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The Effect of Title IX on Gender Disparity in Graduate Education

by

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Abstract

During the 1960s, there were essentially three career choices for women: nurse, secretary, or teacher. Graduate school admissions quotas largely prevented women from pursuing different career paths. Title IX of the Education Amendments of 1972 removed this barrier by making gender discrimination in admissions illegal. This paper examines whether this policy was successful in reducing gender disparity in graduate education. I find a sharp and dramatic convergence of female versus male graduate degree fields coincident with the passage of Title IX. This distributional change occurred as females predominantly moved into male-dominated fields and does not seem to be driven by gender-specific preferences. Further, alternative explanations, including birth control pill access and abortion legalization, were gradual changes and cannot explain the large, national shift in graduate-field distribution that occurred immediately following Title IX. In addition to providing evidence of successful anti-discrimination legislation, this paper sheds new light on the factors responsible for the college gender gap reversal.

JEL Codes: I24, J16, J18

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1 Introduction

One of the most striking changes in American society (and indeed almost all developed nations) is convergence in labor market outcomes between men and women. In 1960, less than 4 out of 10 women were participating in the labor force. In 2000, the female labor force participation rate was 60 percent.[1] Not only did women enter the workforce in large numbers, but they were entering high-skilled, male-dominated occupations. For example, the share of male lawyers decreased from 96 percent to 66 percent between 1960 and 2000.[2] It has been a goal of public policy for decades to try to help reduce these gender disparities in outcomes. But the best available research in terms of what has contributed to this convergence seems to focus on demand factors and technological changes, particularly around fertility, rather than more direct legal attempts to legislate away gender discrimination.[3] Understanding the role of legislation is important because it is a last line of defense to ensuring an equal and just society. Although market forces may be enough to "compete away" discriminatory practices, reality has shown that discrimination can persist even in a competitive environment.[4]

It is not obvious that legislation would reduce discrimination. First and foremost, there is scant evidence of successful anti-discrimination laws.[5] Racial discrimination continued well after the Civil Rights Act of 1875, which dictated equal treatment of African Americans in public accommodations and public transportation. The 1954 Supreme Court case *Brown v. Board of Education of Topeka* did little to end racial segregation in schools. More than 50 years after the Equal Pay Act of 1963 and the Civil Rights Act of 1964, we are still dealing with gender and racial bias in the workplace. One potential reason for the lack of effective anti-discrimination policy is the difficulty in changing people's preferences. In the case of admissions quotas to graduate school, for example, one state commission's report found that medical schools admit very few women because they "[get] married and [do] not persist in the profession" (Discrimination Against Women, 1970, p. 312). This was the prevailing view among school officials at the time and was often cited as a reason for admitting few women to graduate programs.

The goal of this paper is to empirically assess whether policy is effective in reducing discrimination. I examine the specific case of Title IX of the Education Amendments of 1972, which banned gender discrimi-

[1] These statistics are from the U.S. Bureau of Labor Statistics and were retrieved from FRED.

[2] These statistics are based off the 1960 and 2000 Census IPUMS 5 percent samples for people aged 18 to 55.

[3] See, for example, Heckman and Sedlacek (1985), Smith and Ward (1985, 1989), Blau and Kahn (1997, 2000, 2006), Black and Juhn (2000), Mulligan and Rubinstein (2008) for research on demand factors. For research on the role of fertility, see Goldin and Katz (2002), Bailey (2006), Blau and Kahn (2016), Myers (2017).

[4] More specifically, taste-based discrimination may be competed away in equilibrium, but not statistical discrimination, which is an efficient solution to the signal extraction problem. Nevertheless, statistical discrimination as it pertains to protected minority groups is unlawful and violates most common notions of fairness.

[5] The notable exceptions are Heckman and Payner (1989), which found that Title VII of the 1964 Civil Rights Act had a sizable effect on black employment in the South Carolinian textile industry, and Donohue and Heckman (1991), which expanded the geographic focus of the previous study to the entire south.

nation in graduate-school admissions. Focusing on the distribution of fields of study, I find strong evidence that Title IX was successful in reducing gender disparity in graduate education. Moreover, the sharp and dramatic convergence between female and male graduate-degree fields was driven by female movement into male-dominated fields, suggesting that female preferences were not the main barrier. I use two different methods to measure gender convergence: the Segregation Index, also known as the Index of Dissimilarity, and the Earth Mover's Distance algorithm (EMD). Although the segregation index is a popular method for measuring distributional change, EMD is a better measure when studying discrimination as it takes into account which fields people move out of and into, and, more importantly, the distance between fields (using expected salary of the different fields as a measure of distance). This is an important detail because women were barred from entering certain fields prior to Title IX, and those fields were precisely the more lucrative fields. My results do not change by convergence measure, though EMD estimates greater convergence. I also find that female growth after Title IX was concentrated in fields in the top salary tercile. This suggests an indirect role that Title IX played on the labor market. By granting women access to high-skilled occupations, which were also the highest-paid occupations, Title IX led to higher expected returns on human capital investment for women thereby encouraging labor market participation. Indeed, I find that occupational convergence between men and women increased starting with the birth cohort who was first exposed to Title IX in college.

There is one important identification concern that warrants discussion. As Title IX is a national policy, there is no natural comparison group against which to measure the impact of the law. This is an issue if the law were anticipated or if it were passed in response to the changing social attitude at the time, especially regarding admissions policies. In these cases, a simple event-study may result in a biased OLS estimate as I would be unable to disentangle the trend from the impact. These concerns are mitigated when examining the history behind Title IX's passage. The law came at a time when women's rights were expanding, but the main impetus for its passage was persistent gender discrimination in educational institutions. This is supported by data, which show that female enrollment trends changed after Title IX's passage.

The coincidence in timing does not, of course, prove causation; there were a lot of other changes occurring between the late 1960s and early 1970s that may be responsible for the change in female educational choices. However, alternative explanations were gradual changes and are unlikely to explain the large, national shift in graduate-field distribution that occurred between 1972-73 and 1974-75. As a robustness check, I consider two possible explanations that are often cited as causes of change in women's education and labor force behavior: young, single women's increased access to the birth control pill in the late 1960s; and abortion legalization by the Supreme Court in 1973. These two events may have affected women's decisions to pursue graduate studies by lowering the cost of investment. My robustness checks exploit state-level variation in

the adoption of these policies and still finds an increase in convergence right after Title IX's passage.

1.1 Related Literature

This paper relates to a number of existing literature. First and foremost, this paper contributes to the literature on Title IX. Title IX is largely associated with high school and college athletics; one of the seminal papers on Title IX finds that it increased female college attendance and labor market participation by increasing female participation in high school athletic programs (Stevenson, 2010). Other researchers have examined its effect on educational outcomes, but most are historical accounts or qualitative studies (Buek and Orleans, 1973; Stromquist, 1993; Valentin, 1997; DOJ, 2012; Mason and Younger, 2014). Unlike the previous studies on education, my paper conducts a robust quantitative analysis. To my knowledge, this is the first study that seeks to estimate causal effects of Title IX on graduate education.

This paper also expands the literature on the catch-up and over-taking by American women of American men in college attendance and graduation. Despite extensive research, the reasons for this phenomenon are still not fully understood. An increasing college wage premium for females relative to males, changing social norms sped up by the introduction of the birth control pill, and increasing female labor force participation are some of the main explanations put forth by researchers (Goldin and Katz, 2002; Bailey, 2006; Goldin, Katz, and Kuziemko, 2006; Blau and Kahn, 2016). This paper suggests that policy may have also played a role in the reversal of the college gender gap.

Relatedly, this paper contributes to research on gender convergence in the U.S. occupational distribution; one's degree of study is closely linked to one's occupation. The large-scale movement of women into the U.S. labor market and the occupational convergence between men and women over the past 50 years has long been of interest to researchers (Polachek, 1981; Blau, Simpson, and Anderson, 1998; Blau, Ferber, and Winkler, 2014; Olivieri, 2014; Pan, 2015). Much of the literature that seeks to explain this phenomenon focuses on demand factors, specifically the decreasing gender wage gap (Heckman and Sedlacek, 1985; Smith and Ward, 1985, 1989; Blau and Kahn, 1997, 2000, 2006; Black and Juhn, 2000; Mulligan and Rubinstein, 2008). Less work has been done on the supply factors with most of them focusing on the fertility consequences of labor force participation (Goldin, 1988, 1990; Angrist and Evans, 1998; Goldin and Katz, 2002; Bailey, 2006; Myers, 2014). Noting that much of the convergence occurred among high-skilled occupations, my paper suggests that barriers to higher education also affected females' occupational choices.

Finally, this paper adds to the empirical toolbox of convergence measures. Measures of distributional change have broad applications, ranging from studies of residential segregation (Massey and Denton, 1988) to occupational segregation (Blau, Brummund, and Liu, 2013) to income-achievement gaps (Nielsen, 2015).

As such, the literature on convergence measures is long and ever-growing.[6] I contribute to this literature by applying in an economic context a well-known measure in computer science, the Earth Mover's Distance algorithm. As mentioned above, the advantage of EMD is that it takes into account the distance between bins that people are moving into and out of when measuring convergence. This is something the segregation index does not do, but is an important detail when studying discrimination.

I begin the remainder of the paper by providing an historical account of Title IX. Section 3 discusses the empirical evidence on whether colleges and universities complied with Title IX. I describe the data in Section 4 and my main results in Section 5. Section 6 unpacks the distributional change, and Section 7 discusses alternative explanations. I conclude with a discussion of the implications from my results in Section 8.

2 A Brief History of Title IX

2.1 The Status of Education for Women

The 1960s saw a colossal expansion of women's rights. President John F. Kennedy was elected into office on the promise of a New Frontier, ready to confront previously unconquered problems of social and civil injustice. As such, he signed the Equal Pay Act of 1963 into law, abolishing wage disparity based on sex. One year later, the Civil Rights Act of 1964 was passed – a landmark piece of civil rights legislation that ended racial segregation in schools but made no explicit mention of gender discrimination in educational institutions. The fight for women's rights continued, however, and in 1965, President Lyndon B. Johnson signed an executive order banning federal contractors from discrimination in employment based on sex as well as race, color, religion, and national origin (Executive Order 11246).

Despite these advancements, gender discrimination in educational institutions was still pervasive as it was technically not banned. This sparked a national conversation about gender inequalities in pay, rank, and admissions in higher education. A Special Subcommittee on Education in the House of Representatives was formed, and Congressional hearings on Section 805 of H.R. 16098 (Omnibus Post-Secondary Education Act of 1970) began on June 17, 1970. For days, hearing after hearing, statement after statement revealed the dire status of a woman's place in education (Discrimination Against Women, 1970). The statement of Professor Ann Sutherland Harris, Assistant Professor of Art History at Columbia University, summarized it best:

> The rule is a simple one: the higher, the fewer. Although more women than men finish high school (and this has been true since 1920), fewer women than men go on to college, largely

[6] See, for example, Duncan and Duncan (1955), Taeuber and Taeuber (1976), Cowell (1985), Massey and Denton (1988), Ruber, Tomasi, and Guibas (2000), Reardon and Firebaugh (2002), and Reardon (2009).

