it is broken up further in Figure 2.2(b) as the detailed data allows, the Business & Law major actually consists of a wide variety of fields, some of which are female dominated and some of which are male dominated. Lumping them together into a single major loses this interesting variation - interesting because of its implications for wages. As before, the fields are ordered by increasing wages in Figure 2.2(b) and the male dominated ones again lie to the right - Finance, Business Economics, Management Information Systems, etc. More "female" fields lie to the left where wages are lower, i.e. Family and Consumer Sciences, HR and Personnel Management, etc. These fields vary in their main traits from the 'male' Business fields, consistent with studies that indicate women tend to choose fields based on items like level of interaction and other such desirable traits rather than pay and prestige (ie., Zafar 2009, Montmarquette 2002).[5] Aggregating all these majors together in an analysis of the effect of major on wages

[5] Many explanations have been offered as to why women and men enter into different fields during college. These involve both characteristics of the jobs obtained through a given major as well as characteristics of the major itself, and the work it involves. For example, flexibility offered to allow for family life is important primarily to female graduates. This flexibility, or lack of it, is often measured by the size of wage penalties incurred for absence from the labor force (Bronson 2013). In fact previous studies have shown that, when asked, female college entrants rank key characteristics of certain fields differently than their male counterparts. Those which lead to jobs they consider more enjoyable, those that help people, involve interaction with others, and/or family friendly scheduling rank higher than those that bring prestige or increased pay - traits which male respondents tended to rank higher (Zafar 2009, Montmarquette 2002). Beliefs about ability and future spouse's earnings also play a role in female major choice (Wiswall and Zafar 2011), more so than beliefs about future earnings, which are relatively more important to men in these studies.

would completely eliminate the variation by sex present and, in this case, lead to an understatement of the role major plays in explaining the gender wage gap.

2.4 Major and Summary Statistics

2.4.1 Major, Sex, and Pay

Majors included in the sample vary widely in their sex composition. They range from Education, which is 80% female, to the 20% female Engineering major as depicted in Table 2.1. Such variation is the basis for major's role in explaining the gender gap as women and men enter into different majors, which then earn different pay. For the sake of illustration here the 172 majors have been aggregated into eleven main major categories as in Figure 2.1(a) and 2.1(b). The method for aggregation relied primarily on the degree of similarity between fields of study, and the resulting aggregated categories represent some of the most prevalent majors among college graduates. They are inclusive across all ranges of average wages and distributions by sex.

Majors also vary widely in their pay. This results in an interesting relationship between sex composition and wages for these major categories. In Table 2.1, notice that the gender gap for the sample overall is 0.85 but this varies by major. Engineering, a very male dominated field, has more equal pay than the average with a gap of 0.95, while Business, which is fairly balanced, has slightly less equal pay than average with a gap of 0.83. In fact all of the majors in Table 2.1 that consist of a fairly equal proportion of men and women have a lower gender gap than even the average of the sample, which at 0.85 is already significantly lower than 1. The proportion of graduates in each major that then

Table 2.1: Major Summary Statistics

Major	Percent Female	Number of Graduates	Percent with Graduate Degree	Females With Graduate Degree	Median Female Wage	Median Male Wage	Gender Gap
Education	79.1%	23,011	33.0%	34.0%	$36,000	$38,000	0.95
Biology & Medical Sciences	74.0%	27,785	37.3%	35.6%	$43,500	$40,000	1.09
Language	69.2%	9,658	34.0%	36.5%	$33,000	$32,500	1.01
Social Sciences	62.9%	33,048	34.2%	37.5%	$35,000	$40,000	0.88
Liberal Arts & Humanities	56.3%	28,817	23.5%	24.3%	$31,000	$35,000	0.89
Social Services & Trades	55.6%	9,150	20.4%	27.7%	$33,000	$41,400	0.80
Business & Law	50.8%	49,942	17.2%	18.4%	$40,000	$48,000	0.83
Communications	47.8%	22,771	18.7%	19.7%	$38,000	$47,000	0.81
Physical Sciences & Agriculture	47.2%	13,645	31.7%	34.7%	$36,000	$39,000	0.92
Mathematics	44.5%	2,950	41.8%	44.0%	$42,000	$44,000	0.95
Engineering	20.5%	19,151	30.6%	38.1%	$57,000	$60,000	0.95
All Graduates	56.5%	239,928	27.3%	30.0%	$37,500	$44,000	0.85

Note: Majors have been aggregated into 11 main categories, ordered here by decreasing percentage of female graduates. The sample includes 239,928 working college graduates aged 25-30.

go on to attain some level of graduate education also varies by major and by sex. Notice the proportion of females in each major that have a graduate degree – for the sample overall, 30% of female graduates have a graduate degree, higher than the male 24%. However 38% of women in the Social Sciences have a graduate degree while only 18% in Business do, and so on. This variation will be important to consider when observing how much of the gender gap can be explained by major. It is possible that the entire effect of major on the gender gap in wages can be attributed to the fact that some majors are more likely to channel students into a higher paying graduate degree than others if

this lines up with the sex trend, ie. men end up with majors that 'lead to' graduate degrees and therefore higher paying fields. This mechanism will be discussed in further detail after analyzing whether major has a significant impact on the gender wage gap; for now, it is important to note the variation across major and by sex that will be useful in regressions.

Following the literature, this analysis will use a sample of recent college graduates aged 25-30 years old, a total of 239,928 observations. Those below 25 are not included to allow for most of the approximately one-third of the sample who chose to attend graduate school to finish and report wages. Those older than 30 are excluded from the sample for multiple reasons, including minimizing the risk of recall bias in the major field of study variable. Since the major data in this dataset has only been collected since the year 2009, its listing of majors is a relatively contemporary one. It would be easy for someone who graduated twenty or more years ago to have trouble placing what they studied into these classifications, especially with such an extensive list offered, either because it is now called something different/no longer exists, or because of simple human error. Additionally, theory indicates that, since field of study may act as a signal to employers, the importance of education and its facets in determining wage offers fades as employers learn more about the individual and their actual levels of productive capacity, or as training is offered on the job to fill in any knowledge gaps. For people in this age range there is the additional advantage that potential experience will more closely approximate actual experience, a variable not available in the data.

2.4.2 ACS and NCES Major Data

As with Chapter 1, major is a self-reported piece of information and therefore measurement error in the variable is a potential concern. However, comparisons similar

Table 2.2: Comparison of ACS and NCES Data

Major	Percent Female NCES	Percent Female ACS
Computer and information sciences	19.8%	22.3%
Engineering and engineering technology	19.4%	20.5%
Bio/physical science/science tech/math/agriculture	51.2%	53.1%
General Studies and other	65.6%	69.8%
Social sciences	62.7%	62.9%
Humanities	59.4%	58.7%
Health care fields	86.6%	85.0%
Business	49.6%	50.8%
Education	80.6%	79.1%
Other applied	60.7%	60.7%
Total	**57.6%**	**56.5%**

Note: NCES data is derived from the National Center for Education Statistics (NCES) B&B: 09 Baccalaureate and Beyond Longitudinal Study and denotes the proportion of a particular major that is female. A similar number is calculated using the 2009-12 ACS data in aggregated form.

to those conducted in that study (utilizing the National Center for Education Statistics major data) again lend support to the reliability of the data.[6]

Measurement error in the major variable could be a potential issue for identification as major is a main focus of the analysis in this paper. Fortunately, comparison of the ACS data to other currently available data on major fields of study again yields similar distributions of major by sex. The National Center for Education

[6] Comparison of the two data sets yields very similar distributions for recent college graduates as measured by the Duncan Dissimilarity Index. Survey used is the NCES' B&B: 09 Baccalaureate and Beyond.

Statistics (NCES) B&B: 09 Baccalaureate and Beyond Longitudinal Study follows students after they complete their bachelor's degree in order to study their education and work experiences.[7] However the NCES data contains less major categories than the ACS data does. Its main major variable has ten categories, while the detailed version of the variable has forty-five. It is still the closest source for comparison to the ACS data as they are both nationally representative datasets and cover approximately the same cohort of college graduates.

When the ACS data is categorized into roughly the same ten major groups as the NCES, the major distribution by sex is approximately the same across both sources. The Duncan Index for the NCES data is 0.34, while for the ACS data it is 0.35. Tables taken from the NCES site show that the sample of college graduates is 57.6% female, while the ACS data is 56.5% female. Each of the major categories are also very similar in their male-female breakdown, as shown in Table 2.2.

2.4.3 Summary Statistics

In this sample of college graduates, as shown in Table 2.3, 58% are female, 78% are white, and 45% are married. Only 3% of the graduates are divorced, separated, or widowed, while 52% are single/never married. Consistent with a sample this age, the average number of children is low and the work hours are relatively high. Everyone in

[7] Recall from Chapter 1 that the 2009 study interviewed graduates of 2007-08 and is currently following up with these graduates for another interview. It is the third such wave of the study. All studies use a "nationally representative sample of postsecondary students and institutions," according to the NCES website, just like the ACS data.

the sample has at least a bachelors' degree, but 27% of the graduates have obtained some form of education beyond that.

Table 2.3: Summary Statistics

	All	Female	Male
Mean Wage	$44,461 (32,616)	$40,381 (26,780)	$49,754 (38,244)
Percent Female	56.5%	-	-
Percent White	79.4%	79.3%	79.6%
Mean Age	27.60 (1.70)	27.6 (1.70)	27.6 (1.70)
Percent with Graduate Degree	27.3%	29.7%	24.2%
Average Number of Children	0.31 (0.68)	0.34 (0.70)	0.27 (0.65)
Percent Married	43.9%	46.1%	41.1%
Percent Employed Part Time	13.7%	16.0%	10.7%
Average Work Hours per Week	40.87 (10.8)	39.52 (10.5)	42.63 (11.0)
Average Weeks Worked per Year	49.35	49.23	49.53

Note: Sample consists of 239,928 working college graduates aged 25-30. Standard deviation in parentheses, where applicable.

There are differences by sex in the sample, especially in wages, as male graduates earn on average $49,754 while female graduates earn only $40,381. The difference of $9,373 is nearly a fifth of the average male earnings in the sample, consistent with the observed gender gap. More women earn graduate degrees, 29.7% versus 24.2% among men in the sample, and more women are employed part-time, 16.0% versus 10.7% for men. Additionally men work more hours per week, 42.63 on average, although not much more than women at 39.52 on average. Since the sample consists only of recent

graduates aged 25-30, a larger portion of women are married, 46.1%, than men, of whom only 41.1% are married.

2.5 Analysis and Results

2.5.1 Analysis

A Oaxaca decomposition determines the precise role of college major in the ongoing gender gap empirically as follows:

$$\overline{Y_M} - \overline{Y_F} = [\widehat{\beta_M}(\overline{X_M} - \overline{X_F})] + [\overline{X_F}(\widehat{\beta_M} - \widehat{\beta_F})]$$

where the decomposition[8] breaks down the left hand side difference in average pay for men and women into two portions: that which is explainable by observed differences in average characteristics and that which is attributable to differences in returns to these characteristics. The resulting decomposition is best at answering the question: how much of the gender gap in wages can be attributed to different field of study distributions for men versus women? The result achieved will indicate what percent of the 18% difference in pay is attributable to varying major choices by sex.[9]

The dependent variable *Y* is the log of ACS reported annual wages. Reported incomes do show some potential signs of measurement error as there are individuals in the data who reported what appears to be too low of income earned given their number of hours worked and the uniformly applicable federal minimum wage at the time. Therefore

[8] Pioneered by Oaxaca 1973. The same results can be obtained using a fully interactive OLS model, but Oaxaca coefficients are simpler to analyze and interpret.

[9] In the Oaxaca decomposition the *average* difference in pay between men and women is broken up into its explained and unexplained portions. The technical gender gap definition involves the *median* difference in pay between men and women (as in the calculated gaps in Table 2.1). Notice that the gender gap calculated in this way is 0.85, or a 15% difference in pay, while in the Oaxaca the average difference in pay is 18%. For the Oaxaca analysis, the term "gender gap" refers to this average difference.

those reporting annual wages below the legal minimum wage, according to the recorded number of hours and weeks worked, are dropped from the sample.

In the above decomposition X, the vector of independent variables that differ by sex, includes the variable of interest - the major of the college graduate - and several controls. These include demographic controls such as race, comprised of an indicator for minority, age (and age squared), state of residence, and marital status, along with number of children. They also include information about education beyond college, in the form of an indicator for whether the graduate holds any post-baccalaureate degree. Finally there are a set of controls involving information about the work the student participates in - whether they work full time, how many weeks they work during the year, and how many hours worked during each week. Additionally occupation and industry are included. Occupation and industry variables included consist of sixteen grouped industries ranging from agriculture to durable goods to retail trade to public administration. These are further decomposed into over 300 different occupations.

