Gender Differences in First Jobs for New US PhDs in the Mathematical Sciences

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Abstract

We take a long term look at initial employment trends for new doctorates with an eye towards gender, citizenship, and gender and citizenship differences by analyzing data from 1991–2015 AMS-ASA-IMS-MAA-SIAM Annual Surveys. The data show that the unemployment rate for women has been equal to or lower than the rate for men during most of the last quarter century. The one exception is that between 2001 and 2015 the unemployment rate for women who are not U.S. citizens was higher than the rate for non-citizen men. The unemployment rates are higher for males who are U.S. citizens than for non-citizen males in the last fifteen years, a puzzling trend. The data show that men from all pure math programs[1] are considerably more likely than women to take jobs at the top-ranking and top-producing math departments. The data show women take jobs at departments in which the highest degree is a bachelor's degree at much higher rates and men take jobs in business and industry at considerably higher rates. We also find that men from the top-ranking or top-producing doctoral programs tend to be more likely to take jobs at academic institutions or research institutes at least on a par with their degree-granting institutions.

1 Introduction

In this study we investigate employment patterns for new PhDs in mathematics between 1991 and 2015 with an eye toward gender, citizenship and gender $\times$ citizenship[2] differences in unemployment rates, patterns of job types, and comparable employment rates, which we explain in section four. We are concerned about citizenship differences, in large part, because more than half the mathematics PhDs granted by U.S. institutions are awarded to non-U.S. citizens. The data we analyze comes from the Report on New Doctoral Recipients (from U.S. institutions), which is part of the Annual Survey of the Mathematical Sciences published by the American Mathematical Society (AMS). The Report contains data on jobs both in and outside of academia and in and outside the U.S. More detailed information on the data we used in this study appears at the end of this article.

We raise four questions about employment trends for new PhDs.

- Is the percentage of women (respectively, U.S. citizen) new PhDs increasing?
- Are there differences in initial unemployment rates due to gender, citizenship, or gender $\times$ citizenship, for new PhDs from U.S. institutions?
- Are there differences in the type of employment by gender?

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[1]When we speak of pure mathematics departments we exclude departments in applied mathematics, statistics, and biostatistics.

[2]When social scientists and statisticians study the effects of two independent variables and their interaction they use the mathematical symbol $\times$ to denote testing for an interaction effect.

- With regard to academic jobs, are men and women equally likely be employed by departments whose ranking is at least comparable to the degree-granting department?

We will see that women are still not getting more than their share of the jobs, but the same differences that Flahive and the current author observed in previous studies [9] and [8] exist today. For example, women were employed at academic institutions whose highest degree in mathematics is a bachelors degree at a substantially higher rate than men and men were employed in business and industry at a considerably higher rate than women.

2 Percentages of Women and U.S. Citizens Among New PhDs

During the last quarter century women received an average of 28.8% of the mathematics doctorates from U.S. departments. During this period U.S. citizens received 46.0% of the doctorates; women received 28.5% of the doctorates that were awarded to U.S. citizens. We now look at gender $\times$ citizenship differences. We note that the PhDs whose citizenship was unknown at the time of the surveys appear in the All PhDs column, but do not appear in the US or Non US columns.

Table 1: Number of PhDs Granted by Citizenship and Gender (Percentages of all PhDs in Two Column Citizenship Group)

	US		Non US		All PhDs	
Period	F	M	F	M	F	M
1991–2000	1350	3622	1147	4293	2597	8291
	(27.2%)	(72.8%)	(21.1%)	(78.9%)	(23.9%)	(76.1%)
2001–2011	1950	4531	2501	5187	4468	9761
	(30.1%)	(69.9%)	(32.5%)	(67.5%)	(31.4%)	(68.6%)
2012–2015	972	2548	1357	2587	2330	5138
	(27.6%)	(72.4%)	(34.4%)	(65.6%)	(31.2%)	(68.8%)
1991–2015	4272	10701	5005	12067	9395	23190
	(28.5%)	(71.5%)	(29.3%)	(70.7%)	(28.8%)	(71.2%)

Notice that the percentage of new women PhDs was lowest during 1991–2000; during this period the rate for U.S. citizens was considerably higher. In both 2001–2011 and 2012–2015 non-citizen women received a higher percentage of the degrees than the U.S. citizen women. Among U.S. citizens, the percentage of new women PhDs increased slightly in the second period but fell in the most recent period. Among the non-citizens, he percentage of new women PhDs steadily increased. Non-citizen men received a higher percentage of the degrees than citizens during 1991–2000 but the reverse was true in both later periods. We find these trends disturbing.

3 Initial Unemployment Rates

During the last quarter century, 27,504 out of 32,585 new PhDs (84.4%) were known to have jobs in or outside of the U.S. by the time the annual survey was conducted in the year in which they received their degrees. Of the 5,081 new PhDs that didn't report having jobs, 3,464 either remained in the U.S. and had unknown employment status or left the U.S. and didn't report having jobs.[3]

We now will take a closer look at initial unemployment rates, focusing on those who remained in the U.S. after receiving their degrees and were still seeking employment at the time of the survey. Following

[3]The AMS divides new PhDs who remain in the U.S. after receiving their degrees without reported employment into three groups: Still Seeking US, Not Seeking US, and Unknown US. In contrast, all people who leave the U.S. after their degrees are reported as Unknown Non US.

current AMS conventions on unemployment rate calculations, individuals employed outside the U.S. as well as those whose employment status was unknown have been removed from the denominator in the calculation of the unemployment rate. We also adopt the AMS convention of removing those individuals reported as not seeking employment from the denominator. For the entire 25 year period under investigation, the group Not Seeking US accounted for 1.1% of all new PhDs (1.6% of the females and 0.9% of the males). As pointed out in the 2015 survey, these conventions increase the unemployment rate from the rates reported prior to the these adjustments.