> because it is harder for a woman to gain entrance to college with the necessary financial support. Fewer women than men go on to get higher degrees, again largely because graduate departments discriminate against women in admissions policies and in the distribution of fellowships. Once they qualify, the higher-the-fewer rule continues to apply: the higher in terms of rank, salary, prestige or responsibility, the fewer the number of women to be found. (Discrimination Against Women, 1970, pp. 244-245).

Three clear facts about admissions discrimination emerged from the Hearings. First, gender discrimination existed in both undergraduate and graduate admissions, but it was more egregious at the graduate level and prevalent across all disciplines. Moreover, the use of admissions quotas for women was well-known by school administrators and applicants alike. For example, undergraduate admission to University of North Carolina was restricted to females "who are especially well-qualified", but no such restriction for male applicants existed (Discrimination Against Women, 1970, p. 739). In the State of Virginia, 21,000 women were rejected for college entrance over a 3-year period while not one male student was rejected (Discrimination Against Women, 1970, p. 739). At Cornell University, studies on the status of women found that "there were quotas on women applicants operating at all the schools" (Discrimination Against Women, 1970, p. 1077). According to one testimony, when the Dean of Admissions at New York University Law School was approached with the idea of actively recruiting women law students, he responded that there were already too many women and that NYU did not need classes composed of 50 percent women (Discrimination Against Women, 1970, p. 587). According to another testimony, the Dean at Harvard Law School stated that female enrollment at Harvard Law would probably stay at 5 percent of the class as "that was Yale Law School's percentage; and that, after all, there could never be a great influx of women into the school...because the policy was never to give any man's place to a women" (Discrimination Against Women, 1970, p. 587).

Second, there were plenty of highly-qualified female applicants to various graduate school programs. Because women faced discrimination in admissions, those who decided to pursue graduate studies were exceptional students, drawn from the right-tail of the ability distribution. Professor Ann Sutherland Harris recounted stories of her colleagues complaining that women undergraduates needed A or A- grades for graduate school admission while their male counterparts were admitted with B averages (Discrimination Against Women, 1970, p. 248). A University of Chicago Report (hereafter Chicago Report) on the status of its women found that 34 percent of graduate women had grade point averages of A or A-, while the corresponding grade point average for graduate men was 27 percent (Discrimination Against Women, p. 798). In the State School of Agriculture at Cornell, "the mean SAT scores of entering women freshmen are higher than those of men by 30-40 points" (Discrimination Against Women, 1970, p. 1077).[7] Considering that female applicants were more qualified than male applicants, admission criteria that is based on merit

[7] Whether any of these estimates are statistically significantly different is unknown.

alone would result in a higher acceptance rate for women than for men. However, all accounts report that female acceptance rates were tied to their percentage of applicants. For example, 25 percent of the applications to the School of Journalism at Columbia were female and 20 percent of its places were offered to women. Colleges and universities boasted that the acceptance rate for women was proportional to their application percentage, unaware that such a fact belied their unfavorable attitudes towards female applicants.

Third, the notion that women were less committed students than men is not true. This notion was widely-held by school administrators at the time despite a lack of accurate data on attrition rates. It was also used as an explanation by school officials, who were mainly men, when asked why women were discriminated against in admissions (Discrimination Against Women, 1970, p. 248). The Chicago Report, administered in October 1969, was the first of its kind to publish attrition statistics by department. It found that the difference in attrition at the undergraduate level is small, with women being 2 percentage-points more likely to drop out (Discrimination Against Women, 1970, p. 806). At the graduate level, however, there were no consistent differences between men and women in regards to leaving before finishing a degree. Moreover, women stop at the master's level more frequently than men but the reasons for doing so are widely varied – including inadequate performance for the PhD – whereas men are more likely than women to stop due to poor performance (Discrimination Against Women, 1970, p. 806). These statistics are not consistent with the viewpoint that women are less committed students than men. The Report also found that women at the University of Chicago have high career commitment. The questionnaire found that 92 percent of women want to have a career compared to 81 percent of men (Discrimination Against Women, 1970, p. 867). Relatedly, 62 percent of women respondents would be "very disappointed" if they left school before completing their education compared to only 53 percent of men (Discrimination Against Women, 1970, p. 871).[8]

In summary, admissions quotas in graduate schools discriminated against highly-qualified female applicants who were also committed students. The effect on female enrollment, after a removal of these quotas, is expected to be immediate and consequential.

2.2 Title IX Regulations

Title IX was signed into law by President Richard Nixon on June 23, 1972. It mandated that:

> No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance.

The law was broad in scope, covering many aspects of education discrimination, but in regards to admissions, Title IX applied specifically to "institutions of vocational education, professional education, and

[8] Again, it is unclear whether these differences are statistically significantly different, but the magnitudes are large.

graduate higher education, and to public institutions of undergraduate higher education."

Preparations to draft compliance regulations began shortly after its passage. Between August 2-4, 1972, the Department of Health, Education, and Welfare (hereafter HEW) held national hearings to discuss Title IX regulations. In June 1974, an initial draft of the regulations was published in the Federal Register. After reviewing nearly 10,000 comments, HEW edited the regulations, and they were signed into law by President Gerald Ford in May 1975.

Title IX regulations state:

> Compliance with any requirement adopted pursuant to this section may be effected (1) by the termination of or refusal to grant or to continue assistance under such program or activity to any recipient as to whom there has been an express finding on the record, after opportunity for hearing, of a failure to comply with such requirement, but such termination or refusal shall be limited to the particular political entity, or part thereof, or other recipient as to whom such a finding has been made, and shall be limited in its effect to the particular program, or part thereof, in which such noncompliance has been so found, or (2) by any other means authorized by law.

As is made clear in the language, Title IX had severe consequences for non-compliance: any program, department, or school that was found to be practicing gender discrimination after it was notified of the violation would no longer receive federal assistance. As such, schools had an incentive to comply with Title IX regulations. But these regulations were passed three years after Title IX was passed. Did universities and colleges have an incentive to comply with Title IX in the three years prior to 1975? We examine this question in the next section.

3 Did Universities Comply with Title IX?

The 1975 Congressional Hearings before the Subcommittee on Postsecondary Education took place in June 1975, one month after Title IX regulations were signed into law. Their purpose was to review the regulations and hear any contestations. The main opposition was on Title IX's coverage of athletic programs (Sex Discrimination Regulations, 1975, p. 69, 285, 385). Its coverage of sex discrimination in admissions was not contested, likely because it was a well-acknowledged problem by that time. According to Nellie M. Varner, who testified on behalf of the National Association of State Universities and Land-Grant Colleges, the American Council on Education, and the Association of American Universities, "many institutions [had] already begun to respond to the spirit of Title IX" even though the regulations had not been passed and therefore Title IX technically could not be enforced (Sex Discrimination Regulations, 1975, p. 416).

In this section, I examine whether the data are consistent with Congressional testimony. From the wording of Title IX stipulations and compliance regulations, we expect the following to be true about female enrollment trends if universities complied with Title IX:

1. A larger break in trend among graduate students relative to undergraduate students (as Title IX applied specifically to all professional education and graduate higher education admissions)

2. A larger break in trend among public institutions relative to private institutions (as Title IX applied to all public institutions [of undergraduate higher education])

3. A larger break in trend among institutions with more federal funds relative to institutions with less federal funds (as non-compliance will result in termination of federal funds)

I test these predictions using 1969-1975 fall enrollment data from the Higher Education General Information Survey (HEGIS).[9] The HEGIS series were issued by the United States Department of Education to all public and private two-year and four-year institutions in an effort to provide comprehensive information on various aspects of postsecondary education in the U.S. and its territories.

Figure 1 plots the average share of female students between 1969 and 1975. The left column depicts the female share of enrolled graduate students, and the right column depicts the female share of enrolled undergraduate students. The dots are the annual mean shares, weighted by the institution's total enrollment. The vertical line represents the year of a structural break in the enrollment trend. The dashed lines are linear fitted values allowing for a structural break in the trend. The year of the break was found by maximizing the R^2 of the following regression, separately for graduate students and undergraduate students:

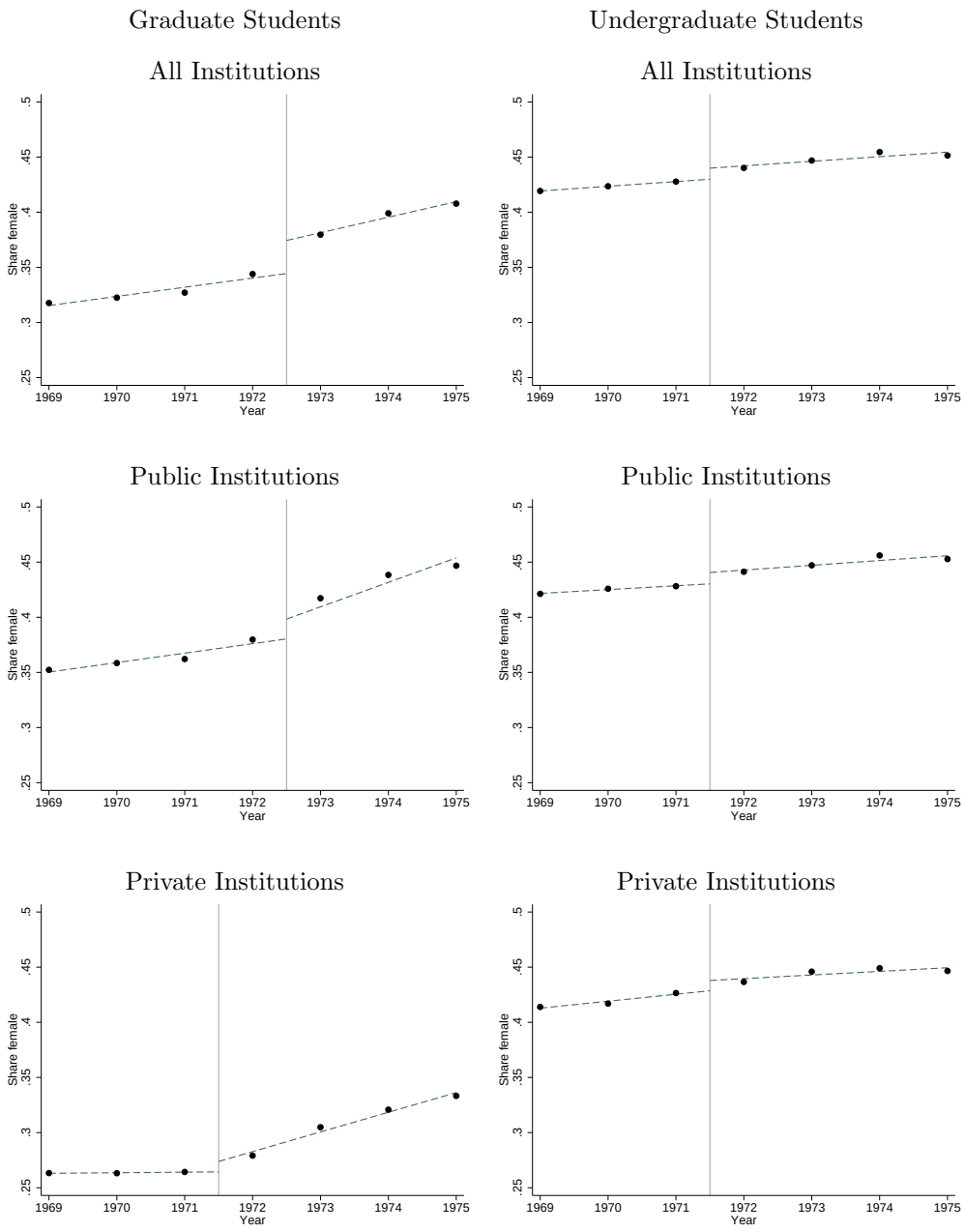
$$F(t) = \beta_0 + \beta_1 \cdot \mathbb{1}\{t > t^*\} + \tau \cdot t + \delta \cdot (t - t^*) \cdot \mathbb{1}\{t > t^*\} + \varepsilon_t \tag{1}$$