2.5.2 Main Results

In Oaxaca decompositions, which sex is used as the "standard" can change the result achieved. Depending on whether female or male coefficients are used as the standard in this decomposition, major helps to explain 13.6-13.8% of the 18.3% gender gap (see Table 2.4).[10] This influence of major is above and beyond simply the impact of field of study leading to employment in a certain industry or occupation or some level of graduate

[10] For all decompositions here, log wages are used as the outcome variable.

school, captured by the occupation, industry, and graduate school variables in the regression. This points towards the importance of major in determining wage premiums/

Table 2.4: Oaxaca Decomposition Results

	Amount/Percentage of Gender Wage Gap Explained by Differences in a Given Characteristic			
Characteristic	**(1) Male Standard**		**(2) Female Standard**	
Major	0.0248*** (0.0028)	13.6%	0.0252*** (0.0024)	13.8%
Labor Force Attachment	0.0877*** (0.0032)	48.1%	0.0923*** (0.0032)	50.5%
Occupation & Industry	0.0516*** (0.0031)	28.3%	0.0341*** (0.0026)	18.7%
Graduate Degree	-0.0044*** (0.0003)	-2.4%	-0.0053*** (0.0003)	-2.9%
Demographic Controls	-0.0008 (0.0008)	-0.5%	0.0019*** (0.0007)	1.1%
Explained difference	0.1589*** (0.0048)	87.1%	0.1482*** (0.0045)	81.2%
Residual difference	0.0236*** [0.0039]	12.9%	0.0342*** (0.0035)	18.8%
Total gender difference	0.1825*** [0.0044]	100.0%	0.1825*** (0.0044)	100.0%

Note: Robust standard errors in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Demographic controls include race, potential experience (age and age squared), educational attainment, number of children, marital status, and state of residence. Labor force attachment includes average hours per week worked, number of weeks worked per year and an indicator for part time employment. Sample includes 239,928 working college graduates included in the 2009-12 ACS.

penalties relative to other majors and indicates that any analysis of the gender gap without major would be misleading. Notice that, when female coefficients are used as the standard, less of the gap is explainable so that more of it ends up being attributable to

either factors that have not been controlled for or possible discrimination. Whether male or female coefficients are used, major appears as a significant determinant of the gender wage gap for recent college graduates.

2.5.3 The Importance of Major

The extensive ACS data achieves a better understanding of major's explanatory power in wages. Previously available data typically had fewer major groupings or required aggregation of many majors as there were not enough observations in each individual one. In fact, major's impact in explaining the gender gap grows by 35% when you use a detailed major variable as opposed to an aggregated one.[11] Table 2.5 demonstrates what a difference this makes. Column 1 is a decomposition with no major variable included. Column 2 includes a very coarse, aggregated major variable with eleven categories as in Table 2.1. It is meant to approximate aggregated data used in previous studies. Column 3 includes the currently available ACS data with 172 majors. The most notable point here is the 35% jump in major's explanatory power from columns 2 to 3, as it moves from accounting for 10.1% to 13.6% of the gap. The result is that a larger portion of the gender gap becomes explainable as opposed to "residual"[12] difference in pay. Also, any measure of major is better than none at all in explaining the gender gap, as a larger portion of the gap is explained in both columns 2 and 3 than in 1, where major is not

[11] Like aggregated major data utilized in previous studies mentioned in the "College Major and the Gender Gap" section.

[12] In all decompositions in the paper, this portion of the difference in pay is due to different returns to characteristics possessed by the two groups. This is often called discrimination but cannot necessarily be labeled as such without complete assurance that the explained portion contains all possible explanatory variables (both observable and not).

accounted for. Leaving major out of the analysis would therefore leave a much larger portion of the gender gap unexplained.

Table 2.5: Importance of Major Data

Characteristic	Amount/Percentage of Gender Wage Gap Explained by Differences in a Given Characteristic					
	(1) Without Major		**(2) Aggregated Major**		**(3) Detailed Major**	
Major			0.0185*** (0.0015)	10.1%	0.0259*** (0.0023)	13.6%
Labor Force Attachment	0.0885*** (0.0032)	48.5%	0.0881*** (0.0032)	48.2%	0.0962*** (0.0026)	48.1%
Occupation & Industry	0.0634*** (0.0028)	34.7%	0.0510*** (0.0029)	28.0%	0.0519*** (0.0025)	28.3%
Graduate Degree	-0.0046*** (0.0004)	-2.5%	-0.0045*** (0.0003)	-2.4%	-0.0046*** (0.0003)	-2.4%
Demographic Controls	-0.0004 (0.0008)	-0.2%	-0.0005 (0.0008)	-0.3%	0.0005 (0.0006)	-0.5%
Explained difference	0.1469*** (0.0045)	80.5%	0.1526*** (0.0045)	83.6%	0.1699*** (0.0037)	87.1%
Residual difference	0.0356*** (0.0036)	19.5%	0.0299*** (0.0036)	16.4%	0.0231*** (0.0031)	12.9%
Total gender difference	0.1825*** (0.0044)	100.0%	0.1825*** (0.0044)	100.0%	0.1931*** (0.0035)	100.0%

Note: Robust standard errors in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Demographic controls include race, potential experience (age and age squared), educational attainment, number of children, marital status, and state of residence. Labor force attachment includes average hours per week worked, number of weeks worked per year and an indicator for part time employment. Sample includes 239,928 working college graduates included in the 2009-12 ACS.

In this analysis of the relationship between college major and wages it is particularly interesting that a college graduate's major matters for their pay above and

beyond the fact that it channels the graduate into a certain occupation. Notice in Table 2.6 that a graduate's occupation and industry explains 34.7% of the gender gap in wages (see Column 2), but when major is added into the analysis (Column 3) this drops to 28.3% and major contains its own explanatory power, accounting for 13.6% of the gap. So some of the reason why occupation matters for wages is actually due to your field of study and, more importantly, major carries an additional premium or penalty reflected in wages. Rather than major serving solely as a mechanism through which to channel students to the corresponding occupation in the labor force, there is some aspect of field of study that leads to its direct impact on wages for college graduates. The exact component of major that results in its influence over wages for male and female graduates could be any number of relevant characteristics. For example, training received in the major, its level of mathematical content (as in Weinberger 1999), amount of rigor and work ethic employed in the curriculum, etc. Regardless, it is clear that major matters in explaining wages by sex beyond just the occupation a major channels students into, where occupations vary in their relative wages.

Major continues to account for a portion of the gender gap when controlling for whether the student attained a graduate degree as well (see Table 2.6). Just as occupation couldn't take away all of major's explanatory power, neither can the fact that your major influences whether or not you attend graduate school (as in Table 2.1). It is beyond the scope of this study to deduce precisely why major helps to explain the gender gap, but these results do rule out that these two channels through which major explains wages make up the entire story behind major's relevance in the gender gap.

Table 2.6: Importance of Major

Characteristic	Amount/Percentage of Gender Wage Gap Explained by Differences in a Given Characteristic					
	(1) Without Major, Occupation & Industry		**(2) Occupation & Industry**		**(3) Major**	
Major					0.0248*** (0.0028)	13.6%
Labor Force Attachment	0.0987*** (0.0034)	54.1%	0.0885*** (0.0032)	48.5%	0.0877*** (0.0032)	48.1%
Occupation & Industry			0.0634*** (0.0028)	34.7%	0.0516*** (0.0031)	28.3%
Graduate Degree	-0.0053*** (0.0004)	-2.9%	-0.0046*** (0.0004)	-2.5%	-0.0044*** (0.0003)	-2.4%
Demographic Controls	0.0021*** (0.0009)	1.1%	-0.0004 (0.0008)	-0.2%	-0.0008 (0.0008)	-0.5%
Explained difference	0.0955*** (0.0036)	52.3%	0.1469*** (0.0045)	80.5%	0.1589*** (0.0048)	87.1%
Residual difference	0.0870*** (0.0029)	47.7%	0.0356*** (0.0036)	19.5%	0.0236*** (0.0039)	12.9%
Total gender difference	0.1825*** (0.0044)	100.0%	0.1825*** (0.0044)	100.0%	0.1825*** (0.0044)	100.0%

Note: Robust standard errors in parentheses. Significance at the 1% level is depicted by ***, at the 5% by **, and at the 10% by*. Demographic controls include race, potential experience (age and age squared), educational attainment, number of children, marital status, and state of residence. Labor force attachment includes average hours per week worked, number of weeks worked per year and an indicator for part time employment. Sample includes 239,928 working college graduates included in the 2009-12 ACS.

Major is therefore able to explain a significant portion of the gender gap beyond its capacity to channel students into different occupations and levels of graduate education, both mechanisms that result in differing levels of pay for college graduates. It

is theoretically possible that college majors earn different pay only because they offer training for different occupations or because some majors acquire more training than others on average, in the form of more years of schooling/graduate school. However, while these mechanisms definitely influence major's impact on wages, this analysis shows that major itself is still important to analyze on its own as it continues to have a direct impact on the gender wage gap above and beyond these channels.

2.6 Conclusion

Despite a reversal in the college graduation gender gap, persistent inequality in major field of study for men and women contributes to the 18.3% wage gap present in recent college graduates. Using a Oaxaca decomposition of the gender wage gap, this analysis finds that major can explain up to 13.8% of the difference in wages simply due to the divergence in majors male and female graduates complete their degrees in. Through use of detailed ACS data, this explanatory power exceeds that of previously used aggregated major data by thirty-five percent.

Additionally the ACS data helps to detect a pattern of persistent and even increasing inequality in major distributions by sex in recent years as quantified by the Duncan Dissimilarity Index, a trend that aggregated major data misses. It is also more precise in estimating the level of gender inequality present among college graduates and the majors they graduate in as detailed data consistently estimates a higher level of inequality than aggregate data does.

Major contributes to the gender wage gap above and beyond its obvious channeling mechanisms. It helps to explain the wage gap beyond its capacity to channel students into related occupations, for example, where certain occupations pay relatively more than others, and beyond its tendency to result in higher pay through graduate school training, where graduates of certain majors are more likely to hold an advanced degree.

Without incorporating information about college major, male and female college graduates entering into different occupations can account for 34.7% of the gender wage gap. However incorporating information about the majors that men and women graduate in takes away from both the portion of the gender gap that is left unexplained and the portion that is attributable to occupation, decreasing the unexplained portion by 33.8% and the portion attributable to occupation by 18.4%. Meanwhile major accounts for its own portion of the gender wage gap, and in a more significant manner than when incorporating more aggregated measures of field of study. For this reason it continues to be a crucial characteristic to consider when discussing any analysis of the difference in wages between men and women. Furthermore, use of less precise major classifications leads to under-identification of the role that major plays in gender inequality among college graduates.

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Appendix

Table 2.A1: Distribution of College Majors in the Sample

Major	Number of Observations	Percent Female	Proportion of Sample
Early Childhood Education	1,504	96.54%	0.63%
Communication Disorders Sciences and Services	1,239	95.80%	0.52%
Medical Assisting Services	358	93.02%	0.15%
Social Work	1,991	91.11%	0.83%
Nursing	7,349	91.05%	3.06%
Family and Consumer Sciences	2,214	90.79%	0.92%
Elementary Education	7,978	90.61%	3.33%
Nutrition Sciences	515	88.16%	0.21%
Miscellaneous Health Medical Professions	447	88.14%	0.19%
Special Needs Education	1,241	87.67%	0.52%
Art History and Criticism	677	86.56%	0.28%
School Student Counseling	41	85.37%	0.02%
Language and Drama Education	1,189	84.52%	0.50%
Educational Psychology	98	83.67%	0.04%
Human Services and Community Organization	421	82.90%	0.18%
Library Science	35	82.86%	0.01%
Counseling Psychology	198	82.32%	0.08%
Miscellaneous Psychology	326	81.29%	0.14%
Clinical Psychology	106	80.19%	0.04%
Teacher Education: Multiple Levels	631	78.61%	0.26%
Community and Public Health	535	78.13%	0.22%
Health and Medical Administrative Services	607	78.09%	0.25%
Visual and Performing Arts	471	77.92%	0.20%
Psychology	12,947	77.44%	5.40%
General Education	4,558	77.20%	1.90%
General Medical and Health Services	1,004	76.29%	0.42%
Medical Technologies Technicians	630	75.87%	0.26%
Treatment Therapy Professions	1,628	74.75%	0.68%
Interdisciplinary Social Sciences	358	74.58%	0.15%
French, German, Latin and Other Common Foreign Language Studies	1,630	74.36%	0.68%
Oceanography	89	74.16%	0.04%
Advertising and Public Relations	1,770	74.07%	0.74%
Social Psychology	45	73.33%	0.02%
Educational Administration and Supervision	79	72.15%	0.03%
Human Resources and Personnel Management	939	71.88%	0.39%
Interdisciplinary and Multi-Disciplinary Studies (General)	383	71.80%	0.16%

