The Effect of Title IX on Gender Disparity in Graduate Education*

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Abstract

This paper examines whether legislation was effective in eliminating discrimination in education. The striking and new finding of my analysis is the sharp and dramatic convergence of female versus male graduate-degree fields coincident with the passage of Title IX in 1972, which banned gender discrimination in graduate admissions. This distributional change occurred as females predominantly moved into male-dominated fields, but it 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 right after Title IX. In addition to providing definitive 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

During the 1960s, there were essentially three career choices for women: nurse, secretary, or teacher. Admissions quotas discriminated against women who wanted to pursue a different career path. Title IX of the Education Amendments of 1972 partially removed these barriers by making gender discrimination in admissions, as well as other areas of education, illegal. This allowed women to pursue degree fields - and thus, occupations - previously open mainly to men, such as law and medicine. Granting women access to high-skilled occupations, which were also the highest-paid occupations, not only reduces gender disparity in graduate degrees and occupations but also increases the expected returns of their human capital investment, further encouraging college matriculation. This paper examines whether Title IX reduced gender disparity in graduate education.

It is not obvious that Title IX would have an observable and immediate impact on graduate education. After all, research on the effectiveness of civil rights legislation is sparse. The notable exceptions are Heckman and Payner (1989), which found that Title VII of the 1964 Civil Rights Act had a sizeable 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. On the other hand, historical accounts during the 1960s reveal that gender discrimination in education was widespread and that there were many qualified female students wanting to further their education who were prevented from doing so. If there were ever a time for policy-makers to make an impact, this was it. The primary goal of this paper is to empirically assess whether legislation was successful in eliminating discrimination in graduate education.

There is one important identification concern that warrants discussion. Since 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, we would not have an estimate of the sole impact of Title IX. In the former, we would have a biased estimate as universities would have changed their admissions policies in anticipation of the new law (also known as Ashenfelter's Dip). In the latter, we would be unable to disentangle the trend from the impact.

These concerns are mitigated when we study the history behind Title IX's passage. The law came at a time when women's rights were expanding, but the main impetus was persistent gender discrimination in educational institutions. This is supported by graduate-school enrollment data, which show that schools were discriminating against female applicants right up until it became illegal. Because Title IX's passage was not influenced by other factors determining female educational choices, like a decreasing gender wage gap, and it directly affected female graduate degrees, its passage can be viewed as a natural experiment.

The striking and new finding of my analysis is the sharp and dramatic convergence of female versus male garduate-degree fields coincident with the passage of Title IX. 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 bins people move out of and into, and, more importantly, the distance between bins (using expected wage 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 distributional convergence was driven by sex-composition effects as females predominantly moved into male-dominated fields after Title IX. This finding is consistent with the hypothesis that barriers were the cause of gender disparity in degree fields rather than gender-specific preferences. Last, I find that female growth was concentrated in fields in the top salary tercile. This suggests an indirect role that Title IX played on the labor market. Title IX led to higher expected returns on human capital investment for women, thereby encouraging labor market participation and entry into high-skilled, highly-paid occupations there were also previously male-dominated.

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 cannot explain the large, national shift in graduate-field distribution that occurred between 1972-73 and 1974-75. I explicitly consider two possible explanations that are often cited as causes of change in female education and labor force behavior. The first is young, single women's increased access to the birth control pill in the late 1960s. The concern is that college-aged women gained access later than their married or older peers, thereby convoluting the effect of Title IX with access to the pill. As a robustness check, I restrict my analysis sample to states where college-aged girls or younger were able to legally obtain the pill before Title IX's passage and find my results hold. This means that pill access is not driving my results as, even in states where young girls always had access to pill, Title IX had an effect on their graduate-degree choices. Second, I examine the legalization of abortion. Although it was legalized nationally by the Supreme Court in 1973, abortions were legal in several states prior to the court case. I argue that the legalization of abortion is not a major confounding event as females had access to abortion before *Roe v. Wade*. However, as a robustness check, I control for state-specific abortion access and find similar results.

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 & Orleans, 1973; Stromquist, 1993; Valentin, 1997; DOJ, 2012; Mason & 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.

One of the biggest puzzles in labor economics over the past 60 years is the catch-up and over-taking by American women of American men in college attendance and graduation. Despite an extensive literature, 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 & Katz, 2002; Bailey, 2006; Goldin, Katz, & Kuziemko, 2006; Blau & Kahn, 2016). These explanations attest to a gradually changing world and female view during this era. However, this paper suggests that policy may have also played an important role in the reversal of the college gender gap.

As one's degree of study is closely linked to one's occupation, this paper also relates to literature on gender convergence in the occupational distribution over the past 50 years and the large-scale movement of women into the U.S. labor market more generally (Polachek, 1981; Blau, Simpson, & Anderson, 1998; Blau, Ferber, & Winkler, 2014; Olivieri, 2014; Pan, 2015). Much of this literature focuses on demand factors, specifically the decreasing gender wage gap (Heckman & Sedlacek, 1985; Smith & Ward, 1985, 1989; Blau & Kahn, 1997, 2000, 2006; Black & Juhn, 2000; Mulligan & 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 & Evans, 1998; Goldin & 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 played a role in 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 & Denton, 1988) to occupational segregation (Blau, Brummund, & Liu, 2013) to income-achievement gaps (Nielsen, 2015). As such, the literature on convergence measures is long and ever-growing (Duncan & Duncan, 1955; Taeuber & Taeuber, 1976; Cowell, 1985; Massey & Denton, 1988; Ruber, Tomasi, & Guibas, 2000; Reardon & Firebaugh, 2002; Reardon, 2009). I contribute to this literature by introducing a well-known measure in computer science, the Earth Mover's Distance algorithm, and applying it to an economics question. As mentioned before, 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 describing the status of women in education and the forces that led to the passage of Title IX in 1972. I also discuss its scope and compliance regulations. Section 3 describes the data and summary statistics, and Section 4 outlines the empirical methodology. Section 5 discusses alternative explanations. Sections 6 and 7 describe the effect of Title IX on graduate-field distribution and on graduate degrees and fields of study, respectively. I discuss implications from my results in Section 8 before concluding.

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 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).

In regards to discrimination in admissions, three clear facts 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). 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). Studies of the status of women at Cornell University found that "there were quotas on women applicants operating at all the schools" (Discrimination Against Women, 1970, p. 1077). The Dean at Harvard Law School announced to the class of 1967 that female enrollment at Harvard Law had reached 5 percent for each class and would probably stay there 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 (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). Considering that female applicants were more qualified than male applicants, admission criteria that is based on merit 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% of the applications to the School of Journalism at Columbia were female and 20% 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 there being a lack of accurate data on attrition rates for both male and female students. 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 more frequently than men stop at the master's level but the reasons for doing so are widely varied – including inadequate performance for the PhD – whereas men are more likely to stop because of poor performance (Discrimination Against Women, 1970, p. 806). The Report also found that women at the University of Chicago have high career commitment. The questionnaire found that 92% of women want to have a career compared to 81% of men (Discrimination Against Women, 1970, p. 867). Relatedly, 62% of women respondents would be "very disappointed" if they left school before completing their education compared to only 53% of men (Discrimination Against Women, 1970, p. 871). In summary, admissions quotas in graduate schools discriminated against highly-qualified female applicants who were also committed students. Therefore, when Title IX banned gender discrimination in graduate-school admissions, the effect on female enrollment would be immediate and consequential.

2.2 Title IX, Regulations, and Compliance

On June, 23, 1972, Title IX was signed into law by President Richard Nixon. 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 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 (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 it had been three years since Title IX was passed. Without these regulations, did universities and colleges have an incentive to comply? Testimony from the 1975 Congressional Hearings before the Subcommittee on Postsecondary Education indicate yes.

The 1975 Congressional Hearings 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, even though the regulations had not be been passed and therefore Title IX technically could not be enforced, "many institutions [had] already begun to respond to the spirit of Title IX" (Sex Discrimination Regulations, 1975, p. 416). The data agree. Panel A of Table 1 lists first-year enrollment in medical school from academic years 1960-70 to 1983-84. Although the number of female enrollment increased each year, the largest increase is in the academic year 1972-1973, the year after Title IX was passed. More importantly, male enrollment dropped drastically from 6-7 percent to a stagnant 1 percent, on average, after Title IX. Panel B lists first-year enrollment numbers in law school over the same time period. Similar to the medical school numbers, the largest increase in female enrollment is in 1973-1974 and male growth becomes negative after 1972-1973. The evidence indicates that universities responded immediately to Title IX, and that there were enough qualified female applicants to meet the demand.

Table 1: First-Year Medical School and Law School Enrollment and Growth Rates

Panel A: Medical School Enrollment

Academic	First-Year Enrollment			Growth Rate		
Year	Total	Male	Female	Total	Male	Female
1969-70	10,422	9,474	948			
1970-71	11,348	10,092	1,256	9%	7%	32%
1971-72	12,361	10,668	1,693	9%	6%	35%
1972-73	13,677	11,377	2,300	11%	7%	36%
1973-74	14,159	11,369	2,790	4%	0%	21%
1974-75	14,763	11,488	3,275	4%	1%	17%
1975-76	15,295	11,648	3,647	4%	1%	11%
1976-77	15,613	11,755	3,858	2%	1%	6%
1977-78	16,136	12,006	4,130	5%	3%	13%
1978-79	16,501	12,339	4,162	2%	3%	1%
1979-80	16,930	12,217	4,713	3%	-1%	13%
1980-81	17,186	12,220	4,966	2%	0%	5%
1981-82	17,286	11,951	5,317	1%	-2%	7%
1982-83	17,254	11,792	5,462	0%	-1%	3%
1983-84	17,150	11,497	5,653	-1%	-3%	3%

Panel B: Law School Enrollment

Academic	First-Year Enrollment			Growth Rate		
Year	Total	Male	Female	Total	Male	Female
1969-70	29,128	27,025	2,103			
1970-71	34,289	30,747	3,542	18%	14%	68%
1971-72	36,171	31,845	4,326	5%	4%	22%
1972-73	35,131	29,623	5,508	-3%	-7%	27%
1973-74	37,018	29,554	7,464	5%	0%	36%
1974-75	38,074	29,068	9,006	3%	-2%	21%
1975-76	39,038	28,566	10,472	3%	-2%	16%
1976-77	39,996	28,642	11,354	2%	0%	8%
1977-78	39,676	27,748	11,928	-1%	-3%	5%
1978-79	40,479	27,155	13,324	2%	-2%	12%
1979-80	40,717	27,227	13,490	1%	0%	1%
1980-81	42,296	27,024	15,272	4%	-1%	13%
1981-82	42,521	26,710	15,811	1%	-1%	4%
1982-83	42,034	25,898	16,136	-1%	-3%	2%
1983-84	41,159	25,110	16,049	-2%	-3%	-1%

Source: *Panel A* - HHS, 1984, p. 112 (Table 48). *Panel B* - ABA.

3 Data and Summary Statistics

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.[1] 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).[2]

This paper focuses on graduate degrees for two reasons. First, gender discrimination in admissions was more egregious at the graduate-school level, even though it also existed in undergraduate admissions. Second, the NSCG 1993 survey does not differentiate between public colleges and private colleges - an important distinction since Title IX applied only to *public* undergraduate institutions. Luckily, Title IX applied to all graduate institutions. Table 2 provides a sense of the status of education before Title IX. In 1965, there were about almost 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 percent. By contrast, only 1.9 percent of females are in business school and 2.5 percent are pursuing an 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.

[1] 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.

[2] 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.

Table 2: 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.