During the 1991–2015 time period, 1,598 of 24,841 (6.4%) of the these new PhDs were still seeking employment at the time of the annual survey; the rate was 0.6% higher for non-U.S. citizens than for citizens.

Table 2 breaks down the unemployment rate by citizenship over three time periods in the last quarter century. In all tables in this section the *All PhDs* column includes new PhDs whose citizenship was unknown at the time of the survey.

Table 2: Number of New PhDs in the US Still Seeking Employment by Citizenship
(Percentages of all New PhDs in Column Cohort)

Period	US	Non US	All PhDs
1991–2000	332 (7.6%)	388 (11.2%)	749 (9.3%)
2001–2011	246 (4.5%)	240 (4.5%)	486 (4.5%)
2012–2015	217 (7.1%)	146 (5.3%)	363 (6.2%)
1991–2015	795(6.1%)	774 (6.7%)	1598 (6.4%)

Notice that during 1991–2000 the unemployment rate for non-U.S. citizens was 47.4% higher than the rate for U.S. citizens. The unemployment rate for 2001–2011 was the same for both U.S. citizens and non-U.S. citizens and was lower than the rate for the preceding decade. The overall unemployment rate increased in 2012–2015. Looking at citizenship differences, the rate for for non-U.S. citizens was 25.5% lower than the rate for U.S. citizens. The early disadvantage for non-U.S. citizens was reversed by the end of the study. It is disappointing that the unemployment rate is inching back up in recent years after a decline during 2000–2011. The reader is reminded that due to the change in groupings, the cycles of new PhDs are unequal in length and hence these percentage differences are suggestive, but not directly comparable. Over the entire 1991–2015 period, the unemployment rate for non-U.S. citizens was 0.6 percentage points higher, which represents 8.6% of the unemployment rate for citizens.

In Table 3, we look at three separate time periods and break down the unemployment rates by gender and citizenship. For U.S. citizens, the rate of those still seeking employment is lower for women during each time period whereas for non-U.S. citizens the rate is at least at high for women during each time period.

Table 3: Number of New PhDs Still Seeking Employment by Citizenship and Gender
(Percentages of all New PhDs in Column Cohort)

	US		Non US		All PhDs	
Period	F	M	F	M	F	M
1991–2000	61 (5.1%)	271 (8.5%)	84 (11.2%)	304 (11.2%)	154 (7.7%)	595 (9.8%)
2001–2011	50 (2.9%)	196 (5.1%)	89 (4.8%)	151 (4.3%)	139 (3.9%)	347 (4.7%)
2012–2015	41 (4.7%)	176 (8.0%)	61 (6.1%)	85 (4.8%)	102 (5.5%)	261 (6.6%)
1991–2015	152 (4.0%)	643 (7.0%)	234 (6.5%)	540 (6.7%)	395 (5.3%)	1203 (6.9%)

Looking at gender $\times$ citizenship differences, the disadvantage for non-U.S. citizens from 1991–2000 is more pronounced for women; the rate for female non-U.S. citizens was more than double the rate for citizens. The disadvantage for non-U.S. citizens lessened during 2001–2011. Notice that for male PhDs during the 2012–2015 period, the unemployment rate for citizens was 3.2 percentage points higher than for non-U.S. citizens, which is 67.3% of the unemployment rate for non-U.S. citizens.

4 Types of Employment

In this section, we look at the types of employment obtained by the various groups of new PhDs We start with general observations with an eye towards gender differences and then break down our observations by public/private degree-granting institutions and citizenship. As we shall see, some of the trends we saw in the earlier studies persist: women take jobs at institutions in which the highest degree is a bachelor's degree at substantially higher rates and men take jobs in business and industry at somewhat higher rates. The AMS changed the annual survey reporting groupings in 2012 so we present data separately for 2012 – 2015. Beginning in 2012 the top-ranking Group I departments were replaced by the top-producing Public Large and Private Large departments. The All Others row in all tables in this section include new PhDs who accepted jobs in statistics, biostatistics or applied math departments, outside the U.S., those who were still seeking or not seeking employment, as well as those whose employment status was unknown at the time of the survey.

4.1 Pure Mathematics Doctorates:All Departments

Let's first group together all the new PhDs who received degrees from pure mathematics programs, that is, Ph.Ds. from Groups I – III departments during 1991–2011 and from Public Large/ Medium/Small and Private Large/Small institutions during 2012–2015. In all, there were 17,753 new PhDs in that cohort, 4,333 (24.4%) of whom were women and 13,420 (75.6%) of whom were men.

The first two tables summarize the findings for new PhDs from pure mathematics doctoral programs who were employed in the U.S. In Table 4 we report for the entire 1991–2011 time period as well give breakdowns for into 1991–2000 and 2001–2011 periods. We look at the 2012–2105 cohort separately in Table 5. Since the number of new pure math PhDs who were employed by statistics, biostatistics, applied mathematics, or operations research (Groups IV and V) departments is very small, we do not include separate data rows on employment in those areas in the table; however they are included in the All Others rows as well as the column total and percentage of column cohort calculations. We remind the reader that in AMS data reports, "other academic" stands for US academic departments other than pure and applied mathematics departments, biostatistics departments, departments whose highest degree is Bachelor's or Master's degrees, and 2 year colleges.