where $F(t)$ is the share of female students in year t and t^* is the year of the structural break in the time series.[10] The parameter τ is a linear time trend before the structural break, β_1 is the size of the structural break, and δ is the linear time trend after the structural break.

[9] Ideally, I would use first-year enrollment data for this analysis. Unfortunately these historical data do not differentiate first-year graduate student enrollment from total graduate student enrollment.

[10] The range of the structural break excludes the first and last years of the time period.

Figure 1: Trends in Female Share of Enrolled Students



Source: HEGIS 1968-1975 Fall Enrollment data.
Notes: Each dot is the mean female share of enrolled students in each year. The dashed line is a fitted linear trend allowing for a break. The break-year was determined by looking for a structural break in the data.

All of the graphs show a structural break that occurred right around the time of Title IX's passage in June 1972. There is a discrete jump in female share among graduate students between Fall 1972 and Fall 1973 at all institutions and at public institutions; this is statistically significant and equal to a 2.2 and a 2.4 percentage-point increase, respectively. The post-break trend is not statistically significantly different

from the pre-break trend. For graduate enrollment at private institutions, there is no discrete jump at the break-year, but the post-break trend increases by 0.9 percentage-points and is statistically significantly different from the pre-break trend. In terms of undergraduate enrollment trends, there is a small, statistically significantly discrete jump in the break-year (around 1 percentage-point increase), which is driven almost entirely by public institutions. These graphs reveal that the data the first two predictions: there is a larger break in female enrollment trend among graduate students relative to undergraduate students, and this break is larger in public institutions relative to private institutions.

To test the third prediction, I examine enrollment trends by the university's funding source. I use 1968 and 1969 financial statistics data from HEGIS to calculate the percentage of the university's general revenue that comes from the federal government.[11] I consider federal government appropriations and federally sponsored research and programs as federal funds, and categorize schools into terciles based on their federal funds revenue share.[12] It is important to note that private and public institutions were equally likely to receive federal funding. The average share of revenue that comes from federal funds for private institutions is 7.8 percent with a standard deviation of 10.5. The analogous statistics for public institutions are 9.6 percent (mean) and 12.5 percent (standard deviation).

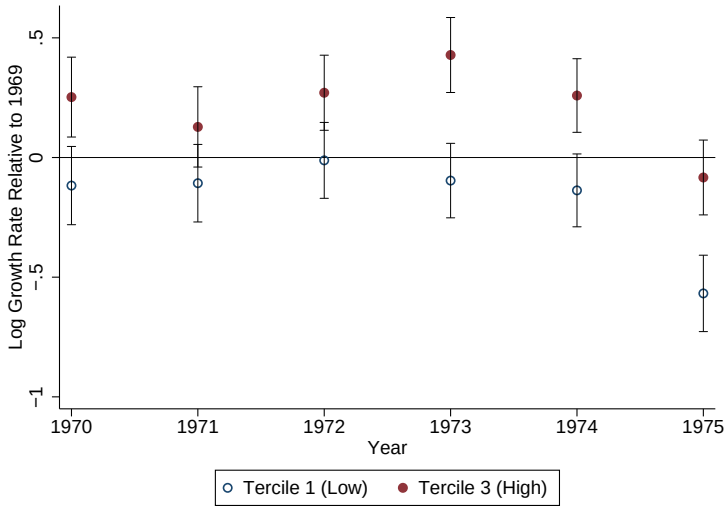
I regress logged growth rate in the female share of total enrollment on a set of year dummies, separately by tercile.[13] The parameters of interest are the coefficients on the year dummies, which tell us how the log growth rate changes annually relative to 1969's log growth rate. These estimates and their corresponding 95% confidence intervals are graphed in Figure 2. Tercile 1 comprises of schools where the federal funds share is in the bottom third. Tercile 3 comprises of schools where the share is in the top third. The hypothesis is that schools in Tercile 3 would experience faster growth rates post-Title IX, in comparison to schools in Tercile 1. We see no significant changes in log growth rate among Tercile 1 schools in the years surrounding Title IX's passage. In contrast, the log female growth rate is positive and statistically significant starting with the Fall 1972 enrollment and peaks in Fall 1973 for schools that rely relatively more on federal funds.

[11] I am only able to use 1968 and 1969 data because starting in 1970, I cannot differentiate federal funds.

[12] There is quite some variation in federal funding shares; the average federal share of revenue between 1968-1969 is 8.7 percent and the median share is 4.9 percent. The 10th and 90th percentiles are 0.1 percent and 21.5 percent, respectively.

[13] Variations where I include state fixed effects and school fixed effects do not significantly change the results.

Figure 2: Relative Female Growth Rate by Federal-Funds Revenue Share



Source: HEGIS 1968-1975 Fall Enrollment data and 1968-1969 Financial Statistics data.
Note: Dots depict each year's increase in log growth rate in the female share of total enrollment relative to 1969's log growth rate, separately by tercile. Terciles are based on the percentage of a school's revenue that comes from federal funds. Wings are 95% confidence intervals.

In summary, the data support the argument that universities responded immediately to Title IX - even before compliance regulations were determined in 1975, and that there were enough qualified female applicants to meet the demand. I find stronger evidence of compliance among graduate schools, which is consistent with the 1970 Congressional Hearings and Title IX regulations. Informed by these findings, the rest of my analysis will focus on graduate degrees.

4 Data and Summary Statistics

I use two data sources for my main analysis: the National Survey of College Graduates, a nationally-representative survey of all college graduates, and the Higher Education General Information Survey, a government survey administered to all U.S. institutions of higher education. I describe both of these data sources in turn.

The National Survey of College Graduates (NSCG) is a longitudinal, biennial survey of U.S. college graduates that began in the 1970s. I use data from the 1993 survey, which surveyed all non-institutionalized, U.S. individuals under the age of 73 with at least a bachelor's degree as of 1993. The individuals who lived through Title IX would have been roughly 40-50 years old in 1993 and, therefore, in this dataset. Most importantly, the 1993 survey is the first of its kind to ask about field of study. The survey asks respondents

to report their field of study and year of degree for their (1) bachelor's degree, (2) most-recent degree, and (3) second most-recent degree. I classify graduate degree as any degree other than a bachelor's degree. This includes master's degrees, professional degrees, and doctoral degrees. All results reported in this paper use data on the highest degree.[14] There are 255 reported fields of study in the NSCG data. I consolidate these into 28 main fields, as categorized by the 2010 Classification of Instructional Programs (CIP).[15] The main NSCG analysis sample considers all graduate degrees obtained before age 35 between 1964 and 1987; this results in 29,310 observations.[16] I combine two-year cells to increase power.

The Higher Education General Information Survey series is a set of surveys that began in the 1960s and is administered by the U.S. Department of Education to all public and private two-year and four-year institutions. As mentioned above, its purpose is to provide comprehensive information on various aspects of postsecondary education in the U.S. and its territories. As such, there are several surveys on enrollment, finance, and earned degrees; my main analysis uses the 1965-1981 series on conferred degrees. Hereafter I refer to the HEGIS dataset as "administrative data" to distinguish it from the person-based survey format of the NSCG. There are an average of 1,789 institutions in the main HEGIS analysis sample, with an average of 12 years of data for a single institution. Although HEGIS, being an administrative source of graduate degree data, has some advantages over the NSCG 1993 survey, my preferred data source for the main analysis is the NSCG because it contains information on individuals, such as birth year, race, and geographic location.

Table 1 provides a sense of the status of education before Title IX using NSCG data.[17] In 1965, there were around 15,000 or 11 percent more male BAs than female BAs. Similarly, in 1970, there were nearly twice as many males with graduate degrees, relative to females. By 1980, however, the number of female graduate degrees more than doubled, and the male-to-female graduate degree ratio was almost at parity. Second, Education is the most popular graduate field of study for both males and females in 1970. But whereas nearly half of all females in graduate school are in education, only 20 percent of males chose that field. In other words, males were more evenly distributed across fields in graduate school whereas females were clustered in education.

The next two most popular graduate fields for men are business, at 14.1 percent, and legal, at 10.3

[14]The highest degree very closely corresponds with most-recent degree. 99.6 percent of respondents in the NSCG 1993 survey have matching highest-degree and most-recent degree types. Of the 447 respondents whose highest degree type and most-recent degree type differ, 134 of them (30 percent) are in the same field-of-study.

[15]CIP was originally developed in 1980 by the U.S. Department of Education's National Center for Education Statistics for the purpose of accurate tracking, assessment, and reporting of fields of study. Please see the online appendix for the crosswalk between NSC 1993 reported field of study and the 2010 CIP major code.

[16]I choose age 35 as an arbitrary cutoff age as most graduate degrees are obtained by then. The average age of a graduate-degree graduate was 30 between 1960-71 and 31 between 1973-90.

[17]The distribution using HEGIS Earned Degrees data is similar. There are 28 aggregated degree fields in HEGIS, 21 of which also appear in NSCG. Looking specifically at the 1970 graduate field-of-study distribution, most of the absolute difference in percentages between the two data sources is small; less than 1 percentage-point. The average absolute percentage-point difference is 1.2 and the largest is 4.4.

percent. By contrast, only 1.9 percent of females are in business school and 2.5 percent are pursuing a law degree in 1970. The disparity between male and female educational choices becomes starker when we consider undergraduate majors. In 1965, back when these graduate students were in college, 6.2 percent of female BAs studied health but only 2.5 percent of males did so. However, males made up 68 percent of graduate health degrees in 1970; men were severely over-represented in medical school. A similar story can be seen for legal degrees. Female and male BAs majored in legal professions in similar proportions (around 0.3-0.4 percent), but males were 4 times more likely to pursue a graduate law degree.

