2022
UPDATE

Who Invents IT?

WOMEN'S PARTICIPATION IN INFORMATION TECHNOLOGY PATENTING

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Introduction

In 2007 and 2012, the National Center for Women & Information Technology, in partnership with 1790 Analytics, published prior reports on gendered patterns in IT patenting, analyzing records from the U.S. Patent and Trademark Office. The original report examined women's patenting rates in IT and how these rates evolved over the prior 25 years. It also identified how these rates differ across IT industry sub-categories and across specific organizations. This new edition updates those findings, examining U.S. patent data from 1980-2020. It updates the following questions from the earlier report:

- What are the overall rates of IT patenting for men, women, and mixed-gender collaborations?
- How have these rates changed during the past five years and how does this compare to the findings from the previous report?
- How do patenting rates differ across IT industry subcategories? (e.g. Communications and Telecommunications, Computer Hardware, Computer Software, Semiconductors)
- How do patenting rates differ across specific companies, organizations, and sectors (e.g., government, academic, industry)?

In addressing these questions, this report also looks at how some of the trends over the past five years are similar to or different from the previous study.

While a wealth of evidence documents the underrepresentation of women in computing and information technology (IT), most of this evidence currently takes the form of "headcount" metrics — that is, metrics that identify the number or percentage of women in technical occupations or their retention, promotion, and attrition rates. But simply paying attention to *how many* women are in these occupations tells us very little about *what* they are actually doing and to what extent they are able to meaningfully contribute to technical innovation. And in fact, we know that even when companies diversify their workforces, members of historically marginalized groups often still face disproportionate difficulty accessing core, creative, technical roles — the place where innovation so often happens.[1]

[1]Ashcraft, C., Eger, E. & McLain, B. (2016). Women in Tech: The Facts (2016 Update). https://ncwit.org/resource/thefacts/

Of course, assessing what women are doing is much more difficult than simply counting how many are present. But we must find ways to do this if we are to truly increase women's meaningful and influential participation in creating the technology of the future. In examining gendered patenting rates, this study serves as one attempt to better understand these dynamics. While patenting, is certainly not the only measure of one's ability to contribute to innovation, it is one important measure of innovation and influence in IT and computing. As a result, examining women's IT patenting rates is important for helping us understand women's involvement in the recognized and rewarded aspects of IT innovation, research, and development. (For related work we are doing to better understand women's ability to contribute meaningfully to innovation, **see our PowerTilt study and assessment tool**, designed to help technical teams assess how influence operates on their teams, especially when it comes to decision-making around innovation).

Identifying the current state of affairs in women's patenting also can provide a benchmark against which to measure future efforts to increase women's patenting activities. In addition, examining differences in women's patenting across industry subcategories and across specific organizations is important for uncovering potential areas for future research — research into "what works" in those companies that may have higher rates of patenting for women.

It is also worth noting a couple of limitations in examining women's patenting rates. The first is that, in this report we are unable to address important intersections of race and gender, given the fact that the U.S. Patent and Trademark Office does not collect demographic information by race/ethnicity. Finding ways to understand differences in patenting rates among women diverse in race and other identities is important work, however. Also in this report, our gender comparisons are limited to men and women since there is also no way to identify people who identify in non-binary ways. We aim to challenge the gender binary by explicitly acknowledging that this conception and methodology otherwise runs the risk of reinforcing it.

20%
of all U.S.-invented IT patents had at least one
WOMAN INVENTOR

I. Summary of Findings

- **Percentage of patents with at least one woman inventor.** In the 41-year period covered by this study (1980-2020) approximately 16% of U.S.-invented IT patents have at least one woman inventor. This reflects an increase from the previous report (1980-2010) when about 13% of U.S.-invented IT patents had at least one woman inventor.

- When only considering the last 5-years, 20% of all U.S.-invented IT patents had at least one woman inventor. Just 5 years before (2011-2015) the percentage was 18%.

- **Percentage of patents invented by women, when accounting for multiple inventors.** Since many patents have multiple inventors, it is more accurate to attribute only a fraction of the patent to women (for example, a patent with two women inventors and one man inventor counts as 2/3 women and 1/3 men). Counting this way over the 41-year period, 7.8% of the U.S.-invented IT patents were produced by women inventors; 9.1% were produced by women in the last five years.

The chart below illustrates how the above updated findings compare to the original report findings.

	Original Report Years (1980-2005)	Total Years Studied (1980-2020)	Last 5 Years (2016-2020)
% of patents with at least one woman inventor *(e.g., any patent with at least one woman inventor is counted)*	9%	16%	20%
% of patents invented by women, when accounting for multiple inventors *(e.g., a patent with 2 men and 1 woman inventor = counted as 2/3 men and 1/3 women)*	4.7%	7.8%	9.1%

- **Long-term trends in women's patenting rates.** Although the overall level of women's participation in IT patents is still relatively low, the trends are somewhat promising. While the rate in 1980 was nearly 2%, the rate in 2020 has increased to approximately 10%, so continuous progress is occurring.

- **Long-term trends in actual numbers of women's patenting (as compared to IT patenting overall).** In general, IT patenting has grown substantially over the 41-year period. For women inventors to increase their share of patenting during this period, their patenting had to increase by even higher growth rates. For example, overall U.S. IT patenting increased almost 17-fold from 27,153 patents in 1980-84 to 452,315 total patents in 2016-2020. For the same time periods, U.S. women's IT patenting saw a nearly 56-fold increase. This is particularly noteworthy because the percentage of women employed in IT remained relatively flat, declining slightly during the past 41-year time period.

- **Differences in subfield.** When considering computing subfields, two bright spots emerge in Artificial Intelligence/Machine Learning where 11.6% of recent patents are women-invented and Computer Software where 10.6% of recent patents are women-invented. While these percentages are still low, they compare favorably to the 9.6% figure for all of IT in 2020.

- **Citation rates.** Mixed-gender teams still produce the most highly cited patents, with citation rates 30-50% higher than the norm for patents of similar age and type. Mixed-gender teams average more inventors than either men- or women-only teams, and controlling for size largely accounts for this increased citation rate. Further research is needed to determine exactly why larger teams produce more highly cited patents. For now, a likely explanation is the fact that during development, inventors and organizations often have an idea of whether an invention is likely to be of significant importance, and that these projects attract more resources and inventors as organizations try to accelerate their development. In addition, it is also possible that originality and diverse thinking do, in fact, influence citation rates but that, at this time, we do not have sensitive enough measures to capture or fully understand these relationships.

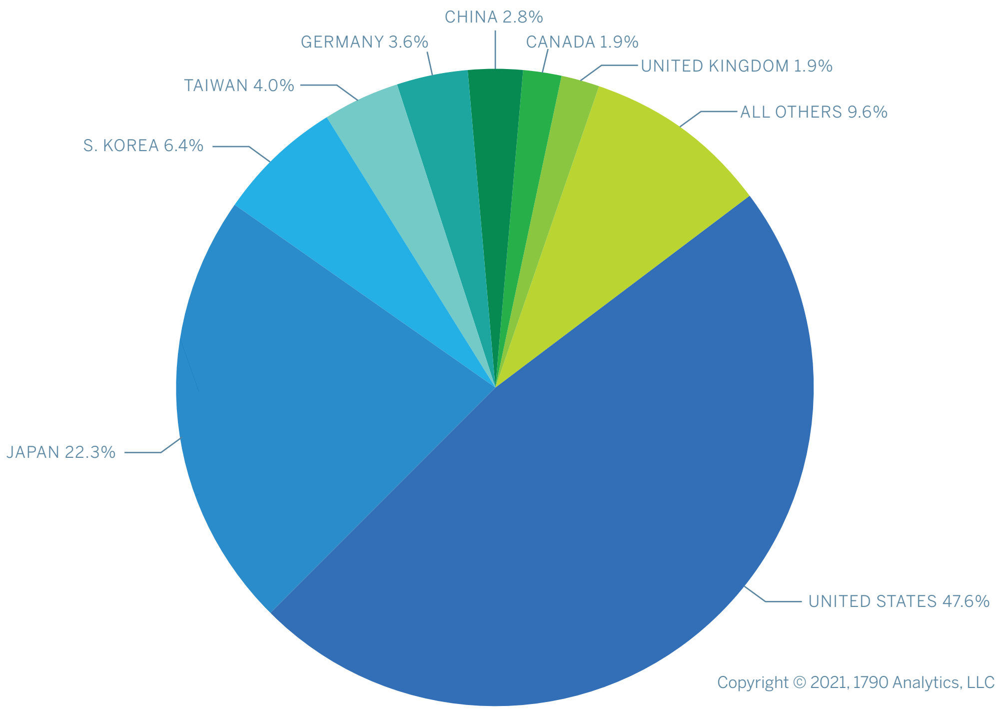
- **Women's patenting rates in individual companies.** Women's patenting rates differ widely from one organization to another. For example, several companies were shown to have 20% to 30% of their patents with at least one woman, while, as in the original 2007 report, some companies still have fewer than 5% of their patents naming a woman inventor. Thus, while some companies still have very low rates of women inventors, at some companies the level of women's inventorship in IT is quite high and steadily increasing. This suggests that individual organizational environments do matter and can influence women's patenting patterns. More research is needed to determine the conditions and practices that foster or inhibit women's patenting.

II. Methodology

To update the original report, the National Center for Women & Information Technology commissioned 1790 Analytics to analyze U.S. IT patents granted by the U.S. Patent and Trademark Office between 2010-2020, the years since the last report was published. For purposes of this and the previous study, IT patents were defined as any patent that fit into the following categories: Communications, Computer Hardware, Computer Peripherals, Computer Software, Semiconductors/Solid State Devices, *Cybersecurity*, and *Robotics* and *Intelligent Manufacturing*. The last two categories were not part of the earlier studies and have been added for the first time here because they are currently important areas within IT. To identify IT patents, 1790 Analytics used a well-defined set of patent filters consisting of patent classifications and keywords for identifying patents in these categories. This set of patent filters has been tested and refined by 1790 Analytics in previous work.