We will make some observations by looking at large differences in percentages of men and women who received pure math PhDs and who were employed in various sectors.

4.1.1 Group I and Public/Private Large Hires

Looking at the period 1991 – 2000 in Table 4 we see a 2.1 point difference in the percentages of men and women who were employed by the top-ranking Group I departments; this 2.1 point difference represents 18.8% of the percentage of women who were employed by Group I departments. Between 2001 and 2011 the difference was more pronounced. We see a 4.2 point

Table 4: Observed Frequencies of First Jobs (Percentages of Column Cohort)
for Pure Math PhDs 1991–2011

	1991–2000			2001–2011			1991–2011		
Emp Type	F	M	All	F	M	All	F	M	All
Gr I	199 (11.2%)	849 (13.3%)	1048 (12.9%)	335 (13.1%)	1216 (17.3%)	1551 (16.2%)	534 (12.3%)	2065 (15.4%)	2599 (14.6%)
Gr II	88 (4.9%)	326 (5.1%)	414 (5.1%)	193 (7.6%)	559 (7.9%)	752 (7.8%)	281 (6.5%)	885 (6.6%)	1166 (6.6%)
Gr III	99 (5.6%)	251 (3.9%)	350 (4.3%)	120 (4.7%)	263 (3.7%)	383 (4.0%)	219 (5.1%)	514 (3.8%)	733 (4.1%)
Masters	161 (9.0%)	416 (6.5%)	577 (7.1%)	202 (7.9%)	351 (5.0%)	553 (5.8%)	363 (8.4%)	767 (5.7%)	1130 (6.4%)
Bachelors	370 (20.8%)	787 (12.3%)	1157 (14.2%)	483 (18.9%)	877 (12.4%)	1360 (14.2%)	853 (19.7%)	1664 (12.4%)	2517 (14.2%)
2Yr	38 (2.1%)	110 (1.7%)	148 (1.8%)	61 (2.4%)	150 (2.1%)	211 (2.2%)	99 (2.3%)	260 (1.9%)	359 (2.0%)
Oth Acad	61 (3.4%)	239 (3.8%)	300 (3.7%)	190 (7.4%)	407 (5.8%)	597 (6.2%)	251 (5.8%)	646 (4.8%)	897 (5.1%)
Res Inst	32 (1.8%)	176 (2.8%)	208 (2.6%)	70 (2.7%)	134 (1.9%)	204 (2.1%)	102 (2.4%)	310 (2.3%)	412 (2.3%)
Govt	36 (2.0%)	141 (2.2%)	177 (2.2%)	90 (3.5%)	202 (2.9%)	292 (3.0%)	126 (2.9%)	343 (2.6%)	469 (2.6%)
Bus/Ind	143 (8.0%)	754 (11.8%)	897 (11.0%)	205 (8.0%)	692 (9.8%)	897 (9.3%)	348 (8.0%)	1446 (10.8%)	1794 (10.1%)
All Others	555 (31.1%)	2324 (36.5%)	2879 (35.3%)	602 (23.6%)	2196 (31.2%)	2798 (29.2%)	1157 (26.7%)	4520 (33.7%)	5677 (32.0%)
Grand Total	1782 (100.0%)	6373 (100.0%)	8155 (100.0%)	2551 (100.0%)	7047 (100.0%)	9598 (100.0%)	4333 (100.0%)	13420 (100.0%)	17753 (100.0%)

difference in the percentages of men and women who were employed by the top-ranking Group I departments; this 4.2 point difference represents 32.1% of the percentage of women who were employed by Group I departments. To put this in perspective, during the same period, 46.9% of all women pure math PhDs received degrees from Group I institutions and 56.1% of the men pure math PhDs received degrees from Group I institutions. Looking only at Group I PhDs, we saw that 24.4% were women and 75.6% were men.

We now turn our attention to the 2012 – 2015 cohort of new pure math PhDs. We will first present the data and then make some observations.

Table 5 shows that between 2012 and 2015 the percentages of men who were employed in Public and Private Large departments were noticeably higher than the percentages for women, with the biggest difference occurring in Private Large hires. At the Public Large departments, we see a 1.9 point difference in the percentages of men and women who were employed by the top-ranking Group I departments; this 1.9 point difference represents 25.7% of the percentage of women who were employed by the Group I departments. At Private Large departments we see a 2.2 point difference in the percentages of men and women who were employed by the top-ranking Group I departments; this 2.2 point difference represents 51.2% of the percentage of women who were employed by Public and Private large departments. The latter was the greatest difference we observed.

Table 5: Observed Frequencies of First Jobs (Percentages of Column Cohort)
for Pure Math PhDs 2012–2015

Employer Type	Female	Male	All
Public Large	94 (7.4%)	332 (9.3 %)	426 (8.8%)
Public Medium	60 (4.7%)	179 (5.0%)	239 (5.0%)
Public Small	51 (4.0%)	129 (3.6%)	180 (3.7%)
Private Large	55 (4.3%)	230 (6.5%)	285 (5.9%)
Private Small	29 (2.3%)	62 (1.7%)	91 (1.9%)
Masters	53 (4.2%)	121 (3.4%)	174 (3.6%)
Bachelors	222 (17.5%)	354 (10.0%)	576 (12.0%)
2 Year	35 (2.8%)	80 (2.3%)	115 (2.4%)
Other Academic	91 (7.2%)	197 (5.5%)	288 (6.0%)
Research Inst	25 (2.0%)	87 (2.4%)	112 (2.3%)
Government	52 (4.1%)	109 (3.1%)	161 (3.3%)
Business/Industry	171 (13.5%)	577 (16.2%)	748 (15.5%)
All Others	328 (25.9%)	1095 (30.8%)	1423 (29.5%)
Grand Total	1266 (100%)	3552 (100%)	4818 (100%)

4.1.2 Group II and Public Medium Hires

There were small differences in the percentages of men and women who were employed by Group II or Public Medium departments. In all time periods of this study, the percentages of male pure math PhDs who were employed by Group II or Public Medium departments were slightly higher that the percentages for females.