Table 1: Summary Statistics of Major Fields of Study in 1965, 1970, and 1980

	1965 BAs		**1970 Grad. Degrees**		**1980 Grad. Degrees**	
Fields of Study	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Legal	0.4%	0.3%	10.3%	2.5%	13.8%	6.7%
Health	2.5%	6.2%	8.1%	6.8%	16.1%	12.5%
Engineering	12.9%		9.9%	0.1%	5.0%	2.1%
Phys. Sci.	3.4%	0.2%	6.2%	1.1%	2.8%	0.7%
Business	30.1%	4.4%	14.1%	1.9%	19.6%	14.4%
Comp. Sci.	0.1%	0.6%	0.8%		2.4%	0.5%
Engin. Tech.	2.2%		0.3%		0.5%	0.1%
Math	5.2%	1.7%	3.6%	1.5%	0.9%	0.8%
Soc. Sci.	5.9%	5.9%	3.8%	1.3%	1.7%	1.9%
Architecture	0.9%		0.4%		1.2%	0.5%
Nat. Resources	1.1%		0.0%		0.2%	0.8%
Agriculture	3.4%		1.6%		1.3%	0.4%
Bio. Sci.	3.0%	2.7%	1.8%	2.7%	2.4%	1.7%
Comm.	1.3%	0.4%	1.7%	2.5%	1.4%	0.7%
Ethnic Stud.		0.4%			0.0%	
Homeland Sec.				0.1%	1.3%	0.3%
History	3.9%	2.9%	1.2%	1.0%	0.4%	0.1%
Pyschology	2.2%	1.3%	3.6%	6.4%	5.0%	5.5%
Pub. Admin.	0.5%	1.5%	2.5%	5.3%	2.6%	5.5%
For. Lang.	0.8%	2.1%	0.5%	3.4%	0.3%	0.2%
Education	11.7%	47.6%	19.6%	47.6%	14.2%	35.0%
Liberal Arts	1.1%	2.1%		0.7%		0.2%
English	1.2%	5.0%	2.2%	4.4%	0.8%	1.3%
Parks & Rec.	0.4%	0.3%	0.4%		0.4%	0.8%
Family Sci.	0.3%	4.8%		2.3%	0.1%	1.2%
Library Sci.		1.2%	0.9%	4.2%	0.4%	2.3%
Perf. Arts	1.8%	8.3%	2.2%	2.1%	1.3%	3.3%
Philosophy	2.9%		3.7%	1.4%	2.9%	0.5%
Not classified	0.6%		0.4%	0.7%	1.0%	0.2%
Total	99.4%	100.0%	99.6%	99.3%	99.0%	99.8%
Number of graduates	150,373	135,576	105,248	58,307	143,458	122,361

Source: NSCG 1993 data.
Notes: Reported fields of study were consolidated into 28 major fields using CIP 2000.

5 Effect on Graduate-field Distributions

5.1 Convergence Measures

This section examines the effect of Title IX on the convergence between male and female distributions of graduate fields of study shown in Table 1. I use two different methods to measure gender convergence. The first is the Segregation Index, also known as the Index of Dissimiliarity, developed by Duncan and Duncan (1955). The segregation index is used to measure change in the distribution of an unordered, categorical variable and has been used in a variety of applications, from measuring racial segregation in neighborhoods (Massey and Denton, 1988) to gender segregation in occupations (Blau, Brummund, and Liu, 2013). It is calculated as follows:

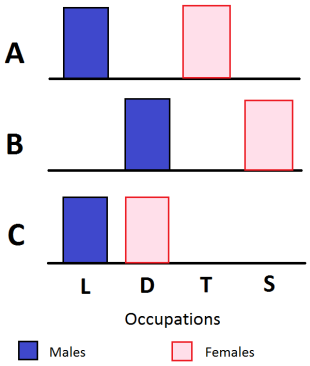
$$S_t = (0.5) \cdot \sum_i |m_{it} - f_{it}| \tag{2}$$

where m_{it} is the share of all male graduate students in degree-field i in year t and f_{it} is the share of all female graduate students in field i in year t. This measure indicates the percentage of women (men) who would have to change graduate fields for the overall distributions of men and women to be identical. For example, if the share of women in all fields is the same as their share of total graduate degrees, then the segregation index is 0. Therefore, larger values indicate greater segregation (divergence) and smaller values indicate greater integration (convergence).

As is clear from the formula, the segregation index does not consider the ordering of the fields of study. For example, a segregation index of 30 means that 30 percent of women (or 30 percent of men) need to change their degree-field but there is little constraint on specifically which exact field-of-study these women (men) move to or where they moved from. In some cases, however, this is an important detail. I illustrate this point with a simple example below.

Say we would like to measure gender segregation in the occupation distribution. For simplicity, assume there are four occupation categories: L, D, T, and S. Figure 3 presents three different examples of occupation distributions by gender: A, B, and C. The segregation index for all three scenarios is equal to 100 ($= 0.5 \cdot (|100 - 0| + |0 - 100|)$). According to the segregation index, these three distributions have the same level of gender segregation.

Figure 3: Convergence Measure Example



Let us add some structure and assume that L is Lawyers, D is Doctors, T is Teachers, and S is Secretaries. Lawyers and Doctors are highly-paid occupations while Teachers and Secretaries are lower-paid. Now it matters which occupations men and women are segregated into, and it is less clear that segregation is the same for these three distributions. Distributions A and B seem similar in that men are in high-paid occupations and women in low-paid occupations. In contrast distribution C is different, with both men and women in high-paid occupations (men are lawyers and women are doctors); somehow distribution C is less unequal or segregated than A or B because in C men and women are in similarly paid occupations.

The distinction between A and B on the one hand and C on the other arises because, when assessing the level of gender segregation, we inherently assign values to occupations.[18] The value induces an ordering and distance (metric) for the occupations, and how *far* we move matters. Figure 3 is drawn to reflect this ordering, with the occupations ordered along the x-axis according to the wage: Secretaries earn less than Teachers, Teachers less than Doctors, and Doctors less than Lawyers. The ordering and the distance in Figure 3 has meaning.

Consider again distributions A and B versus C. Distribution A is a society where all women are teachers and all men are lawyers. Lawyers and teachers are far apart, as measured by wage. For distribution B, men and women are also far apart. Distribution C, however, represents a world where men and women are closer. This is the sense in which distributions A and B are more segregated or divergent than distribution C; if we want to move men and women to be in the same occupation, for distribution C we don't have to move people very far (in terms of wages). To relate this to the segregation index, for gender inequality we care about *where* we move that 30 percent of women relative to where they came from. A woman moving from a low-wage, female-dominated occupation to a high-wage, male-dominated occupation would indicate more

[18] Wage is one example of a "value" of an occupation.

convergence (decreasing segregation) compared to moving her to a low-wage, male-dominated occupation.

The Earth Mover's Distance is a metric that incorporates the idea that we care about the distance moved. It measures the difference between two distributions by asking how we move one distribution (the women) to the other distribution (the men) and keeping track of *how far* the women have to be moved. In other words, the EMD is the minimal cost that must be paid to transform one distribution into the other. For example, say we have a male distribution of I graduate fields, $M = [m_1, \cdots, m_i, \cdots, m_I]$, and a female distribution of J graduate fields, $W = [w_1, \cdots, w_j, \cdots, w_J]$. To transform distribution M to distribution W, the EMD is defined as follows:

$$\text{EMD}(M, W) = \frac{\sum_{i=1}^{K} \sum_{j=1}^{K} d_{ij} f_{ij}}{\sum_{i=1}^{K} \sum_{j=1}^{K} f_{ij}} \tag{3}$$

where i, j denote graduate-field category for distributions M and W, respectively, d_{ij} is the distance between graduate-field categories m_i and w_j, and f_{ij} is the total number of people who are being moved between m_i and w_j.[19]

EMD measures where and how far probability mass must be moved when transforming the female into the male distribution, and so the ordering of categories is non-trivial. In my application, I order graduate fields by expected salary. I define a field's expected salary as the median salary for everyone who obtained a graduate degree in that field between 1962 and 1991. Because EMD considers categories that are further away from each other to have a higher "moving cost", the ordering by expected salary is a logical one.

5.2 Results

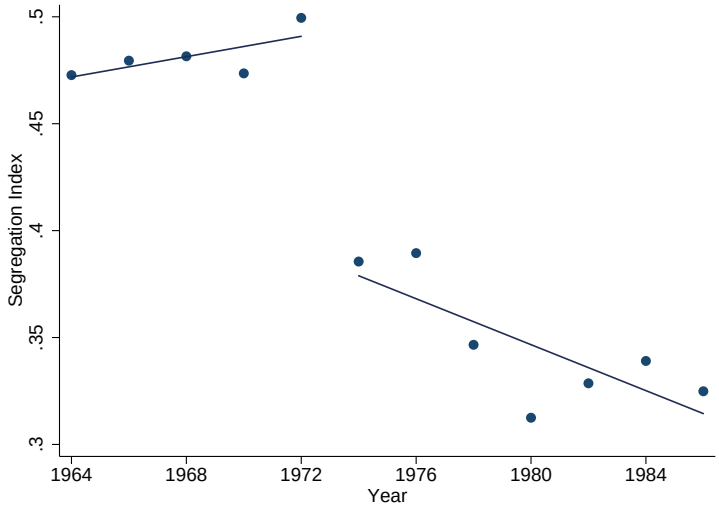
In this section, I provide graphical evidence of gender convergence in graduate-field distribution after Title IX's passage. Figure 4 plots the segregation index between the male distribution and the female distribution from 1964 to 1986. In 1964, the segregation index is 47 percent. This means that 47 percent of the women with graduate degrees would need to change their field of study in order to have the same overall graduate-field distribution as men. By 1986, the index drops down to 32 percent. There is a marked break in the segregation index between 1972 and 1974 as depicted by the solid lines. The solid lines in the graph are fitted linear trends allowing for a break. The break-point was found by looking for a structural break in the data (equation (1)). I find that the male and female distributions became 13 percentage-points more similar, as measured by the segregation index, after Title IX's passage. Notice that the timing is consistent with what we found in Figure 1. A majority of graduate degrees are master's degrees, so it is not surprising that we see a structural break in convergence trend starting with degrees that were conferred in spring 1974

[19] Appendix A describes EMD in more detail.

and spring 1975.[20]

Figure 5 compares distributional change as measured by the Segregation Index and EMD. Both convergence measures are normalized to their respective 1964 values. The two measures show the same picture. I find a structural break between 1972 and 1974 whether I use the Segregation Index or EMD. Both measures estimate that distributional convergence increased around 20 percent after Title IX's passage, relative to its 1964 value. EMD, however, estimates greater convergence. Considering how these two measures are calculated, this implies that most of the convergence were in fields that were further apart. I explore this further in Section 6. For the rest of my analysis, I report estimates using the preferred EMD measure.