4 Empirical Methodology

4.1 Convergence measures

I use two different methods to measure gender convergence in graduate-field distribution. 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 & Denton, 1988) to gender segregation in occupations (Blau, Brummund, & Liu, 2013). It is calculated as

follows:

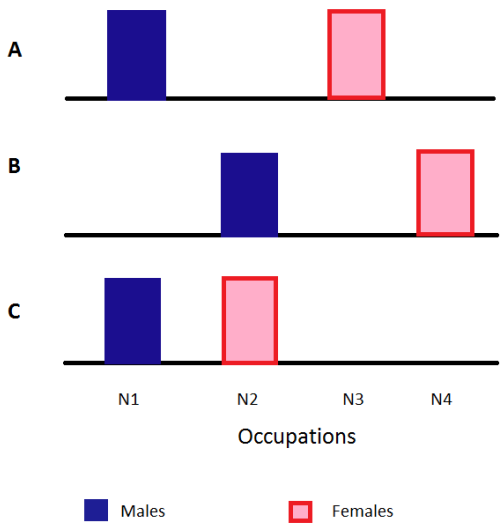
$$S_t = (0.5) \cdot \sum_i |m_{it} - f_{it}| \tag{1}$$

where m_{it} is the share of all male graduate students in 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 graduate-field distributions of men and women to be the same. 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 and smaller values indicate greater integration.

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 no constraint on where you move these women (men) or where you take them from. In some cases, however, this is an important detail. I illustrate my point with a simple hypothetical example below.

Say we would like to measure gender segregation in the occupation distribution. For simplicity, assume there are four occupation categories: N1, N2, N3, and N4. Figure 1 presents three different sets of occupation distributions by gender: A, B, and C. The segregation index for all three scenarios is equal to 100. According to the segregation index, these three distributions have the same level of gender segregation.

Figure 1: Segregation Index Example



Now, say that N1 is Lawyers, N2 is Doctors, N3 is Teachers, and N4 is Secretaries. Would you say that

gender segregation is equal across all three scenarios? No, right? Distribution A and Distribution B seem pretty similar, but Distribution C, where all men are lawyers and all women are doctors, is quite different from the other two. The reason is that, when assessing the level of gender segregation, we inherently assign values to each occupation category. For example, in a society where all men are lawyers, there is less resulting gender segregation if a female secretary becomes a doctor than if she became a teacher. Put another way, there is a non-constant "cost" to move an individual to different occupations. Specifically, it is more "costly" to move from secretary to lawyer than it is to move from secretary to teacher. This cost is something that I would like to incorporate in my convergence measure. To relate this to the segregation index, we care where we move the 30 percent of women (or men). This is an important detail for this case as we are studying discrimination and the fact that women were barred from entering certain fields and subsequently, occupations. Therefore, a woman moving to an occupation from which she was previously banned would indicate greater integration in comparison with her moving to an occupation that was still female-dominated.

The Earth Mover's Distance is a metric that measures the difference between two distributions by taking into account both within-category and cross-category differences. It is the minimal cost that must be paid to transform one distribution into the other. For example, to transform distribution M to distribution F, the EMD is defined as follows:

$$EMD(M,F) = \frac{\sum_{i=1}^{K}\sum_{j=1}^{K} d_{ij} f_{ij}}{\sum_{i=1}^{K}\sum_{j=1}^{K} f_{ij}} \tag{2}$$

where i, j denote graduate-field category for distributions M and F, 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. Appendix A describes EMD in more detail. Because EMD considers cross-category differences, the ordering of categories is non-trivial. In my application, I order graduate fields by decreasing 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.[3]

4.2 Gender convergence in graduate-field distribution

I estimate the following regression to obtain statistical estimates of Title IX's impact on graduate-field distribution:

$$Y_t = \beta_0 + \delta \cdot \mathbb{1}\{\texttt{Title IX}\} + \tau + \varepsilon_t \tag{3}$$

[3] An alternative method of ordering graduate fields is by gender-parity. I redo my distributional analyses using this alternative method of ordering and find similar results. See the Online Appendix for results.

where Y_t is the gender convergence measure in year t (either segregation index or EMD), $\mathbb{1}\{\texttt{Title IX}\}$ is an indicator dummy if year t is 1974-75 or later, and τ is a quartic time trend. The parameter of interest is δ, which tells us if there is a discrete break in convergence measure between the years 1972-73 and 1973-74. For the distributional analysis, I collapse my data into two-year cells to reduce noise.

Title IX became law in July 1972, which means the earliest observed impact would be on two-year master's degrees, in 1974. Most studies on the effectiveness of new laws find a lagged impact due to an adjustment period allowing for institutions to conform to new regulations and/or people to learn about the new law and adjust their behavior accordingly. But in the case of Title IX, an immediate effect would not be surprising as (1) there were a number of qualified female applicants who were previously being rejected, and (2) changing admissions quotas is costless and universities complied immediately.[4]

Under the assumptions that Title IX is relevant (it affected admissions rates for women), excludable (it did not directly affect the graduate degrees except through its impact on admissions), and valid (it is uncorrelated with other determinants of female graduate degrees), its passage can be used as a natural experiment or an instrument to recover the effects of the removal of admissions quotas for women on gender disparity in graduate education. These assumptions are trivially satisfied. Title IX explicitly addresses gender discrimination in graduate schol admissions, and Table 1 shows 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 Title IX 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 show the exact opposite.

Table 3: LATE Framework

		Counterfactual World without Title IX		**World with Title IX**	
Sub-group	**Group**	**BA**	**Grad. degree**	**BA**	**Grad. degree**
1	Always taker	X	X	X	X
2	Complier			X	
3	Complier	X		X	X
4	Complier			X	X
5	Defier	X	X	X	
6	Defier	X	X		
7	Defier	X			
8	Never taker	X		X	
9	Never taker				

It is an informative exercise to think about our analysis in a LATE framework. There are four instrument-dependent groups of the population known as "always taker", "never taker", "complier", and "defier". These

[4]See Section 2 and Table 1.

four groups can be further classified into nine different sub-groups, defined by the manner in which individuals react to Title IX's passage (see Table 3). An "X" indicates that an individual's educational attainment. For example, sub-group 1 depicts an individual who has a BA and a graduate degree in the absence of Title IX, and would also have a BA and a graduate degree in a world with Title IX. Because his behavior is not affected by Title IX, this individual is defined as an "always taker". As the NSCG surveys all individuals with a bachelor's degree, my analysis can only say something about first eight sub-groups (sub-group (9) drops out). If I further assume there are no defiers, then my sample is reduced to 5 sub-groups: (1), (2), (3), (4), and (8).

4.3 Gender disparity in graduate education

I also examine Title IX's impact on gender disparity at a more granular level. Whereas the previous methodology looks at change in the distribution of graduate fields of study, my aim here is to unpack the distributional change into degree-specific and field-specific changes. I run the following difference-in-differences regression:

$$Y_{it} = \beta_0 + \beta_1 \cdot F_i + \beta_2 \cdot \mathbb{1}\{\texttt{Title IX}\} + \delta \cdot \left(\mathbb{1}\{\texttt{Title IX}\} \times F_i \right) + X'\gamma + \varepsilon_{it} \tag{4}$$

where Y_{it} denotes the educational outcome for individual i in year t, which is restricted to graduate degrees obtained by age 35.[5], F_i is a female dummy, X is a vector including highest-degree-granting school's region, birth-year fixed effects, and a quartic time trend. 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 if the degree was earned before 1972. The parameter of interest is δ, which gives us the female-male difference in educational outcome due to Title IX. To relate this to the LATE framework, the DID methdology compares outcomes from the pre-Title IX group, sub-group (8), to the post-Title IX group, sub-groups (2), (5), and (8). The estimate on the impact of Title IX, δ, therefore, comes from compliers: (2) and (5).

I restrict my analysis sample to years between 1967 and 1985. 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.

I consider several educational outcomes as a proxy for gender disparity. The first looks at female-male

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

differences in each field. The second is the field's expected salary. I create terciles of graduate field by expected annual salary, where expected annual salary is the median overall salary between 1961 and 1991 for both males and females. Appendix A1 lists the fields that are in these three groups. Comparing the top tercile (fields with the highest expected salary) to the bottom tercile (fields with the lowest expected salary), we see that the latter contains those considered stereotypically "female", such as Education, English, Family Science, and Library Science, and those in the former, stereotypically "male", such as Business, Computer Science, Engineering, and Legal Professions. The third educational outcome is the level of gender parity in the degree field. In particular, I categorize a field into terciles by its average female share between 1962 and 1970. Appendix A2 lists the fields that are in these three groups. This list is highly correlated with the grouping by expected salary (see Appendix A1, indicating that the graduate fields that were male-dominated were also the most lucrative.

The identifying assumption for DID is that the treatment group and the comparison group were exhibiting similar trends in the outcome variable prior to the treatment. This allows us to obtain counterfactual estimates of the treatment group's outcome in the absense 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. Figure 2 graphs gender-specific graduate degree trends by expected salary. The pre-trends assumption is satisfied for most of the analyses; the questionable ones are those in the top and bottom salary terciles in the everyone sample. Pre-trend plots for other analyses are in the Online Appendix.

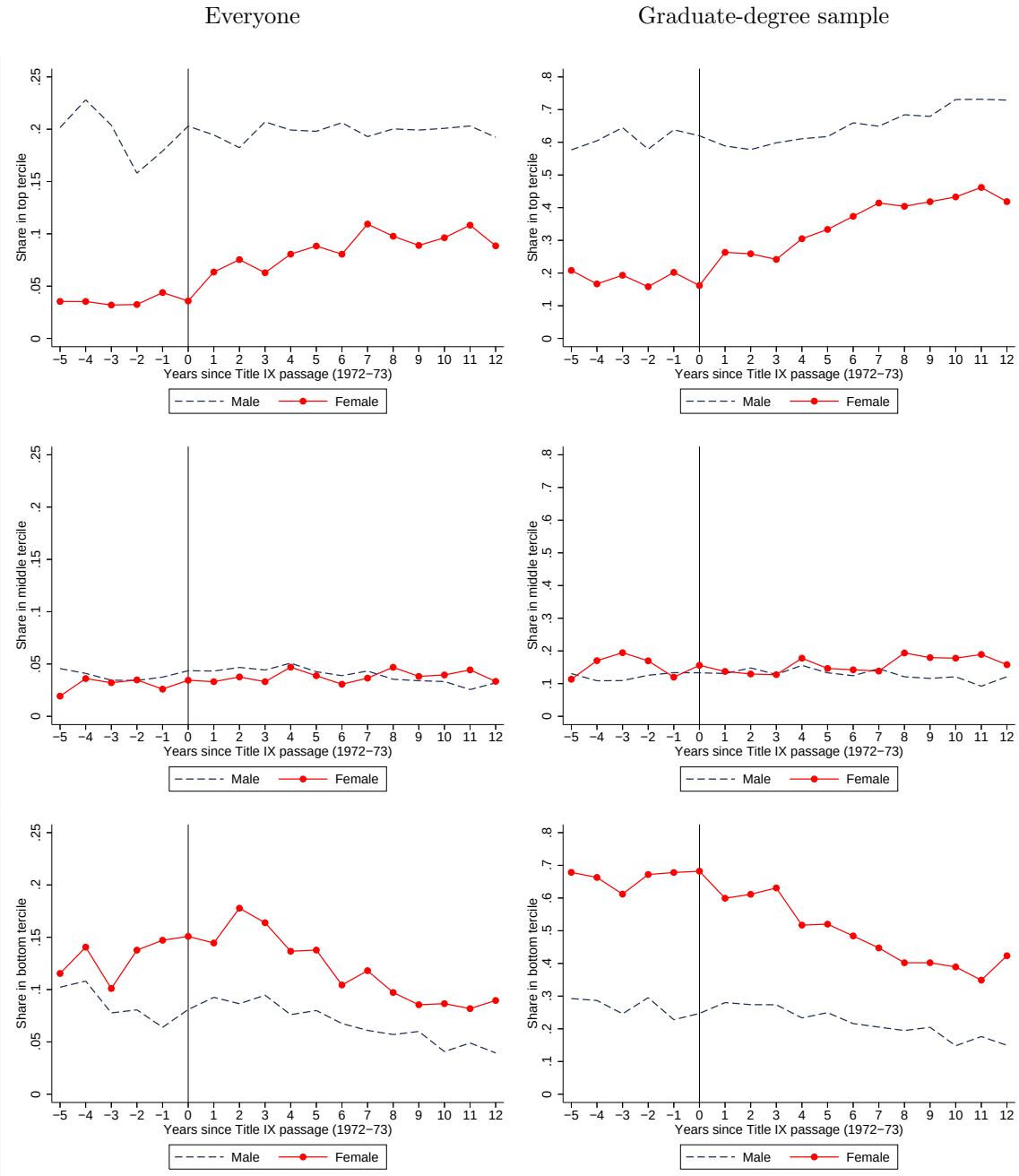
5 Alternative explanations

In this section, I discuss two main alternative explanations that may have contributed to gender convergence in graduate education in the absence of Title IX.