Anthropology and Archeology	1,266	71.41%	0.53%
Animal Sciences	835	71.38%	0.35%
Sociology	4,234	71.37%	1.76%
Area, Ethnic, and Civilization Studies	1,010	71.29%	0.42%
Studio Arts	710	71.13%	0.30%
Linguistics and Comparative Language and Literature	452	69.47%	0.19%
Pharmacology	55	69.09%	0.02%
English Language and Literature	6,729	69.04%	2.80%
Mathematics Teacher Education	582	68.04%	0.24%
Humanities	219	68.04%	0.09%
Art and Music Education	1,400	67.43%	0.58%
Commercial Art and Graphic Design	3,318	67.36%	1.38%
Industrial and Organizational Psychology	97	67.01%	0.04%
Journalism	2,405	66.65%	1.00%
Science and Computer Teacher Education	334	66.47%	0.14%
Liberal Arts	2,930	66.35%	1.22%
Intercultural and International Studies	706	66.29%	0.29%
Pre-Law and Legal Studies	414	65.94%	0.17%
Communications	7,387	65.80%	3.08%
Health and Medical Preparatory Programs	282	65.60%	0.12%
Zoology	331	65.56%	0.14%
Drama and Theater Arts	1,362	64.76%	0.57%
Ecology	372	64.52%	0.16%
Food Science	163	64.42%	0.07%
Fine Arts	2,406	64.38%	1.00%
Neuroscience	295	64.07%	0.12%
Biology	8,441	63.50%	3.52%
International Business	861	62.95%	0.36%
Pharmacy, Pharmaceutical Sciences, and Administration	781	62.61%	0.33%
Composition and Speech	509	62.48%	0.21%
Hospitality Management	1,240	62.34%	0.52%
Botany	66	62.12%	0.03%
Genetics	134	61.94%	0.06%
Physiology	592	61.49%	0.25%
International Relations	896	60.83%	0.37%
General Social Sciences	523	59.66%	0.22%
Marketing and Marketing Research	7,112	59.55%	2.96%
Miscellaneous Agriculture	73	58.90%	0.03%
Nuclear, Industrial Radiology, and Biological Technologies	90	58.89%	0.04%
Microbiology	557	58.53%	0.23%
Miscellaneous Education	542	57.93%	0.23%
Secondary Teacher Education	844	57.46%	0.35%

Multi-disciplinary or General Science	1,869	56.88%	0.78%
Cognitive Science and Biopsychology	141	56.74%	0.06%
Other Foreign Languages	338	55.92%	0.14%
Accounting	7,128	55.67%	2.97%
Molecular Biology	568	54.40%	0.24%
Miscellaneous Social Services	132	53.79%	0.06%
Public Administration	246	53.25%	0.10%
Public Policy	220	52.27%	0.09%
Geosciences	81	51.85%	0.03%
Environmental Science	916	51.75%	0.38%
Mass Media	1,870	51.23%	0.78%
Miscellaneous Biology	377	51.19%	0.16%
Biochemical Sciences	1,194	51.17%	0.50%
Chemistry	2,183	50.48%	0.91%
Physical Fitness, Parks, Recreation, and Leisure	3,749	49.80%	1.56%
Criminology	637	49.14%	0.27%
Political Science and Government	6,275	48.27%	2.62%
Music	1,868	47.75%	0.78%
Business Management and Administration	13,831	47.63%	5.76%
Geology and Earth Science	465	47.53%	0.19%
United States History	95	47.37%	0.04%
Criminal Justice and Fire Protection	5,279	47.30%	2.20%
Social Science or History Teacher Education	851	47.00%	0.35%
Actuarial Science	88	46.59%	0.04%
Astronomy and Astrophysics	69	46.38%	0.03%
Physical and Health Education Teaching	1,237	45.76%	0.52%
Mathematics	2,580	45.00%	1.08%
Film, Video and Photographic Arts	1,064	44.83%	0.44%
Cosmetology Services and Culinary Arts	269	44.61%	0.11%
Statistics and Decision Science	184	44.57%	0.08%
Miscellaneous Business and Medical Administration	682	43.99%	0.28%
Business Economics	531	43.69%	0.22%
Biomedical Engineering	392	42.60%	0.16%
General Business	6,920	42.54%	2.88%
Environmental Engineering	135	42.22%	0.06%
Architecture	1,767	42.16%	0.74%
History	4,961	42.09%	2.07%
Court Reporting	39	41.03%	0.02%
Natural Resources Management	513	40.74%	0.21%
Geography	709	40.34%	0.30%
Agricultural Economics	120	39.17%	0.05%
Atmospheric Sciences and Meteorology	140	38.57%	0.06%
Chemical Engineering	1,136	38.03%	0.47%

Applied Mathematics	186	37.63%	0.08%
Physical Sciences	43	37.21%	0.02%
Biological Engineering	261	37.16%	0.11%
Communication Technologies	532	37.03%	0.22%
Philosophy and Religious Studies	1,895	36.68%	0.79%
General Agriculture	439	35.54%	0.18%
Finance	6,393	35.26%	2.66%
Economics	4,559	35.07%	1.90%
Soil Science	23	34.78%	0.01%
Operations, Logistics and E-Commerce	415	33.98%	0.17%
Industrial and Manufacturing Engineering	790	33.92%	0.33%
Mathematics and Computer Science	30	33.33%	0.01%
Management Information Systems and Statistics	1,135	33.04%	0.47%
Agriculture Production and Management	580	32.76%	0.24%
Plant Science and Agronomy	381	32.02%	0.16%
Materials Engineering and Materials Science	249	29.72%	0.10%
Theology and Religious Vocations	1,253	29.29%	0.52%
Geological and Geophysical Engineering	22	27.27%	0.01%
Computer Networking and Telecommunications	431	27.15%	0.18%
Engineering Mechanics, Physics, and Science	116	26.72%	0.05%
Computer and Information Systems	1,862	26.48%	0.78%
Architectural Engineering	122	25.41%	0.05%
Computer Information Management and Security	325	24.31%	0.14%
Information Sciences	609	23.97%	0.25%
Petroleum Engineering	63	23.81%	0.03%
Computer Programming and Data Processing	142	23.24%	0.06%
Physics	1,100	23.09%	0.46%
Engineering and Industrial Management	109	22.94%	0.05%
Civil Engineering	1,996	21.84%	0.83%
Miscellaneous Engineering	386	21.24%	0.16%
General Engineering	1,590	21.19%	0.66%
Mining and Mineral Engineering	34	20.59%	0.01%
Electrical Engineering Technology	399	20.30%	0.17%
Miscellaneous Engineering Technologies	385	20.26%	0.16%
Computer Science	5,438	20.15%	2.27%
Metallurgical Engineering	36	19.44%	0.02%
Nuclear Engineering	72	19.44%	0.03%
Electrical Engineering	3,537	17.78%	1.47%
Computer Engineering	1,984	17.39%	0.83%
Forestry	202	17.33%	0.08%
Aerospace Engineering	519	16.96%	0.22%
Electrical and Mechanic Repairs and Technologies	65	16.92%	0.03%
Engineering Technologies	179	16.76%	0.07%

Industrial Production Technologies	247	15.79%	0.10%
Mechanical Engineering	3,566	13.40%	1.49%
Transportation Sciences and Technologies	673	13.08%	0.28%
Naval Architecture and Marine Engineering	61	11.48%	0.03%
Military Technologies	10	10.00%	0.00%
Construction Services	651	8.29%	0.27%
Mechanical Engineering Related Technologies	190	5.26%	0.08%
Precision Production and Industrial Arts	8	0.00%	0.00%
All Majors	**239,928**	**56.47%**	**100.00%**

Table 2.A2: Aggregation of Major Data

Major Category	Proportion of Sample	ACS Aggregate Majors Included	ACS Detailed Majors Included
Education	9.6%	Education Administration and Teaching	General Education Educational Administration and Supervision School Student Counseling Elementary Education Mathematics Teacher Education Physical and Health Education Teaching Early Childhood Education Science and Computer Teacher Education Secondary Teacher Education Special Needs Education Social Science of History Teacher Education Teacher Education: Multiple Levels Language and Drama Education Art and Music Education Miscellaneous Education
Biology & Medical Sciences	11.6%	Biology and Life Sciences Medical and Health Sciences and Services	Biology Biochemical Sciences Botany Molecular Biology Ecology Genetics Microbiology Pharmacology Physiology Zoology Miscellaneous Biology Neuroscience General Medical and Health Services Communications Disorders Sciences and Services Health and Medical Administrative Services Medical Assisting Services Medical Technologies Technicians Health and Medical Preparatory Programs Nursing Pharmacy, Pharmaceutical Sciences, and Administration Treatment Therapy Professions Community and Public Health Miscellaneous Health Medical Professions
Language	4.0%	Linguistics and Foreign Languages English Language, Literature, and Composition	Linguistics and Comparative Language and Literature French, German, Latin and Other Common Foreign Language Other Foreign Languages English Language and Literature Composition and Speech
Social Sciences	13.8%	Psychology Social Sciences	Psychology Educational Psychology Clinical Psychology Counseling Psychology Industrial and Organizational Psychology Social Psychology Miscellaneous Psychology General Social Sciences Economics Anthropology and Archeology Criminology Geography International Relations Political Science and Government Sociology

			Miscellaneous Social Sciences
Liberal Arts & Humanities	12.0%	Liberal Arts and Humanities Library Science Interdisciplinary and Multi-Disciplinary Studies (General) Philosophy and Religious Studies History Theology and Religious Vocations Fine Arts Area, Ethnic, and Civilization Studies Architecture	Architecture Area, Ethnic, and Civilization Studies Liberal Arts Humanities Library Science Interdisciplinary and Multi-Disciplinary Studies (General) Intercultural and International Studies Nutrition Sciences Neuroscience Mathematics and Computer Science Cognitive Science and Biopsychology Interdisciplinary Social Sciences Multi-disciplinary or General Science Philosophy and Religious Studies Theology and Religious Vocations Fine Arts Drama and Theater Arts Music Visual and Performing Arts Commercial Art and Graphic Design Film, Video and Photographic Arts Art History and Criticism Studio Arts History United States History
Social Services & Trades	3.8%	Criminal Justice and Fire Protection Public Affairs, Policy, and Social Work Construction Services Electrical and Mechanic Repairs and Technologies Precision Production and Industrial Art Cosmetology Services and Culinary Arts	Cosmetology Services and Culinary Arts Criminal Justice and Fire Protection Public Administration Public Policy Human Services and Community Organization Social Work Construction Services Electrical and Mechanic Repairs and Technologies Precision Production and Industrial Arts
Business & Law	20.8%	Family and Consumer Sciences Business Law	Family and Consumer Sciences Court Reporting Pre-Law and Legal Studies General Business Accounting Actuarial Science Business Management and Administration Operations, Logistics and E-Commerce Business Economics Marketing and Marketing Research Finance Human Resources and Personnel Management International Business Hospitality Management Management Information Systems and Statistics Miscellaneous Business and Medical Administration
Communications	9.5%	Communications Communication Technologies Computer and Information Sciences	Communications Journalism Mass Media Advertising and Public Relations Communication Technologies Computer and Information Systems Computer Programming and Data Processing Computer Science Information Sciences Computer Information Management and Security Computer Networking and Telecommunications

Physical Sciences & Agriculture	5.7%	Agriculture Environment and Natural Resources Physical Sciences Nuclear, Industrial Radiology, and Biological Technologies Physical Fitness, Parks, Recreation, and Leisure	General Agriculture Agriculture Production and Management Agriculture Economics Animal Sciences Food Science Plant Science and Agronomy Soil Science Miscellaneous Agriculture Environmental Science Forestry Natural Resources Management Physical Fitness, Parks, Recreation, and Leisure Materials Engineering and Materials Science Multi-disciplinary or General Science Physical Sciences Astronomy and Astrophysics Atmospheric Sciences and Meteorology Chemistry Geology and Earth Science Geosciences Oceanography Physics Nuclear, Industrial Radiology, and Biological Technologies
Mathematics	1.2%	Mathematics and Statistics	Mathematics Applied Mathematics Statistics and Decision Science
Engineering	8.0%	Engineering Engineering Technologies Military Technologies Transportation Sciences and Technologies	General Engineering Aerospace Engineering Biological Engineering Architectural Engineering Biomedical Engineering Chemical Engineering Civil Engineering Computer Engineering Electrical Engineering Engineering Mechanics, Physics, and Science Environmental Engineering Geological and Geophysical Engineering Industrial and Manufacturing Engineering Materials Engineering and Materials Science Mechanical Engineering Metallurgical Engineering Mining and Mineral Engineering Naval Architecture and Marine Engineering Nuclear Engineering Petroleum Engineering Miscellaneous Engineering Engineering Technologies Engineering and Industrial Management Electrical Engineering Technology Industrial Production Technologies Mechanical Engineering Related Technologies Miscellaneous Engineering Technologies Military Technologies Transportation Sciences and Technologies

Chapter 3

Sex Composition of the Skilled Labor Market and Part-Time Employment*

Abstract

As college majors shift in their sex composition, the average preferences of their graduates evaluating job prospects upon graduation, and of firms analyzing their profits upon hiring, may change. This paper explores the impact of the sex composition of potential labor markets on the types of work employed in the college educated labor market. Using data from the American Community Survey (ACS), it will evaluate how the market responds to more female entrants as the share of a major that is female increases from 1980-2008.