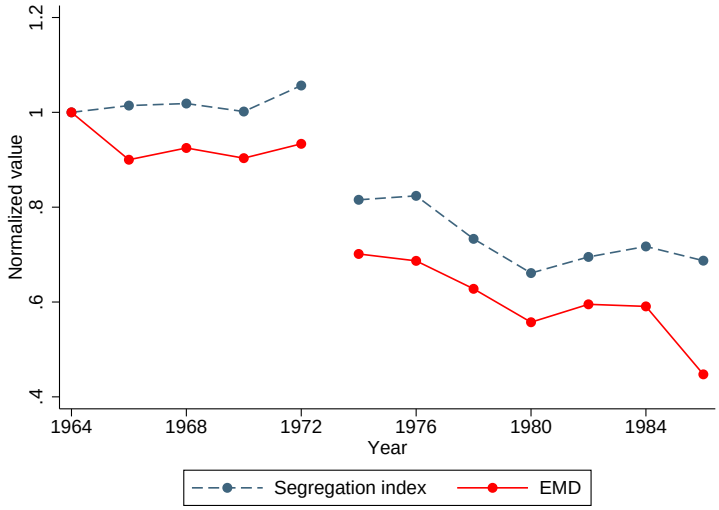
Figure 4: Level of Segregation between Female and Male Distributions



Source: NSCG 1993 data.
Note: The dots are mean values for each year. Lines are fitted linear trends allowing for a break between 1972-73 and 1974-75. The break year was determined by looking for a structural break in the data.

[20]The average share of graduate degrees that are master's degree is 75 percent between 1965 and 1981, and the range is 74 percent to 77 percent.

Figure 5: Female-Male Convergence in Graduate-Field Distributions



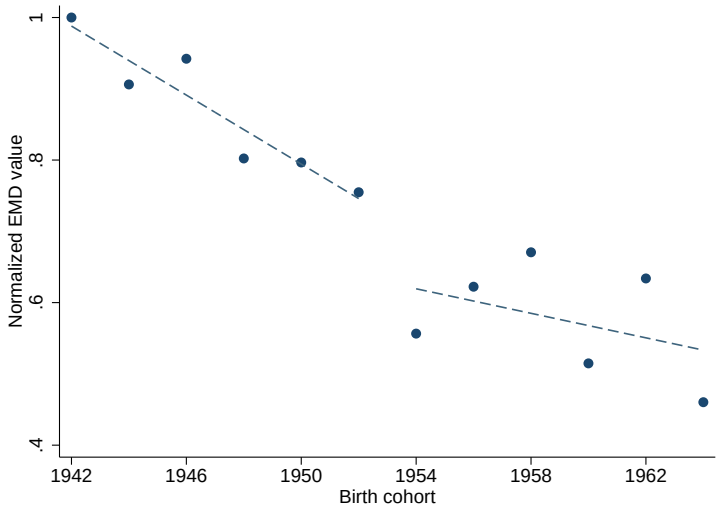
Source: NSCG 1993 data.
Note: Values are normalized to 1964-65, separately for Segregation Index and EMD. Lines are connected values allowing for a break between 1972-73 and 1974-75. The break year was determined by looking for a structural break in the data.

I also conduct an analysis by birth-cohort rather than degree-year. This specification will inform us which *cohort* was most affected by the Title IX policy. As a result, the interpretation differs slightly from the degree-year analysis. In the previous analysis, we see an immediate impact on earned degrees - as early as spring 1975. I argue that this is not surprising as there were many qualified female graduate school applicants who, prior to Title IX, would have been rejected solely on the basis of admissions quotas.

A cohort analysis, however, empirically assesses the impact of Title IX on an entire birth cohort. To the extent that a decision to pursue graduate studies in a particular field requires some advance planning and preparation, we expect that Title IX would impact younger cohorts through their human capital investments and decisions. In other words, we would expect initial effects of Title IX to be concentrated among freshmen and sophomores in college, who have time to react to the new policy, as opposed to juniors and seniors who would not be able to change their major or post-college plans as easily.

Figure 6 graphs the results. Consistent with my hypothesis, I find a structural break between cohorts born in 1952-1953 and 1954-1955. The first cohort (1952-53) turned 19-20 years old in 1972, and the second cohort (1954-55) turned 17-18 years old.

Figure 6: Female-Male Convergence by Birth Cohort



Source: NSCG 1993 data.
Note: Each dot is the normalized EMD distance between male and female distributions in that year. The dashed line is a fitted linear trend allowing for a break between 1952-53 and 1954-55 cohorts. The break-year was determined by looking for a structural break in the data.

Under the argument that Title IX was unexpected and sudden, our estimate from the degree analysis can be thought of as the impact on those who would have applied to graduate school in the absence of Title IX, whereas the estimate from the cohort analysis can be thought of as the impact on that group plus those who were induced to apply to graduate school as a result of Title IX. To use the language of the treatment effects literature, the former group is known as "always takers" and the latter group that was induced to apply to graduate school is known as "compliers". The cohorts born between 1942 and 1953 began their college years under the assumption that admissions quotas would still be operating when they graduated from college. Therefore, women who had applied to graduate school in the fall of 1972 and were accepted "randomly" when Title IX passed, can be thought of as a variant of an "always taker".[21]

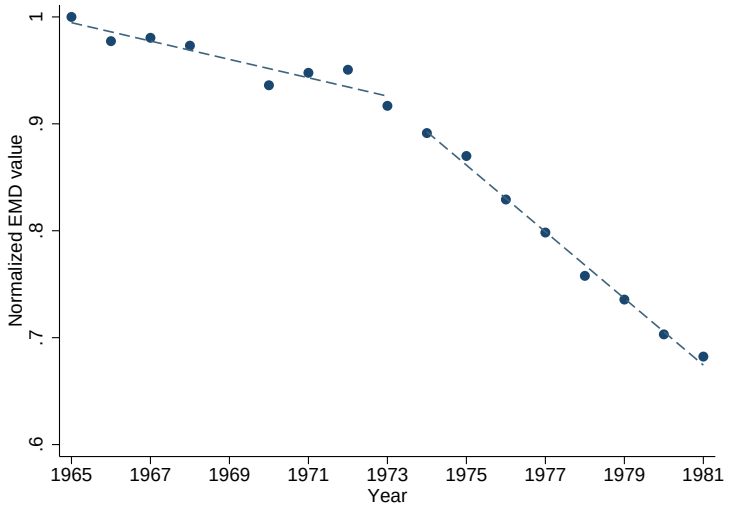
Last, I confirm my results by using administrative data on earned degrees and the specific fields by gender. Using HEGIS Earned Degrees data from 1965 to 1981, I estimate the EMD distance between male and female distributions of graduate degree-fields and plot them in Figure 7.[22] Similar to my analysis using NSCG data, I find that the two distributions were converging over time with a break between Fall 1973 and Fall 1974. This break-point coincides with the earliest year that we would expect to see a change in earned degrees post-Title IX. Before 1973, convergence moved more slowly relative to the period after 1973. For

[21]These women may also be considered compliers in terms of their decision to pursue graduate studies as Title IX's passage induced them to apply to graduate school the following fall. However, they would be restricted in the graduate field of study, which would most likely to similar to their undergraduate major choice. In terms of the graduate degree-field, therefore, these women can be considered as a type of "always taker".

[22]There are no data available for 1969.

example, the slope in the pre-Title IX period is -0.01, while the slope steepens to -0.03 in the post-Title IX period.

Figure 7: Female-Male Convergence using Administrative Data



Source: HEGIS 1965-1981 Earned Degrees data.
Note: Each dot is the normalized EMD distance between male and female distributions in that year. The dashed line is a fitted linear trend allowing for a break between 1973 and 1974. The break-year was determined by looking for a structural break in the data.

Title IX's passage can be used as a natural experiment or an instrument under the assumptions that it is relevant (it affected admissions rates for women), excludable (it did not directly affect the number of female graduate degrees except through its impact on admissions), and valid (it is uncorrelated with other determinants of female graduate degrees), These assumptions are trivially satisfied. Title IX explicitly addresses gender discrimination in graduate school admissions, and Section 3 provides evidence that female enrollment numbers increased relative to male's after its passage. Moreover, a review of the history of the passage of Title IX reveals that it was passed because of persistent gender discrimination in educational institutions. This invalidates the argument that other determinants of increased female graduate degrees, say a decreasing wage gap, is correlated with Title IX's passage. In fact, historical testimony shows the exact opposite. Therefore, these results can be interpreted as a causal estimate of the effect of the removal of admissions quotas for women on gender disparity in graduate education. More importantly, I get similar results despite using different analysis methods (Segregation Index vs. EMD) and data sources (NSCG data vs. HEGIS data).

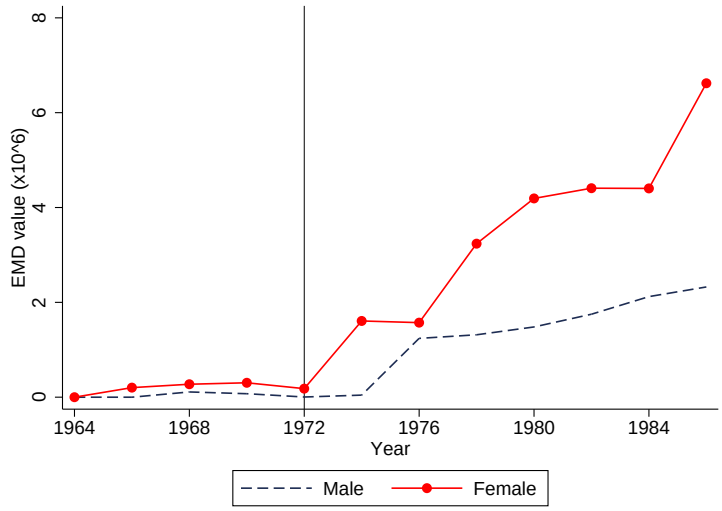
6 Unpacking Distributional Change

6.1 Female versus Male Movement

The previous section establishes a large, discrete, nationally-observed break in convergence between male and female graduate-field distributions. Here, I explore Title IX's effect at a more granular level. I am interested in unpacking the observed distributional changes to better understand the drivers of the observed change. As a first step, I examine whether the structural break is due to predominantly female movement, predominantly male movement, or both. I compare the female distribution of graduate fields to the female distribution from 1964-65, and similarly for the male distributions.[23]

Figure 8 tells us that gender convergence in graduate fields was driven by female movement. Larger EMD values relate to greater distributional divergence whereas smaller EMD values relate to distributional convergence. Prior to 1972, the female graduate-field distribution did not look very different from the distribution in 1964 and the same is true for males. After 1972, however, females and males begin entering different fields from their 1964-peers, but the change among females begins earlier and is larger.