4.1.3 Group III Hires

During 1991–2011 we see a 1.3 point difference in the percentages of men and women who were employed by the Group III departments with women having the higher percentage; this 1.3 point difference represents 34.2% of the percentage of men who were employed by Group III departments. During 2012 and 2015 the percentage of women who were employed by Public Small departments was 0.4 points higher than the percentage for men; this 0.4 point difference represents 11.1% of the percentage of men who were employed by Public Small departments. Over the same period, the percentage of men who were employed by Private Small departments was 0.6 points higher than the percentage for women; this 0.6 point difference represents 35.3% of the men who were employed by Private Small departments.

4.1.4 Bachelor's Degree Only Hires

There were striking gender differences in the percentages of male and female new pure math PhDs who took jobs in departments in which the highest mathematics degree is a bachelor's degree during all periods of this study. The reader should first refer to Table 4 to follow our observations. Between 1991 and 2000 the percentage of women who took jobs at bachelor's-only departments was 8.5 points higher than for men; this 8.5 point difference represents 69.7% of the percentage of men who were employed by bachelor's-only departments. Between 2001 and 2011 the difference was slightly less but still large; the percentage of women who took these jobs was 6.5 points higher than the percentage of men; this 6.5 point difference represents 52.4% of the percentage of men who were employed by bachelor's-only departments. Looking at Table 5, we see the percentage difference increased during 2012–2015; the percentage of women was 7.5 points higher than the percentage of men who were employed by bachelor's-only departments; this 7.5 point difference represents 75.0% of the percentage of men who were employed by bachelor's-only departments. This is the largest difference we observed for bachelor's-only hires. This gender difference was substantial in every period under analysis.

4.1.5 Business and Industry Hires

There were considerable gender differences in the percentages of new pure math PhDs who took jobs in business and industry. During 1991 and 2000, the percentage of men taking jobs in business and industry was 3.8 points higher than the percentage for women; this 3.8 point difference represents 47.5% of the percentage of women who took jobs in business and industry. For 2001–2011 the percentage of men taking jobs in business and industry was 1.8 points or 22.5% higher than the percentage for women. During both of these periods, the percentage of women who took jobs in business and industry remained constant at 8.0%, whereas the percentage for men who took jobs in business and industry dropped from 11.8% to 9.8%; this drop caused the gender difference to lessen. In the most recent period, 2012–2105, the percentage of men taking jobs in business and industry was 2.7 points or 20.0% higher than the percentage for women. Notice that the percentage of women who took jobs in business and industry between 2012 and 2015 was 13.5% compared to 8.0% for both 1991–2000 and 2000–2011. Thus the percentage gender differences observed for jobs accepted in business and industry has diminished in recent years.

4.2 Pure Mathematics Doctorates: Group I Public/Private and Public/Private Large Departments

The top-ranking or top-producing departments award more of the doctorates than any other group of departments. Between 1991 and 2011, 38.0% of all new Ph.Ds and 53.8% of the pure math PhDs came from Group I Public or Private departments. Between 2012 and 2015, 33.3% of all new PhDs and 51.4% of the pure math PhDs came from Public or Private Large departments. We now look at how they fared in the U.S. job market. Since Group I wasn't subdivided into Group I Public and Group I Private until 1996 we start Table 6 in 1996.

We see in Tables 6 and 7 that the gender differences we saw for jobs obtained at Group I departments by all pure math PhDs are greatly reduced when looking only at new PhDs from the top-ranking or top-producing departments. As in Tables 4 and 5, the denominators in the percentage of column cohort calculations include new PhDs who accepted other nonacademic jobs, those who were still seeking or not seeking employment, as well as those whose employment status was unknown at the time of the survey. We continue to see very large gender differences in jobs taken at bachelor's-only departments and substantial differences in jobs taken in business and industry, particularly for Group I Public PhDs. Our data also show that more than half of the jobs in business and industry between 1991 and 2011 went to Group I PhDs. We remind the reader that since the number of these PhDs who obtain jobs in statistics, biostatistics, applied mathematics, or operations research is very small we do not include data on employment in those areas as rows in our table; however they are included in column total and percentage of column cohort calculations.