The empirical evidence indicates that, although women continue to be more likely to work part-time than men, a ten percent increase in female graduates in a field results in a 7% *decrease* in the likelihood that a woman works part-time, and an 8.2% *increase* in the likelihood that a male graduate does. These results are robust to changing the time period studied and to different specifications of part-time work. Additionally women demonstrate increased levels of labor force attachment in the form of more full-time and even overtime work, with increases in their likelihood of 9.6% and 1.4%, respectively.

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3.1 Introduction

A steadily increasing number of college graduates are female, enough that today women are a majority of degree holders. This change in the sex composition of the skilled labor force translates to a change in average preferences for college-educated workers in the characteristics of jobs they prefer. In general women seek different uses of their diploma than their male counterparts, as they prefer fields of study that lead to work that is more flexible, among other things.

While completing their degrees college graduates have chosen a major; however, on average we observe men and women making different decisions regarding their field of study as they seek characteristics of a major and resulting employment that they consider important. For example, flexibility offered to allow for family life tends to be important primarily to female graduates. This flexibility, or lack of it, is often measured by the size of wage penalties incurred for absence from the labor force (Bronson 2013).

In fact previous studies have shown that, when asked, female college entrants rank key characteristics of certain fields differently than their male counterparts. Those which lead to jobs they consider more enjoyable, those that help people, involve interaction with others, and/or family friendly scheduling rank higher than those that bring prestige or increased pay - traits which male respondents tended to rank higher (Zafar 2009, Montmarquette 2002).

Crucially, as students express different preferences for favorable job traits versus wages, they then directly relate these to their choice of major while in college. Students

also tend to work in jobs consistent with the characteristics they stated as important in their preferences (Wiswall and Zafar 2016). There exists, therefore, a definitive relationship between students' job related preferences, their major decisions, and the jobs they work at upon graduating.

Over time there are a number of majors that have experienced changes in their sex composition. Majors in the sciences, for example Biology, Physical Sciences, and Chemistry, have experienced a significant increase in the number of female graduates (at least a ten percent increase over the past few decades), as have majors in Business, i.e. Accounting and Human Resources.

As more women enter into these fields, their preferences regarding work alter the profile of workers available to the relevant labor market. This paper will examine whether firms and employees within that labor market respond to these changing pools of potential workers by altering the availability of and desire for flexible work characteristics such as part time employment. For employers, these changes would be based on an evaluation of their profitability under situations with different levels of part time employment versus a less flexible work environment. For workers, the college graduates within the relevant labor market, this would be based on their preferences regarding labor force attachment as the sex composition of the workforce changes.

Together these demand and supply sides of the labor market interact to respond to the changes in female representation in the market. Theoretically it is unclear whether the result of these two movements is an increase or decrease in part-time work in the

market. The answer becomes an interesting empirical insight. This paper will use American Community Survey (ACS) data to determine the impact of an increasingly female labor force on the amount of part-time work in the labor market. The results indicate that a ten percent increase in the proportion of female graduates in a field results in a seven percent *decrease* in the likelihood that women work part-time, and a 8.2% *increase* in the likelihood for men.

3.2 Theoretical Framework

Firms maximize profitability when making hiring decisions. To do so they seek to minimize costs by offering the lowest wages possible. However workers in the skilled labor force will be unwilling to accept lower pay for a job they consider to have more undesirable characteristics than their next best option. In fact potential employees face a tradeoff between the amenities a job has to offer, such as flexible work hours, and its wages. Firms profits will increase as wages (*w)* and amenities (*a)* decrease:

$$\pi_{mc} = \pi_{m}(w_c, a_c)$$

where the profits π of a firm offering jobs to graduates of a certain major *m* in a cohort *c* depends on the wages and amenities provided. If offering amenities to employees has a cost, then profits will increase as firms are able to maintain the same level of amenities and pay lower wages, or decrease as they offer more amenities at the same wage rate. However firms will be indifferent between costs in the form of wages or amenities and will trade them off accordingly.

Workers seek to maximize their utility by choosing a major they believe will lead to jobs with their desired characteristics. They will require a compensating wage differential in their pay in order to take on fields with traits they consider undesirable.[1] For the typical female graduate, for example, a compensating wage differential may be required when a job involves overtime hours or plentiful travel. Accordingly potential labor market entrants maximize their utility:

$$U_{mc} = U_m(w_c, a_c)$$

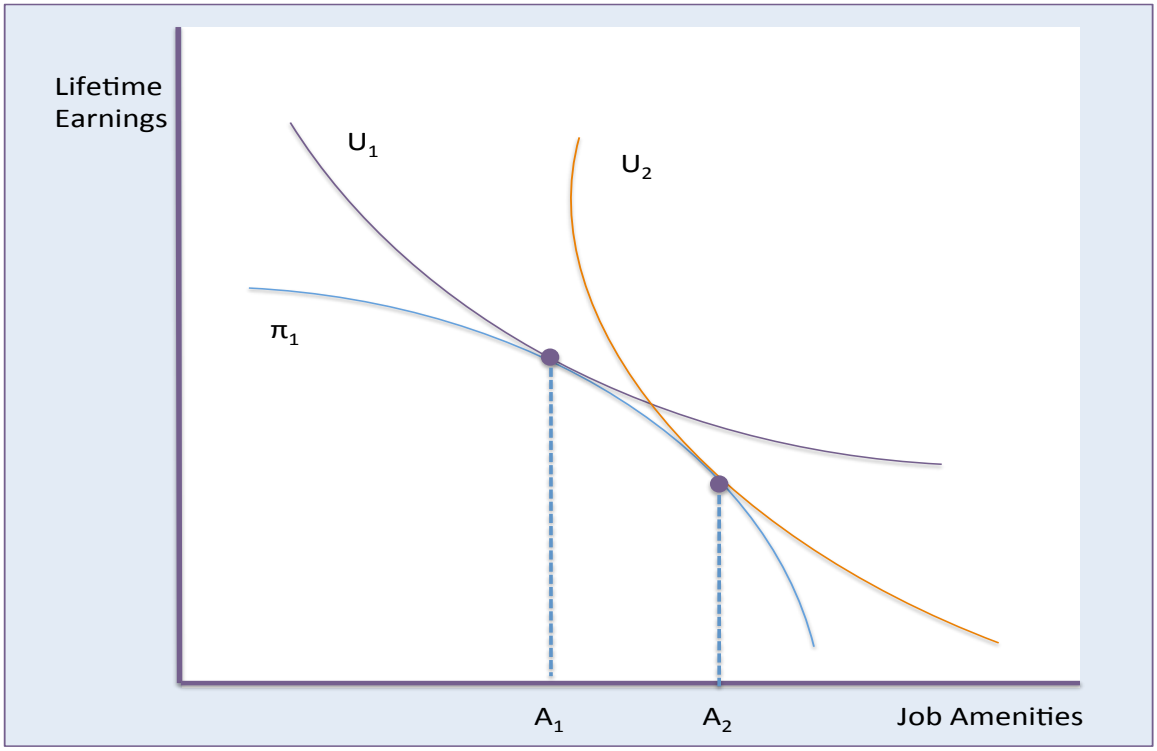
where students in major *m* and cohort *c* experience utility increases as wages and amenities rise. In this case students are willing to accept less amenities only in exchange for higher wages and similarly will be willing to take lower wages from firms in exchange for a more pleasant job.

The result will be that students within a given major will match with a firm offering the best wage-amenity combination suitable to their preferences. In Figure 3.1(a) the indifference curve U_1 represents an example of preferences typical of a given major and cohort. Notice that along the curve, students in that group will be willing to take various bundles of either relatively higher wage and lower amenities or relatively lower wage and higher amenities, or somewhere in between.

Now consider what happens as the graduating students in that same major become more female, as in a more recent cohort of Accounting graduates (for example).

[1]Recall that these may vary by gender, with male graduates placing more importance on characteristics such as prestige, and female graduates emphasizing traits such as flexible work hours and interaction with others.

Figure 3.1(a): Supply Side Response to Increased Female Labor Market Presence



Assuming female graduates have a stronger preference for amenities such as flexible work hours than for wages, the marginal rate of substitution between job amenities and wages changes:

$$\text{MRS}_{aw} = \frac{dw}{da} = \frac{MU_a}{MU_w}$$

as the new cohort on average requires a higher price to give up desired job amenities and so the MRS rises. The more recent graduates are less willing to trade off amenities for wages. In that case the average preferences for the newer cohort in that major will strongly favor amenities rather than wages, and the result will be matches made at lower wage levels and higher levels of amenities such as job flexibility. This result is illustrated in the indifference curve U_2 in Figure 3.1(a). Notice the tilt in the indifference curve as

newer cohorts preferences change, resulting in different wage-amenity matches as the labor market moves from A_1 to A_2. Similar illustrations can be made for all majors as their sex composition changes.

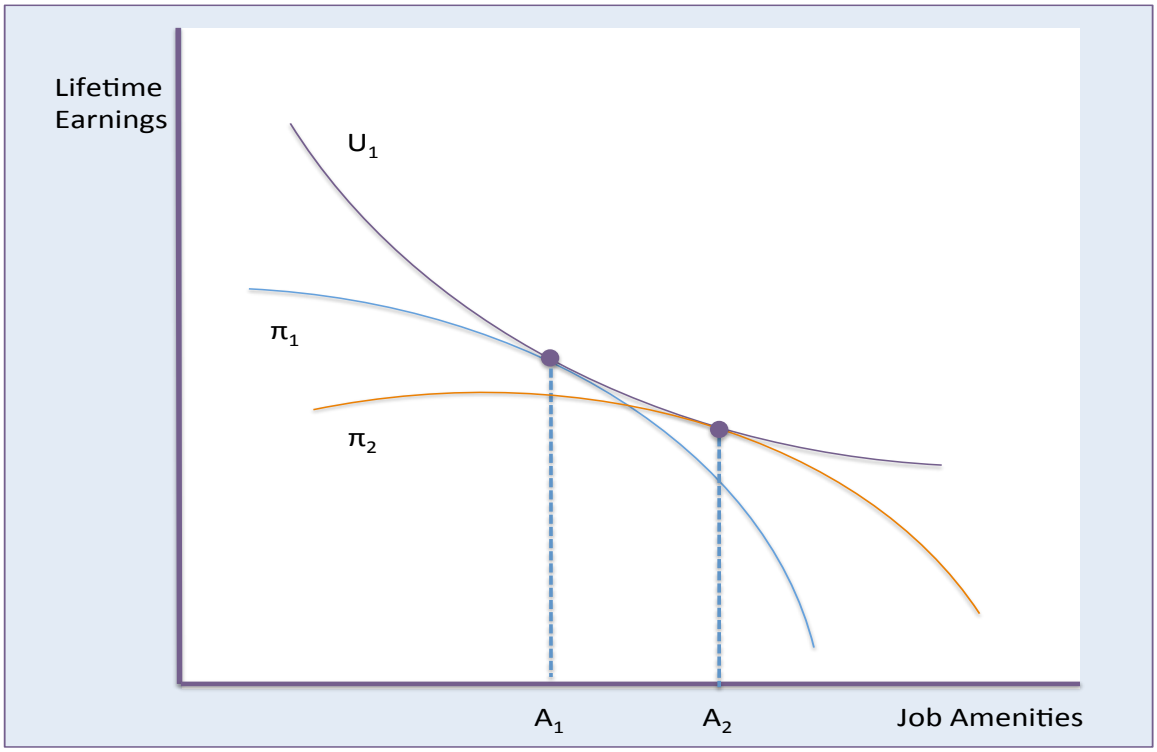
Alternatively, the market could start at indifference curve U_2 and experience an increase in female entrants. As more and more women enter the market this may encourage increased female labor market participation, as in a network effect. In that case preferences of the participants in the labor market shift toward an inclination for wages, rather than amenities such as flexible work. This effectively decreases the MRS and moves the market to preferences represented by indifference curve U_1. This time the equilibrium amount of job amenities decreases from A_2 to A_1. Which of these movements occurs among college graduates on the supply side of the labor market depends on average preferences, making the actual result theoretically ambiguous.