Figure 8: Distributional Change in Graduate Fields by Gender



Source: NSCG 1993 data.
Note: This figure plots distributional change in graduate-field distributions relative to the 1964 distribution, separately for each gender. The vertical line depicts the year that Title IX was passed.

[23]This analysis is another advantage of EMD over the Segregation Index; we cannot do this with the segregation index because it uses absolute gender differences in its formula.

6.2 By Salary Tercile

In this section, I examine which degree-fields contributed to the observed distributional change. Since EMD orders degree-fields by salary in its calculation, I classify each field into terciles based on its expected salary.[24] I then estimate a difference-in-differences (DID) regression model, comparing the female-male difference in graduate degrees obtained before and after Title IX's passage. Because my DID methodology compares female degrees to male degrees, there is a mechanical relationship between the two especially when comparing gender differences within a particular degree field. To bypass this issue, I restrict my analysis sample to whites. Whites make up 90 percent of the NSCG sample allowing the white-male share to vary independently of the white-female share.

The regression model is as follows:

$$\begin{aligned} Y_{it}^c = {} & \beta_0^c + \beta_1^c \cdot F_i + \beta_2^c \cdot \mathbb{1}\{\texttt{Title IX}\} + \delta^c \cdot \Big(F_i \times \mathbb{1}\{\texttt{Title IX}\} \Big) \\ & + \tau_0^c \cdot t + \tau_1^c \cdot (F_i \times t) + + \tau_2^c \cdot \Big((t - \texttt{Title IX}) \times \mathbb{1}\{t > \texttt{Title IX}\} \Big) \\ & + \tau_3^c \cdot \Big(F_i \times (t - \texttt{Title IX}) \times \mathbb{1}\{t > \texttt{Title IX}\} \Big) + X'\gamma^c + \varepsilon_{it}^c \end{aligned} \tag{4}$$

where $Y_{it}^c = 1$ if individual i obtained a graduate degree in tercile c in year t, F_i is a female dummy; the indicator dummy, $\mathbb{1}\{\texttt{Title IX}\}$, is equal to 1 if the graduate degree was earned in 1974 or later and equal to 0 otherwise; X is a vector including fixed effects for the highest degree-granting school's region and birth-year. The parameter τ_0^c is a linear time trend for male graduate degrees, and τ_1 is the female-male difference in pre-trend. The parameter τ_2^c is the post-Title IX time trend for male degrees, and τ_3^c is the female-male difference in post-trend. The parameter of interest is δ^c, which gives us the female-male difference in graduate degrees in tercile c due to Title IX.

Before Title IX, 31 percent of men had a graduate degree, with 61 percent of these in the top salary tercile. Women, by contrast, were 38 percent less likely to hold a graduate degree in comparison with men, and two-thirds of their degrees were in the *bottom* salary tercile. If Title IX were successful in removing gender discrimination, which was more salient in more-lucrative fields, we would expect to see monotonically decreasing effects as we move from high to low salary terciles. Table 2 confirms this. Title IX led to a 14 percentage-point increase in female graduate degrees in the top salary tercile, relative to males'. By contrast, female graduate degrees in the bottom salary tercile dropped by 11 percentage-points, relative to males'. To understand the magnitude of these effects, consider the overall increase in female share in these fields. The share of female graduate degrees in the top salary tercile increased by 19.5 percentage-points between

[24] See Appendix A1 for the list of degree fields by tercile.

1964-72 and 1974-87. Title IX explains about 73 percent (= 14.3/19.5) of the growth in this tercile during this period.

The identifying assumption for DID is that the treatment group (white women) and the comparison group (white men) were exhibiting similar trends in the outcome variable prior to the treatment (Title IX's passage). This allows us to obtain counterfactual estimates of the treatment group's outcome in the absence of treatment. For the purposes of this study, this means that male share of graduate degrees should be on a similar trend as female graduate degrees before Title IX's passage. We see from Table 2 that this assumption holds; the coefficient on τ_1 is very small (from -0.7 percent to 0.6 percent) and is not statistically significant.

Table 2: Gender Difference in Graduate Degrees by Salary Tercile

Dependent variable: Graduate degree in tercile t before age 35			
Salary tercile	**Top (Highest)**	**Middle**	**Bottom (Lowest)**
	(1)	(2)	(3)
Female	13.32	-2.065	-11.26
	(8.710)	(3.694)	(8.878)
Title IX	-0.0445*	0.0156	0.0290
	(0.0239)	(0.0109)	(0.0205)
Female x Title IX	0.143***	-0.0355**	-0.107***
	(0.0274)	(0.0130)	(0.0246)
Time trend	-0.0160***	0.00646***	0.00955*
	(0.00448)	(0.00127)	(0.00465)
Female x Time trend	-0.00699	0.00107	0.00593
	(0.00442)	(0.00188)	(0.00451)
Post-Title IX time trend	0.00882	-0.00310	-0.00572
	(0.00508)	(0.00229)	(0.00508)
Female x Post-Title IX time trend	0.0140**	0.00406	-0.0181***
	(0.00537)	(0.00329)	(0.00533)
Male distribution of baseline outcome	0.609	0.118	0.273
Female distribution of baseline outcome	0.185	0.149	0.666
Observations	20,544	20,544	20,544
Controls	Yes	Yes	Yes

Source: NSCG 1993 data.
Notes: Analysis sample is restricted to whites who obtained a graduate degree before age 35. Salary terciles are created using the field's median salary between 1961-1991. Baseline outcome is the mean outcome before 1972. Controls include fixed effects for birth-year and the region of highest degree-granting school. Standard errors are in parentheses and are clustered by region. *** p< 0.01, ** p< 0.05, * p< 0.1

6.3 By Gender Parity

Admissions quotas for women existed across all graduate fields of study, but data and testimonies reveal that they were more egregious in some. This may be one explanation for why there were few women in law and engineering in 1970, as we saw in Table 1. If there were differing levels of discrimination across fields, then a removal of these barriers-to-entry would have differing effects by field. Specifically, one would expect Title IX to have larger effects on female degrees in fields where women faced greater discrimination and

smaller effects in fields with less discrimination.

Another explanation for low female representation in certain fields would be that female preferences differ from male preferences. That is, there may be few females in law or engineering because males differentially prefer these fields. If this were true, a removal of barriers-to-entry would have no effect on female share in these fields. That is, even if law school admissions quotas for women were removed, we would still see few women in law school, relative to men, because women have a distaste for law. In this section, I explore this issue further and examine whether Title IX had heterogeneous effects by gender parity. This also provides an indirect test for the presence of gender discrimination in graduate education.

I proxy for the level of gender parity in the degree field by using the field's average female share of degrees between 1962 and 1970 and categorize fields into terciles based on female share.[25] This list is highly correlated with the grouping by expected salary, indicating that graduate fields that were male-dominated were also the most lucrative. I estimate equation (4) separately for each gender-parity tercile and report results in Table 3.

Not only did Title IX decrease gender disparity most in fields where females were historically under-represented, but its effects decrease by increasing female representation. After Title IX, women are 9.5 percentage-points more likely than men to pursue male-dominated degrees, and 12 percentage-points less likely to pursue a female-dominated degree. If gender discrimination in graduate admissions existed and Title IX accomplished what it had set out to do, then these results and patterns are exactly what we would expect to see. Again, the pre-trends are not statistically significantly different between men and women, satisfying the DID assumption.

[25] Appendix A2 lists the fields that are in these three groups.

Table 3: Gender Difference in Graduate Degrees by Gender Parity

Dependent variable: Graduate degree in tercile t before age 35			
Gender parity tercile	**Top (M-dom.)**	**Middle**	**Bottom (F-dom.)**
	(1)	(2)	(3)
Female	1.008	14.94	-15.94
	(9.121)	(8.462)	(9.216)
Title IX	-0.0462*	0.0103	0.0359
	(0.0233)	(0.0226)	(0.0313)
Female x Title IX	0.0949***	0.0210	-0.116**
	(0.0202)	(0.0279)	(0.0366)
Time trend	-0.00562	-0.00904**	0.0147**
	(0.00522)	(0.00284)	(0.00584)
Female x Time trend	-0.000726	-0.00760	0.00833
	(0.00463)	(0.00430)	(0.00468)
Post-Title IX time trend	0.00748	0.00116	-0.00864
	(0.00514)	(0.00369)	(0.00493)
Female x Post-Title IX time trend	0.00403	0.0133**	-0.0173***
	(0.00703)	(0.00529)	(0.00487)
Male distribution of baseline outcome	0.483	0.255	0.262
Female distribution of baseline outcome	0.073	0.217	0.710
Observations	20,544	20,544	20,544
Controls	Yes	Yes	Yes

Source: NSCG 1993 data.
Notes: Analysis sample is restricted to whites who obtained a graduate degree before age 35. Gender parity terciles are created using the field's mean share of females between 1962-1970. Baseline outcome is the mean outcome before 1972. Controls include fixed effects for birth-year and the region of highest degree-granting school. Standard errors are in parentheses and are clustered by region. *** p< 0.01, ** p< 0.05, * p< 0.1

7 Alternative Explanations

In this section, I address alternative explanations that may have contributed to gender convergence in graduate education in the absence of Title IX. The 1960s and 1970s were a time of great social change so it is not hard to imagine that other factors may explain increased convergence in graduate-field distribution. Two events that are often cited as causes of change in female education and labor force behavior are increased access to birth control by young, single women in the late 1960s and the legalization of abortion in 1973. I will address both of these in turn.

7.1 Access to the Birth Control Pill

The introduction of the birth control pill in 1960 as an oral contraceptive was an important milestone in advancing female rights and civil liberties. It not only gave women sexual freedom, but it also lowered the cost of making long-term career investments. With greater certainty over the pregnancy consequences

of sex, women no longer needed to worry about an unintended pregnancy interrupting their education or career.

The concern in estimating a causal effect of Title IX is that young, single women gained access to the pill around the same time that Title IX was passed. When *Enovid* first became publically available, it was first available only to married women or to those above the age of majority. During the late 1960s, several states lowered their age of majority thereby granting a large set of young women access to the pill. These legal changes came about mainly in response to the discrepancy in minor's rights highlighted by the ongoing Vietnam War. In particular, 18-year old men were being drafted but were not allowed to vote until they were 21 (Paul, Pilpel, and Wechsler, 1974). Aside from changes in the age of majority, there were other legal ways that single, female minors could obtain the pill. Some states enacted a medical consent law that granted unmarried minors capacity to consent, while others had judicial or legislative recognition of a mature minor doctrine. Figure 9 illustrates each state's year of legal change granting 19 year olds pill access.