Table 6: Observed Frequencies of First Jobs (Percentages of Column Cohort) for Group I PhDs 1996–2011

	Group I Public			Group I Private		
Employer Type	Female	Male	All	Female	Male	All
Group I Public	143 (13.5%)	528 (14.7%)	671 (14.4%)	68 (11.9%)	251 (11.6%)	319 (11.6%)
Group I Private	67 (6.3%)	288 (8.0%)	355 (7.6%)	102 (17.9%)	400 (18.5%)	502 (18.3%)
Group II	78 (7.4%)	299 (8.3%)	377 (8.1%)	41 (7.2%)	120 (5.5%)	161 (5.9%)
Group III	37 (3.5%)	70 (1.9%)	107 (2.3%)	8 (1.4%)	28 (1.3%)	36 (1.3%)
Masters	65 (6.1%)	123 (3.4%)	188 (4.0%)	11 (1.9%)	37 (1.7%)	48 (1.8%)
Bachelors	168 (15.9%)	289 (8.0%)	457 (9.8%)	54 (9.5%)	118 (5.4%)	172 (6.3%)
2 Year	13 (1.2%)	47 (4.4%)	60 (1.3%)	2 (0.4%)	8 (0.4%)	10 (0.4%)
Other Academic	47 (3.4%)	140 (3.9%)	187 (4.0%)	28 (4.9%)	107 (4.9%)	135 (4.9%)
Research Inst	27 (2.5%)	72 (2.0%)	99 (2.1%)	26 (4.6%)	86 (4.0%)	112 (4.1%)
Government	38 (3.6%)	96 (2.7%)	134 (2.9%)	16 (2.8%)	40 (1.8%)	56 (2.0%)
Business/Industry	90 (8.5%)	396 (11.0%)	486 (10.4%)	58 (10.2%)	246 (11.3%)	304 (11.1%)
All Others	286 (27.0%)	1246 (34.7%)	1532 (32.9%)	157 (27.5%)	727 (33.5%)	884 (32.3%)
Grand Total	1059 (100.0%)	3594 (100.0%)	4653 (100.0%)	571 (100.0%)	2168 (100.0%)	2739 (100.0%)

Notice that for both Group I Public and Group I Private new doctorates, the percentage of women who were employed by bachelor's-only departments is nearly double the percentage for men.

Table 7: Observed Frequencies of First Jobs (Percentages of Column Cohort) for Public/Private Large PhDs 2012–2015

	Public Large			Private Large		
Employer Type	Female	Male	Totals	Female	Male	Totals
Public Large	53 (14.3%)	177 (14.2 %)	230 (14.2%)	22 (12.0%)	88 (13.1%)	110 (12.8%)
Public Medium	18 (4.9%)	47 (3.8%)	65 (4.0%)	6 (3.3%)	30 (4.5 %)	36 (4.2%)
Public Small	5 (1.4%)	30 (2.4%)	35 (2.2%)	1 (0.5%)	5 (0.7 %)	6 (0.7%)
Private Large	17 (4.6%)	98 (7.8%)	115 (7.1%)	31 (16.9%)	103 (15.3%)	134 (15.6%)
Private Small	7 (1.9%)	19 (1.5%)	26 (1.6%)	5 (2.7%)	9 (1.3%)	14 (1.6%)
Masters	7 (1.9%)	20 (1.6%)	27 (1.7%)	4 (2.2%)	8 (1.2%)	12 (1.4%)
Bachelors	55 (14.9%)	83 (6.6%)	138 (8.5%)	12 (6.6%)	22 (3.3%)	34 (4.0%)
2 Year	7 (1.9%)	17 (1.4%)	24 (1.5%)	2 (1.1%)	2 (0.3%)	4 (0.5%)
Other Academic	24 (6.5%)	63 (5.0%)	87 (5.4%)	16 (8.7%)	34 (5.0%)	50 (5.8%)
Research Inst	10 (2.7%)	34 (2.7%)	44 (2.7%)	4 (2.2%)	27 (4.0%)	31 (3.6%)
Government	14 (3.8%)	48 (3.8%)	62 (3.8%)	9 (4.9%)	7 (1.0%)	16 (1.9%)
Business/Industry	54 (14.6%)	204 (16.3%)	258 (15.9%)	29 (15.8%)	119 (17.7%)	148 (17.3%)
All Others	96 (25.4%)	406 (31.9%)	502 (30.4%)	42 (23.0%)	215 (32.0%)	257 (30.1%)
Grand Total	370 (100%)	1250 (100%)	1620 (100%)	183 (100%)	674 (100%)	857 (100%)

We next consider the most recent cohort of new PhDs from Public Large and Private Large departments and summarize the data in Table 7. As usual, the denominators in the percentage of column cohort calculations include new PhDs who accepted other nonacademic jobs, those who were still seeking or not seeking employment, as well as those whose employment status was unknown at the time of the survey.

We call your attention to a few striking details in Table 7. First of all, there is still a very large difference in percentages of women and men with PhDs from Public Large and Private Large departments who were employed by bachelor's-only departments; the percentage of women taking bachelor's-only jobs is at least double the percentage for men. This large gender difference was present in every period of our study and is not diminishing. Looking at U.S. citizens only, there are considerable gender differences in PhDs from Private Large programs who were employed by either Public or Private Large departments. For U.S. citizen PhDs from Private Large programs, 9.6% of the women versus 15.5% of the men were employed by Public Large departments and 12.0% of the women versus 19.1% of the men took jobs at Private Large departments. We will revisit these differences in our next section on at least comparable employment rates. We also note that for new PhDs from Public Large programs, the percentage of men and women who took jobs in business and industry is higher than the percentage who take jobs at Public Large departments; the same is true for new Private Large PhDs. This was not the case for 1991-2011 PhDs. Just as in the earlier years, most of the new PhDs who went into business and industry received their degrees from top-producing institutions. If we look at only U.S. citizens, we see that 19.3% of the women (versus 13.5% of the men) from Private Large PhD programs took jobs in business and industry. Looking at U.S. citizen PhDs from Public Large programs, 17.9% of the men and 9.2% of the women took jobs in business and industry.