Included patents were limited to those granted by the U.S. Patent and Trademark Office because the U.S. is one of the largest consumers of IT products. As a result, any company wishing to sell these products in the United States would need to obtain a U.S. patent. **Figure 1** shows the distribution of U.S. Information Technology patents by inventor country. Roughly 70% of all IT U.S. patents are produced by U.S. and Japanese inventors. Given this distribution, the content of this report focuses on the findings for U.S.-invented IT patents.

FIGURE 1. **Top Inventor Countries: Percentage of Patents by Inventor Country (U.S. Information Technology Patents Granted 1980-2020)**



B. Name Matching Procedure

Unfortunately, the U.S. Patent and Trademark Office does not record the gender of the inventors for each patent; therefore, 1790 Analytics used the names given on the patents as indicators of gender. A majority of these names are gender-specific (e.g. John, Robert, Susan), so one could easily scan this list and assign gender to each name. However, a much more precise and automated process was needed for identifying thousands of names that rank lower than the top 150. To do so, 1790 Analytics used the Social Security Administration (SSA) database which maintains a list of the top 1000 most popular baby names each year from 1900-2019. This established a list of 4,000+ unique names that could be matched to the IT patent database.

Gender-ambiguous names (e.g. Terry, Lee, Chris, and Jan), required a number of other steps to determine gender. First, whenever possible, both the first name and the middle name were used. For example, if the name is Terry James Smith, the gender is assigned as man, while Terry Louise Smith would be assigned as woman. This is not always possible, however, because often only a middle initial is listed on the patent. In this case, 1790 Analytics used the SSA database records for how many boys and girls are given a name. These percentages were used to decide what percentage of patents to count as “men” and “women.” For example, the SSA database indicates that 82% of people named Terry are men and 18% are women; therefore, if Terry is listed as a first inventor 749 times, 82% of the 749 patents are assigned to the men count and 18% to the women count. To be as accurate as possible we used both the first name and the middle name to determine gender. For example, if the first name is Terry, we try to match the middle name. Hence, if the name is Terry James Smith it’d be counted as a man, while Terry Louise Smith is counted as a woman. This is not always possible, because often only a middle initial is listed on the patent.

To augment the SSA list, a set of 200+ first names were identified via a web search for names that are prominent on several hundred patents but that are not typical American names. For example, the name Sanjay can be found on 676 U.S.-invented IT patents but is not on the SSA list. To identify gender for these names 1790 Analytics identified websites of professors on the world wide web via a search such as (‘Sanjay’) and (‘professor’ or ‘cv’ or ‘department’ or ‘resume’) — since university professors often include a photograph on their resumes. When possible, a set of 10 or more websites were identified in order to create a multiplier for names that could go with either gender.

Next, we remove any names that are truly ambiguous. For example, we keep Terry since 82% of the time it is a man's name. However for any names in the 50%-75% man or woman range (e.g. Avery or Taylor) we discard the name as ambiguous.

We also augmented the process with multiple software libraries. In the 2010 report we augmented the name matching with the Genderyzer web site (http://jofish.com/cgi-bin/genderyze.py) to identify names that are not found in the Social Security database.

For this analysis we also tested a Python library called GenderGuesser (https://pypi.org/project/gender-guesser/) previously known as sexMachine. The advantage of this library is that it takes a country name as a parameter (e.g. Jean (USA) = woman but Jean (France) = man).

In a large test set of U.S.-invented patents the GenderGuesser process sees 6.67% women's inventorship while the 1790 process sees 6.71% so they match within 4 one hundredths of one percent. The 1790 process has slightly fewer unknowns because it involved the hand search of web CV's with pictures discussed above.

In the end, we combined GenderGuesser to the process in the following way:

1. Cases that may have been unknown in previous studies but could be identified by the GenderGuesser were added into this study.

2. Cases where there were contradictions in gender between the models were mostly added to the ambiguous category (except for large patenting names that were looked up by hand).

Overall, this doesn't change the trends in women's inventorship in any meaningful way. It slightly reduces the number of unknown gender cases and slightly increases the number of ambiguous gender cases.

In total, 96.1% of the U.S.-invented patents had at least one gender matchable name. Most patents have more than one inventor. The typical U.S.-invented IT patent has 2.58 U.S. inventors of which 2.29 or 89% were matched.

PROCEDURE FOR ASSIGNING INVENTORSHIP ON MULTIPLE-INVENTOR PATENTS

When multiple inventors produce a patent, accurately crediting the inventorship of that patent becomes difficult. Sometimes companies list the primary inventor first; however, many companies list all inventors alphabetically. As a result, identifying the key researcher and the relative contributions of each author is impossible. Despite this difficulty, many analysts in the industry do assign the patent to the first inventor. Because of this precedent, this report also presents results by first inventor, where the gender of the first inventor determines whether the patent is counted as “man” or “woman” invented.

To enhance our understanding of women’s patenting, however, we also present results using two other counting methods: 1) adding all patents that have at least one woman inventor to the women’s count and 2) “fractionally attributing” inventorship for each patent. While the first method helps identify patents that would have been overlooked when counting by first author only, it also tends to overestimate women’s patenting because, for example, a patent that is invented by one woman and one man would be counted as a woman’s patent.

To account for this discrepancy, we also then present findings by “fractional attribution,” a method that allows us to account for multiple inventors. For example, suppose a patent lists Susan, Lisa, and John as inventors. In this case 2/3 of the patent is assigned to the women’s count and 1/3 to the men’s count. If instead it is invented by Terry, John, and Lisa, Fractional Attribution is used for Terry. This, then, assigns (0.82*(1/3) + 1/3) = 0.61 to the men’s count and (0.18*(1/3) + 1/3) = 0.39 to the women’s count. The next section first presents the results by first inventor and then by fractional attribution of inventorship.

III. Results

Gendered IT Patenting Rates

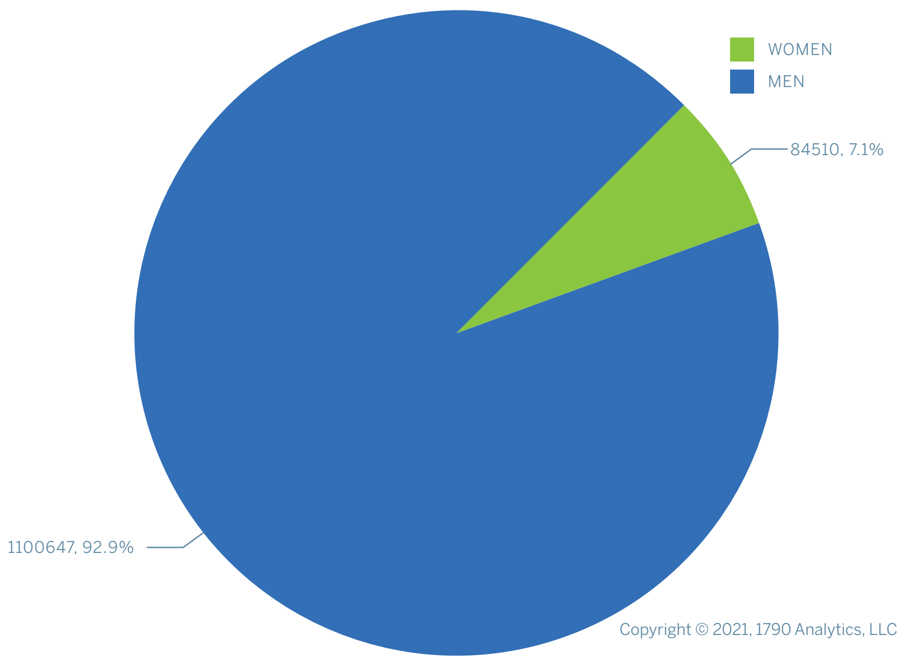
As discussed in the previous section, determining “inventorship” is more difficult than it may first appear, and different counting methods present slightly different pictures. To give the fullest picture, this section presents the percentage of patents invented by women in three different ways: 1) percentage of patents that have a woman listed as the *first* inventor, 2) percentage of patents with *at least one* woman inventor, and 3) percentage of patents invented by women when accounting for *multiple inventors* on one patent.

Percentage of Patents with at Least One Woman Inventor. In the 41-year period covered by this study (1980-2020) approximately 16% of U.S.-invented IT patents have at least one woman inventor. This reflects an increase from the previous report (1980-2010) when about 13% of U.S.-invented IT patents had at least one woman inventor.

When considering only the last 5-years, 20% of all U.S.-invented IT patents had at least one woman inventor. Just 5 years before that in the period 2011-15 the percentage was 18%.