On the other side of the market, firms that comprise the demand for labor choose what wage-amenity combinations to offer employees using their isoprofit curve. In the case that there is some change in the field, such as a technology shock that makes the relative price of amenities (p_a) lower/relative wages higher, the equilibrium may change. As the price ratio, p_a/w, or the slope of the isoprofit curve, decreases, firms in the labor market shift from π_1 to π_2. Notice the rotation in the curve as firms shift toward offering amenities rather than wages (see Figure 3.1(b)). The end result is that matches will be made at lower wage levels and higher offerings of amenities such as job flexibility.

Again there is an alternative scenario where the labor market becomes increasingly more female and firms move to utilize women's labor in the most profitable

way possible. In this case firms start at the isoprofit curve π_2 but as wages drop relative to the price of amenities, perhaps due to the existence of a gender wage gap, the price

Figure 3.1(b): Demand Side Response to Increased Female Labor Market Presence



ratio increases and firms shift from π_2 to π_1. This results in a decline of amenities offered, from A_2 to A_1. Just as on the supply side, whether the market moves from A_1 to A_2 or from A_2 to A_1 is theoretically ambiguous and leaves room for an interesting empirical analysis as together any movement by employees (the supply side) and employers (the demand side) make up the total effect of sex composition on part-time employment.

3.3 Job Amenities: Part-Time Employment

To determine the impact of changing sex composition by major on the characteristics of jobs in the labor market, this analysis utilizes data from the U.S. Census American Community Survey (ACS) for the years 2009-13. The Census is a large, representative dataset containing information on major field of study for those individuals who have completed a college degree.[2] Major is provided as a very detailed, 172 classification variable, with majors ranging from Petroleum Engineering to Economics to Social Work, and everything in between. See the Appendix for a detailed breakdown of the major variable used in this analysis.

Assuming that students choose their majors partially based on the future job characteristics they desire,[3] graduates of a certain major and cohort make up the labor market pool for employers in that field to choose from. Changes to the demographics of these potential employees, and therefore changes to average worker preferences, may then require firms to reevaluate what they have to offer in order to take full advantage of the labor available to them. The ACS provides information on the hours worked by graduates over time. This information will be utilized to characterize one of the most important job amenities that men and women rank differently: the availability of flexible/part-time work.

Over time part time work among college graduates has become less common as the college premium rises. There was a well-documented rise in the returns to a college

[2] Majors are not provided in the data for students who didn't complete a degree.
[3] Recall Wiswall and Zafar (2016) that established a direct relationship between students' job preferences, the majors they choose, and the jobs they work at upon graduating.

education relative to high school in the 1980s, the beginning of the time period studied in this analysis,[4] that has been attributed in large part to some combination of student ability and skills along with relatively high demand for skilled work (Taber 2001, Heckman and Vytlacil 2001, Grogger and Eide 1995).[5] This came about despite the fact that real wage rates were relatively stagnant during this period. In the 1990s the premium continued to rise. Its growth slowed in the later part of that decade, but the premium continues to exist at historically high levels (Goldin and Katz 2007, Autor et al 2005, Card and DiNardo 2002) – making the opportunity cost of working part-time relatively high for a college graduate.

In fact in the ACS data, of those who graduated college in the first half of the 1980s,[6] 22.33% currently work part time, whereas for those who graduated in the early 2000s this fell to 20.23% - an approximate decrease of nine percent. However majors that became more female during this time period, while still experiencing the overall decline in part-time work, showed less of a decline. Notice in Table 3.1 that for majors with growth in their female graduates above the median 6.57 percentage point increase during this time period,[7] the proportion of graduates working part time decreased by 1.27 percentage points, whereas majors with below median changes in their share of female graduates experienced larger drops in their part time workers, 2.92 percentage points.

[4] The time period is chosen due to the existence of thorough data. Prior to 1980 many majors lack sufficient observations to break down by gender and still have significant identifying variation. Robustness checks will show that the results are similar using different time periods.
[5] See also Bound and Johnson 1992, Katz and Murphy 1992, Murphy and Welch 1992, 1989.
[6] Those who graduated from 1980-84 – for the early 2000s, 2000-04.
[7] The median increase is quoted for those majors that demonstrated an increase in their female graduates from 1980-2004.

Majors that became more male experienced a similar decrease in part time employment of 2.57 percentage points.

Table 3.1: Female Graduates and Part-Time Employment

Majors with:	**Percent Female: 1980 Cohort**	**Average Change in Proportion Female**	**Percent Part-Time: 1980 Cohort**	**Average Change in Part-Time Employment**
Above Median Increase in Female Graduates	42.59%	10.58 p.p.	19.95%	-1.36 p.p.
Below Median Increase in Female Graduates	49.44%	3.24 p.p.	22.29%	-3.07 p.p.
Increase in Male Graduates	72.11%	-4.24 p.p.	26.57%	-2.81 p.p.

Note: Data is taken from the 2009-13 ACS. Majors are broken down into those above the median increase of 6.57 percentage points (p.p.) in the proportion of female graduates, below that median increase, and majors with a decrease in female graduates.

Since the overall trend has been a decrease in part-time employment, the relatively smaller decreases for majors with increases in female graduates indicate possible concessions by firms responding to the changing preferences of their labor market candidates. This is certainly true as female graduates consistently rank flexible work as a relevant factor in choosing their major, and therefore their field of work, much more so than male graduates. While this relationship between labor force attachment and sex composition of graduates is not yet sufficient basis to imply causation, it points toward some correlation between an increasingly female labor force and the amount of part time work in a field.

3.4 Data and Summary Statistics

3.4.1 Data

The Census now collects data on majors for college graduates in its American Community Survey (ACS). Past iterations of this survey contained information only on educational attainment. As of 2009 the ACS now also collects information on field of study for those who report completion of a college degree. Those who progressed toward a degree but did not complete it do not report a major in the data. Therefore all individuals in the sample for this survey will have attained at least a bachelor's degree.

The ACS major data is very detailed, with 172 major classifications total (see Appendix for detailed breakdown). This analysis will utilize survey years 2009-13 and will include a sample of graduates who completed their degrees between 1980-2008. The data is very thorough during this time period, with each graduating cohort having a significant number of observations by major and sex.[8]

While the ACS collects information on completion of a degree and the relevant major, it does not record the exact date of completion of that degree. Therefore this analysis creates graduating cohorts in the sample using the best approximation of a 'typical' college graduate's path, with graduation at age 22. This means that each year in the sample forms a graduating cohort using those who reported completing a bachelor's at some point in the 2009-13 surveys and were 22 years old that cohort year.

[8] Prior to 1980 these start to be less representative, as the detailed nature of the major classifications in the survey result in some majors that didn't exist a few decades ago, or if they did, didn't have a significant number of graduates of a certain sex.

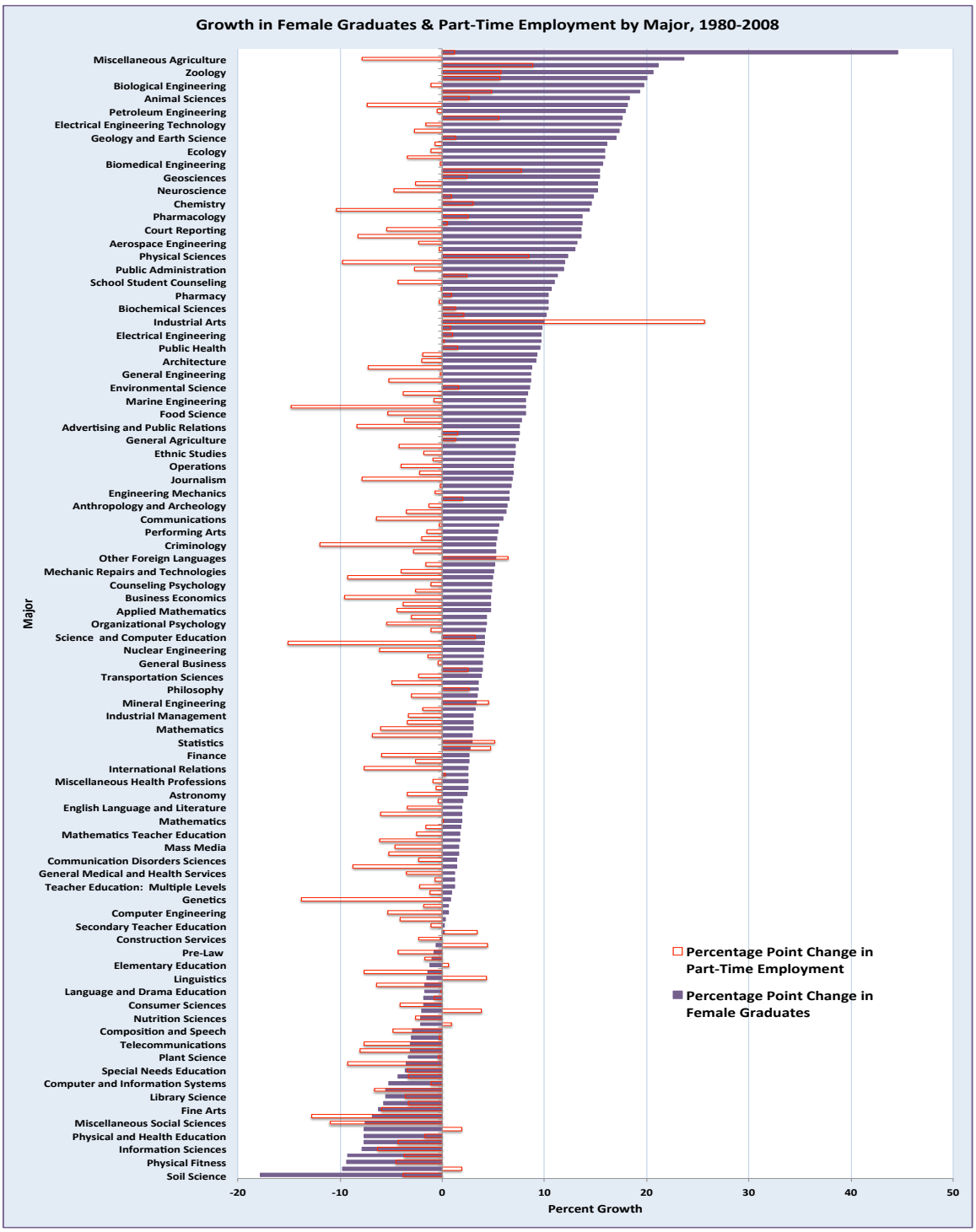
Additionally, since major data is only available as of 2009, information on cohort labor force attachment is derived from that point onward. For example, a graduate who was 22 in 1985 will report in the 2009 survey that they have graduated and will also report information on their work hours *currently*, at approximately age 46. All such information is pooled for the 2009-13 surveys, and then used to create a profile of labor force attachment across the span of a career for a graduate in a given field. The analysis will include graduates up until 2008, to allow for various forms of cohort formation. The details of these cohorts will be discussed in the section on analysis. To align with that analysis the statistics presented here will include graduates up until 2008, although the conclusions and trends are not altered significantly by changing this time frame slightly.[9]

3.4.2 Sex Composition and Part-Time Employment by Major Across Cohorts

There have been significant changes in the sex composition for certain majors over time. Majors such as Business Administration, for example, are 2.61 percentage points more female in the 2000-04 graduating cohort than in the 1980-84 cohort (see Figure 3.2). For illustration here, cohorts are grouped into five-year bins to avoid any potential anomalies or outliers associated with a certain graduating year. Economics is 3.01 p.p. more female, Accounting 9.22 p.p., Human Resources and Personnel Management 14.79 p.p., and Applied Mathematics 4.72 p.p. In the sciences, Biology became 13.71 percentage points more female, Neuroscience 15.21 p.p., Physical Sciences 12.30 p.p., Microbiology 6.74 p.p., Chemistry 14.61 p.p., and Geology 17.00 p.p. Fields in Engineering have also experienced significant increases in the proportion of female graduates, with General

[9] Robustness check to come, analyzing alternate cohort formations.

Figure 3.2



Note: Data is taken from the 2009-13 ACS. The 172 majors in the survey are ordered by decreasing change in proportion of female graduates over time. Only every other major is labeled here for the sake of illustration. For the detailed list of majors ranked by change in percent female see Appendix.

Engineering seeing an 8.66 percentage point increase, Aerospace Engineering at 13.13 p.p., Mechanical Engineering at 4.26 p.p., and Environmental Engineering with an increase over this time period of 17.62 p.p.[10] The largest increase in the proportion of female graduates was in Oceanography, with a 44.54 percentage point rise.