4.3 Statistics and Biostatistics Doctorates:All Departments

Before we leave this section, we take a brief look and employment patterns for statistics and biostatistics degree recipients. The applied mathematics degree recipients form a much smaller cohort and we will not analyze their employment patterns in this section. During 1991 and 2000 there were 2,038 degree recipients in statistics or biostatistics (31.9% women) and between 2001 and 2011 there were 3,582 degree recipients (45.3% women). Between 2012 and 2015, there were 2,010 degree recipients in statistics or biostatistics (43.4% women). It would be interesting to better understand why statistics/biostatistics attracts relatively more women than pure mathematics; 24.8% of the pure math doctorates between 1991 and 2015 were awarded to women. The number of statistics/biostatistics degree recipients is increasing over time. In 2015, we observed that 34% of all new PhDs wrote dissertations in statistics/biostatistics, more than in any other area. The majority of statistics degree recipients take jobs at departments with doctoral statistics programs, at "other academic" institutions, in non-US academic departments, in government, or in business and industry. In the Table 8 we will focus our attention to these employment types. We again recall that in AMS data reports, "other academic" stands for US academic departments other than pure and applied mathematics departments, statistics and biostatistics departments, departments whose highest degree is Bachelor's or Master's degrees, and 2 year colleges. The All Others row, as well as the denominators in the percentage of column cohort calculations, includes new PhDs who accepted jobs at pure math, applied math, departments whose highest degree is Bachelor's or Master's degrees, and 2 year colleges, those who were still seeking or not seeking employment, and those whose employment status was unknown at the time of the survey.

Notice that between 1991 and 2011 a large percentage of statistics/biostatistics degree recipients took jobs in government or in business and industry. During 2012–2015 the percentage of statistics/biostatistics degree recipients who took jobs in government, business, and industry was even greater.

5 At Least Comparable Employment Rates

In this section we ask whether new PhDs attain employment in academia at a level at least comparable to that of their degree-granting institution. We consider jobs at Research Institutes

Table 8: Observed Frequencies of First Jobs (Percentages of Column Totals)
for Statistics and Biostatistics PhDs 1991–2015

	1991–2000			2001–2011			2012–2015		
Employer Type	Female	Male	Totals	Female	Male	Totals	Female	Male	Totals
Stat/Biostat	104 (16.0%)	202 (14.6%)	306 (15.0%)	231 (14.2%)	325 (16.6%)	556 (15.5%)	101 (11.6%)	191 (16.8%)	292 (14.5%)
Other Academic	76 (11.7%)	144 (10.4%)	220 (10.8%)	294 (18.1%)	323 (16.5%)	617 (17.2%)	126 (14.4%)	141 (12.4%)	267 13.3%)
Research Inst	37 (5.7%)	37 (2.7%)	74 (3.6%)	108 (6.7%)	77 (3.9%)	185 (5.2%)	45 (5.2%)	42 (3.7%)	87 (4.3%)
Government	35 (5.4%)	63 (4.5%)	98 (4.8%)	99 (6.1%)	84 (4.3%)	183 (5.1%)	46 (5.3%)	53 (4.7%)	99 (4.9%)
Business/ Industry	179 (27.5%)	368 (26.5%)	547 (26.8%)	408 (25.1%)	523 (26.7%)	931 (26.0%)	301 (34.5%)	411 (36.1%)	712 (35.4%)
NonUS Academic	57 (8.8%)	174 (12.5%)	231 (11.3%)	69 (4.3%)	104 (5.3%)	173 (4.8%)	29 (3.3%)	49 (4.3%)	78 (3.9%)
All Others	180 (27.7%)	510 (36.7%)	690 (33.9%)	370 (22.8%)	505 (25.8%)	875 (24.4%)	224 (25.7%)	251 (22.1%)	475 (23.6%)
Grand Total	650 (100.0%)	1388 (100.0%)	2038 (100.0%)	1623 (100.0%)	1959 (100.0%)	3582 (100.0%)	872 (100.0%)	1138 (100.0%)	2010 (100.0%)

or Other Non-Profits as desirable and group them with the top-ranking or top-producing departments (refer to Table 9).[4] As noted in past studies [9], [8], since the data collected from departments does not give detailed information on the type of position, a definitive answer to this question is not possible. Given that caution, the information in Table 9 again indicates that women are slightly *less* likely to obtain positions at least comparable with their training. Note that the comparable employment rates for both females and males from Group II institutions improved between 2001 and 2011, particularly the rates for women. The comparable employment rate for Public Medium departments between 2012 and 2015 was far less favorable to women. Doctorates from Group I and Public/Private Large are most likely to accept employment at a department comparable to their degree-granting department; the comparable employment rate for doctorates from Private Large institutions is substantially higher than all other comparable employment rates. The AMS has recently reported percentages of females produced and hired by the various groups of departments in Supplemental Table F.1: Females as a Percentage of New PhDs Produced and Hired by Doctoral-Granting Department Grouping. The only way to get the most recent table is to download the pdf file of the entire Report on New Doctoral Recipients from the AMS website on the survey [10] and look at the Supplemental Tables at the end of the file; the Supplemental Tables do not appear in the report that is published in the Notices of the AMS.

During the first period, men from Group I programs were 14.0% more likely than women to take comparable employment jobs and women from Group III programs were 23.3% more likely than men to take comparable employment jobs. The gender difference in Group III degree recipients reversed itself in the second period, during which other gender differences were reduced.