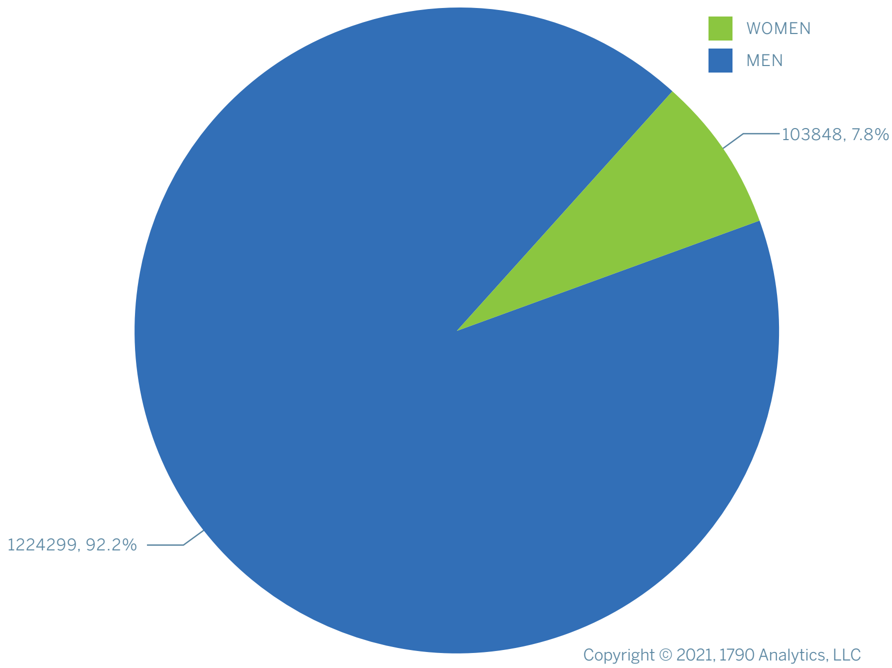
Percentage of Patents with Women as "First Inventors. When assigning inventorship by first inventor, 93% of the matched first inventors on U.S.-invented patents are men and 7% of the matched first inventors are women (roughly 11% could not be gender matched) (see **Figure 2**). Women fared slightly better over the past 5 years (2016-2020) with 8% of patents listing a woman first inventor.

FIGURE 2. **Number and Percent of First Inventors by Gender U.S.-Invented Information Technology Patents 1980-2020 (Excluding Unmatched; Dual Gender Names Fractionally Attributed)**



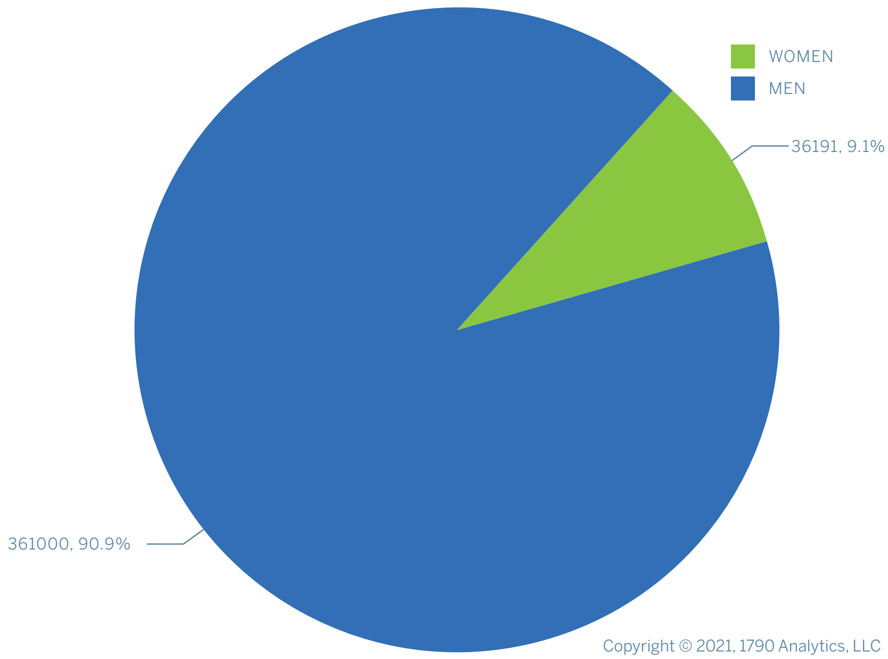
Percentage of Women-invented Patents When Accounting for Multiple Inventors. When assigning authorship fractionally — where a patent with 2 men and 1 woman inventor is counted 2/3 men and 1/3 women (see methods for more detail) — the numbers shift slightly, with 8% of U.S.-invented patents being women-invented and 92% men-invented (see **Figure 3**).

FIGURE 3. **Fractionally Attributed Inventors by Gender U.S.-Invented Information Technology Patents 1980-2020**



This is up slightly from the first report when 4.7% of patents were women-invented. Again, we also see improvement in the last 5 years. **Figure 4** shows 9% of IT patents granted 2016-2020 are women-invented.

FIGURE 4. **Fractionally Attributed Inventors by Gender U.S.-Invented Information Technology Patents 2016-2020**



To further illuminate the nature of gender and team collaboration over the 41-year period, it is helpful to consider how many U.S.-invented IT patents are produced by teams of multiple inventors and the gender makeup of these collaborative teams (see **Figure 5**). Roughly 35% of patents are produced by a single man inventor, while only 2.1% are produced by a single woman inventor. The second most frequent team composition is two men inventors, accounting for 25% of patents; thus, 65% of all patents are produced by teams of one or two men. While approximately 16% of patents list at least one woman, most of these are on teams with at least one man.

FIGURE 5. **Collaboration Statistics for U.S.-Invented Information Technology Patents 1980-2020 (Counts of Gender Matched U.S. Co-invented Patents)**

# of Men Co-inventors	# of Women Co-inventors	# of Patents	% of Total	Cumulative % of Total
1	0	455479	34.53%	34.53%
3+	0	334221	25.34%	59.88%
2	0	315192	23.90%	83.77%
3+	1	61321	4.65%	88.42%
1	1	48105	3.65%	92.07%
2	1	42970	3.26%	95.33%
0	1	27883	2.11%	97.44%
3+	2	11678	0.89%	98.33%
1	2	6083	0.46%	98.79%
2	2	5858	0.44%	99.23%
3+	3+	3592	0.27%	99.51%
0	2	3338	0.25%	99.76%
1	3+	1200	0.09%	99.85%
2	3+	1194	0.09%	99.94%
0	3+	778	0.06%	100.00%
		1318892	100.00%	

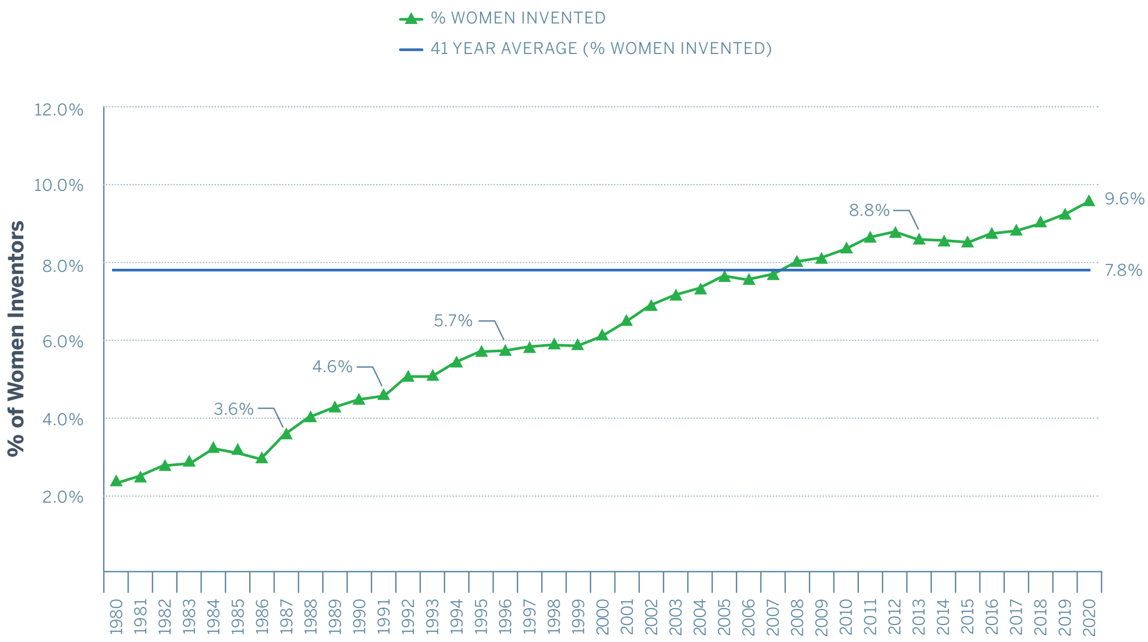
Figure 6 shows a slight improvement in the last 5 years with almost 20% of patents having at least one woman inventor.

FIGURE 6. **Collaboration Statistics for U.S.-Invented Information Technology Patents 2016-2020 (Counts of Gender Matched U.S.-Co-invented Patents)**

# of Men Co-inventors	# of Women Co-inventors	# of Patents	% of Total	Cumulative % of Total
1	0	117960	30.05%	30.05%
3+	0	108052	27.53%	57.58%
2	0	89365	22.77%	80.35%
3+	1	23132	5.89%	86.24%
1	1	15911	4.05%	90.29%
2	1	15090	3.84%	94.14%
0	1	9060	2.31%	96.44%
3+	2	4955	1.26%	97.71%
2	2	2430	0.62%	98.33%
1	2	2369	0.60%	98.93%
3+	3+	1621	0.41%	99.34%
0	2	1276	0.33%	99.67%
1	3+	535	0.14%	99.80%
2	3+	457	0.12%	99.92%
0	3+	313	0.08%	100.00%
		392526	100.00%	

Trends in Women Patenting Patterns Over Time. Although overall patenting rates for women have been and remain quite low, the picture improves when we look at trends over time. While women account for only 8% of total U.S.-invented patents (when counting fractionally), that percentage has increased steadily from nearly 2% in 1980 to 6% in 2001 to nearly 10% in 2020 — nearly a 5-fold increase (see **Figure 7**).