On the other hand some majors have changed very little, or have become more male. For example History is now only 0.34 percentage points more female, and Early Childhood Education continues to stay consistently female with a decrease in female graduates of only 0.97 p.p. Fine Arts became 6.25 p.p. less female over the time period studied, Computer Science 7.65 p.p., and Soil Science demonstrated the largest decrease in proportion female for the sample at 17.76 percentage points.

At the same time part time employment became less common for more recent cohorts. In fact the median change in the proportion of graduates employed part-time across all majors was a decrease of 1.96 percentage points, or approximately nine percent. For many of the majors that became significantly more female, however, the decline in part-time employment was smaller as firms responded to the changing preferences of their potential labor force.

For example, Mechanical Engineering saw only a 1.12 percentage point decline in part-time employment, and Microbiology a 0.20 p.p. decline. Other majors that experienced increases in the proportion of female graduates actually demonstrated an increase in the proportion of graduates employed part-time despite the overall decrease in

[10] All changes quoted in percentage point terms. If a major was 10% female in the 1980-84 cohort, and 15% female in the 2000-04 cohort, this would be a 5% increase.

part-time work during this time period. For example, Environmental Engineering increased its proportion of female graduates significantly and also increased its proportion of part-time work by 5.57 percentage points. Many of the sciences that saw increases in female graduates also increased the amount of part-time work: Chemistry by 2.98 p.p., Geology by 1.33 p.p., Physics by 1.97 p.p., and Physical Sciences by 8.46 p.p.

Other majors whose proportion of female graduates increased over time experienced significant decreases in part-time employment. Among these is Business Administration, which experienced an increase in its female graduates yet saw part-time employment decline more than the median decrease, at 2.57 percentage points. Part-time employment in Accounting declined by 1.96 p.p. The largest decrease came in Art History, a major with a 4.08 percentage point increase in female graduates, but a 15.11 p.p. decline in part-time work. On the other hand, the largest increase in part-time employment, a 25.64 percentage point increase, occurred in Industrial Arts – a major with a ten percentage point increase in female graduates. The potentially opposing correlations in the proportion of college graduates employed part-time by major call for an interesting causal analysis to determine the impact of an increasingly female labor force on the type of work offered.

3.4.3 Summary Statistics

This sample of college graduates is composed of 1,703,664 college graduates who were 22 years old from 1980-2008. The average age is 40, with the older cohort on average currently 51 years old and the younger cohort 31. Again, as in Figure 3.2, cohorts have

been grouped into five-year bins for the sake of comparison. The majority of the sample is white and married. On average 36% have a degree beyond their bachelor's.

Table 3.2: Summary Statistics

	All	**1980-84 Cohort Group**	**2000-04 Cohort Group**
Age	40.36 (7.78)	50.99 (2.00)	31.04 (1.99)
White	79.60% (40.30%)	83.66% (36.97%)	77.35 (41.86%)
Married	70.59% (45.57%)	73.70% (44.03%)	61.94% (48.55%)
Graduate Education	36.40% (48.11%)	37.26% (48.35%)	34.67% (47.59 %)
Current Wage	$62,903.71 ($70,356.22)	$72,008.15 ($81,939.88)	$48,551.56 ($46,172.28)
Female	54.54% (20.93%)	52.46% (22.41%)	56.79% (20.04%)
Median Change in Proportion Female		3.64 p.p.	
Part-Time or Not Working	22.24% (7.13%)	22.55% (6.81%)	20.68% (6.38%)
Median Change in Proportion Part-Time		-2.36 p.p.	
Observations	1,703,664	329,016	309,673

Note: Data is taken from the 2009-13 ACS. Sample includes college graduates aged 22 from 1980-2008. Standard deviation in parentheses, where applicable. Part-time means work of less than thirty-five hours per week.

Graduates in the sample report current average earnings of $62,904. The younger 2000-04 cohort earns on average less than this, $48,552, as they are closer to the start of their careers, and the older 1980-84 cohort earns more on average, $72,008. Wages here are the current earnings of the graduates as reported in the 2009-13 ACS. Approximately

half of the graduates are female and twenty-two percent work part-time or are not working (less than thirty-five hours per week). When the proportion of female graduates is calculated by major for each cohort, the median change in the percent of female graduates is 3.64 percentage points. When the proportion of part-time work is calculated by major for each cohort, the median change over time is a decline of 2.36 p.p.

3.5 Analysis and Results

3.5.1 Empirical Analysis

To determine the extent of labor market response to increased female presence in a field, the estimating equation is as follows:

$$part\text{-}time_{imc} = \beta_1 female_{imc} + \beta_2 female\ share_{mc} + \beta_3 female*female\ share_{imc} + X_{imc} + \alpha_m + \gamma_c + \varepsilon_{imc}$$

where the likelihood that an individual college graduate i from major m and cohort c works part-time is determined by their sex, the percentage of graduates in their labor market who are female, a set of controls X, and the usual error. Controls used in this analysis include state of residence, and race as characterized by an indicator for minorities. Additionally major and cohort fixed effects are included to capture any part of the fluctuation in job amenities that is attributable to a particular nuance of a given major or cohort rather than to the variation in female graduates that this analysis is interested in.

Recall that desired job amenities differ by sex, with female graduates placing more importance on amenities such as flexible work hours and/or part-time employment.

For this analysis, therefore, job amenities offered will be characterized by part-time work. Also recall that the ACS data only includes information on major as of 2009, so that part-time work is being measured in the current surveys. So part-time work measures whether the graduate is currently working part-time, as measured by anything less than thirty-five hours per week. This includes those graduates of a given major that are not working, reporting zero hours per week, although robustness checks will show that the results are not altered significantly by excluding this group of graduates.[11] Inclusion of these graduates allows for variation in labor force participation by major to be a relevant part of the understanding of labor market response to the sex composition of workers.

The data does not include information on timing of graduation, so graduating cohorts are being constructed based on age, with assumed graduation at age 22. To form the relevant labor market for a college graduate, each individual in the sample is grouped with other graduates of their major and age. This assumes that the relevant labor market for a graduate of Civil Engineering, for example, is composed of other graduates in that major working at a subset of firms offering employment in Civil Engineering. To most accurately capture the relevant labor market for an individual in the sample, each graduate is grouped with all other graduates who are in their major and are of the same age, plus or minus five years.[12] This formation of cohorts relies on the relevance to a particular worker of other graduates with similar age/experience levels but not those in very different career stages. For example, the labor market for new Economics majors,

[11] Robustness checks will also determine similar results when measuring part-time work as twenty hours or less per week.

[12] Robustness checks will show that this formation of a cohort can be altered, to plus or minus three years or even an individual year, without significant impact on the results.

around age 22, is arguably irrelevant to an economist much later in their career at age 40. It also means that the sample consists of only graduates aged 27 and above, to allow for grouping of all individuals with the appropriate cohort (so for 27 year old graduates, those aged 22-32). Therefore the period of analysis will end with graduates in 2008, as those who are 27 in 2013, the latest ACS survey utilized here, were 22 in that year.

In the regression above, β_1 captures the effect of being female on your likelihood to work part-time or, as people who don't work are included in this categorization, not work at all. The effect of an increasing proportion of women in your labor market, as characterized by others in your major and cohort (those up to 5 years younger or older than you) is then captured by β_2. This captures the effect observed in Figure 3.1(a), where the average preferences of a labor market change and so the amount of part-time work in that market changes as well. However this effect is not limited to women, as theoretically it is possible for both men and women to work part-time with an increased or decreased likelihood as the proportion of women in the labor market goes up. The evaluation of whether a given woman in the sample is more likely to work part-time as her labor market becomes increasingly female is embodied by β_3, the interaction of both the impact of being female and experiencing an increase in the number of women in your labor market on the likelihood of working part-time. This figure captures the effect of an increasingly female labor force on the type of work employed, net of (controlling for) the difference in the likelihood of working part-time for men and women. The coefficient β_2, therefore, captures the impact of an increasingly female labor force on the likelihood that

men work part-time, while the combined β_2 and β_3 capture the proportionately different impact on women.

3.5.2 Results

The results suggest that the labor market responds to increases in the proportion of potential employees that are female by increasing the amount of part-time work in the

Table 3.3: Main Results

Dependent: Part-Time	**(1) All Graduates**	**(2) Bachelor's Degree Only**
Female	1.04***	1.09***
	(0.06)	(0.07)
Female Share	0.82***	1.24***
	(0.12)	(0.15)
Female * Female Share	-1.52***	-1.57***
	(0.10)	(0.12)
Demographic Controls	YES	YES
Cohort FE	YES	YES
Major FE	YES	YES
Observations	1,703,664	1,083,547

Note: Robust standard errors in parentheses, clustered at the major-cohort level. Significance at the 1% level is depicted by ***, at the 5% level by **, and at the 10% level by *. Data is taken from the 2009-13 ACS and consists of 1,703,664 college graduates who graduated from 1980-2008. Part-time is defined as work of less than thirty-five hours per week, including zero hours.

relevant field. In fact a ten percent increase in the graduates of a given major that are female increases the likelihood of part-time work employed in that field by 8.2% (see Table 3.3, Column 1).

The results indicate that being a female graduate increases your likelihood of being employed part-time or not working at all by 1.04% relative to men in the sample. This is the β_1 result from the analysis. Additionally a ten percent increase in the proportion of your labor market that is female will result in an 8.2% increase in the likelihood that the graduate is employed part-time. This result for β_2 applies to all individuals in the sample, both men and women, and aligns with the theory depicted in Figure 3.1(a), where average preferences in a labor market change as the proportion of women in the market increases. As in the empirical results here, the response is an increase in part-time work.

Interestingly, the likelihood of a particular woman in the sample being employed part-time decreases as her labor market becomes more female. In other words, women are more likely to be employed part-time than men (β_1), and an increasingly female labor market does increase the amount of part-time work in the market for men (β_2), but as more women enter into a labor market female graduates in the field are less likely to be employed part-time. The results indicate that a ten percent increase in the share of women in the labor market decreases the likelihood of women being employed part-time by seven percent (β_2 plus β_3).

Graduates with advanced degrees are arguably members of a different labor market than their counterparts with only a bachelor's degree, even those in a similar age group and of the same major. Excluding those individuals from the sample (see Table 3.3, Column 2) in an attempt to more closely match students with their appropriate

market yields similar results.[13] Women continue to be more likely to work part-time, and an increasingly female labor market increases the likelihood of working part-time for all participants. However in this case a female graduate is 3.3%, rather than 7%, less likely to work part-time as the result of a ten percent increase in the share of women in the labor market.

3.5.3 Full-Time and Overtime Employment

These results suggest that the labor market responds to the increased presence of women by increasing the intensity of work they are employed in; in other words, by employing

Table 3.4: Full-Time Employment

Dependent:	**(1)** **≥ 40 Hours**	**(2)** **Overtime**	**(3)** **Working**
Female	-1.05*** (0.06)	-0.68*** (0.04)	-0.27*** (0.03)
Female Share	-0.55 *** (0.13)	-0.80*** (0.12)	-0.50*** (0.09)
Female * Female Share	1.51 *** (0.11)	0.94*** (0.07)	0.30*** (0.06)
Demographic Controls	YES	YES	YES
Cohort FE	YES	YES	YES
Major FE	YES	YES	YES
Observations	1,703,664	1,703,664	1,703,664

Note: Robust standard errors in parentheses, clustered at the major-cohort level. Significance at the 1% level is depicted by ***, at the 5% level by **, and at the 10% level by *. Data is taken from the 2009-13 ACS and consists of 1,703,664 college graduates who graduated from 1980-2008. Overtime is defined as work of greater than or equal to fifty hours per week.

[13] Alternatively the female share of the market can be calculated at the major-age-degree level so as not to exclude these graduates, again with similar results.

them in a more full-time capacity. While women are still more likely to work part-time than men, the impact of an increasingly female labor force on the likelihood of working part-time is actually larger for men than it is for women. The more women that enter the labor market, the more accommodations it seems firms and coworkers are willing to make to work with women and utilize them more in their workforce as the norms about female labor force attachment change. In fact in Table 3.4 notice how an increasingly female labor force also leads to an increased likelihood of women working full time and overtime hours. A ten percent increase in the proportion of the labor market that is female leads to a 9.6% increase in the likelihood that a women works forty or more hours, and a 1.4% increase in the likelihood that she works overtime hours (fifty or more).

3.5.4 Employee or Employer Response: Supply and Demand-Side Effects

The results may be due to impact in the labor market on the workers/graduates, or the firms, and are likely attributable to some combination of both. It is still the case that women in the market are more likely to work part-time than men. However on the supply side of the market, increased female presence encourages increased labor force attachment - a form of network effects as mentioned in the theoretical framework. It is in fact common for workers to prefer employment among those who are similar to them, in race, for example, or sex, age, etc., as in Becker's theory of employee discrimination (for tests and discussion of this theory, see Becker 2010, Frijters, et al. 2003, Fershtman and Gneezy 2001, Ragan and Tremblay 1988). This is consistent with the decline in part-

time employment/the increase in full-time employment as more women enter the labor market, making women more comfortable becoming fuller participants in the workforce.