5.1 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. A look at historical data reveals that there were two big waves of popularity in the history of the birth control pill. The first wave occurred among married women with the pill's introduction. In 1961, the number of women estimated to be on the pill was 408,000. Within one year, the number nearly tripled to 1,187,000. By 1965, four years after its inception, there were an estimated 5 million women on the pill (FDA, 1966, p.

Figure 2: Graduate degree trends by Salary Terciles



Source: NSCG 1993 data.

5). The pharmaceutical industry quickly jumped on this profitable bandwagon. Starting out with just one manufacturer and one product, *Enovid*, there were 10 different products and seven manufacturers by March 1966 (FDA, 1966, p. 61, 67). By 1974, there were over 45 types on the market (HEW, 1975, p. 26).

The second wave of popularity occurred among single women during the late 1960s. There are no (good)

utilization data for single women, but two surveys reveal a drastic change on college campuses between 1966 and 1970 (Barbato et. al, 1968; Barato, 1971). Of college health services that prescribed the pill for contraceptive purposes in 1966, less than 10 percent did so for unmarried female students. By contrast, 100 percent of them did so for its married female students.[6] Conditional on having a prescription, 25 percent of colleges with a dispensing pharmacy would fulfill the prescription for unmarried women. In 1970, however, 63 percent of college physicians prescribed hormonal contraceptive medications (compared with 48 percent in 1966), and 77 percent of colleges that did so prescribed them to unmarried women.[7]

These numbers hint at an underlying cultural revolution that was occurring in the 1960s (May, 2011). It is linked to a sexual revolution among married women, but its influence on single women is less clear.[8] "Polls taken at the time indicated that single women who were already sexually active were enthusiastic about the pill because it allowed them to enjoy sex more fully. But those who were not engaging in sex were not likely to do so simply because the pill was now available. As one doctor noted, 'The pill does not make people decide to have sex. It is after they decide to have sex that they go get the pill."' (May, 2011, p. 73). Indeed, one study finds that the pill did little in the short-run to promote cohabitation as a substitute for marriage (Finn, 2012). If there were scores of young, single women waiting for the pill to curb their fertility, then we would expect out-of-wedlock birth rates or abortion rates to drop suddenly - which it did not. Moreover, there were other contraceptive methods available before the pill that were just as effective.

This is not to say that the pill had no influence whatsoever. Younger women were more likely to use oral contraceptives in comparison with older women.[9] Moreover, the pill was more popular among college-educated women relative to those with less than a high school education.[10] The fact that the pill was popular among young, college-educated women indicates it may have affected important life decisions by lowering the cost of making long-term career investments. Indeed, the general consensus of the economic literature is that young women's access to the pill in the late 1960s and early 1970s had a significant impact on their marital and fertility decisions, as well as educational and occupational choices, and even on the well-being of their children (Goldin & Katz, 2002; Bailey, 2006; Guldi, 2008; Ananat & Hungerman, 2012).[11]

The concern in estimating a causal effect of Title IX is that young, single women gained access to the

[6] When considering all 321 surveyed colleges which may not necessarily have a dispensing pharmacy on campus, these numbers drop to 4 percent and 45 percent, respectively.

[7] These numbers are from ACHA-affiliated colleges for the best comparison between the two surveys, as the 1966 survey only surveyed ACHA-affiliated colleges.

[8] Bailey (2012) finds that the pill contributed to a decrease in *marital* fertility.

[9] According to a 1965 survey, 26 percent of married women under 30 years of age were current users compared with 8 percent of those over 30 (FDA, 1966, p. 18).

[10] The percentage of users varied strongly and positively with extent of education, from 37 percent of college graduates to 12 percent for women with less than a high school education. (FDA, 1969, p. 13).

[11] Joyce (2013a, 2013b) questions whether these papers, which use variation in changes of state laws regarding minors' access to the pill, establish a causal link, but Bailey, Guldi, and Hershbein (2013a) point to a catalogue of studies using different data sources and levels of variation in law changes that all point to the same general conclusion about the effectiveness of the pill.

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, & 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.

Fortunately, I am able to exploit idiosyncratic variation in the state's legal language to isolate the effect of Title IX. If these legal changes were related to educational equity, then I would not be able to use this variation across states to address the problem caused by increased access to the birth control pill. I restrict my data sample to states where minors had access to the pill before Title IX. Now, my estimate will be the sole effect of Title IX. More importantly, females in these states had access to the pill while they were in college. If pill access were to affect females' decisions on graduate field of study, it would have an impact at both the undergraduate and graduate level. A woman who wants to attend medical school not only cannot get pregnant during medical school, but also during her undergraduate studies so that she will be able to attend medical school.

Table 4 lists the states where young women had access to the pill in 1969. It compares the coding used in Goldin and Katz (2002) to Myers (2012). Goldin and Katz classify 9 states where the earliest legal age to obtain the pill was 18 or younger in 1969. Myers defines 15 states where the earliest age of pill access was between 18-20 in 1969. Most of the differences between these two codings (likely) come from the difference in earliest age cutoffs. To be thorough, I use both authors' coding laws in my robustness checks.

5.2 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. Any positive, significant effects I see in my analysis, therefore, would be due to both *Roe v. Wade* and Title IX. However, I argue that the legalization of abortion is not a major confounding event as

Table 4: Coding comparison of state laws regarding young women's access to contraceptive services in 1969

States	Goldin-Katz	Myers	States	Goldin-Katz	Myers
Alabama			Montana		X
Alaska		X	Nebraska		X
Arizona			Nevada	X	X
Arkansas	X	X	New Hampshire		
California	X		New Jersey		
Colorado			New Mexico		
Connecticut			New York		
Delaware			North Carolina		
District of Columbia			North Dakota		X
Florida			Ohio		X
Georgia	X		Oklahoma	X	X
Hawaii		X	Oregon		
Idaho	X	X	Pennsylvania		
Illinois		X	Rhode Island		
Indiana			South Carolina		
Iowa			South Dakota		
Kansas			Tennessee		
Kentucky	X	X	Texas		
Louisiana			Utah	X	X
Maine		X	Vermont		
Maryland			Virginia		
Massachusetts			Washington		
Michigan			West Virginia		
Minnesota			Wisconsin		
Mississippi	X	X	Wyoming		
Missouri			**Total**	**9**	**15**

Source: Goldin and Katz (2002), Table 2; Myers (2012), Table 2.
Notes: "Goldin-Katz" lists states whose earliest legal age to obtain contraceptive services without parental consent is 18 or younger in 1969. "Myers" lists states where the earliest age of pill access for women was between 18-20 in 1969.

females had access to abortion before *Roe v. Wade*.

Abortion was not illegal in all states prior to *Roe v. Wade*. Rather, states had differing standards for legal abortions. Table 5 outlines the eight major categories of state abortion laws as of the end of 1970. Category 1 is the strictest category, prohibiting abortion except when necessary to save the mother's life. Categories 3 and 4 have vague wording that can be interpreted to allow abortions even in cases where the mother's life is not threatened. Despite the restrictive laws in Category-1 states, women were still able to obtain abortions. In fact, "women residing in 10 states with Category 1 abortion laws obtained more legal abortions per 1000 live births than women from Georgia, South Carolina, and North Carolina, all of which have Category 4 (ALI-type) laws" (Bourne et. al, 1970). Figure 3 depicts the abortion ratio by state of residence in 1970 in rank order. As expected, the four states where abortion was legal before *Roe v. Wade* – New York, Washington, Hawaii, and Alaska – have some of the highest abortion ratios. But more interestingly, females from states where abortion was illegal were able to travel to another state to obtain abortions.

It was not difficult to obtain an abortion. The Center for Disease Control, which began abortion surveil-

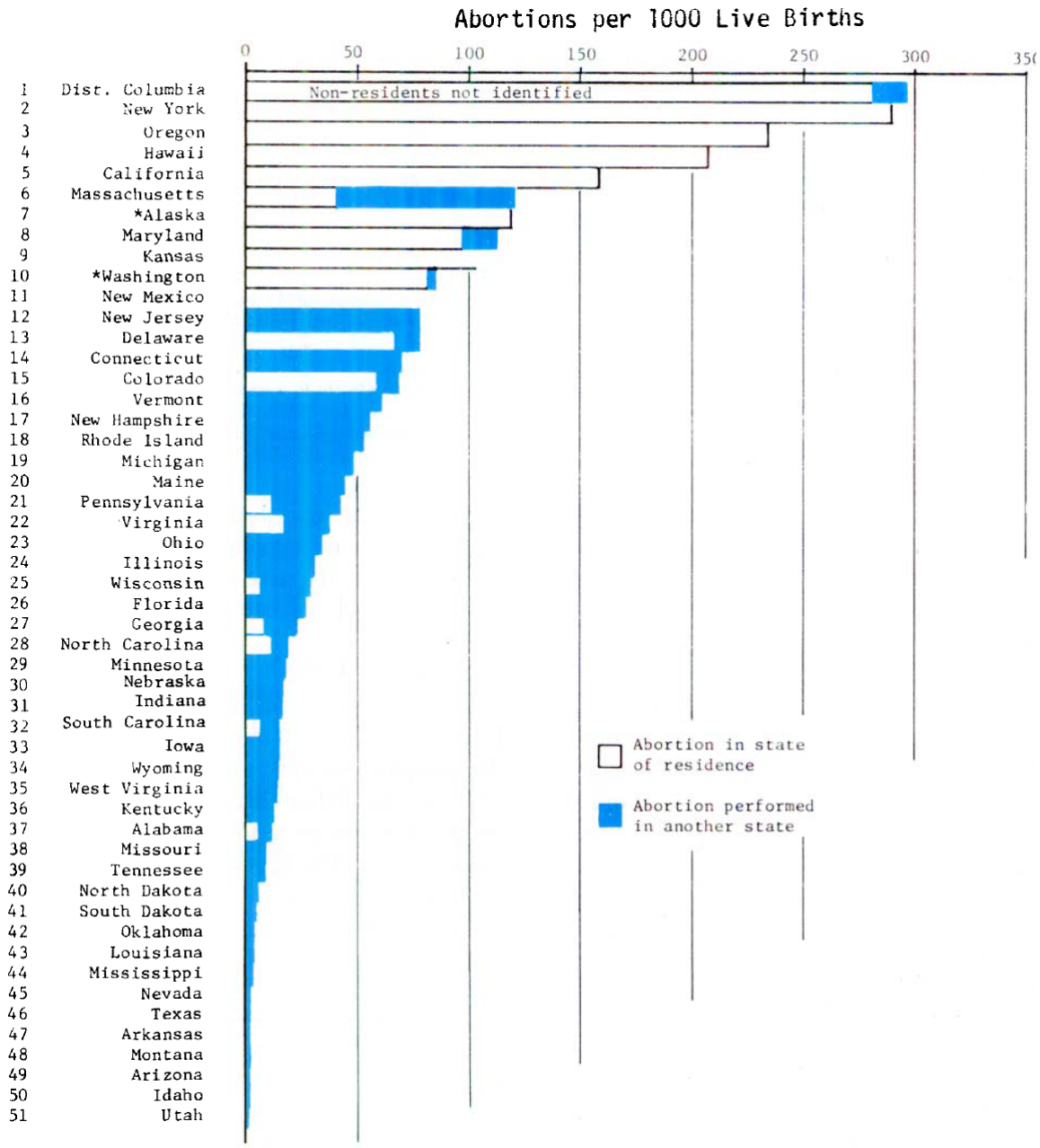
Table 5: Major Categories of American Abortion Laws, as of January 1, 1970