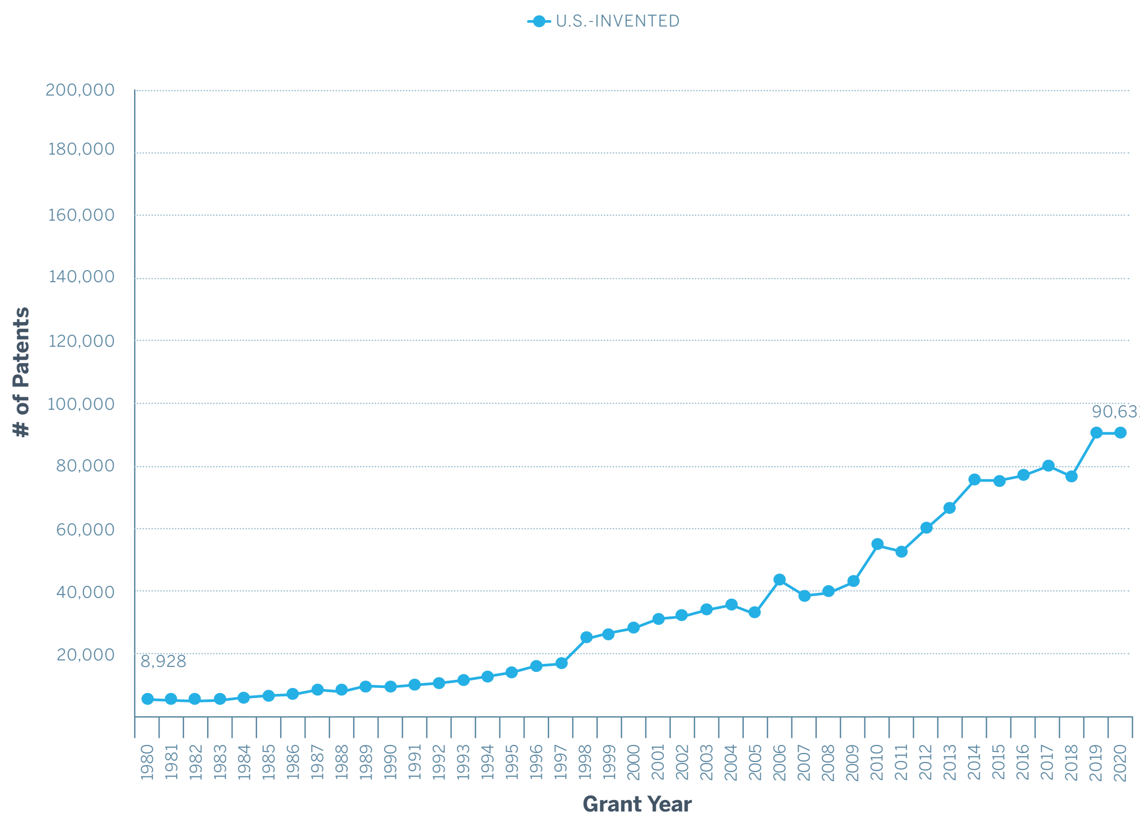
FIGURE 7. **Percent of Women-Invented Patents over Time (U.S.-Invented Technology Patents — Fractional Counting)**



The combination of this 5-fold increase in the percentage of women-invented patents with the 20-fold increase in U.S.-invented IT patenting (see **Figure 8**) translates to a roughly 100-fold increase in women's IT patenting for the period.

This is particularly noteworthy because, during the same period, the percentage of women employed in IT has remained relatively flat (at about 26%), even declining somewhat from 32% in 1983 to 25% in 2009 (with a high of 37% in 1990-1991).

FIGURE 8. **All U.S.-Invented Information Technology Patents Over Time**



PATENTING RATES BY INFORMATION TECHNOLOGY SUBCATEGORY

In this section, we explore how women's patenting rates vary across IT subcategories, which, for the most part, mirror the trends in IT patenting overall. **Figure 9** shows the share of patents attributed to women over time in each of the subcategories. Note that the recently added subcategories (AI/Machine Learning and Robotics) do not go back to 1980 because there were few patents prior to 2000 or prior to 2010 for the AI/Machine Learning category. We notice that the share of women patenting is growing in each category over time in most cases. One exception is the AI/ML category where the percentage of women's inventorship has been largely flat. However, although it is not trending upwards, the share of patents is highest in this category. The share of patents attributed to women is lowest in Cybersecurity and is actually lower than it was in 2008.

FIGURE 9. **Percent of Women-Invented Patents Over Time (U.S.-Invented Information Technology Patents By Subcategory) (Trendlines Smoothed via 5-Year Running Averages)**

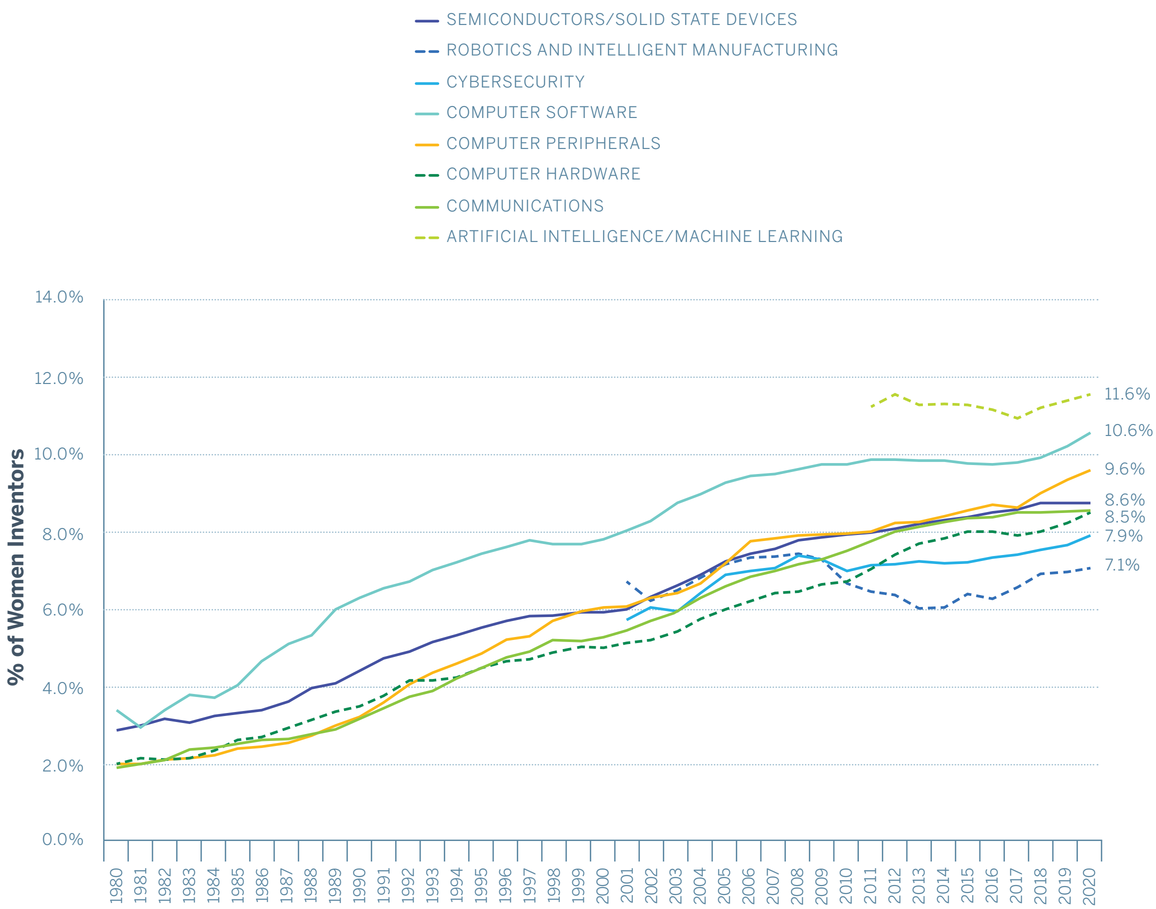


Figure 10 contains collaboration patterns for the subcategories of Information Technology. In general, men-only teams in these subcategories produce 84-86% of all patents, while mixed-gender teams account for 11-14% of all patents, and women-only teams account for 2-3% of patents. The exceptions are Computer Software and AI/ML. In these categories there are more women-invented patents, more mixed-gender team patents and, consequently, fewer men-only patents.

FIGURE 10. Men and Women Collaboration Statistics by Category

U.S.-Invented U.S. Information Technology Patents

		Women Only		Mixed-Gender Team		Men Only	
Sub-Category	**# Matchable Patents**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Artificial Intelligence/Machine Learning	15,076	519	3.4%	3,291	21.8%	11,266	74.7%
Communications	343,305	8,375	2.4%	38,954	11.3%	295,976	86.2%
Computer Hardware	318,497	6,737	2.1%	43,048	13.5%	268,712	84.4%
Computer Peripherals	107,056	2,579	2.4%	15,471	14.5%	89,006	83.1%
Computer Software	273,472	8,349	3.1%	47,655	17.4%	217,468	79.5%
Cybersecurity	85,522	1,884	2.2%	12,264	14.3%	71,374	83.5%
Robotics and Intelligent Manufacturing	18,541	353	1.9%	2,636	14.2%	15,552	83.9%
Semiconductors/Solid-State Devices	276,562	5,959	2.2%	36,873	13.3%	233,730	84.5%

Figure 10, however, does not account for the varying numbers of men and women on different collaboration teams. Many of these teams include several men but only one woman. To get a better understanding of the contribution of each gender, inventorship is again computed fractionally (where a patent with 2 men and 1 woman is counted as 2/3 men and 1/3 women). From this perspective, we see that U.S. women are responsible for about 9% of the patents on average, up from 2.7% forty years ago (see **Figure 11**).