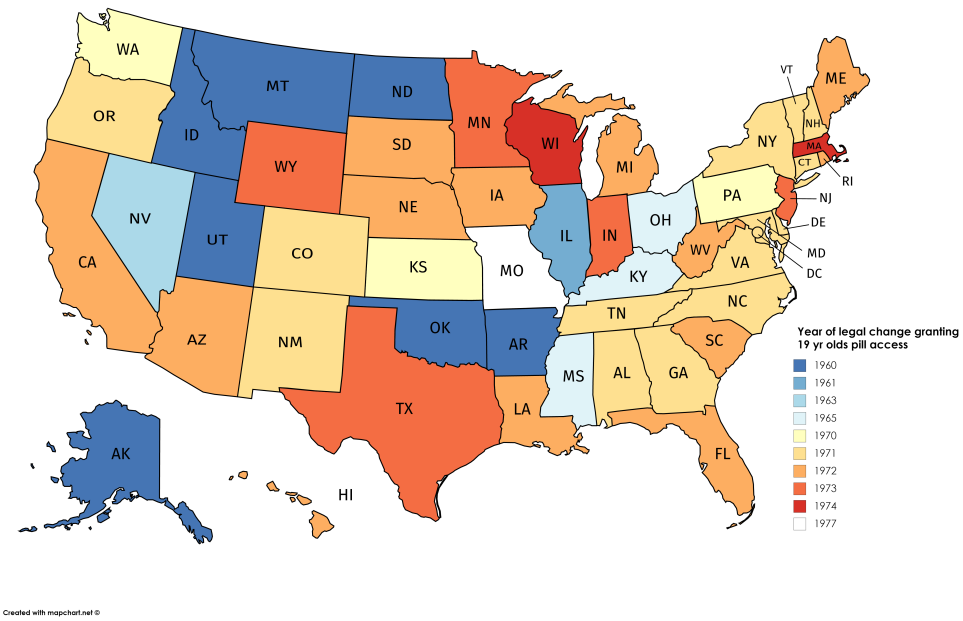
Although there is variation across states, a majority of states changed their law between 1971 and 1973. To examine whether my nationally-observed jump towards convergence is driven by these states, I drop them from my analysis sample and redo my analysis.[26] Figure 10 graphs the results using HEGIS Earned Degrees data.[27] The structural break is found after Title IX's passage, but it is one year earlier than the break-year found in the main analysis sample. One possible explanation for this is that these results are driven by states that changed their law in 1960.[28] To the extent that the pill affected female educational choices and graduate school aspirations, we would expect to see an earlier impact for this more motivated group.

[26] I consider five papers that exploit state-level variation in which minors gained access to the birth control pill (Myers, 2017). The legal codings used by these authors all differ. I drop the 30 states in which at least four of the five codings agree that the year of legal change for that state was between 1971 and 1973. These states are Alabama, Arizona, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Indiana, Iowa, Louisiana, Maine, Maryland, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, and West Virginia.

[27] I use HEGIS data for this analysis rather than NSCG data because the state restriction severely limits the number of observations in the NSCG data, which is a sample survey.

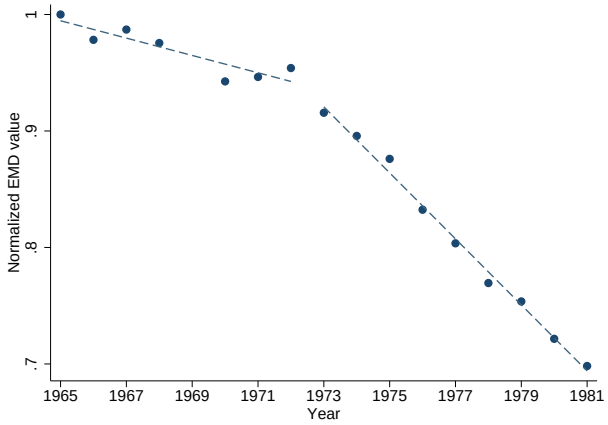
[28] Around 70 percent of conferred degrees in this analysis sample are from the seven states that granted legal access in 1960.

Figure 9: Year of Legal Change Granting 19 year olds Pill Access



Source: Myers (2017), Appendix Table A-1.
Note: This map displays the legal codings preferred by Myers (2017).

Figure 10: Gender Convergence After Dropping States with Legal Changes Between 1971-1973



Source: HEGIS 1965-1981 Earned Degrees data; Myers (2017), Appendix Table A-1.
Note: The sample is restricted to states that passed laws granting 19 year olds pill access before 1971 or after 1973. Values are normalized to 1965. Lines are fitted linear trends allowing for a break between 1972 and 1973. The break year was determined by looking for a structural break in the data.

7.2 Legalization of Abortion

A second alternative explanation to Title IX is the 1973 landmark U.S. Supreme Court case *Roe v. Wade* that legalized abortion. Just as the birth control pill lowered the cost of long-term investments for women, abortions gave women more choice and control over their lives. If a woman became pregnant while in college or graduate school, she would have had no choice but to drop out of her program. Therefore, by allowing females to terminate their pregnancies, we would expect *Roe v. Wade* to increase the number of female graduates. As a result, any positive, significant effects I see in my analysis would be due to both *Roe v. Wade* and Title IX.

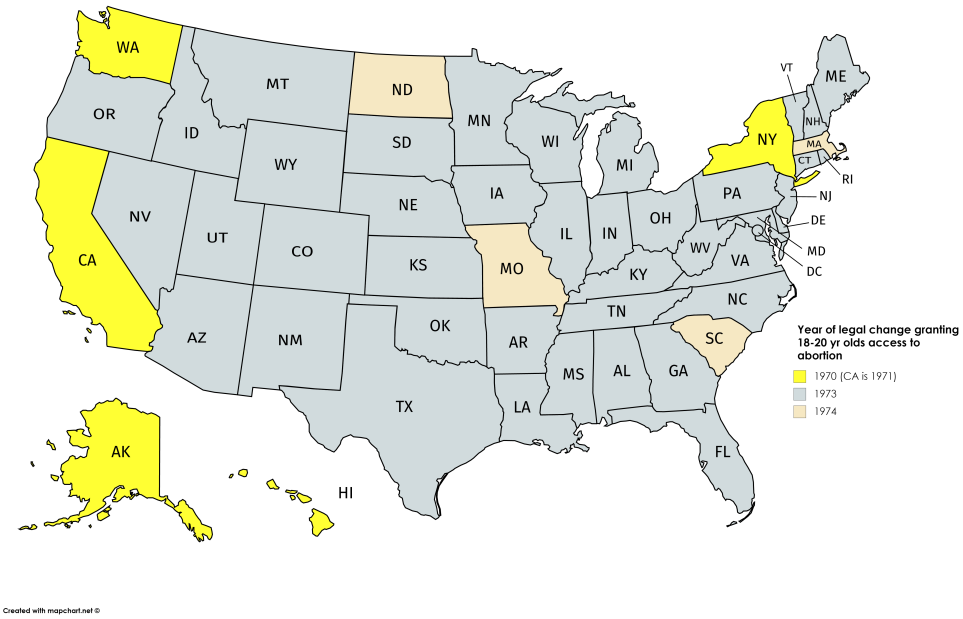
Unlike pill access, there is much less state variation in when single, college-aged women were able to obtain legal abortions. Figure 11 is very monochromatic as nearly all of the states legalized abortion in 1973. Fortunately, there are five states that legalized abortion in 1970-1971 (also known as "Repeal States").[29] To control for the potentially confounding effects of *Roe v. Wade*, which passed in 1973, I restrict my analysis to these five Repeal States.[30] Figure 12 plots the normalized EMD values for earned degrees in these five states and finds a structural break right after Title IX's passage. Similar to my results when controlling for pill access, I find that the structural break occurred one year earlier than in my main analysis. This is not surprising as these young women had access to legal abortions in 1970, three years before Title IX's passage. It is important to note that these five Repeal States are different from the states in my pill-access sample, so my results from this robustness check are not being driven by the same states.[31]

[29] Missouri, New York, North Dakota, South Carolina, and Washington legalized abortion in 1970. California legalized abortion in 1971.

[30] As with the pill analysis, I use HEGIS data for this robustness check as opposed to NSCG data due to the small sample size.

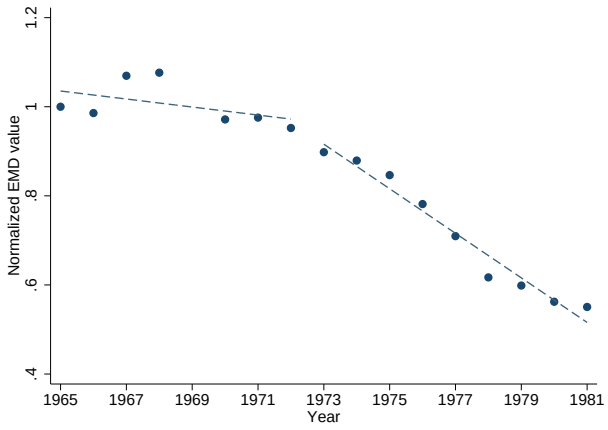
[31] The sates that are in both samples are Missouri, North Dakota, and Washington.

Figure 11: Year of Legal Change Granting 18-20 year olds Access to Abortion



Source: Myers (2016), Table 2.

Figure 12: Gender Convergence After Restricting Sample to Repeal States



Source: HEGIS 1965-1981 Earned Degrees data; Myers (2016), Table 2.
Note: The sample is restricted to the 5 repeal states that allowed 18-20 year olds to obtain abortions in 1970, before Title IX was passed. Values are normalized to 1965. Lines are fitted linear trends allowing for a break between 1972 and 1973. The break year was determined by looking for a structural break in the data.

In summary, I find that increased access to the birth control pill and abortion legalization, though they certainly affected female human-capital and labor-market decisions, were not the driving forces behind increased convergence between male and female graduate fields of study observed in the early 1970s.

8 Discussion

During the 1960s, there were essentially three career choices for women: nurse, secretary, or teacher. Graduate school admissions quotas largely prevented women from pursuing different career paths. Title IX of the Education Amendments of 1972 removed this barrier by making gender discrimination in admissions illegal. This paper provides evidence that legislation played a role in female higher-educational choices. My analysis finds that Title IX sped up the gradual change that was occurring in graduate education during this time.

Because Title IX is a national policy, it is difficult to find useful variation to measure the impact of the law. This is a concern if the law were anticipated or if it were passed in response to the changing social attitude at the time. However, graduate-school enrollment data reveal that enrollment patterns changed after discrimination became illegal. This is in line with historical accounts that state that the main impetus for Title IX's passage was gender discrimination in educational institutions. As a result, Title IX's passage can be thought of as a natural experiment. I find that its effect on graduate-field distribution was large, discrete, and nationally-observed. I also find that the distributional change was driven by a reduction in gender disparity among the most-lucrative fields, which also happen to be male-dominated. I specifically consider two alternative explanations that are often cited as causes of change in female education and labor force behavior and find they cannot fully explain my results. Ultimately, it is difficult to find causal factors other than Title IX that would have an effect focused so specifically on graduate-degree fields, and also limited so sharply to the years immediately surrounding the passage of Title IX.