Major categories of state abortion laws		**States having similar abortion laws**
1	Abortion allowed only when necessary to preserve the life of the pregnant woman	Arizona, Connecticut, Florida, Idaho, Illinois, Indiana, Iowa[a], Kentucky, Louisiana[b], Maine, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, North Dakota, Ohio, Oklahoma, Rhode Island, South Dakota, Tennessee, Utah, Vermont, West Virginia, Wyoming
2	Indications for legal abortion include threats to the pregnant woman's life and forcible rape	Mississippi
3	"Unlawful" or "unjustifiable" abortions are prohibited	Massachusetts, New Jersey, Pennsylvania
4	Abortions allowed when continuation of the pregnancy threatens the woman's life or health	Alabama
5	American Law Institute Model Abortion Law: "A licensed physician is justified in terminating a pregnancy if he believes that there is substantial risk that continuance of the pregnancy would gravely impair the physical or mental health of the mother or that the child would be born with grave physical or mental defect, or that the pregnancy resulted from rape, incest, or other felonious intercourse."	Arkansas, California (does not include fetal deformity), Colorado, Delaware, Kansas, Maryland (does not include incest), New Mexico, North Carolina, South Carolina, Virginia
6	Abortion law based on the May 1968 recommendations of the American College of Obstetricians and Gynecologists allows abortion when the pregnancy resulted from felonious intercourse, and when there is risk that continuance of the pregnancy would impair the physical or mental health of the mother. "In determining whether or not there is substantial risk (to the woman's physical or mental health), account may be taken of the mother's total environment, actual or reasonably foreseeable."	Oregon
7	No legal restriction on reasons for which an abortion may be obtained prior to viability of the fetus	Alaska, Hawaii, New York, Washington[c]
8	Legal restrictions on reasons for which an abortion may be obtained were invalidated by court decision	District of Columbia, Georgia, Texas, Wisconsin

Source: Bourne et. al (1970), Table 1.
Notes: [a] In *State vs. Dunklebarger*, the Iowa statute, which is couched in terms of saving the life of the woman, has been interpreted to suggest that preservation of health is sufficient, 221 NW 592 (Iowa, 1928).
[b] Although the Louisiana abortion statute does not contain an express exception to the "crime of abortion" the Louisiana Medical Practice Act authorizes the Medical Board to suspend or institute court proceedings to revoke a doctor's certificate to practice medicine in the state when the doctor has procured or aided or abetted in the procuring of an abortion "unless done for the relief of a woman whose life appears imperiled after due consultation with another licensed physician" (La Rev Stat Ann 37:1261).
[c] The abortion laws of several other states have been ruled unconstitutional by lower state trial courts; however, these decisions are binding only in the jurisdiction in which the decision was rendered.

lance in 1969, estimates that more than 200,000 legal abortions were performed in 1970. According to the 1970 Public Health Reports issue, the largest proportion of abortions were among women aged 20 to 24 (35.7 percent) and the second largest proportion was among women aged 15-20 (23.7 percent). Moreover, 66 percent of the women were not married. These facts imply that the legalization of abortion is not a worrisome confounder as females in my analysis – single, college-aged women – had access to abortion before *Roe v. Wade*. However, as a robustness check, I include a measure of abortion access in my regression model.

Figure 3: Ratios of Reported Legal Abortions to Live Births by State of Residence in Rank Order, 1970



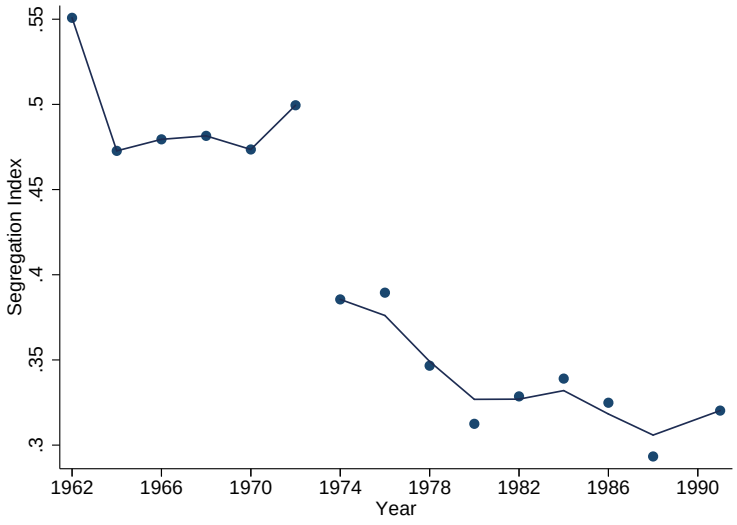
Source: Bourne et. al, 1970, Figure 1.
Notes: All states reported between July-December 1970 except: * Alaska, July 21-December 31, 1970; Washington, December 3-December 31, 1970.

Specifically, I categorize states into classes of abortion access, using Figure 3 as a reference. This categorical measure will more accurately capture females' access to abortion compared to a binary measure.

6 Effect on graduate-field distribution

First, I provide graphical evidence of gender convergence in graduate-field distribution. Figure 4 plots the segregation index from 1962-63 to 1990-91 for all graduate degrees obtained by age 35. The graph depicts a downward trend in the index, indicating that the male and female distributions of graduate fields of study were converging over time. For example, in 1962-63, the segregation index is 55 percent. This means that more than half of the women with graduate degrees would need to change their field of study in order to obtain the same graduate-field distribution as men. By 1990-91, the index drops down to 32 percent. In addition to the downward trend, there is a marked jump towards convergence between 1972-73 and 1974-75 as depicted by the solid lines. The solid lines in the graph are lowess smoothers allowing for a break between 1972-73 and 1974-75. The break-point was found by looking for a structural break in the data. Specifically, I regressed the segregation index against a year dummy and a quartic time trend and chose the year that maximized the R-squared of the regression. R-squared values are in Appendix Table A3.

Figure 4: Female-Male Convergence in Graduate Field Distributions

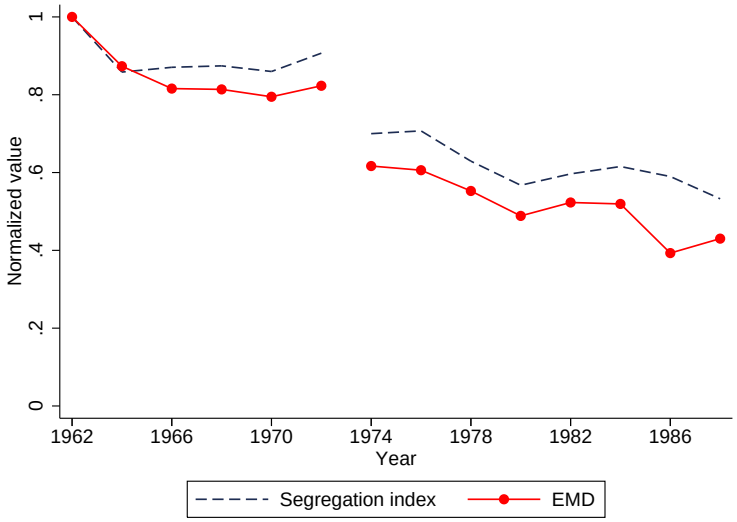


Source: NSCG 1993 data.
Note: Years have been collapsed to 2-year cells to reduce noise. The graph with single-year cells looks very similar (see Appendix Figure A1). The solid line is the lowess smoother applied to the data allowing for a break between 1972-73 and 1974-75. The break year was determined by looking for a structural break in the data (see Table A3).

The EMD does not have an easy interpretation like the Segregation Index (Rubner, Tomasi, & Guibas, 2000). To compare the EMD with the Segregation Index, I normalized both to their 1962 values and plotted them on the same scale (Figure 5). Convergence as measured by EMD is always greater than when measured by the segregation index, which implies that most of the convergence were in fields that were further apart.

We explore this further in Section 7.

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



Source: NSCG 1993 data.
Note: Years have been collapsed to 2-year cells to reduce noise. The graph with single-year cells looks very similar (see Appendix Figure A1). Values have been normalized to 1962, separately for Segregation Index and EMD. The solid line is the lowess smoother applied to the data allowing for a break between 1972-73 and 1974-75. The break year was determined by looking for a structural break in the data (see Table A3).

Table 6 reports estimates from equation (3) using both measures. The coefficients on the quartic time trend tells us that the two distributions were converging over time, at a decreasing rate. The estimates on the Title IX dummy tell us that Title IX had a large and statistically significant impact on this downward trend. Title IX led to a 11 percentage-point decrease in the segregation index (Column 1). Put another way: in 1962, 55 percent of women (men) needed to change their graduate field-of-study in order to obtain similar distributions for men and women. Title IX decreased that number by 20 percent (= 11/55). When I use the EMD measure, the estimate more than doubles. When we take into consideration which graduate fields women moved out of and into, Title IX increases gender convergence by 27 percentage-points (Column 4). One concern is that access to the birth control pill may be a confounding factor. Although there is no evidence of a shock in 1974 in pill-utilization rates or development history of the pill, I control for access to the pill using two different methods as a robustness check. The estimates do not change much. In one specification, the coefficient becomes insignificant, but the magnitude is still similar (Column 5). These results indicate that access to the pill cannot completely explain the sharp gender integration in graduate fields of study observed between 1972-73 and 1974-75.