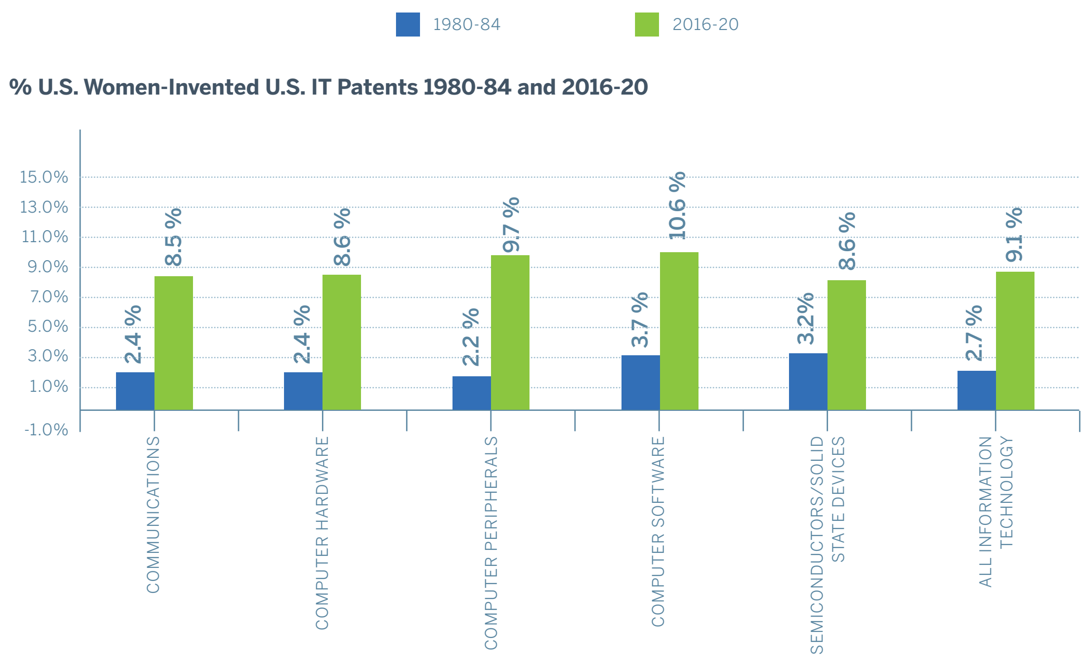
FIGURE 11. Percentage of Women-Invented U.S. Information Technology Patents for Two Time Periods (Fractional Counts 1980-84 and 2016-20)

U.S.-Invented U.S. Information Technology Patents

	1980-84					2016-20				
Category	**# Patents**	**# Women Patents**	**Women % of Total**	**# Men Patents (Fractional)**	**Men % of Total**	**# Patents**	**# Women Patents**	**Women % of Total**	**# Men Patents (Fractional)**	**Men % of Total**
Artificial Intelligence/Machine Learning	N/A	N/A	N/A	N/A	N/A	11388	1340	11.77%	10048	88.23%
Communications	8629	208	2.41%	8421	97.59%	97067	8291	8.54%	88776	91.46%
Computer Hardware	4227	100	2.35%	4127	97.65%	103866	8890	8.56%	94976	91.44%
Computer Peripherals	3868	86	2.24%	3782	97.76%	36019	3478	9.66%	32541	90.34%
Computer Software	1192	44	3.66%	1148	96.34%	86994	9258	10.64%	77736	89.36%
Cybersecurity	N/A	N/A	N/A	N/A	N/A	41861	3320	7.93%	38541	92.07%
Robotics and Intelligent Manufacturing	N/A	N/A	N/A	N/A	N/A	7507	547	7.28%	6960	92.72%
Semiconductors/Solid-State Devices	9237	299	3.24%	8938	96.76%	67613	5814	8.60%	61799	91.40%
All Information Technology	27153	737	2.71%	26416	97.29%	452315	40937	9.05%	411377	90.95%

Figure 12 shows the trends of women's patenting over time, comparing rates of patenting in each subcategory from 1980-1984 to rates from 2016-2020. While the numbers are still low, slow progress has been made in each category.

FIGURE 12. **% of Women-Invented U.S. Information Technology Patents (Fractional Counts 1981-84 and 2016-20)**



Citation Analysis

Background on Citation Analysis. In this section we examine citation rates for patents invented by women, men, and mixed-gender teams. High citation rates indicate that a patent contains technological information of particular importance. As a result, examining the citation rates of women-invented patents is one way of measuring their influence, importance, and potential return on investment. For example, companies with high citation rates have been shown to perform better in the stock market and have experienced increases in sales and profits.[2]

Determining citation rates, however, involves more than simply counting the number of citations a particular patent has accrued. For example, older patents are likely to be more highly cited since they have had more time to accrue citations. Furthermore, average citation rates differ across technologies. A patent with 10 citations, therefore, may be very highly cited, or not very highly cited, depending on its age and technology category.

To account for these differences, citation counts were normalized by technology and year in order to determine the 'expected cite count' for patents from the same year and technology class. Dividing the citation count of a particular patent by the expected count results in a "citation index," a normalized measure of the impact of a particular patent. For example, a citation index of 9.99 suggests the patent is cited about 10 times as often as typical patents of the same age and technology class.

The citation index can be extended beyond a single patent to a set of patents (i.e., all men-invented communication patents, all women-invented communication patents, or all mixed-gender team invented communication patents — see **Figure 13**). In fact, applying the citation index to a set of patents tends to provide a more accurate picture since a larger patent set will dilute the effects of any outliers. The citation index for a set of patents is determined by taking the sum of the citations for that set (i.e., the sum of the citations for all men-invented communication patents) and dividing by the sum of the expected citation counts for all communication patents.[3] Applying the citation index to these patent sets allows us to compare patent sets of differing sizes with different age profiles (e.g., compare the averages for all of the men-invented communications patents, for all of the women-invented communication patents, for all of the mixed-gender team invented communication patents).

[2] A. Breitzman and F. Narin, U.S. 6175824: Method and apparatus for choosing a stock portfolio, based on patent indicators (Patent Application U.S.1999/353613, 14 July 1999).

P. Thomas, A relationship between research indicators and financial performance. In: 6th International Conference on Science and Technology Indicators, Leiden, The Netherlands, 24–27 May 2000

F. Narin, E. Noma, R. Perry, Patents as indicators of corporate technological strength, Research Policy, Volume 16, Issues 2–4, August 1987, Pages 143–155

[3] Remember that communication patents will have different expected counts depending on age of patents, so we add these different expected citation counts for different ages to get the average expected citation count for all communication patents. We then divide the total number of citations for men-invented patents by this overall expected citation count. This process is repeated for women and mixed-gender invented patents).

FIGURE 13. **% of Women-Invented U.S. Information Technology Patents (Fractional Counts 1981-84 and 2016-20)**

HIGHEST CITED PATENT SET — SECOND HIGHEST CITED PATENT SET — THIRD HIGHEST CITED PATENT SET

U.S.-Invented Information Technology Patents

	Women Only Invented		Men Only Invented		Mixed-Gender Team	
	# Patents	Citation Index	# Patents	Citation Index	# Patents	Citation Index
Artificial Intelligence/Machine Learning	519	0.89	11266	1.30	3291	1.30
Communications	8375	1.02	295976	1.21	38954	1.34
Computer Hardware	6737	1.09	268712	1.26	43048	1.30
Computer Peripherals	2579	1.30	89006	1.33	15471	1.45
Computer Software	8349	1.12	217468	1.28	47655	1.30
Cybersecurity	1884	1.34	71374	1.51	12264	1.50
Robotics and Intelligent Manufacturing	353	1.13	15552	1.48	2636	1.41
Semiconductors/Solid-State Devices	5959	1.17	233730	1.28	36873	1.44

Differences in Citation Rates for Men, Women, and Mixed-Gender Teams. As illustrated in **Figure 13**, patents[4] invented by mixed-gender teams — teams consisting of at least one woman and at least one man — are cited more often than patents invented by women-only or men-only teams (with the exception of robotics and cybersecurity, where men-only teams are more highly cited). In the original study, we noted that both the diversity of thought and the fact that mixed-gender teams tend to be larger might be possible explanations that would lead to more innovative inventions. We have since investigated the relationship between mixed-gender teams and higher citation rates further and found that controlling for size largely accounts for this increased citation rate.

So why exactly do larger teams produce more highly cited patents? We investigated a few possible explanations, but, to date, the answer remains unclear. First, the originality index also rises with team size. This index measures the extent to which a patent draws on a wider range of prior art or different kinds of technologies. In other words, a relatively simple or incremental invention will have a lower index than complex inventions drawing from multiple areas of technical expertise. Initially, we thought perhaps the higher originality indexes of larger teams might explain their higher citation rates. A regression analysis, however, revealed that originality has very little explanatory power for higher citation rates once team size is factored in. In other words, team size seems to matter more than the originality index when predicting citation rates. This result, however, might be because the originality index is a rather insensitive measure — that is, it is primarily designed to distinguish highly original patents rather than to measure smaller differences in originality.

[4]Citation indexes are based on the average of all U.S. patents in each technology class invented anywhere in the world (including the U.S., Japan, and all other countries filing patents). In general, we see that U.S.-invented IT patents have a higher citation index than Japanese- invented IT patents. All of the U.S.-invented patent sets have citation indices exceeding 1.0, suggesting that the U.S.- invented IT patents are cited more often than average for all U.S. patents invented in other countries of the same age and technology class.