On the demand side, employers also tend to reveal preferences for working with individuals who are similar to themselves, as in Becker's theory of employer discrimination (see Becker 2010, Kolpin and Singell 1996, Baldwin and Johnson 1992). In the case where more women enter that labor market, employers become more female and may therefore become more accommodating to women in their workforce. The cost to the firm of hiring women, in terms of wages and the disutility associated with working with them, decreases with the increased female presence, making wages relatively cheaper than amenities - consistent with the decrease in part-time work/increase in full-time employment found in the results.

In fact notice in Table 3.4, Column 3 that not only does increased female presence in the labor market lead to increased labor force attachment for women, but it also leads to a decline in the likelihood that men are working at all. A ten percent increase in the proportion of the labor force that is female decreases the likelihood that a male graduate works at all by five percent. It is unclear whether this is an employee or employer based response, or a combination of both, although in combination the end result of an increase in female representation in the labor force is a clear decline in part-time work for women.

3.6 Robustness Checks and Alternative Specifications

3.6.1 Part-Time Hours

The results are robust to altering assumptions made about each component of the analysis: how part-time work is measured, how cohorts are defined, and the relevant time period of analysis. For example when defining part-time work as twenty hours or less, rather than thirty-five as in the main specification, women are still less likely to be employed part-time as their labor market becomes more female. Notice in Table 3.5, Column 1 that as a labor market becomes ten percent more female, the likelihood that a female graduate is employed part-time falls by 5.2%. This is a similar though slightly smaller effect than when measuring part-time work at a cutoff of thirty-five hours.

It is still the case here that women are more likely than men to work part-time, and that an increase in the share of the labor market that is female increases the likelihood that male graduates work part-time. The ten percent increase in share female increases the likelihood of a male graduate being employed part-time by 4.3%, again similar to the 8.2% increase from the main specification but this time substantially smaller, with an almost fifty percent decrease in the effect found.

In the main specification, any graduate in a particular labor force who works less than thirty-five hours is grouped together into the part-time category, including those reporting zero hours worked in a week. If instead those individuals who are not working are excluded from the part-time group (see Column 2), and are in the sample together with the graduates working more than thirty-five hours, the results are very similar to the

main specification. A ten percent increase in females in the labor market results in a 9.1% decrease in the likelihood that a woman works part-time, a slightly larger decrease than the 7.0% in the main specification.

Table 3.5: Alternative Measures of Part-Time Work Hours

Dependent: Part-Time	**(1) ≤ 20 Hours**	**(2) Non-Workers Not Part-Time**	**(3) Working Graduates Only**
Female	0.68 ***	0.77***	0.95***
	(0.05)	(0.03)	(0.04)
Female Share	0.43***	0.31***	0.39***
	(0.11)	(0.09)	(0.10)
Female * Female Share	-0.95***	-1.22***	-1.49***
	(0.09)	(0.06)	(0.07)
Demographic Controls	YES	YES	YES
Cohort FE	YES	YES	YES
Major FE	YES	YES	YES
Observations	1,703,664	1,703,664	1,534,871

Note: Robust standard errors in parentheses, clustered at the major-cohort level. Significance at the 1% level is depicted by ***, at the 5% level by **, and at the 10% level by *. Data is taken from the 2009-13 ACS and consists of 1,703,664 college graduates who graduated from 1980-2008, except in Column 3 where graduates who are not working are excluded.

Finally if those who work zero hours are excluded from the sample entirely (see Column 3), the likelihood that a woman is employed part-time drops by 11.0% when the labor market becomes ten percent more female. This is the largest effect yet, as the drop in part-time work exceeds the increase in women in the market.

3.6.2 Cohorts

The results are also robust to redefining the cohorts used in the analysis. In the main specification it was assumed that an individual graduate's relevant cohort consisted of other graduates in their major who were similar in age. For that particular specification, an age group of those graduates anywhere from five years younger to five years older

Table 3.6: Alternative Cohorts

Dependent: Part-Time	**(1) Single Year**	**(2) +/- 3 Year Cohort**
Female	1.04***	1.05***
	(0.054)	(0.06)
Female Share	0.69***	0.81***
	(0.11)	(0.12)
Female * Female Share	-1.51***	-1.54***
	(0.10)	(0.10)
Demographic Controls	YES	YES
Cohort FE	YES	YES
Major FE	YES	YES
Observations	1,703,664	1,703,664

Note: Robust standard errors in parentheses, clustered at the major-cohort level. Significance at the 1% level is depicted by ***, at the 5% level by **, and at the 10% level by *. Data is taken from the 2009-13 ACS and consists of 1,703,664 college graduates who graduated from 1980-2008. Part-time is defined as work of less than thirty-five hours per week, including zero hours.

than an individual in the sample was utilized as the relevant cohort, as someone with twenty years more experience than a new entrant into the market is unlikely to be a significant component of the new entrant's labor market.

If the cohorts are altered slightly to include only those individuals who are three years younger or older than the graduate, rather than five years, the results still hold (see Table 3.6, Column 2). In this case a ten percent increase in the proportion of the labor market that is female results in a decrease of 7.3% in the likelihood that a woman works part-time, almost identical to the 7.0% decrease when cohorts are defined with five-year bands. Again women are more likely to work part-time than men, and the likelihood that a male graduate works part-time increases by 8.1% when the market becomes ten percent more female.

The results also hold when defining a cohort as graduates of a given major, in a single year (with no aggregating across different ages). The ten percent increase in women in the relevant labor market leads to an 8.4% decline in the likelihood that women work part-time, a slightly larger effect than with the plus/minus five-year cohort bins.

3.6.3 Time Period

Finally, the results are also robust to changing the time period analyzed. In the preferred specification, the analysis covers those who graduated/were 22 years old in any year from 1980-2008. If this is extended to 1975-2008, the results are very similar with a ten percent increase in the female proportion of the labor market leading to seven percent decrease in the likelihood women work part-time just as before (Table 3.7, Column 1).

As the time period is limited to more recent graduates the effect of an increasingly female labor market becomes even stronger. For the sample from 1985-2008, the ten percent increase results in a 14.3% decline in the likelihood that women work part-time,

and for 1990-2008 a 22.9% decrease (see Columns 2 and 3). These effects are significantly stronger than in the preferred specification, indicating that the importance of the share of the labor market that is female is higher for more recent graduates.

Table 3.7: Alternative Time Periods

Dependent: Part-Time	**(1) 1975-2008**	**(2) 1985-2008**	**(3) 1990-2008**
Female	1.04 ***	1.76***	2.77***
	(0.06)	(0.07)	(0.08)
Female Share	0.82***	1.38***	2.33***
	(0.12)	(0.13)	(0.15)
Female * Female Share	-1.52***	-2.81***	-4.62***
	(0.10)	(0.12)	(0.15)
Demographic Controls	YES	YES	YES
Cohort FE	YES	YES	YES
Major FE	YES	YES	YES
Observations	1,703,664	1,374,648	1,052,933

Note: Robust standard errors in parentheses, clustered at the major-cohort level. Significance at the 1% level is depicted by ***, at the 5% level by **, and at the 10% level by *. Data is taken from the 2009-13 ACS and consists of 1,703,664 college graduates who graduated from 1980-2008, except as redefined in Columns 2 and 3. Part-time is defined as work of less than thirty-five hours per week, including zero hours.

In general the results are robust to alternative specifications of part-time/flexible work (job amenities), definitions of cohorts, and the time period studied. Regarding job amenities that are of interest to women, such as flexible work, working with people, etc., only information on work hours is available in the ACS data. There remains an interesting question as to whether these results hold with regard to some of the other job amenities women favor.

3.7 Conclusion

This paper finds that the increased availability of female workers in a labor market leads participants to alter their decisions regarding flexible work. As more and more women graduate from college in a certain major, changing the average preferences of potential workers and the options available to firms, employment in that major becomes more part-time for men and less part-time for women. In fact a ten percent increase in female graduates will result in a seven percent *decrease* in the likelihood that a woman works part-time, and an 8.2% *increase* for men.

It is still the case that women in this analysis are more likely to work part-time than men, consistent with expressed preferences regarding flexible work. However as more women enter the labor market either female workers become more comfortable with increased labor force attachment, or firms become more willing to accommodate these altered preferences, or both. The result is an increase in the amount of full-time and overtime work undertaken by women in the labor market, and a decrease in part-time employment.

These results utilize the 2009-13 ACS, studying graduates from 1980-2008, and are robust to changing the specification of part-time employment, the definition of relevant cohort labor markets, as well as changing the time period studied. In general part-time work is defined as thirty-five hours or less, however the results are robust to altering this definition to twenty hours. They are also robust to different treatment of those graduates who are not working, with a ten percent increase in female graduates

resulting in a seven percent decline in part-time work by women when part-time is thirty-five hours or less, including zero hours, and a 9.1% decline when part-time is thirty-five hours or less, excluding those working zero hours.

The changes in the types of work college graduates are employed in are the combined result of supply and demand-side effects as average worker preferences and firm profits change. The theoretical impact of these changes is ambiguous, but there is a clear empirical influence of an increasingly female labor force on the amount of part-time work in the market. There remains interesting future work to determine what portion of this impact is due to employee, and which portion to employer, responses to the changing sex composition of the labor market.

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Appendix

Table 3.A1: Female Graduates and Part-Time Employment for All College Majors

Major	1980-84 Percent Female Graduates	Percentage Point Change in Female Graduates	1980-84 Percent Part-Time	Percentage Point Change in Part-Time Employment
Oceanography	21.12%	44.54%	12.73%	1.16%
Miscellaneous Agriculture	40.97%	23.60%	20.91%	-7.82%
Botany	50.30%	21.11%	25.00%	8.90%
Zoology	41.31%	20.63%	20.27%	5.79%
Miscellaneous Biology	38.44%	19.98%	16.15%	5.62%
Biological Engineering	19.09%	19.77%	17.44%	-1.14%
Cognitive Science and Biopsychology	30.71%	19.31%	20.00%	4.85%
Animal Sciences	48.21%	18.31%	16.47%	2.58%
Public Policy	42.52%	18.09%	23.95%	-7.35%
Petroleum Engineering	9.36%	17.91%	11.37%	-0.46%
Environmental Engineering	32.96%	17.62%	20.00%	5.57%
Electrical Engineering Technology	6.77%	17.56%	15.02%	-1.60%
Molecular Biology	40.60%	17.33%	21.66%	-2.75%
Geology and Earth Science	25.65%	17.00%	15.65%	1.33%
Agricultural Economics	23.88%	16.14%	15.81%	-0.73%
Ecology	50.62%	15.90%	22.81%	-1.15%
Miscellaneous Psychology	63.27%	15.88%	29.19%	-3.39%
Biomedical Engineering	26.65%	15.67%	15.94%	-0.17%
Health and Medical Preparatory Programs	41.24%	15.44%	17.72%	7.79%
Geosciences	25.69%	15.44%	16.13%	2.39%
Hospitality Management	45.53%	15.24%	23.51%	-2.58%
Neuroscience	45.60%	15.21%	25.71%	-4.71%
Human Resources and Personnel Management	60.25%	14.79%	19.62%	0.89%
Chemistry	35.68%	14.61%	16.42%	2.98%
Architectural Engineering	17.58%	14.40%	21.48%	-10.37%
Pharmacology	51.89%	13.72%	16.47%	2.52%
Biology	47.70%	13.71%	20.40%	0.46%
Court Reporting	45.15%	13.57%	25.00%	-5.43%
Clinical Psychology	68.75%	13.55%	29.29%	-8.23%
Aerospace Engineering	6.80%	13.13%	12.52%	-2.29%
Chemical Engineering	25.74%	13.03%	13.56%	-0.27%