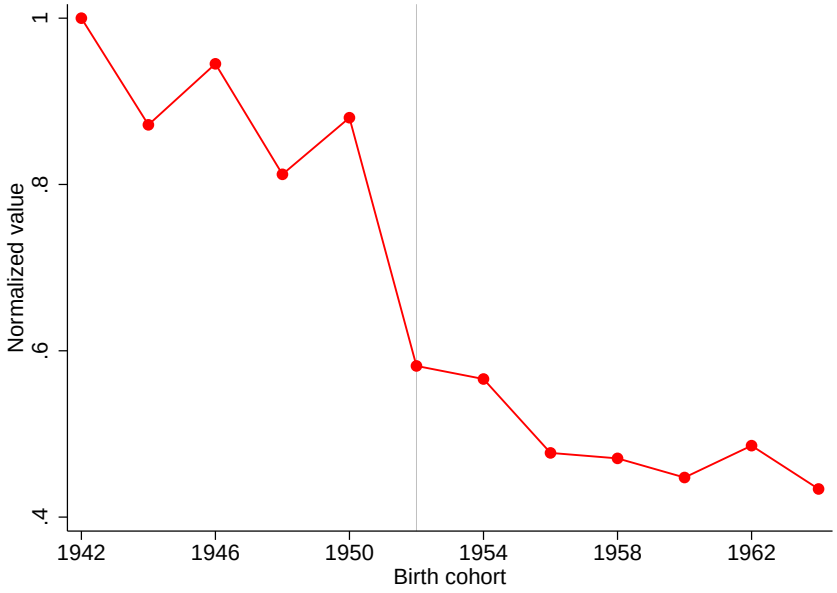
One interesting question is why Title IX was successful in reducing discrimination while past policies were not. One possible explanation is the existence of an enforcement mechanism. Although *Brown v. Board of Education* ruled that segregated schools is unconstitutional, it offered no guidelines on how to comply with the ruling. In contrast, compliance regulations for Title IX were clearly stated and communicated to all schools, which may have strengthened the policy's effect. For example, after Title IX regulations were signed into law, the HEGIS Fall Enrollment Survey, which had been administered to all U.S. post-secondary institutions since 1968, included a page that clearly states that completion of the survey is mandatory for "all institutions of higher education which receive, are applicants for, or expect to be applicants for Federal financial assistance" (Codebook for HEGIS 1976 Fall Enrollment Survey). The data also support this theory; institutions who relied more on federal funding had larger female enrollment growth rates (see Figure 2).

As one's occupation is closely related to one's graduate degree, a natural question is whether Title IX had any second-order effects on the occupational distribution. There are two reasons one may expect to see increased convergence in occupations as a result of Title IX. First, high-paying occupations are more likely to

require additional training. For example, law and healthcare practitioners - two of the top ten occupations in terms of median hourly wage - require graduate degrees.[32] Second, I find that Title IX increased the relative number of female graduate degrees in more-lucrative fields (see Table 2). As women pursue graduate degrees in increasing numbers, their return on human capital investment increases, also increasing the opportunity cost of not joining the labor force.

Figure 13 plots the EMD values for occupational distributions by birth cohort. Following my previous analysis, I focus on birth cohorts between 1942 and 1964 and collapse the data into two-year cohort cells. I use each cohort's occupation between ages 35 and 39 and aggregate them into the 25 major categories as classified by the Census Bureau. For the EMD calculation, I order occupations by their median hourly wage for full-time workers aged 18-55 between 1960 and 1990.

Figure 13: Female-Male Convergence in Occupation Distributions



Source: 1960-2000 Census data; 1965-1999 CPS data.
Note: The sample is restricted to all persons aged 35-39 and born between 1942-1964. Values are normalized to 1942-43 birth cohorts.

We see a general trend towards male and female convergence in the earlier cohorts, but there is a marked break in the trend starting with the 1952-53 cohort (denoted by the vertical gray line). This cohort were juniors and seniors in college when Title IX was passed, which is consistent with the results of my main analysis. Specifically, EMD estimates around 30 percent *greater* convergence in the occupational distributions starting with the cohort that was first exposed to Title IX.

[32]Hourly wage is calculated using 1960-1990 Census data and 1965-1989 CPS data for all full-time workers between the ages of 18 and 55. Occupations are aggregated into 25 major categories as defined by the 2010 census occupational system. See `https://usa.ipums.org/usa/volii/occ_acs.shtml` for these categories.

This result is consistent with a paper by Hsieh and co-authors (2016), which examines how female-male occupational convergence between 1960 and 2008 affected growth in aggregate output per worker. The authors find that one-quarter of growth in US GDP per person can be explained by declining labor market discrimination and barriers to human capital attainment, and that declining obstacles to accumulating human capital were more important than declining labor market discrimination. The authors define declining human capital barriers broadly as decreased monetary costs associated with accumulating occupation-specific human capital, and so do not distinguish between Title IX's passage, which banned the use of admissions quotas in graduate schools, and medical advancements in contraception such as the birth control pill. One contribution of my paper is the examination of the removal of a specific human capital barrier (Title IX) and its resulting impact. In terms of policy implications geared towards reducing gender disparity in labor outcomes, this paper provides optimistic evidence for the role of legislation.

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Appendix

A The Earth Mover's Distance (EMD) Algorithm

The Earth Mover's Distance is a metric that measures the difference between two distributions that considers both within-bin and cross-bin differences. In a nutshell, it is the minimal cost that must be paid to transform one distribution into the other. Computation of EMD is borne from the transportation problem. Suppose that several suppliers, each with a given amount of goods, are required to supply several consumers, each with a given limited capacity. For each supplier-consumer pair, the cost of transporting a single unit of goods is given. The transportation problem is then to find a least-expensive flow of goods from the suppliers to the consumers that satisfies the consumers' demand. The following formalization of EMD is reproduced from Rubner, Tomasi, and Guibas (2000) for the reader's convenience. The notation has been adapted to apply to the context of occupational convergence.

The computation of EMD can be formalized by the following linear programming problem:

Let

$$M = \{(m_1, s_1^m), \cdots, (m_K, s_K^m)\}$$

be the male occupation distribution with K occupation categories, where m_i is occupation i and s_i^m is the share of males in occupation i.

Analogously, let

$$W = \{(w_1, s_1^w), \cdots, (w_K, s_K^w)\}$$

be the female occupation distribution with K occupation categories; and let $\mathbf{D} = [d_{ij}]$ be the difference matrix where d_{ij} is the difference between occupations m_i and w_j, that minimizes the overall cost

$$WORK(M, W, \mathbf{F}) = \sum_{i=1}^{K} \sum_{j=1}^{K} d_{ij} f_{ij},$$

subject to the following constraints:

$$
\begin{aligned}
f_{ij} &\geq 0, \quad 1 \leq i \leq K, \quad 1 \leq j \leq K && (5)\\
\sum_{i=1}^{K} f_{ij} &\leq s_i^m, \quad 1 \leq i \leq K && (6)\\
\sum_{j=1}^{K} f_{ij} &\leq s_i^w, \quad 1 \leq j \leq K && (7)\\
\sum_{i=1}^{K}\sum_{j=1}^{K} f_{ij} &= \min\left(\sum_{i=1}^{K} s_i^m, \sum_{j=1}^{K} s_i^w\right) && (8)
\end{aligned}
$$

Constraint (5) allows moving people from M to W and not vice versa. Constraint (6) limits the number of males who can be moved in an occupation to their share (i.e., if 30 percent of males are doctors, the number of male doctors who can be moved to another occupation is limited to that 30 percent). Constraint (7) is the analog for occupation categories in F; and constraint (8) forces to move the maximum number of people possible. This maximum number is called the total flow. Once the transportation problem is solved, and the optimal flow F is found, the earth mover's distance is defined as the resulting work normalized by the total flow:

$$EMD(M, F) = \frac{\sum_{i=1}^{K}\sum_{j=1}^{K} d_{ij} f_{ij}}{\sum_{i=1}^{K}\sum_{j=1}^{K} f_{ij}}$$

The normalization factor is the total weight of the smaller distribution, because of constraint (8). Thus, the EMD naturally extends the notion of the dissimilarity between two distributions.

Table A1: List of Major Fields of Study by Salary Tercile

Fields in the Top Tercile
Architecture and Related Services
Business, Management, Marketing, and Related Support Services
Computer and Information Sciences and Support Services
Engineering
Engineering Technologies and Engineering-Related Fields
Health Professions and Related Programs
Legal Professions and Studies
Mathematics and Statistics
Physical Sciences
Social Sciences
Fields in the Middle Tercile
Agriculture, Agriculture Operations, and Related Sciences
Area, Ethnic, Cultural, Gender, and Group Studies
Biological and Biomedical Sciences
Communication, Journalism, and Related Programs
History
Homeland Security, Law Enforcement, Firefighting and Related Protective Services
Natural Resources and Conservation
Psychology
Public Administration and Social Service Professions
Fields in the Bottom Tercile
Education
English Language and Literature/Letters
Family and Consumer Sciences/Human Sciences
Foreign Languages, Literatures, and Linguistics
Liberal Arts and Sciences, General Studies and Humanities
Library Science
Parks, Recreation, Leisure, and Fitness Studies
Philsophy and Religious Studies; Theology and Religious Vocations
Visual and Performing Arts

Source: NSCG 1993 data.

Table A2: List of Major Graduate Fields of Study by Gender Parity

Fields in the Top Tercile (Lowest 1962-1970 Female Share)
Agriculture, Agriculture Operations, and Related Sciences
Architecture and Related Services
Business, Management, Marketing, and Related Support Services
Computer and Information Sciences and Support Services
Engineering
Engineering Technologies and Engineering-Related Fields
Homeland Security, Law Enforcement, Firefighting and Related Protective Services
Legal Professions and Studies
Philsophy and Religious Studies; Theology and Religious Vocations
Physical Sciences
Fields in the Middle Tercile
Biological and Biomedical Sciences
Communication, Journalism, and Related Programs
Health Professions and Related Programs
History
Mathematics and Statistics
Natural Resources and Conservation
Parks, Recreation, Leisure, and Fitness Studies
Social Sciences
Visual and Performing Arts
Fields in the Bottom Tercile (Highest 1962-1970 Female Share)
Area, Ethnic, Cultural, Gender, and Group Studies
Education
English Language and Literature/Letters
Family and Consumer Sciences/Human Sciences
Foreign Languages, Literatures, and Linguistics
Liberal Arts and Sciences, General Studies and Humanities
Library Science
Psychology
Public Administration and Social Service Professions

Source: NSCG 1993 data.