We also found no consistent significant relationship (using one-way ANOVAs) between the citation index and team characteristics such as self-citations, sector of organization (e.g., university, industry, non-profit) or country of organization. Further research is needed to determine exactly why larger teams produce more highly cited patents. For now, a likely explanation is the fact that during development, inventors and organizations often have an idea of whether an invention is likely to be of significant importance. Technologies that look particularly promising will attract more resources and inventors as organizations try to accelerate their development. In addition, inventors will happily join technical projects that look to be particularly promising. Similarly, it is also still possible that originality and diverse thinking do, in fact, influence citation rates but that, at this time, we do not have sensitive enough measures to capture or fully understand these relationships.

ORGANIZATIONAL DIFFERENCES

This section explores women's IT patenting patterns across different organizations. This analysis reveals that women's patenting rates differ widely from one organization to another. In both "small patenting entities" (those with less than 100 patents during 2016-2020), and "large patenting entities" (those with at least 350 patents during 2016-2020), men, women, and mixed-gender team patenting rates vary widely.

Figure 14 identifies the top 10 "small patenting entities" with the lowest percent of men-only patents in each of the five industry subcategories, while **Figure 15** shows the top 10 "large patenting entities" (Identifying the lowest percent of men-only patents is the easiest way to identify companies with the highest rates of women-only or mixed-gender team patents overall.) The results identify a very wide range of differences among companies, with men's patenting rates in "small entities" ranging from a low of 3% and a high of 70%. The "large entities" also display a range, but a much narrower range from a low of 63% and a high of 80%.

FIGURE 14. **Top 10 "Small Patenting Entities" with Women Inventorship 2016-20 (Organizations with 25 to 100 Patents 2016-20; Lowest % of Men Only Patents)**

U.S.-Invented U.S. Information Technology Patents

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Artificial Intelligence/Machine Learning					
1	Gyrfalcon Tech. Inc.	40	50.0%	42.5%	7.5%
2	Snap Inc	36	36.1%	25.0%	38.9%
3	Ford Motor Co.	60	55.0%	3.3%	41.7%
4	NVIDIA Corp.	34	52.9%	2.9%	44.1%
5	Pearson Plc	28	50.0%	0.0%	50.0%
6	State Farm Insurance Co.	33	48.5%	0.0%	51.5%
7	Brain Corporation	46	47.8%	0.0%	52.2%
8	Accenture Ltd.	71	35.2%	11.3%	53.5%
9	Verizon Comm. Inc	75	32.0%	8.0%	60.0%
10	Bank of America Corp.	64	34.4%	0.0%	65.6%
Communications					
1	Movandi Corp	61	96.7%	0.0%	3.3%
2	TP Lab Inc	29	65.5%	27.6%	6.9%
3	Uhnder Inc	32	81.2%	9.4%	9.4%
4	Enseo Inc	65	87.7%	0.0%	12.3%
5	Convida Wireless LLC	98	62.2%	0.0%	37.8%
6	Tango Networks Inc	36	58.3%	0.0%	41.7%
7	Toshiba Corp	26	34.6%	23.1%	42.3%
8	Allstate Corp	56	42.9%	10.7%	46.4%
9	Witricity Corp	39	51.3%	0.0%	48.7%
10	Enghouse Systems Ltd.	26	42.3%	7.7%	50.0%
Computer Hardware					
1	Ubiome Inc.	53	100.0%	0.0%	0.0%
2	Gyrfalcon Tech. Inc.	30	63.3%	26.7%	10.0%
3	Alibaba Group Holding Ltd	63	20.6%	55.6%	23.8%
4	Mass Mutual Life Ins.	26	34.6%	19.2%	46.2%
5	Winbond Electronics Corp.	39	41.0%	12.8%	46.2%
6	University of South Florida	30	36.7%	16.7%	46.7%
7	Itron Inc.	38	52.6%	0.0%	47.4%
8	United States Postal Serv	33	42.4%	9.1%	48.5%
9	Razer USA Inc	40	45.0%	0.0%	55.0%
10	Ambarella Inc	29	41.4%	3.4%	55.2%
Computer Peripherals					
1	Magnecomp International Ltd.	30	66.7%	10.0%	23.3%
2	Bank of America Corp.	95	58.9%	3.2%	37.9%
3	Wells Fargo & Co	25	52.0%	8.0%	40.0%
4	Corning Inc.	53	56.6%	0.0%	43.4%
5	Cerner Corporation	33	48.5%	6.1%	45.5%
6	Allscripts Software	26	38.5%	15.4%	46.2%
7	Accenture Ltd.	36	41.7%	2.8%	55.6%
8	Procter & Gamble Co.	43	41.9%	2.3%	55.8%
9	Atheer Inc	34	41.2%	2.9%	55.9%
10	Open Invention Network Llc	77	18.2%	23.4%	58.4%

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Computer Software					
1	Kofax Inc	42	88.1%	0.0%	11.9%
2	Transform Sr Brands	28	42.9%	17.9%	39.3%
3	NYSE Group	29	48.3%	10.3%	41.4%
4	Nice Systems Ltd	43	58.1%	0.0%	41.9%
5	Dexcom Inc	94	56.4%	0.0%	43.6%
6	Adidas AG	40	55.0%	0.0%	45.0%
7	Mass Mutual Life Insurance	41	51.2%	2.4%	46.3%
8	MoneyGram International Inc	38	47.4%	5.3%	47.4%
9	Western Union Co	42	40.5%	11.9%	47.6%
10	ASML Holding NV	63	47.6%	4.8%	47.6%
Cybersecurity					
1	Flexiworld Technologies	26	96.2%	0.0%	3.8%
2	Itron Inc.	29	62.1%	0.0%	37.9%
3	Convida Wireless LLC	26	57.7%	0.0%	42.3%
4	Sap SE	40	30.0%	15.0%	55.0%
5	Servicenow Inc.	63	36.5%	1.6%	61.9%
6	State Farm Insurance Co.	66	34.8%	3.0%	62.1%
7	Unisys Corp.	51	33.3%	3.9%	62.7%
8	Early Warning Services	27	37.0%	0.0%	63.0%
9	NEC Corp	37	35.1%	0.0%	64.9%
10	Maxlinear Inc	26	34.6%	0.0%	65.4%
Robotics and Intelligent Manufacturing					
1	Brain Corporation	74	44.6%	0.0%	55.4%
2	Global Foundries Inc	47	34.0%	4.3%	61.7%
3	Harvard University	31	35.5%	0.0%	64.5%
4	Massachusetts Institute of Technolog	41	26.8%	4.9%	68.3%
5	Ford Motor Co.	29	31.0%	0.0%	69.0%
6	Intel Corporation	55	30.9%	0.0%	69.1%
7	Berkshire Grey	34	29.4%	0.0%	70.6%
8	Autodesk Inc.	34	29.4%	0.0%	70.6%
9	General Motors Corp	66	18.2%	10.6%	71.2%
10	Intouch Technologies	40	27.5%	0.0%	72.5%
Semiconductors/Solid-State Devices					
1	Nanotek Instruments	37	10.8%	89.2%	0.0%
2	Macronix International Co. Ltd.	25	32.0%	56.0%	12.0%
3	PDF Solutions	97	86.6%	0.0%	13.4%
4	Enel X North America	29	69.0%	17.2%	13.8%
5	Soitec SA	32	28.1%	53.1%	18.7%
6	Navitas Semiconductor Inc.	35	68.6%	2.9%	28.6%
7	Case Western Reserve University	68	66.2%	4.4%	29.4%
8	Integer Holdings Corp	58	65.5%	0.0%	34.5%
9	Nike Inc	26	61.5%	0.0%	38.5%
10	GLO Ab	53	49.1%	9.4%	41.5%

FIGURE 15. Top 10 "Large Patenting Entities" with Women Inventorship 2016-20 (Organizations with 350+ Patents 2016-20; Lowest % of Men Only Patents)

U.S.-Invented U.S. Information Technology Patents

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Artificial Intelligence/Machine Learning					
1	Microsoft Corporation	515	515	2.3%	63.7%
2	International Business Mach	1381	1381	4.5%	65.2%
3	Alphabet Inc.	578	578	2.2%	78.7%
4					
5					
6					
7					
8					
9					
10					
Communications					
1	Verizon Communications Inc	1405	25.4%	4.4%	70.2%
2	International Business Mach	2410	25.5%	3.9%	70.6%
3	New T-Mobile (former T-Mo	1851	25.8%	3.4%	70.8%
4	Facebook Inc	582	22.2%	2.7%	75.1%
5	Intel Corporation	3007	18.8%	5.8%	75.5%
6	Qualcomm Inc	6890	21.1%	3.4%	75.6%
7	InterDigital Inc	936	22.6%	1.2%	76.2%
8	General Motors Corp	439	20.0%	3.6%	76.3%
9	Blackberry Ltd.	461	14.5%	7.6%	77.9%
10	Apple Inc	2609	20.2%	1.5%	78.3%
Computer Hardware					
1	Bank of America Corp.	628	33.6%	2.9%	63.5%
2	CapitalOne	780	27.8%	2.8%	69.4%
3	Verizon Communications Inc	515	24.1%	4.5%	71.5%
4	International Business Mach	13302	24.6%	2.9%	72.5%
5	Microsoft Corporation	4916	24.8%	1.6%	73.6%
6	Apple Inc	2427	21.7%	1.0%	77.3%
7	Qualcomm Inc	1626	19.1%	2.8%	78.1%
8	HP Inc	677	19.1%	2.8%	78.1%
9	Facebook Inc	951	19.2%	2.5%	78.2%
10	Netapp Inc	484	19.0%	2.7%	78.3%
Computer Peripherals					
1	Microsoft Corporation	2100	32.5%	1.6%	65.9%
2	AT&T Inc	374	28.3%	2.7%	69.0%
3	International Business Mach	1907	23.7%	4.5%	71.8%
4	Apple Inc	2251	26.7%	1.0%	72.3%
5	Facebook Inc	893	23.0%	4.1%	72.9%
6	Intel Corporation	500	20.8%	3.8%	75.4%
7	Western Digital Corp.	611	23.2%	0.7%	76.1%
8	Xerox Corp	474	20.7%	1.9%	77.4%
9	Amazon.com Inc.	929	20.3%	1.9%	77.7%
10	Alphabet Inc.	1576	20.3%	1.8%	77.9%