There are two ways to think about distributional convergence. First, convergence between male and

Table 6: Effect of Title IX on Gender Convergence in Graduate-field Distribution

Convergence measure:	**Segregation Index**			**EMD**		
	(1)	(2)	(3)	(4)	(5)	(6)
Post-1974	-0.109***	-0.0999*	-0.137***	-0.273***	-0.231	-0.298**
	(0.0359)	(0.0520)	(0.0481)	(0.0618)	(0.227)	(0.117)
Time trend	-0.0223	-0.0535*	-0.0195	-0.0855**	0.0130	-0.136**
	(0.0194)	(0.0280)	(0.0259)	(0.0333)	(0.122)	(0.0629)
Time trend^2	0.00264	0.00420	0.00170	0.0104**	-0.00342	0.0165*
	(0.00261)	(0.00378)	(0.00349)	(0.00448)	(0.0165)	(0.00848)
Time trend^3	-0.000128	-0.000148	-6.00e-05	-0.000479**	0.000160	-0.000754*
	(0.000122)	(0.000176)	(0.000163)	(0.000209)	(0.000769)	(0.000396)
Time trend^4	2.02e-06	1.84e-06	6.22e-07	7.12e-06**	-2.54e-06	1.14e-05*
	(1.88e-06)	(2.72e-06)	(2.51e-06)	(3.22e-06)	(1.19e-05)	(6.10e-06)
Constant	0.562***	0.805***	0.660***	1.078***	1.190***	1.128***
	(0.0410)	(0.0594)	(0.0549)	(0.0705)	(0.259)	(0.133)
Observations	30	30	30	30	30	30
Controls for birth control pill?		Goldin-Katz	Myers		Goldin-Katz	Myers

Source: NSCG 1993 data.
Notes: Regression of convergence measure against a quartic time trend and an indicator dummy. Outcome variable for (4)-(6) is normalized EMD value. BCP sample controls for access to birth control by limiting analysis sample to states where minors were able to access to the pill in 1969. "Goldin-Katz" uses states as defined by Goldin and Katz (2002). "Myers" uses states as defined by Myers (2014). See Table 4 for full list of states.

female graduate-field distributions can occur because of a change in sex composition within degree fields. For example, if women predominantly enter male-dominated fields and vice versa. It can also occur from changing relative sizes of segregated and integrated fields. For example, a secular decline in male-dominated graduate fields of study would result in greater distributional integration even if the within-field segregation (sex composition) remained unchanged. To better understand the sources of observed changes in the graduate-field distribution over time, I decompose the change in the overall segregation index into sex-composition and field-mix components.[12] The sex-composition effect measures how much the segregation index would have changed if the sex-composition within graduate fields changed but the relative size of each graduate field remained constant. By contrast, the field mix effect measures how much the overall index would have changed if the sex-composition within graduate fields remained the same but the relative size of graduate-fields changed. For example, the change in segregation index between years 1 and 2 can be decomposed as follows:

$$\text{Sex-composition effect} = \left((0.5) \cdot \sum_i \left| \frac{q_{i1} T_{i2}}{\sum_j q_{j1} T_{j2}} - \frac{p_{i1} T_{i2}}{\sum_j p_{j1} T_{j2}} \right| \right) - S_1 \tag{5}$$

$$\text{Graduate field mix effect} = S_2 - \left((0.5) \cdot \sum_i \left| \frac{q_{i1} T_{i2}}{\sum_j q_{j1} T_{j2}} - \frac{p_{i1} T_{i2}}{\sum_j p_{j1} T_{j2}} \right| \right) \tag{6}$$

where $p_{it} = F_{it}/T_{it}$ is the share of women in field i at time t, $q_{it} = M_{it}/T_{it}$ is the share of men, and S_t is the segregation index in year t.

[12] I follow the decomposition method used by Blau, Brummund, and Liu (2013), but it was initially proposed by Fuchs (1975).

Table 7 reports results. Reported change is the average annual change times 10. There are small movements from year to year, but the largest change is by far between 1972-73 and 1974-75 when the segregation index decreased by 11.4 percentage-points. This 11.4 percentage-point change is largely made up of changes in sex composition within occupations (88%) with the remaining 12 percent due to changes in the field mix.

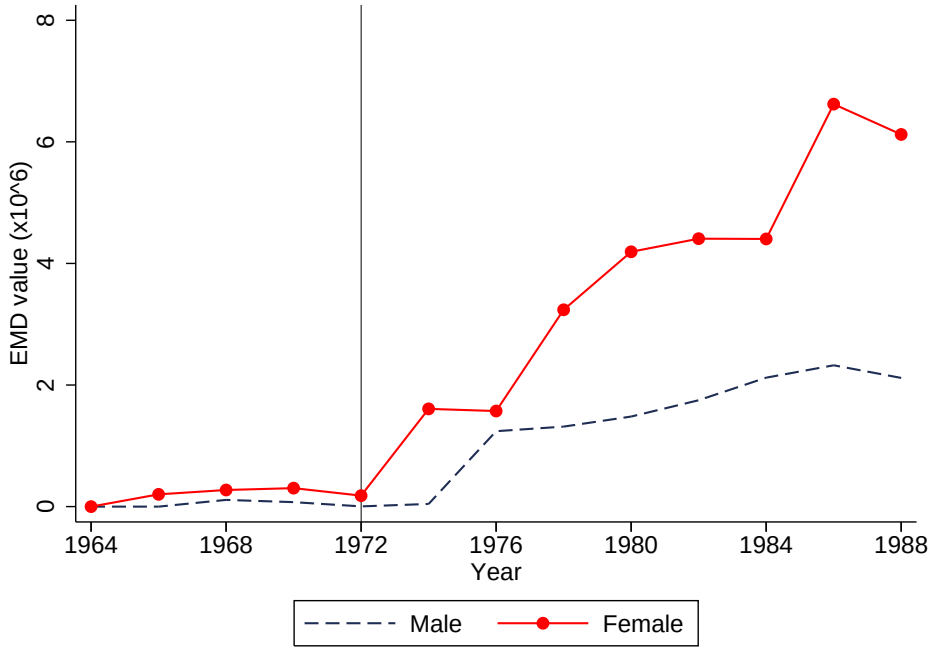
Table 7: Segregation index decomposition

Year	**Total Change**	**Sex Composition**		**Field Mix**	
		Absolute	**% of Total**	**Absolute**	**% of Total**
1962-64	-0.781	-0.603	77%	-0.177	23%
1964-66	0.068	-0.094	-139%	0.161	239%
1966-68	0.020	0.066	325%	-0.046	-225%
1968-70	-0.080	-0.154	193%	0.074	-93%
1970-72	0.259	0.302	116%	-0.042	-16%
1972-74	-1.139	-0.999	88%	-0.141	12%
1974-76	0.039	-0.007	-17%	0.046	117%
1976-78	-0.429	-0.417	97%	-0.012	3%
1978-80	-0.341	-0.245	72%	-0.096	28%
1980-82	0.161	0.344	214%	-0.183	-114%
1982-84	0.104	0.144	138%	-0.039	-38%
1984-86	-0.142	-0.157	111%	0.015	-11%
1986-88	-0.315	-0.241	76%	-0.075	24%
1988-90	0.269	0.202	75%	0.067	25%

Source: NSCG 1993 data.
Notes: Total and absolute change numbers are average change x 10.

To further explore this phenomenon, I use EMD to measure female convergence and male convergence separately over time. In particular, I am interested in understanding whether the discrete break is due to predominantly female movement, predominantly male movement, or both. We cannot do this with the segregation index because it uses absolute gender differences in its formula. Specifically, I compare the female distribution of graduate fields from 1966-67 onwards to the female distribution from 1964-65, and similarly for the male distributions. Figure 6 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 1964-64 and the same is true for males. After 1972, females and males are entering different fields from their 1964-peers, but the change among females begins earlier and is greater.

Figure 6: Covergence in graduate fields by gender



Source: NSCG 1993 data.
Note: Years have been collapsed to 2-year cells to reduce noise. The graph with single-year cells looks very similar (see Appendix Figure A1). Values have been normalized to 1964, separately for males and females.

7 Effect on graduate fields of study

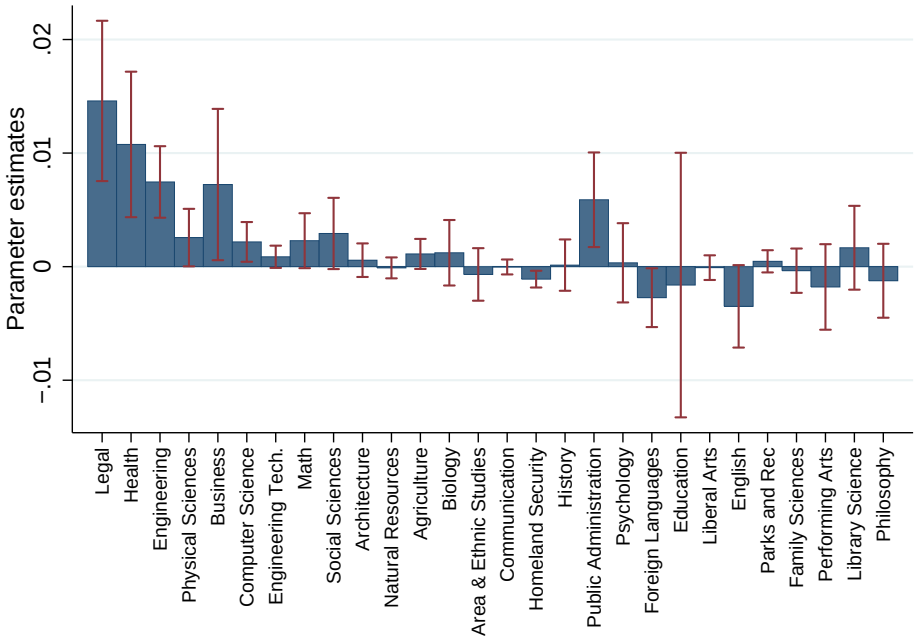
The previous section established the following facts: (1) Title IX induced gender convergence in graduate-field distributions by banning discrimination in admissions, (2) the effect is large, discrete, nationally-observed, and cannot be explained by the more gradual effect of pill access or abortion legalization, and (3) gender convergence was driven by changes in sex-composition, particularly by female movement. Here, I explore Title IX's impact on gender disparity at a more granular level. I am interested in unpacking the observed distributional changes into degree-specific and field-specific changes.

First, I conduct a degree-level analysis to explore which fields were most affected by Title IX. I estimate equation (4) separately for each field of study, so Y_{ift} is equal to 1 if individual i earned a graduate degree before age 35 in field f. The parameter of interest, δ_f, tells us the effect of Title IX on the gender gap in graduate degree field f. Parameter estimates are plotted in Figure 7 with graduate fields on the horizontal axis. For example, Title IX is associated with a 1.5 percentage-point increase in female JDs relative to male JDs, a 1.1 percentage-points increase in female MDs relative to male MDs, and a 0.2 percentage-point *decrease* in female graduate education degrees relative to males. All of these estimates are highly statistically

significant, with the exception of education. When we consider that the graduate fields are reported in rank order of salary, the results become more interesting. Most of the graduate fields in the upper-end of the salary spectrum experienced positive female relative growth while those near the bottom of the salary spectrum experienced negative or near-zero relative growth.

Figure 7: Gender difference in graduate degrees by field

Everyone



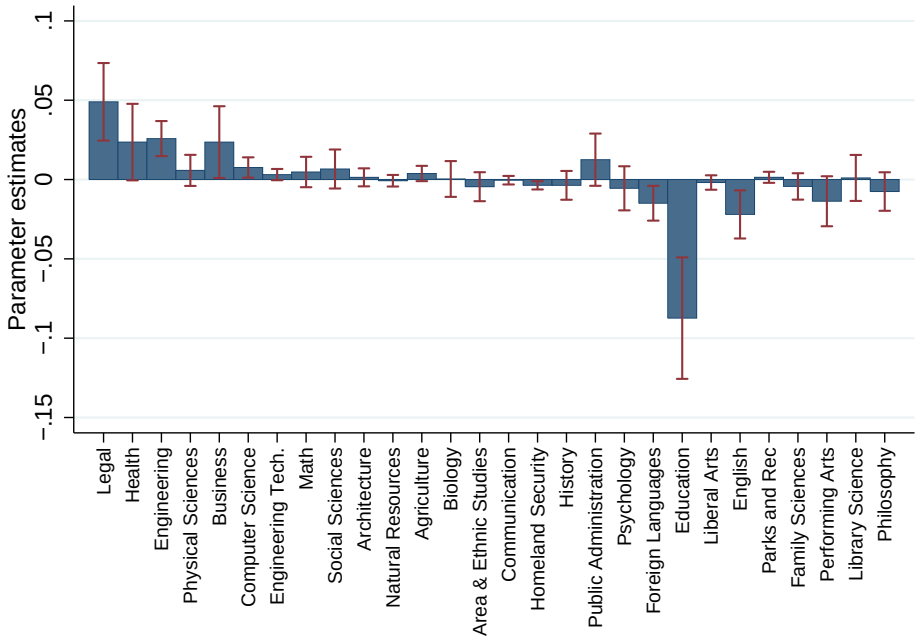
Source: NSCG 1993 data.
Notes: Parameter estimates are field-specific female-male differences in likelihood. Specifically, they are the δ_f from the following regression model: $Y_{ift} = \beta_{0f} + \beta_{1f} \cdot F_{if} + \beta_{2f} \cdot \mathbb{1}\{\texttt{Title IX}\} + \delta_f \cdot \left(\mathbb{1}\{\texttt{Title IX}\} \times F_{if}\right) + X'\gamma + \varepsilon_{ift}$. Wings on bars represent 95% confidence intervals.