[4]For Group I PhDs we calculated the percentage who obtained jobs at Group I departments or Research Institutes/Other Non-Profits; for Group II PhDs we calculated the percentage who obtained jobs at Group I - II departments or Research Institutes/Other Non-Profits; and for Group III PhDs we calculated the percentage who obtained jobs at Group I - III departments or Research Institutes/Other Non-Profits.

Table 9: At Least Comparable Employment Rates for New Pure Math PhDs 1991–2015

PhD Granting Institution											
1991–2000						2001–2011					
Group I		Group II		Group III		Group I		Group II		Group III	
F	M	F	M	F	M	F	M	F	M	F	M
22.2%	25.3%	12.8%	13.0%	14.3%	11.6%	28.5%	29.0%	18.2%	18.9%	15.2%	17.6%

2012–2015									
Public Large		Private Large		Public Medium		Public Small		Private SmalI	
F	M	F	M	F	M	F	M	F	M
21.6%	24.7%	31.1%	32.4%	14.7%	18.6%	15.8%	18.8%	28.1%	25.3%

Next we turn our attention to the degree recipients between 2012 and 2015 and calculate at least comparable employment rates. [5]

During this period, men from Public Large programs were 14.4% more likely than women to take a job at a department comparable to their degree-granting department. Men from Public Medium and Public Small departments were 26.5%, respectively 19.0%, more likely than women to take a job at a department at least comparable to their degree-granting department. Women from Private Small departments were 11.1% more likely than men to take a job at a department at least comparable to their degree-granting department.

Looking at Table 9 we see that men who received their degrees from most programs were more likely than women to be employed by a department at least comparable to their degree-granting department. The only substantial exception was the Private Small doctorates during 2012–2015, where women were more likely than men to be employed by a department at least comparable to their degree-granting department.

Table 10 summarizes at least comparable employment rates for U.S. citizens.

Table 10: At Least Comparable Employment Rates for New Pure Math PhDs US Citizens Only 1991–2015

PhD Granting Institution											
1991–2000						2001–2011					
Group I		Group II		Group III		Group I		Group II		Group III	
F	M	F	M	F	M	F	M	F	M	F	M
23.4%	24.8%	12.2%	12.4%	18.4%	10.9%	27.8%	30.9%	16.5%	17.0%	16.9%	18.8%

2012–2105									
Public Large		Private Large		Public Medium		Public Small		Private SmalI	
F	M	F	M	F	M	F	M	F	M
21.5%	23.7%	26.4%	38.9%	15.6%	19.4%	18.3%	19.3%	31.6%	25.1%

From 1991 to 2000, women from Group III doctoral programs were much more likely to be

[5] For the most recent cohorts of Public and Private Large PhDs we consider employment at Public/Private Large or Research Institutes/Other Non-Profits as employment at least comparable to where the degree was obtained. For Public Medium doctorates, we consider employment at Public/Private Large, Public Medium, or Research Institute/Other Non-Profit as at least comparable employment. For PhDs from Public or Private Small, we consider employment at Public/Private Large, Public Medium, and Public/Private Small as employment at least comparable to where the degree was obtained.

employed by at least comparable departments than men. The gender difference was substantially greater than when we didn't filter by citizenship. In both other cases and for all types of 2001–2011 doctorates for U.S. citizens, men were more likely than women to be employed by at least comparable departments.

The striking gender differences for 2012–2015 doctorates were for Private Large and Private Small degree recipients. For the former group, men were 47.3% more likely to be employed by at least comparable departments and in the latter group women were 25.9% more likely to be employed by at least comparable departments. Looking at citizenship differences, women with degrees from Private Large institutions who are U.S. citizens were less likely than non-U.S. citizens to be employed by at least comparable departments; men from Private Large departments who are U.S. citizens were more likely than women to be employed by at least comparable departments.

We looked at the question of at least comparable employment in both of our earlier studies. Starting in 2011, the AMS has reported percentages of females produced and hired by the various groups of departments in Supplemental Table F.1: Females as a Percentage of New PhDs Produced and Hired by Doctoral-Granting Department Grouping. The only way to get the most recent table is to download the pdf file of the entire report at the AMS website for the survey `http://www.ams.org/profession/data/annual-survey/2015Survey-NewDoctorates-Report.pdf` and look at the Supplemental Tables at the end of the file. Percentages for males are not reported but can easily be calculated from the table for females. We hope that in the future AMS will report on at least comparable employment rates.

6 Conclusion

We summarize our findings on the four questions that we proposed to study.

Is the percentage of women (respectively, U.S. citizen) new PhDs increasing? The percentage of U.S. citizen women new PhDs increased and then decreased during the three time periods of our study. Since 2001 non-citizen women received a higher percentage of new degrees than citizen women. The percentage of non-citizen women receiving PhDs has steadily increased over the three periods of our study. Non-citizen men received a higher percentage of degrees than citizens during 1991–2000 but the reverse was true in both later periods.

Are there gender, citizenship or gender $\times$ citizenship differences in initial unemployment rates? We found that between 1991 and 2000 the unemployment rate for non-U.S. citizens was substantially higher than the rate for U.S. citizens. Between 2012 - 2015 the trend reversed itself and the unemployment rate for non-U.S. citizens was considerably lower than the rate for citizens. During all periods of our study the unemployment rate for women was somewhat lower than the rate for men. When we looked at gender $\times$ citizenship differences we found that between 1991 and 2000 the unemployment rate for women who are non-U.S. citizens was more than double the rate for women who are citizens.