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Computer Software					
1	United Services Automobile	352	46.0%	7.1%	46.9%
2	Bank of America Corp.	583	45.5%	5.1%	49.4%
3	State Farm Mutual Automob	545	39.3%	2.4%	58.3%
4	eBay Inc	511	28.6%	8.2%	63.2%
5	International Business Mach	6315	30.8%	5.7%	63.5%
6	Visa Inc	510	27.6%	6.7%	65.7%
7	Microsoft Corporation	2914	28.9%	2.5%	68.6%
8	MasterCard Inc	426	23.9%	5.6%	70.4%
9	Qualcomm Inc	937	21.9%	7.3%	70.9%
10	Ford Motor Co.	385	26.5%	1.6%	71.9%
Cybersecurity					
1	Bank of America Corp.	597	35.3%	3.4%	61.3%
2	Facebook Inc	454	27.8%	2.9%	69.4%
3	International Business Mach	3266	25.6%	4.4%	70.0%
4	CapitalOne	366	25.4%	2.7%	71.9%
5	Microsoft Corporation	1652	22.7%	2.0%	75.3%
6	Verizon Communications Inc	487	19.7%	4.3%	76.0%
7	Qualcomm Inc	612	19.3%	2.9%	77.8%
8	AT&T Inc	895	17.2%	3.7%	79.1%
9	Alphabet Inc.	1127	18.3%	1.6%	80.1%
10	Apple Inc	734	18.0%	0.7%	81.3%
Robotics and Intelligent Manufacturing					
1	None with 350+ Patents				
2					
3					
4					
5					
6					
7					
8					
9					
10					
Semiconductors/Solid-State Devices					
1	Intel Corporation	2594	28.1%	2.0%	69.9%
2	Applied Materials Inc.	1978	26.0%	1.4%	72.6%
3	Universal Display	376	26.6%	0.8%	72.6%
4	Apple Inc	1321	25.2%	0.8%	74.0%
5	NXP Semiconductors NV	761	21.2%	3.7%	75.2%
6	International Business Mach	7114	22.5%	2.1%	75.3%
7	Qualcomm Inc	1052	21.3%	2.9%	75.8%
8	Lam Research Corp.	890	19.6%	1.7%	78.8%
9	Cree Inc.	392	18.4%	2.8%	78.8%
10	Global Foundries Inc	2513	19.1%	2.1%	78.8%

When considering the bottom 10 "small patenting entities" (**Figure 16**) we see that in most cases men's patenting rates are at 100%, with some companies ranging from 88-99%.

FIGURE 16. **Bottom 10 'Small Patenting Entities' with Women Inventorship 2016-20 (Organizations with 25 to 100 Patents 2016-20; Highest % of Men Only Patents)**

U.S.-Invented U.S. Information Technology Patents

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Artificial Intelligence/Machine Learning					
1	Strong Force IOT Portfolio	47	0.0%	0.0%	100.0%
2	Micron Technology Inc.	35	2.9%	0.0%	97.1%
3	Norton Lifelock (formerly Symantec C	40	2.5%	2.5%	95.0%
4	Toyota Motor Corp	35	2.9%	2.9%	94.3%
5	Blackberry Ltd.	31	6.5%	0.0%	93.5%
6	Halliburton Co. (Holding)	28	7.1%	0.0%	92.9%
7	eBay Inc	37	5.4%	2.7%	91.9%
8	HRL Laboratories LLC	71	8.5%	0.0%	91.5%
9	Splunk Inc	53	7.5%	1.9%	90.6%
10	Mitsubishi Electric Corp	41	9.8%	0.0%	90.2%
Communications					
1	Parallel Wireless Inc	100	0.0%	0.0%	100.0%
2	Murata Manufacturing Co. Ltd.	97	0.0%	0.0%	100.0%
3	MBIT WIRELESS INC	76	0.0%	0.0%	100.0%
4	ISCO International Llc	76	0.0%	0.0%	100.0%
5	Nippon Telegraph & Telephone Corp.	68	0.0%	0.0%	100.0%
6	CPG Technologies Llc	58	0.0%	0.0%	100.0%
7	Starkey Labs Inc	54	0.0%	0.0%	100.0%
8	Headwater Partners 1 LLC	54	0.0%	0.0%	100.0%
9	Cohere Technologies Inc	52	0.0%	0.0%	100.0%
10	Ubiquiti Networks Inc	49	0.0%	0.0%	100.0%
Computer Hardware					
1	FedEx Corp	61	0.0%	0.0%	100.0%
2	Xcelera Inc	55	0.0%	0.0%	100.0%
3	Dynamics Inc	49	0.0%	0.0%	100.0%
4	STRONG FORCE IOT PORTFOLIO 2	47	0.0%	0.0%	100.0%
5	Osterhout Design Group	46	0.0%	0.0%	100.0%
6	BIOCATCH LTD	43	0.0%	0.0%	100.0%
7	Inphi Corp	41	0.0%	0.0%	100.0%
8	Liqid Inc	38	0.0%	0.0%	100.0%
9	Storagecraft Technology Corp	36	0.0%	0.0%	100.0%
10	Rackspace Hosting Inc	36	0.0%	0.0%	100.0%
Computer Peripherals					
1	Manufacturing Resources Internationa	53	0.0%	0.0%	100.0%
2	Tactual Labs Co	53	0.0%	0.0%	100.0%
3	P4TENTS1 LLC	46	0.0%	0.0%	100.0%
4	Magna International Inc.	40	0.0%	0.0%	100.0%
5	Micron Technology Inc.	38	0.0%	0.0%	100.0%
6	Osterhout Design Group	37	0.0%	0.0%	100.0%
7	Ultrahaptics IP	34	0.0%	0.0%	100.0%
8	Koch Industries Inc	34	0.0%	0.0%	100.0%
9	Sentons Inc	34	0.0%	0.0%	100.0%
10	Commvault Systems Inc.	30	0.0%	0.0%	100.0%

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Computer Software					
1	CFPH LLC	96	0.0%	0.0%	100.0%
2	Global Tel Link Corp	46	0.0%	0.0%	100.0%
3	Imagination Technologies Group Plc	44	0.0%	0.0%	100.0%
4	Fortinet Inc	41	0.0%	0.0%	100.0%
5	A10 Networks Inc	39	0.0%	0.0%	100.0%
6	AppLovin	36	0.0%	0.0%	100.0%
7	ARC Devices Ltd	33	0.0%	0.0%	100.0%
8	Broadband ITV Inc	32	0.0%	0.0%	100.0%
9	Blinker Inc	31	0.0%	0.0%	100.0%
10	BGC Partners Inc	31	0.0%	0.0%	100.0%
Cybersecurity					
1	Global Tel Link Corp	79	0.0%	0.0%	100.0%
2	A10 Networks Inc	62	0.0%	0.0%	100.0%
3	Xcelera Inc	58	0.0%	0.0%	100.0%
4	Sophos Ltd	53	0.0%	0.0%	100.0%
5	ConvergeOne Inc	50	0.0%	0.0%	100.0%
6	Biocatch Ltd	49	0.0%	0.0%	100.0%
7	IBoss Inc	48	0.0%	0.0%	100.0%
8	Sonos Inc	47	0.0%	0.0%	100.0%
9	FedEx Corp	47	0.0%	0.0%	100.0%
10	Digimarc Corp.	45	0.0%	0.0%	100.0%
Robotics and Intelligent Manufacturing					
1	ABB Ltd	41	0.0%	0.0%	100.0%
2	Johnson Controls International	33	0.0%	0.0%	100.0%
3	Sumitomo Heavy Industries Ltd.	30	0.0%	0.0%	100.0%
4	Applied Materials Inc.	54	3.7%	0.0%	96.3%
5	Walmart Stores Inc	52	3.8%	0.0%	96.2%
6	Halliburton Co. (Holding)	39	5.1%	0.0%	94.9%
7	Brooks Automation Inc.	31	6.5%	0.0%	93.5%
8	Softbank Corp	65	9.2%	0.0%	90.8%
9	Rockwell Automation Inc	61	11.5%	0.0%	88.5%
10	Globus Medical Inc	25	12.0%	0.0%	88.0%
Semiconductors/Solid-State Devices					
1	China Electronics Corp	67	0.0%	0.0%	100.0%
2	Avalanche Technology Inc	62	0.0%	0.0%	100.0%
3	Atomera Inc (Formerly Mears Techno	55	0.0%	0.0%	100.0%
4	Manufacturing Resources Internationa	51	0.0%	0.0%	100.0%
5	Toshiba Corp	42	0.0%	0.0%	100.0%
6	Zeno Semiconductors Inc	39	0.0%	0.0%	100.0%
7	Deere & Co.	39	0.0%	0.0%	100.0%
8	HeartFlow Inc	37	0.0%	0.0%	100.0%
9	Causam Energy Inc	36	0.0%	0.0%	100.0%
10	Caterpillar Inc.	35	0.0%	0.0%	100.0%

In contrast, for the bottom 10 "large patenting entities (**Figure 17**)," men's patenting rates range from 64-96%, with most being around the mid 70s or 80s.