The estimates depicted in Figure 7 are the unconditional effect of Title IX on obtaining a graduate degree, which captures any effect on females who previously would not have attended graduate school. That is, Title IX may have had a second-order effect by inducing women to attend graduate school who otherwise would not have. To separate out the first-order effect of eliminating discrimination in admissions from the second-order effect of inducing females to attend graduate school, I subset the analysis sample to all graduate degrees obtained before age 35 and estimate equation (4). The parameter of interest, δ_f, now estimates the effect of Title IX on gender disparity within a graduate field of study conditional on having a graduate degree. As a result, the parameter estimates across all fields sum to zero; some fields will see an influx of women and others will see an outflow of women, but there is no constraint on exactly which fields will be positive and which will be negative. The results are striking (Figure 8). The fields that all saw an inflow of

women are those in the top half of the salary-spectrum while those in the bottom half saw an outflow. More importantly, the graduate field with the largest relative loss of women post-Title IX is education: female graduate education degrees post-Title-IX decreased by nearly 9 percentage-points in comparison to males. This is interesting as, only four years prior, education was the most popular field, making up nearly 50 percent of female graduate degrees.[13]

Figure 8: Gender difference in graduate degrees by field

Graduate-degree Sample



Source: NSCG 1993 data.
Notes: Parameter estimates are field-specific female-male differences in likelihood. Specifically, they are the δ_f from the following regression model: $Y_{ift} = \beta_{0f} + \beta_{1f} \cdot F_{if} + \beta_{2f} \cdot \mathbb{1}\{\texttt{Title IX}\} + \delta_f \cdot \left(\mathbb{1}\{\texttt{Title IX}\} \times F_{if}\right) + X'\gamma + \varepsilon_{ift}$. Wings on bars represent 95% confidence intervals.

These patterns are robust to controlling for pill access and abortion access.[14] The effect sizes for some fields, like legal and engineering, are smaller but they are larger for others, like. However, we still see the same pattern of positive relative female growth in more-lucrative fields of study and little to negative relative growth in less-lucrative fields.

As a robustness check, I take a closer look at specific degrees that differ in their expected years of completion. For example, medical degrees require four years of education. If Title IX were driving our

[13] See Table 2.
[14] See Appendix Figure A2.

results, we should not expect to see a positive effect on relative female medical degrees before 1976, which is the earliest year that one could have obtained a medical degree post-Title IX. I conduct this check on three different graduate degrees: medical degrees (MDs), law degrees (JDs), and business administration degrees (MBAs). I then categorize years into three groups (pre-1972, expected completion year or later, and year(s) where the degree is in-progress) and run the following regression:

$$\begin{aligned} Y_{it} = \beta_0 &+ \beta_1 \cdot F_i + \beta_2 \cdot \mathbb{1}\{\texttt{pre-1972}\} + \beta_3 \cdot \mathbb{1}\{\texttt{in-progress years}\} \\ &+ \beta_4 \cdot \mathbb{1}\{\texttt{expected completion year}\} + \delta_1 \cdot \left(\mathbb{1}\{\texttt{pre-1972}\} \times F_i\right) \\ &+ \delta_2 \cdot \left(\mathbb{1}\{\texttt{in-progress years}\} \times F_i\right) + \delta_3 \cdot \left(\mathbb{1}\{\texttt{expected completion year}\} \times F_i\right) + X'\gamma + \varepsilon_{it} \end{aligned} \tag{7}$$

where Y_{it} is equal to 1 if individual i obtained the graduate degree of interest (MD, JD, or MBA) in year t, F_i is a female dummy, and X is a vector including highest degree-granting school's region, birth-year fixed effects, and a quartic time trend. The indicator dummies are mutually exclusive and categorize the years in terms of "in-progress" and "completion" years. For example, for a medical degree, $\mathbb{1}\{\texttt{pre-1972}\}$ is equal to 1 for all years prior to and including 1972. The indicator dummy, $\mathbb{1}\{\texttt{in-progress years}\}$, is equal to 1 for years 1973 through 1975, inclusive. The indicator dummy, $\mathbb{1}\{\texttt{expected completion year}\}$, for medical degrees is equal to 1 for years 1976 and later. The parameters of interest are δ_2 and δ_3. Specifically, we would expect δ_2 to be non-positive and δ_3 to be positive.

Table 8 reports results. We see negative or close to zero estimates for years that the graduate degree is in-progress and a positive estimate in the expected completion year and beyond. These patterns are what we would expect if Title IX truly did remove barriers to graduate admissions across different degrees. The coeficient magnitudes are small, but that is because the total number of these degree-holders is small. For example, 3 percent of male BA holders between 1967 and 1972 had a medical degree. For female BA holders, the share is even smaller at 0.4 percent. Therefore, I conduct a t-test to see whether the coefficient for the year(s) during which the degree is in-progress (δ_2) is statistically equivalent to the coefficient for the expected completion year (δ_3). For all three degrees, the t-test rejects the null that the two coefficients are equal.

The previous analysis found that most of the relative female growth after Title IX were in degree fields that were in the upper-end of the salary rank order list. Here, I conduct a statistical analysis of that finding by estimating the impact of Title IX by salary tercile. I run the DID regression model, specified in equation (4), separately for each tercile.

Before Title IX, 31 percent of men had a graduate degree, with 61 percent (= 0.19/0.31) 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 (= 0.13/0.20) were in the *bottom* salary tercile. If Title IX were

Table 8: Relative female growth in specific degrees

	JD	**MD**	**MBA**
	(1)	(2)	(3)
Degree-in-progress year(s)	-0.0033	-0.00336	0.000707
	(0.00546)	(0.00853)	(0.00939)
Expected completion year	0.00492	0.00895	0.0169**
	(0.00489)	(0.00652)	(0.00694)
p-value of t-test	0.0469	0.0144	0.0181

Source: NSCG 1993 data.
Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. *** p< 0.01, ** p< 0.05, * p< 0.1

successful in removing gender discrimination, which was more salient in more-lucrative fields, we would expect to see monotonically decreasing effects by expected salary. Table 9 confirms this. Panel A predicts the unconditional likelihood of obtaining a graduate degree in a particular salary tercile. Title IX led to a 5 percentage-point increase in female graduate degrees in the top salary tercile relative to male graduate degrees in that tercile. The effect on middle tercile is smaller at 0.7 percentage-points but still statistically significant. Title IX had no effect on female graduate degrees in the bottom salary tercile. In Panel B, I restrict the analysis sample to graduate-degree holders and find that most of the relative female growth was in top-tercile fields as females switched out of less-lucrative fields. To understand the magnitude of these effects, consider the overall increase in female share in these fields. The share of female degrees in the top salary tercile increased by 17.4 percentage-points between 1962-71 and 1975-85. Title IX explains about 30 percent (= 5.1/17.4) of the growth in this tercile during this period.

When I break out the regressions by degree-type, it becomes clear that Title IX allowed women to trade-up their degrees (Table 10). The largest relative female growth is in fields in the top salary tercile for both PhDs and MAs. Although the magnitude of these coefficients are small (around 3 percentage-points), the effect sizes are very large when we consider the share of females with master degrees or doctoral degrees in the top two salary terciles: less than 3 percent of females have a master degree in a field in the top two salary terciles prior to 1972. The number for those with a PhD is even smaller (1 percent). When looking at graduate-degree holders only, we see that most of the change is driven by women substituting away from low-paying master's degrees (Panel B of Table 10).

8 Discussion

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

Table 9: Gender difference in graduate degrees by salary tercile

Panel A: Everyone			
	(1)	(2)	(3)
Female × Title IX	0.0514***	0.00679*	-0.00919
	(0.00636)	(0.00363)	(0.00687)
Avg. Male Pre-1972 Probability	0.191	0.038	0.084
Avg. Female Pre-1972 Probability	0.036	0.030	0.129
Observations	57,940	57,940	57,940
Salary Tercile	Top	Middle	Bottom
Controls?	Yes	Yes	Yes

Panel B: Graduate-degree sample			
	(1)	(2)	(3)
Female × Title IX	0.151***	-0.00187	-0.149***
	(0.0183)	(0.0139)	(0.0195)
Avg. Male Pre-1972 Probability	0.610	0.121	0.268
Avg. Female Pre-1972 Probability	0.184	0.154	0.662
Observations	17,434	17,434	17,434
Salary Tercile	Top	Middle	Bottom
Controls?	Yes	Yes	Yes

Source: NSCG 1993 data.
Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. *** p< 0.01, ** p< 0.05, * p< 0.1

and engineering in 1970, as we saw in Table 2. Although Title IX was a national policy aimed at eliminating gender discrimination in admissions at all graduate schools, 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 may 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 they did not prefer that field of study. 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 estimate equation (4) for each tercile and report results in Table 11. Not only did Title IX decrease gender disparity most in fields where females were historically under-represented, its effects decrease by increasing female representation. After Title IX, women are 3.4 percentage-points more likely than men to pursue male-dominated degrees, and are no more or less likely to pursue a female-dominated degree. When

Table 10: Gender difference in graduate degrees by salary tercile and degree-type

	Panel A: Everyone					
	Professional degree or PhD			**Master's degree**		
	(1)	(2)	(3)	(4)	(5)	(6)
Female × Title IX	0.0255***	0.000633	0.00167	0.0259***	0.00616*	-0.0109
	(0.00446)	(0.00138)	(0.00137)	(0.00485)	(0.00337)	(0.00679)
Avg. Male Pre-1972 Probability	0.101	0.013	0.010	0.090	0.025	0.074
Avg. Female Pre-1972 Probability	0.010	0.005	0.003	0.026	0.025	0.126
Observations	57,940	57,940	57,940	57,940	57,940	57,940
Salary Tercile	Top	Middle	Bottom	Top	Middle	Bottom
Controls?	Yes	Yes	Yes	Yes	Yes	Yes
	Panel B: Always Takers					
	Professional degree or PhD			**Master's degree**		
	(1)	(2)	(3)	(4)	(5)	(6)
Female × Title IX	0.0802***	-0.00300	0.00396	0.0710***	0.00113	-0.153***
	(0.0145)	(0.00538)	(0.00519)	(0.0167)	(0.0129)	(0.0195)
Avg. Male Pre-1972 Probability	0.322	0.040	0.032	0.288	0.081	0.236
Avg. Female Pre-1972 Probability	0.051	0.024	0.018	0.133	0.130	0.644
Observations	17,434	17,434	17,434	17,434	17,434	17,434
Salary Tercile	Top	Middle	Bottom	Top	Middle	Bottom
Controls?	Yes	Yes	Yes	Yes	Yes	Yes

Source: NSCG 1993 data.
Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. *** p< 0.01, ** p< 0.05, * p< 0.1

we subset the sample to graduate-degree holders, we see that Title IX's effect is mainly concentrated in male-dominated fields (11 percentage-points) with women switching out of female-dominated fields in large numbers. These findings do not change much when we control for the birth control pill and abortion.[15] 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.