Are there differences in the type of employment by gender? We saw some striking differences in types of employment. A higher percentage of men take jobs at the top-ranking and top-producing departments than women. A substantially higher percentage of women take jobs at bachelor's degree only departments than men. Moreover, the percentage of men who take jobs in government, business and industry is considerably higher than the percentage for women.

With regard to academic jobs, are men and women equally likely to be employed by departments whose ranking is at least comparable to the degree-granting department? During the first period of our study, 1991–2000, the percentage of men receiving degrees from Group I departments who were employed by at least comparable departments was 14.0% higher than the percentage for women, whereas the percentage of women receiving degrees from Group III departments who were employed by at least comparable departments was 23.3% higher than the percentage for men. The gender difference for Group III doctorates reversed itself during 2001-2011, during which time all gender differences were reduced. Between 2012 and 2015, U.S. citizen males graduating from Private Large departments were much more likely than women to be employed by at least comparable employment departments. During the same time period U.S. citizen females from Private Small departments were more likely than males to be employed by at least comparable departments. Other gender differences in at least comparable employment rates were less pronounced.

We encourage all doctoral departments and programs to help minimize the number of Unknowns by supplying as much information about their recent PhDs as possible. The follow-up survey Employment Experiences of New Doctorates (EENDR) that AMS sends to new PhDs is a less valuable resource since less than half of the new PhDs responded to the survey in recent years [3]. We also encourage new doctorates to return this survey to the AMS after degree completion.

7 Notes on the Data

Each year the AMS conducts a census of new PhDs by sending surveys to all departments that grant doctoral degrees in mathematics, statistics, applied mathematics and operations research as well as follow-ups to all PhD recipients. Over the years there have been changes in what data is collected and how it is reported. Between 1991 and 2011 the AMS reported data for doctorate-granting pure mathematics departments partitioned into Groups I, II, and III, based on the latest ranking of U.S. doctoral departments as determined by the National Research Council (NRC), a part of the National Academies of Science. Starting in 1996 Group I was subdivided into Group I Public and Group I Private and Groups IV and V were added. Group IV consisted of statistics and biostatistics programs and Group V applied mathematics and operations research programs. We excluded doctorates in operations research (Group Vb) from our current study since they are few in number; during 1991-2011 there were only 174 new PhDs in operations research. In recent years the AMS hasn't surveyed operations research departments or programs.

The NRC released reports and rankings of research doctoral programs in 1982, 1995 and 2010 [5], [6], [7]. Subsequently, the AMS, followed the recommendations of the Joint Data Committee to use these rankings to create three groups of pure mathematics doctoral programs, with Group I consisting of the top-rated programs.[6] The 2010 NRC report [7] does not give a single ranking of programs but rather ranks programs on five different scales with each score presented as a range of rankings; the scales are base on 20 characteristics [4]. Starting in 2012, upon the advice of the Joint Data Committee, the AMS partitioned the pure mathematics departments[7] into Math Public Large, Math Public Medium, Math Public Small, Math Private Large, and Math Private Small. This subdivision was based solely on the number of PhDs produced by the departments as reported on the annual surveys between 2000 and 2010. Lists

[6]Between 1996 and 2011 Group I Public consisted of the top 25 U.S. public mathematics departments and Group I Private the top 23 private departments; Group II contained the next 56 departments; Group III contained the remaining U.S. departments reporting a doctoral program in mathematics; Group IV contained U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program; and Group Va consisted of all U.S. departments (or programs) in applied mathematics/applied science reporting a doctoral program.

[7]When we speak of pure mathematics departments we exclude departments in applied mathematics, statistics, and biostatistics

of the departments in these groups as well as a comparison with the former groups can be found on the AMS website for the current annual survey [1] or past surveys [2].[8] Due to this change, we do separate analyses for the time periods 1991-2011 and 2012 - 2015.[9]

The response rate for all groups treated in this report has been very high; the 2015 Annual Survey reports that information was provided by 312 of the 318 doctoral-granting departments queried. Survey response rates by grouping are reported by the AMS in the annual surveys published in the *Notices of the American Mathematical Society* [10] and available online. Despite the high overall response rate, over the past several years an increasing number of departments have sent the AMS only basic information on their new PhDs and have often omitted data on employment status. The number of unknowns would be even higher but for web searches by the AMS that secured additional employment information, especially for those in academia. This is among the reasons why the AMS conjectures new PhDs who are categorized as Unknowns are skewed toward new PhDs in non-academic employment and individuals who may no longer be in the U.S. The survey data also do not either distinguish between one-year and multi-year jobs or identify tenure-stream positions.

8 Acknowledgements

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[8] As of March 2017, Math Public Large consists of 26 public departments with an annual production rate between 7.0 and 24.2 PhDs per year; Math Public Medium consists of 40 public departments with an annual production rate between 3.9 and 6.8 per year; Math Public Small consists of the remaining 64 public departments. Math Private Large consists of 24 private departments with an annual production rate between 3.9 and 19.8 PhDs per year and Private Small consists of the remaining 28 departments.

[9] 20 out of 25 former Group I Public and 6 former Group II departments comprise Math Public Large; 22 of the former Group I Private departments plus 1 Group II and 1 Group III departments comprise Math Private Large; 5 of the former Group I Public departments moved to Math Public Medium; they are Georgia Institute of Technology, University of North Carolina at Chapel Hill, University of Oregon, University of Utah, and University of Virginia. Arizona State University, Louisiana State University-Baton Rouge, North Carolina State University Texas A&M University, University of California-Davis, and University of Iowa are the former Group II departments that round out Math Public Large. Claremont Graduate University and Emory University were added to Math Private Large.

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