Physical Sciences	32.77%	12.30%	19.44%	8.46%
International Business	50.25%	11.98%	29.36%	-9.79%
Public Administration	49.43%	11.84%	21.40%	-2.71%
Multi-disciplinary or General Science	46.96%	11.23%	21.10%	2.44%
School Student Counseling	80.48%	11.00%	20.79%	-4.35%
Industrial and Manufacturing Engineering	24.54%	10.70%	13.61%	-0.06%
Pharmacy, Pharmaceutical Sciences, and Administration	53.84%	10.41%	23.31%	0.91%
Actuarial Science	33.26%	10.38%	19.57%	-0.33%
Biochemical Sciences	39.69%	10.35%	17.85%	1.31%
Humanities	58.48%	10.14%	32.58%	2.09%
Precision Production and Industrial Arts	0.00%	10.00%	7.69%	25.64%
Military Technologies	8.00%	9.71%	19.23%	0.77%
Electrical Engineering	10.49%	9.71%	10.86%	1.02%
Civil Engineering	16.38%	9.62%	12.13%	0.16%
Community and Public Health	67.65%	9.54%	26.89%	1.52%
Accounting	51.31%	9.22%	19.23%	-1.96%
Architecture	30.78%	9.20%	23.07%	-1.98%
Film, Video and Photographic Arts	35.22%	8.76%	31.88%	-7.27%
General Engineering	14.36%	8.66%	13.71%	-0.22%
Physiology	49.23%	8.64%	26.54%	-5.21%
Environmental Science	46.49%	8.55%	19.97%	1.63%
Psychology	68.82%	8.40%	30.01%	-3.80%
Naval Architecture and Marine Engineering	4.67%	8.19%	8.43%	-0.84%
Cosmetology Services and Culinary Arts	33.36%	8.18%	32.12%	-14.80%
Food Science	61.10%	8.14%	28.41%	-5.34%
Criminal Justice and Fire Protection	40.46%	7.77%	19.25%	-3.68%
Advertising and Public Relations	63.62%	7.57%	28.24%	-8.31%
Geological and Geophysical Engineering	24.21%	7.51%	15.12%	1.55%
General Agriculture	24.17%	7.50%	14.18%	1.27%
Intercultural and International Studies	59.85%	7.13%	31.45%	-4.26%
Area, Ethnic, and Civilization Studies	63.14%	7.11%	29.32%	-1.76%
Health and Medical Administrative Services	72.64%	7.05%	22.41%	-0.90%
Operations, Logistics and E-Commerce	29.08%	6.96%	13.85%	-4.07%
Interdisciplinary and Multi-Disciplinary Studies (General)	65.74%	6.96%	23.28%	-2.24%
Journalism	59.99%	6.88%	26.99%	-7.86%
Microbiology	55.60%	6.74%	22.86%	-0.20%
Engineering Mechanics, Physics, and Science	15.47%	6.57%	11.07%	-0.72%
Physics	16.99%	6.51%	14.97%	1.97%

Anthropology and Archeology	63.99%	6.32%	29.88%	-1.26%
Political Science and Government	41.28%	6.28%	20.39%	-3.48%
Communications	57.93%	5.96%	27.72%	-6.48%
Liberal Arts	61.10%	5.58%	28.77%	-0.27%
Visual and Performing Arts	73.97%	5.46%	39.00%	-1.52%
Atmospheric Sciences and Meteorology	21.38%	5.36%	15.00%	-2.06%
Criminology	45.50%	5.28%	28.18%	-11.98%
Miscellaneous Engineering	18.84%	5.20%	13.25%	-2.79%
Other Foreign Languages	59.41%	5.19%	29.45%	6.42%
Social Work	85.22%	5.16%	28.49%	-1.62%
Electrical and Mechanic Repairs and Technologies	7.63%	5.04%	18.92%	-3.98%
Marketing and Marketing Research	53.51%	4.93%	26.07%	-9.27%
Counseling Psychology	73.87%	4.88%	30.60%	-1.11%
Geography	35.48%	4.87%	20.96%	-2.61%
Business Economics	35.83%	4.77%	21.51%	-9.58%
Natural Resources Management	37.01%	4.77%	18.85%	-3.85%
Applied Mathematics	35.70%	4.72%	20.16%	-4.39%
Social Psychology	69.94%	4.38%	29.63%	-3.05%
Industrial and Organizational Psychology	65.87%	4.33%	26.74%	-5.48%
Mechanical Engineering	10.01%	4.26%	10.10%	-1.12%
Science and Computer Teacher Education	62.77%	4.13%	16.19%	3.24%
Art History and Criticism	81.22%	4.08%	43.49%	-15.11%
Nuclear Engineering	9.60%	4.06%	8.97%	-6.19%
Agriculture Production and Management	24.55%	4.03%	13.79%	-1.37%
General Business	42.37%	3.93%	19.64%	-0.43%
Metallurgical Engineering	19.88%	3.90%	12.71%	2.51%
Transportation Sciences and Technologies	9.17%	3.81%	17.44%	-2.27%
Mechanical Engineering Related Technologies	4.60%	3.53%	15.45%	-4.92%
Philosophy and Religious Studies	32.07%	3.51%	25.21%	2.62%
Human Services and Community Organization	79.50%	3.43%	28.61%	-2.99%
Mining and Mineral Engineering	9.80%	3.31%	12.50%	4.52%
Drama and Theater Arts	58.94%	3.19%	32.00%	-1.90%
Engineering and Industrial Management	23.79%	3.03%	14.40%	-3.29%
Economics	35.24%	3.01%	20.94%	-3.40%
Mathematics and Computer Science	39.76%	2.99%	17.12%	-6.01%
Educational Psychology	84.03%	2.94%	26.71%	-6.85%
Statistics and Decision Science	50.26%	2.88%	23.47%	5.11%
Theology and Religious Vocations	26.47%	2.77%	23.10%	4.70%

Finance	35.04%	2.61%	18.50%	-5.94%
Business Management and Administration	46.94%	2.61%	18.16%	-2.57%
International Relations	57.05%	2.50%	26.19%	-7.60%
United States History	42.76%	2.49%	19.26%	0.33%
Miscellaneous Health Medical Professions	84.04%	2.48%	37.45%	-0.89%
Miscellaneous Engineering Technologies	20.10%	2.47%	14.59%	-0.61%
Astronomy and Astrophysics	38.99%	2.40%	19.61%	-3.43%
Educational Administration and Supervision	60.39%	2.00%	10.16%	-0.37%
English Language and Literature	67.14%	1.88%	31.05%	-3.44%
Industrial Production Technologies	10.48%	1.88%	11.51%	-6.04%
Mathematics	43.94%	1.88%	20.66%	0.08%
General Education	76.39%	1.79%	24.79%	-1.58%
Mathematics Teacher Education	65.56%	1.70%	20.90%	-2.51%
Sociology	69.68%	1.68%	29.06%	-6.12%
Mass Media	50.65%	1.60%	24.75%	-4.60%
Communication Technologies	34.29%	1.57%	22.57%	-5.27%
Communication Disorders Sciences and Services	94.68%	1.40%	30.71%	-2.36%
Medical Assisting Services	89.41%	1.40%	51.13%	-8.71%
General Medical and Health Services	71.03%	1.22%	26.79%	-3.48%
Art and Music Education	65.41%	1.19%	24.89%	-0.75%
Teacher Education: Multiple Levels	79.09%	1.18%	18.98%	-2.24%
Miscellaneous Education	56.04%	0.86%	19.58%	-1.22%
Genetics	57.46%	0.77%	28.36%	-13.82%
Interdisciplinary Social Sciences	70.99%	0.64%	29.39%	-1.86%
Computer Engineering	20.56%	0.55%	17.10%	-5.37%
History	40.49%	0.34%	24.02%	-4.13%
Secondary Teacher Education	57.95%	0.22%	18.27%	-1.13%
Materials Engineering and Materials Science	31.42%	0.15%	15.08%	3.38%
Construction Services	7.75%	-0.21%	10.79%	-2.29%
Engineering Technologies	21.42%	-0.60%	8.31%	4.40%
Pre-Law and Legal Studies	71.27%	-0.76%	24.59%	-4.28%
Early Childhood Education	97.59%	-0.97%	29.80%	-1.76%
Elementary Education	91.60%	-1.19%	23.28%	0.64%
French, German, Latin and Other Common Foreign Language Studies	75.65%	-1.45%	34.82%	-7.64%
Linguistics and Comparative Language and Literature	75.52%	-1.52%	34.56%	4.31%
General Social Sciences	62.82%	-1.69%	32.48%	-6.41%
Language and Drama Education	83.32%	-1.72%	25.26%	-0.05%
Social Science or History Teacher	48.75%	-1.81%	20.42%	-0.77%

Education				
Family and Consumer Sciences	93.11%	-1.84%	34.97%	-4.14%
Nuclear, Industrial Radiology, and Biological Technologies	55.10%	-1.98%	20.22%	3.85%
Nutrition Sciences	90.90%	-2.07%	36.23%	-2.62%
Medical Technologies Technicians	77.76%	-2.15%	24.01%	0.92%
Composition and Speech	67.60%	-2.91%	35.11%	-4.79%
Nursing	93.19%	-3.03%	29.22%	-0.27%
Computer Networking and Telecommunications	34.83%	-3.09%	19.88%	-7.66%
Miscellaneous Business and Medical Administration	49.50%	-3.15%	23.69%	-8.08%
Plant Science and Agronomy	37.44%	-3.37%	17.61%	-0.39%
Studio Arts	69.09%	-3.49%	40.58%	-9.28%
Special Needs Education	92.69%	-3.67%	22.35%	-3.38%
Forestry	26.11%	-4.28%	15.53%	-3.37%
Computer and Information Systems	38.54%	-5.23%	14.11%	-1.12%
Treatment Therapy Professions	81.37%	-5.52%	33.22%	-6.65%
Library Science	85.88%	-5.58%	28.27%	-3.63%
Management Information Systems and Statistics	43.28%	-5.71%	15.53%	-3.32%
Fine Arts	66.73%	-6.25%	37.34%	-5.96%
Commercial Art and Graphic Design	71.45%	-6.83%	38.29%	-12.80%
Miscellaneous Social Sciences	62.22%	-7.55%	27.87%	-11.01%
Music	55.67%	-7.63%	35.26%	1.89%
Physical and Health Education Teaching	53.36%	-7.64%	20.51%	-1.73%
Computer Science	33.09%	-7.65%	17.90%	-4.36%
Information Sciences	36.94%	-7.83%	16.33%	-6.32%
Computer Information Management and Security	35.31%	-9.31%	15.95%	-3.74%
Physical Fitness, Parks, Recreation, and Leisure	58.56%	-9.33%	26.09%	-4.58%
Computer Programming and Data Processing	43.12%	-9.77%	20.93%	1.87%
Soil Science	37.88%	-17.76%	20.00%	-3.87%
All Majors	**47.10%**	**5.36%**	**22.33%**	**-2.10%**

Conclusion

This dissertation explored topics in the economics of higher education, with an emphasis on the relationships between college major decisions, gender, and the labor market. It contributed to an understanding of the determinants of students' college major decisions and how those decisions influence the gender wage gap as well as the types of work employed in the college educated labor market.

The first chapter established the importance of labor market conditions in students' college major decisions, and therefore the future composition of the labor market. Students choose higher paying majors when the unemployment rate is high during college attendance; however, in general women are less sensitive to pay by major across the business cycle than men are.

Additionally students are most sensitive to measures of average pay by major rather than measures of pay that incorporate information on the age-wage profile, marital status, race composition and other relevant determinants of a major's wage. However students do include information about the relative employability of a major in their decision-making. Changes in student major decisions are due to switching majors, rather than changing their path toward completion of their degrees, as the likelihood of attaining a bachelor's is unaffected by the business cycle.

The second chapter re-evaluated the role of college major in the gender wage gap using detailed data that detects previously unobservable trends in college major. The relevance of this data, and this chapter, is that the detailed classification of college majors

reveals previously estimated levels of inequality in major distributions by sex to be significantly understated. Additionally they fail to detect the increase in inequality for male and female graduates taking place in recent years. These observations dictate the importance of another look at the impact of college major decisions on the gender wage gap. In fact the detailed data is able to explain a significantly larger portion of the gender wage gap than more aggregated major data does.

Differences in major decisions by sex are therefore a vital determinant of the gender gap. In fact the effect of major is significant beyond just its ability to channel students into certain occupations or a graduate education, each factors that influence major's ability to determine wages. Major influences the occupation graduates are employed in, each of which pays differently. Additionally some majors are more likely than others to lead to graduate education, and students with a graduate education on average earn more than those with just a bachelor's. However major continues to have explanatory power in the gender wage gap above and beyond these important factors.

Finally, the third chapter determines the impact of an increasingly female labor market on the amount of part-time work in the college-educated workforce. As more women graduate from college average firm and worker preferences may change. The result is that, while women continue on average to be more likely to be employed part-time than men, increases in the proportion of female graduates in a field result in a decreased likelihood that women work part-time and an increase in the likelihood that men do.

Additionally women's labor force attachment increases as the number of women in their field does, with the likelihood that they work full-time or even overtime hours increasing significantly. The shift of sex composition by major appears to therefore be responsible for changes in average preferences of graduates and of firms analyzing potential profits upon hiring them.

Overall this dissertation has explored the relevance of gender, the labor market, and major decisions in analysis of the economics of higher education. It presented evidence on the influence of the business cycle on student major decisions, how these decisions influence the ever-present gender wage gap, and how the changes in major decisions by sex can influence the types of work in the college educated labor market.