In Section 7, I found that Title IX increased the relative number of female graduate degrees in more-lucrative fields. A natural question is whether Title IX had any second-order effects on the occupational distribution. As females pursue graduate degrees in increasing numbers, their return on human capital investment increases, also increasing the opportunity cost of not joining the labor force. As a result, we would expect to see gender convergence in occupations as well, around the time that Title IX was passed.

Figure 9 plots the normalized segregation-index and EMD values for occupational distributions by birth cohort. I use each cohort's occupation at age 30. Because I impute the birth-year using the person's age, I collapse the data into two-year cohort cells. For the EMD calculation, I order occupations by their median hourly wage for full-time workers between 1968 and 1990. When measuring occupational convergence using the Segregation Index, we see that there is some convergence over time but it is slight; the index barely gets

[15]See Appendix Table A5.

Table 11: Gender difference in graduate degrees by gender parity

Panel A: Everyone			
	(1)	(2)	(3)
Female × Title 9	0.0342***	0.0187***	-0.00387
	(0.00554)	(0.00477)	(0.00691)
Avg. Male Pre-1972 Probability	0.152	0.079	0.082
Avg. Female Pre-1972 Probability	0.016	0.038	0.141
Observations	57,940	57,940	57,940
Gender-parity Tercile	Top	Middle	Bottom
Controls?	Yes	Yes	Yes

Panel B: Graduate-degree sample			
	(1)	(2)	(3)
Female × Title 9	0.109***	0.0288*	-0.138***
	(0.0163)	(0.0172)	(0.0190)
Avg. Male Pre-1972 Probability	0.486	0.253	0.261
Avg. Female Pre-1972 Probability	0.081	0.195	0.724
Observations	17,434	17,434	17,434
Gender-parity Tercile	Top	Middle	Bottom
Controls?	Yes	Yes	Yes

Source: NSCG 1993 data.
Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. Top gender-parity tercile consists of fields with the lowest 1962-1970 female share of degrees. Bottom gender-parity tercile consists of fields with the highest 1962-1970 female share of degrees. *** p< 0.01, ** p< 0.05, * p< 0.1

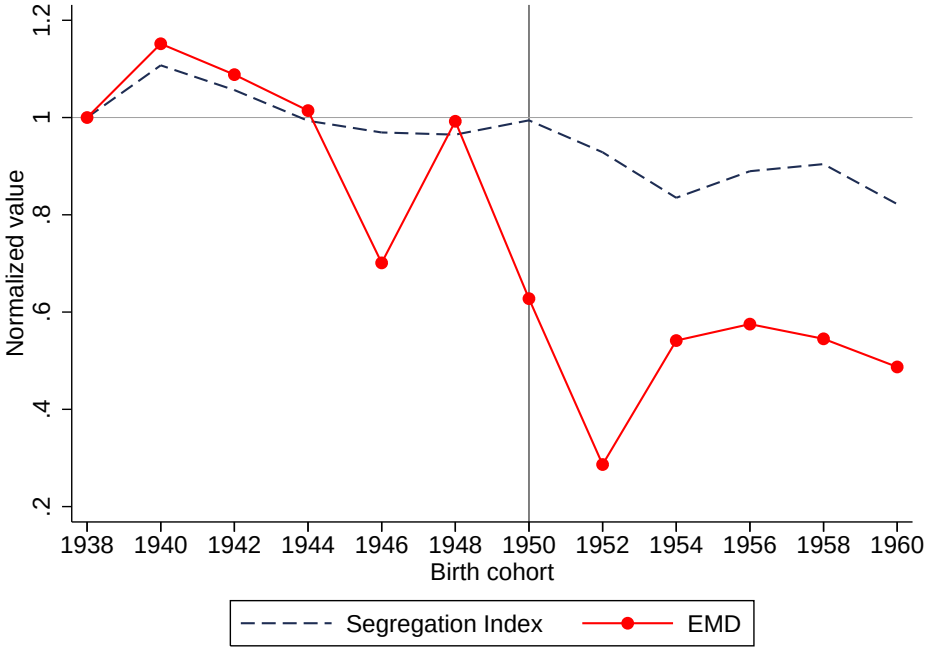
below 80 percent of the 1938 cohort's segregation-index value. Although EMD starts off on a similar path as the Segregation Index, it diverges greatly starting with the 1950 cohort (denoted by the vertical black line). The 1950 cohort turned 24 in 1974, which is the oldest cohort possibly affected by Title IX.[16] Specifically, EMD estimates around 20 percent *more* convergence in the occupational distributions in comparison with the segregation index. This highlights the importance for taking into account which occupation categories experienced movement.

9 Conclusion

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

[16]Assuming individuals were 22 in the year that they graduated from college, the oldest person whose graduate-education decision was affected by Title IX would be 24 in 1974. This is also assuming that individuals went straight from undergraduate to graduate school.

Figure 9: Female-Male Convergence in Occupation Distributions



Source: NSCG 1993 data.
Note: Years have been collapsed to 2-year birth-cohort cells to reduce noise. Values have been normalized to 1938-1939 cohort, separately for Segregation Index and EMD.

social attitude at the time. However, graduate-school enrollment data reveal that medical schools and law schools were discriminating against female applicants right up until it 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.

These findings shed new light on the factors responsible for the college gender gap reversal and the subsequent occupational convergence between men and women. Title IX was successful in reducing gender disparity in graduate education, but the implications for these findings extend to a more aggregate level.

Hsieh and co-authors (2013) find that improved allocation of talent in the occupational distribution explains 15-20 percent of growth in aggregate output per worker between 1960 and 2008. To the extent that banning gender discrimination in admissions improves the allocation of talent by allowing qualified women to pursue any career path, this policy also has important implications for the macroeconomy.

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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:

$$
\begin{aligned}
f_{ij} &\geq 0, \quad 1 \leq i \leq K, \quad 1 \leq j \leq K && (8)\\
\sum_{i=1}^{K} f_{ij} &\leq s_i^m, \quad 1 \leq i \leq K && (9)\\
\sum_{j=1}^{K} f_{ij} &\leq s_i^w, \quad 1 \leq j \leq K && (10)\\
\sum_{i=1}^{K}\sum_{j=1}^{K} f_{ij} &= \min\left(\sum_{i=1}^{K} s_i^m, \sum_{j=1}^{K} s_i^w\right) && (11)
\end{aligned}
$$

Constraint (8) allows moving people from M to W and not vice versa. Constraint (9) 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 (10) is the analog for occupation categories in F; and constraint (11) 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 (11). 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

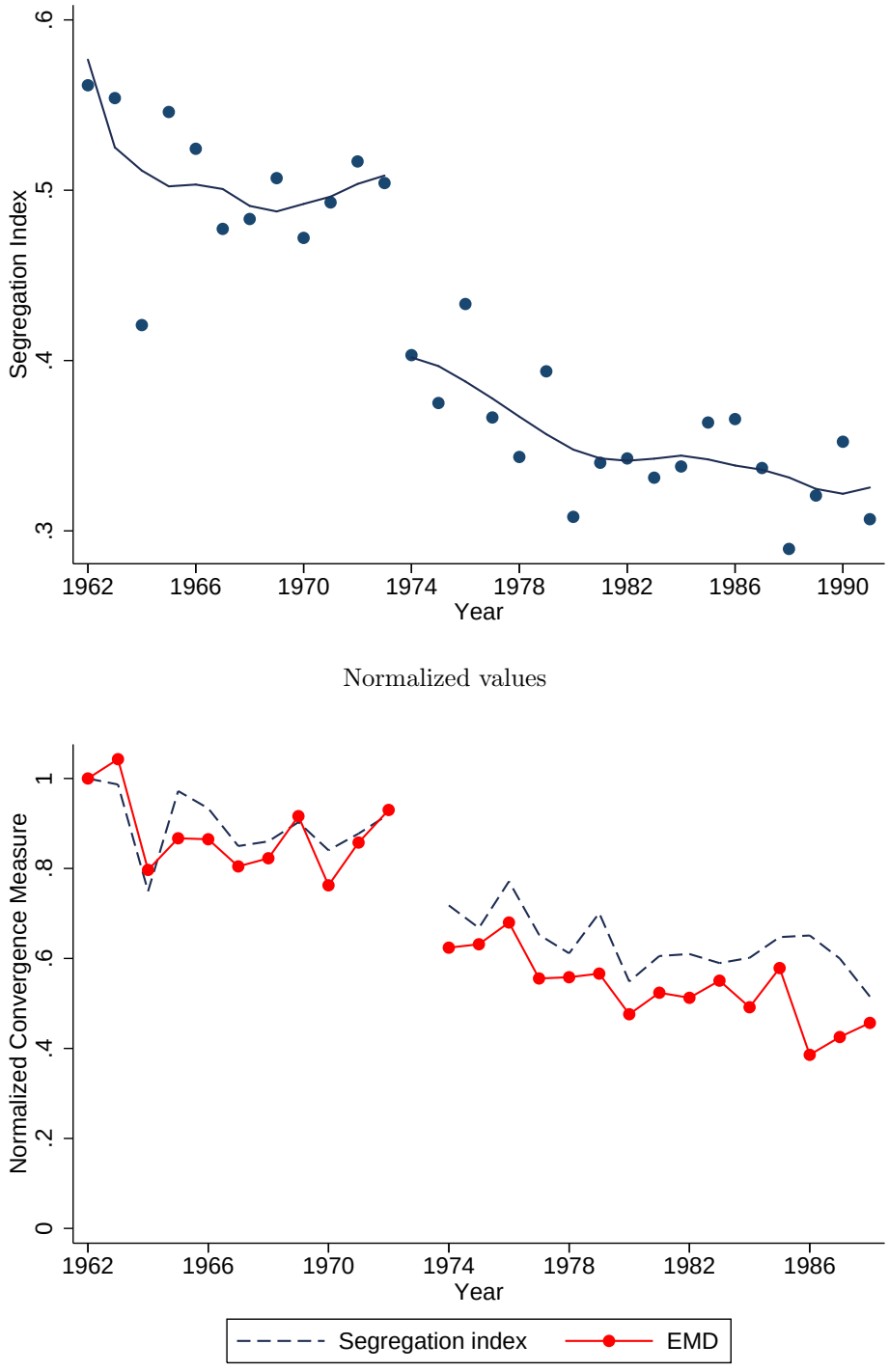
Source: NSCG 1993 data.

Table A3: Estimating structural break

	R-squared	
Indicator year	**Seg. Index**	**EMD**
1963	0.836	0.878
1964	0.868	0.916
1965	0.836	0.874
1966	0.822	0.875
1967	0.821	0.878
1968	0.831	0.892
1969	0.841	0.901
1970	0.832	0.881
1971	0.837	0.891
1972	0.825	0.877
1973	0.827	0.887
1974	***0.870***	***0.930***
1975	0.845	0.896
1976	0.824	0.883
1977	0.837	0.887
1978	0.826	0.876
1979	0.820	0.874
1980	0.823	0.874
1981	0.825	0.884
1982	0.831	0.888
1983	0.832	0.888
1984	0.835	0.878
1985	0.832	0.876
1986	0.821	0.878
1987	0.824	0.874
1988	0.830	0.874
1989	0.820	0.875
1990	0.820	0.876

Source: NSCG 1993 data.
Notes: N = 30. R^2 values are from an OLS regression of convergence measure against a quartic time trend and an indicator dummy.

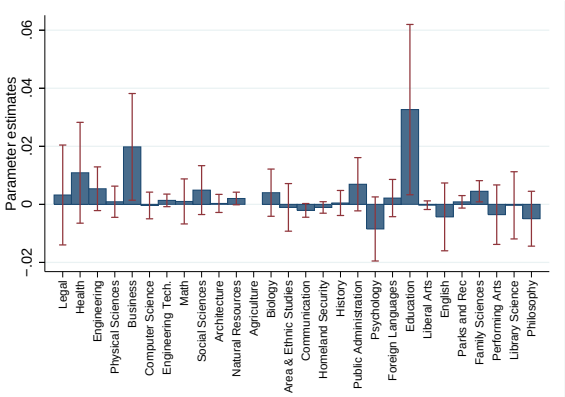
Figure A1: Female-Male Convergence in Graduate Field Distributions, all years



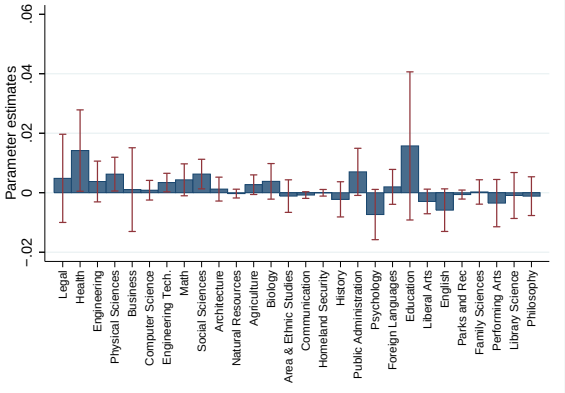
Source: NSCG 1993 data.
Note: The solid line is the lowess smoother applied to the data allowing for a break between 1973 and 1974. The break year was determined by looking for a structural break in the data (see Table A3).

Figure A2: Gender difference in graduate degrees by field

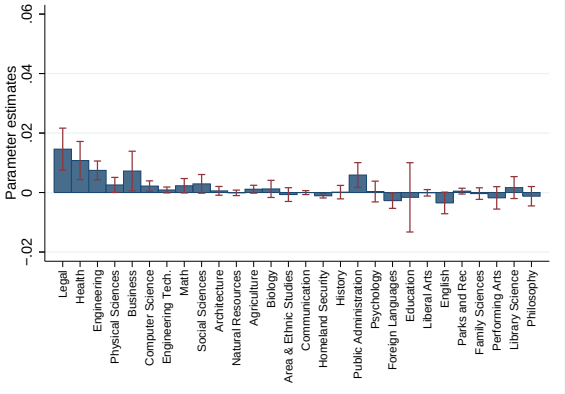
Controlling for birth control pill (Myers)



Controlling for birth control pill (Goldin-Katz)



Controlling for abortion legalization



Source: NSCG 1993 data.
Notes: Parameter estimates are field-specific female-male differences in likelihood. Specifically, they are the δ_f from the following regression model: $Y_{ift} = \beta_{0f} + \beta_{1f} \cdot F_{if} + \beta_{2f} \cdot \mathbb{1}\{\texttt{Title IX}\} + \delta_f \cdot \left(\mathbb{1}\{\texttt{Title IX}\} \times F_{if}\right) + X'\gamma + \varepsilon_{ift}$ I control for access to birth control by limiting the analysis sample to states where minors were able to access to the pill in 1969. "Goldin-Katz" uses states as defined by Goldin and Katz (2002). "Myers" uses states as defined by Myers (2014). See Table 4 for full list of states. I control for abortion legalization by including state-level categories of the strictness of abortion laws prior to 1973.

Table A4: Gender difference in graduate degrees by salary tercile

Panel A: Everyone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Female × Title 9	0.0474***	0.00115	0.0267	0.0462***	0.00175	0.00297	0.0511***	0.00679*	-0.00887
	(0.0167)	(0.00981)	(0.0180)	(0.0134)	(0.00796)	(0.0147)	(0.00636)	(0.00363)	(0.00686)
Observations	8,020	8,020	8,020	11,874	11,874	11,874	57,921	57,921	57,921
Salary Tercile	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Controls for:									
Time-trend and fixed-effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth control pill?	Goldin-Katz	Goldin-Katz	Goldin-Katz	Myers	Myers	Myers			
Abortion?							Yes	Yes	Yes

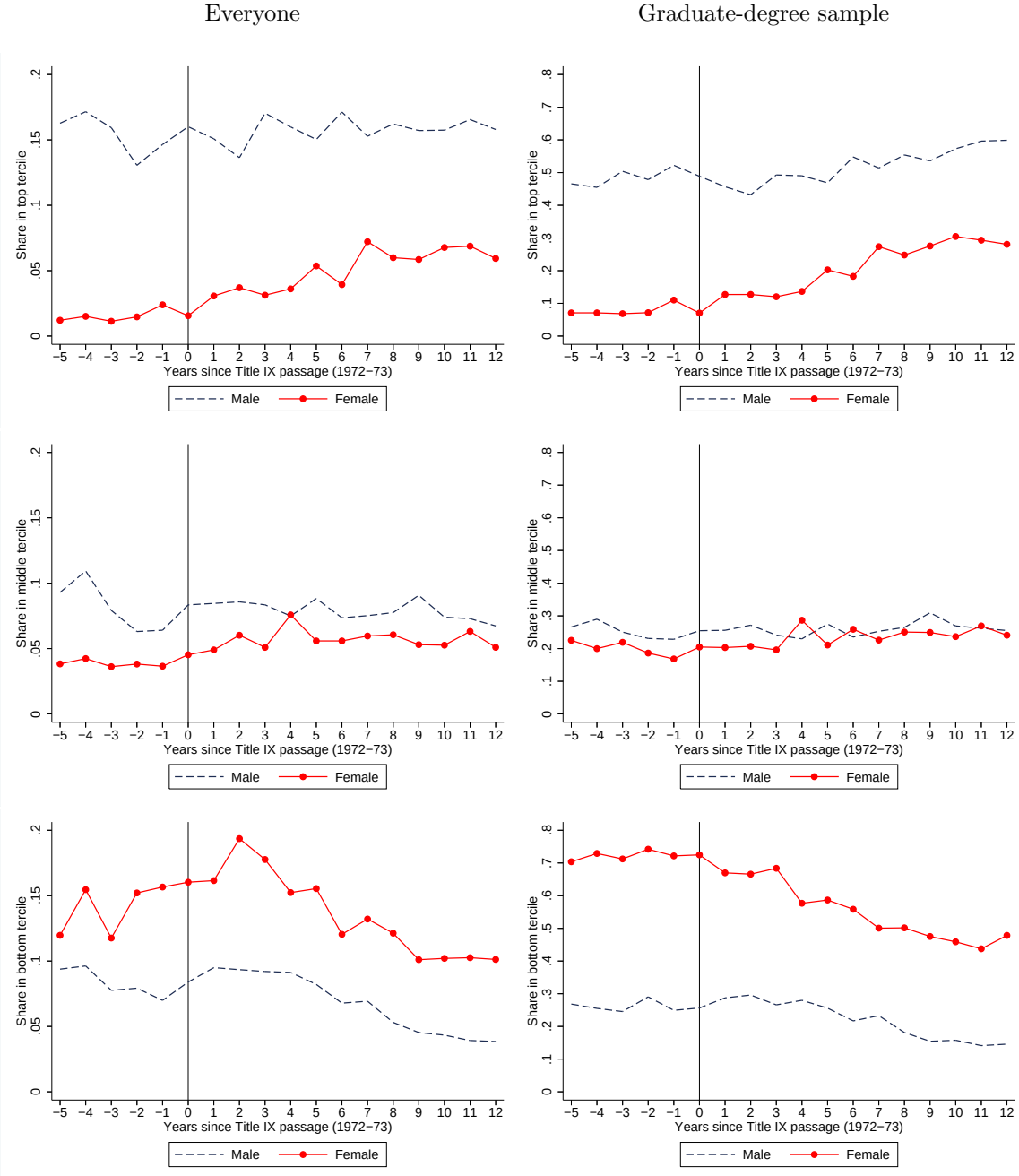
Panel B: Graduate-degree sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Female × Title 9	0.136***	-0.0527	-0.0836	0.175***	-0.0319	-0.144***	0.149***	-0.00182	-0.147***
	(0.0513)	(0.0398)	(0.0540)	(0.0409)	(0.0334)	(0.0449)	(0.0183)	(0.0139)	(0.0195)
Observations	2,361	2,361	2,361	3,580	3,580	3,580	17,429	17,429	17,429
Salary Tercile	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Controls for:									
Time-trend and fixed-effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth control pill?	Goldin-Katz	Goldin-Katz	Goldin-Katz	Myers	Myers	Myers			
Abortion?							Yes	Yes	Yes

Source: NSCG 1993 data.

Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. I control for access to birth control by limiting the analysis sample to states where minors were able to access to the pill in 1969. "Goldin-Katz" uses states as defined by Goldin and Katz (2002). "Myers" uses states as defined by Myers (2014). See Table 4 for full list of states. I control for abortion legalization by including state-level categories of the strictness of abortion laws prior to 1973. *** p< 0.01, ** p< 0.05, * p< 0.1

Figure A3: Graduate Degree Trends by Gender-parity Terciles



Source: NSCG 1993 data. Notes: Top gender-parity tercile consists of fields with the lowest 1962-1970 female share of degrees. Bottom gender-parity tercile consists of fields with the highest 1962-1970 female share of degrees.

Table A5: Gender difference in graduate degrees by gender parity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Everyone									
Female × Title 9	0.0250*	0.0228*	0.0275	0.0229*	0.0234**	0.00458	0.0340***	0.0186***	-0.00354
	(0.0143)	(0.0134)	(0.0179)	(0.0118)	(0.0101)	(0.0149)	(0.00554)	(0.00477)	(0.00690)
Observations	8,020	8,020	8,020	11,874	11,874	11,874	57,921	57,921	57,921
Gender-parity Tercile	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Controls for:									
Time-trend and fixed-effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth control pill?	Goldin-Katz	Goldin-Katz	Goldin-Katz	Myers	Myers	Myers			
Abortion?							Yes	Yes	Yes
Panel B: Graduate-degree sample									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Female × Title 9	0.0721	0.0341	-0.106**	0.102***	0.0478	-0.149***	0.107***	0.0287*	-0.136***
	(0.0458)	(0.0503)	(0.0535)	(0.0353)	(0.0402)	(0.0440)	(0.0164)	(0.0172)	(0.0190)
Observations	2,361	2,361	2,361	3,580	3,580	3,580	17,429	17,429	17,429
Gender-parity Tercile	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Controls for:									
Time-trend and fixed-effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth control pill?	Goldin-Katz	Goldin-Katz	Goldin-Katz	Myers	Myers	Myers			
Abortion?							Yes	Yes	Yes

Source: NSCG 1993 data.

Notes: Controls include a quartic time trend, school region fixed effects, and birth-year fixed effects. Top gender-parity tercile consists of fields with the lowest 1962-1970 female share of degrees. Bottom gender-parity tercile consists of fields with the highest 1962-1970 female share of degrees. I control for access to birth control by limiting the analysis sample to states where minors were able to access to the pill in 1969. "Goldin-Katz" uses states as defined by Goldin and Katz (2002). "Myers" uses states as defined by Myers (2014). See Table 4 for full list of states. I control for abortion legalization by including state-level categories of the strictness of abortion laws prior to 1973. *** p< 0.01, ** p< 0.05, * p< 0.1