FIGURE 17. **Bottom 10 "Large Patenting Entities" with Women Inventorship 2016-20 (Organizations with 350+ Patents 2016-20; Highest % of Men Only Patents)**

U.S.-Invented U.S. Information Technology Patents

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Artificial Intelligence/Machine Learning					
1	Alphabet Inc.	578	19.0%	2.2%	78.7%
2	International Business Mach	1381	30.3%	4.5%	65.2%
3	Microsoft Corporation	515	34.0%	2.3%	63.7%
4					
5					
6					
7					
8					
9					
10					
Communications					
1	Charter Communications Inc	354	5.9%	1.1%	92.9%
2	Comcast Corp	494	6.5%	1.6%	91.9%
3	Sony Corp	456	7.5%	0.9%	91.7%
4	Maxlinear Inc	380	8.2%	0.5%	91.3%
5	CenturyLink Inc	471	8.5%	1.9%	89.6%
6	Amazon.com Inc.	1560	8.9%	1.6%	89.5%
7	Marvell Technology Group L	758	9.2%	2.5%	88.3%
8	Samsung Electronics Co Ltd	874	8.9%	2.9%	88.2%
9	Ericsson	760	10.9%	1.1%	88.0%
10	Texas Instruments Inc	841	9.6%	2.5%	87.9%
Computer Hardware					
1	PURE Storage Inc	456	7.0%	0.2%	92.8%
2	Micron Technology Inc.	2059	5.1%	3.7%	91.1%
3	Rambus Inc.	523	8.4%	0.6%	91.0%
4	Norton Lifelock (formerly Sy	395	6.3%	2.8%	90.9%
5	Honeywell International Inc.	624	7.5%	1.9%	90.5%
6	Commvault Systems Inc.	367	10.6%	0.0%	89.4%
7	Texas Instruments Inc	423	9.7%	2.6%	87.7%
8	Marvell Technology Group L	517	10.4%	2.7%	86.8%
9	NVIDIA Corp.	519	12.9%	0.8%	86.3%
10	Amazon.com Inc.	3183	12.8%	1.4%	85.8%
Computer Peripherals					
1	Sony Corp	350	4.9%	2.0%	93.1%
2	Synaptics Inc.	372	11.3%	2.4%	86.3%
3	Seagate Technology Plc	861	13.7%	0.8%	85.5%
4	Sonos Inc	411	11.9%	3.2%	84.9%
5	Dell Technologies Inc	661	13.0%	2.3%	84.7%
6	HP Inc	944	17.3%	3.3%	79.4%
7	Alphabet Inc.	1576	20.3%	1.8%	77.9%
8	Amazon.com Inc.	929	20.3%	1.9%	77.7%
9	Xerox Corp	474	20.7%	1.9%	77.4%
10	Western Digital Corp.	611	23.2%	0.7%	76.1%

Categ	Assignee	# Patents 2016-20	% Mixed-Gender Teams	% Women Only	% Men Only
Computer Software					
1	Sony Corp	424	7.1%	2.1%	90.8%
2	Walmart Stores Inc	517	10.1%	3.1%	86.8%
3	Apple Inc	1084	15.3%	1.3%	83.4%
4	Boeing Co. (The)	506	16.8%	1.6%	81.6%
5	SalesforceCom Inc	466	15.0%	3.9%	81.1%
6	Cisco Systems Inc.	554	16.2%	2.9%	80.9%
7	Adobe Inc.	631	17.3%	1.9%	80.8%
8	Dell Technologies Inc	1073	14.9%	4.5%	80.6%
9	Amazon.com Inc.	3121	18.3%	1.3%	80.3%
10	Siemens Aktiengesellschaft	549	18.8%	3.1%	78.1%
Cybersecurity					
1	Norton Lifelock (formerly Sy	504	6.7%	3.4%	89.9%
2	Amazon.com Inc.	1519	10.7%	0.6%	88.7%
3	Oracle Corporation	451	11.1%	1.1%	87.8%
4	T-Mobile	375	13.9%	1.6%	84.5%
5	Dell Technologies Inc	1389	14.0%	2.2%	83.7%
6	Cisco Systems Inc.	778	12.2%	5.8%	82.0%
7	Intel Corporation	1540	16.5%	1.7%	81.8%
8	Apple Inc	734	18.0%	0.7%	81.3%
9	Alphabet Inc.	1127	18.3%	1.6%	80.1%
10	AT&T Inc	895	17.2%	3.7%	79.1%
Robotics and Intelligent Manufacturing					
1	None with 350+ Patents				
2					
3					
4					
5					
6					
7					
8					
9					
10					
Semiconductors/Solid-State Devices					
1	On Semiconductor Corporat	578	3.8%	0.7%	95.5%
2	Qorvo	376	4.5%	0.5%	94.9%
3	Dell Technologies Inc	542	4.1%	1.3%	94.6%
4	Eaton Corp.	357	5.3%	0.8%	93.8%
5	Infineon Technologies AG	513	5.8%	0.6%	93.6%
6	Xperi Holding Corporation (F	500	9.0%	0.2%	90.8%
7	Raytheon Co.	677	11.4%	1.0%	87.6%
8	Samsung Electronics Co Ltd	368	10.1%	2.7%	87.2%
9	Western Digital Corp.	735	11.0%	1.9%	87.1%
10	Micron Technology Inc.	1826	11.9%	2.4%	85.7%

Some companies have also produced large increases in women's rates of patenting in the past five years since the original study ranging from a 17% decrease in men's patenting to a 48% decrease. And likewise, a number of companies have seen a range of decreases in women's patenting, with men's rate of patenting up by anywhere from 3% to 23%.

These findings also raise additional questions for future research. For example, as noted earlier, many questions remain regarding the relationship between team size and increased citation rates. Better understanding this relationship is important for understanding this phenomenon. In addition, the patenting data alone tells us little about the reasons for the dramatic differences across organizations. As a result, future research would do well to explore how the demographic makeup and size of a company influences their women's patenting rates. For example, do companies with higher women's patenting rates also employ larger numbers of women? What other characteristics, if any, do higher women-patenting companies share? Do specific organizational practices and conditions contribute to women's higher patenting rates and if so, in what ways? This additional research is necessary to understand the reasons for the existing variance across companies. The fact that these differences exist, however, does suggest that specific contexts do make a difference and that there is no industry-wide systemic reason for the low level of women's patenting overall.

RESULTS BY SECTOR

Figure 18 shows U.S. patent activity by sector for two time periods (1980-1984 and 2016-2020). We see that in the most recent period U.S. firms obtained about 81.9% of IT patents, which is up from 69.3% in the prior period. In the same period, individual inventors have dropped by about 8% and U.S. Government agency patenting has dropped by 5%. It is not clear why there are fewer patents by individuals, although perhaps rising costs of obtaining patents may have something to do with it. The government agency reduction in patenting is a function of the Bayh-Dole Act, which was enacted in 1980, but started to affect patent ownership in the late 1980's. The biggest impact of the Bayh-Dole Act is the presumption of ownership of a patent funded by the government. For example, the California Institute of Technology (CalTech) operates NASA's Jet Propulsion Lab. Prior to the Bayh-Dole Act, any patent produced by the lab would be assigned to NASA. Under the current law, the patent would be assigned to CalTech with a royalty-free license going to NASA. Similarly, Rand Corp runs several federally funded research centers for the Department of Defense and Department of Energy, so patents that would have been assigned to those agencies in the early time-period are now assigned to Rand.

FIGURE 18. **U.S.-Invented Information Technology Patenting by Sector for Two Time Periods**

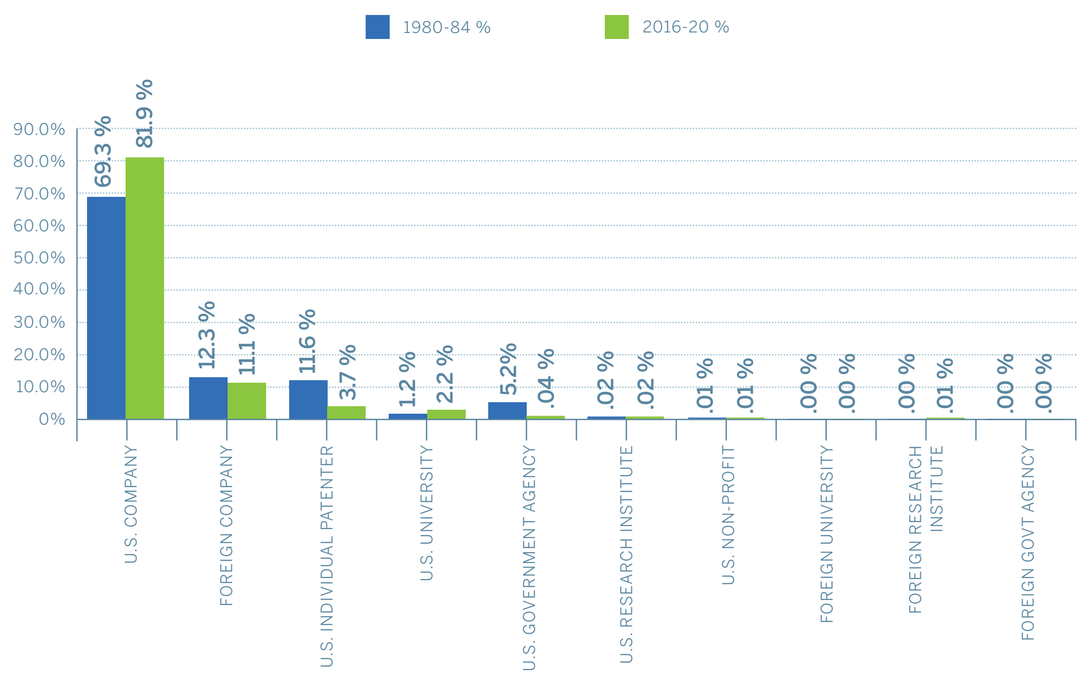
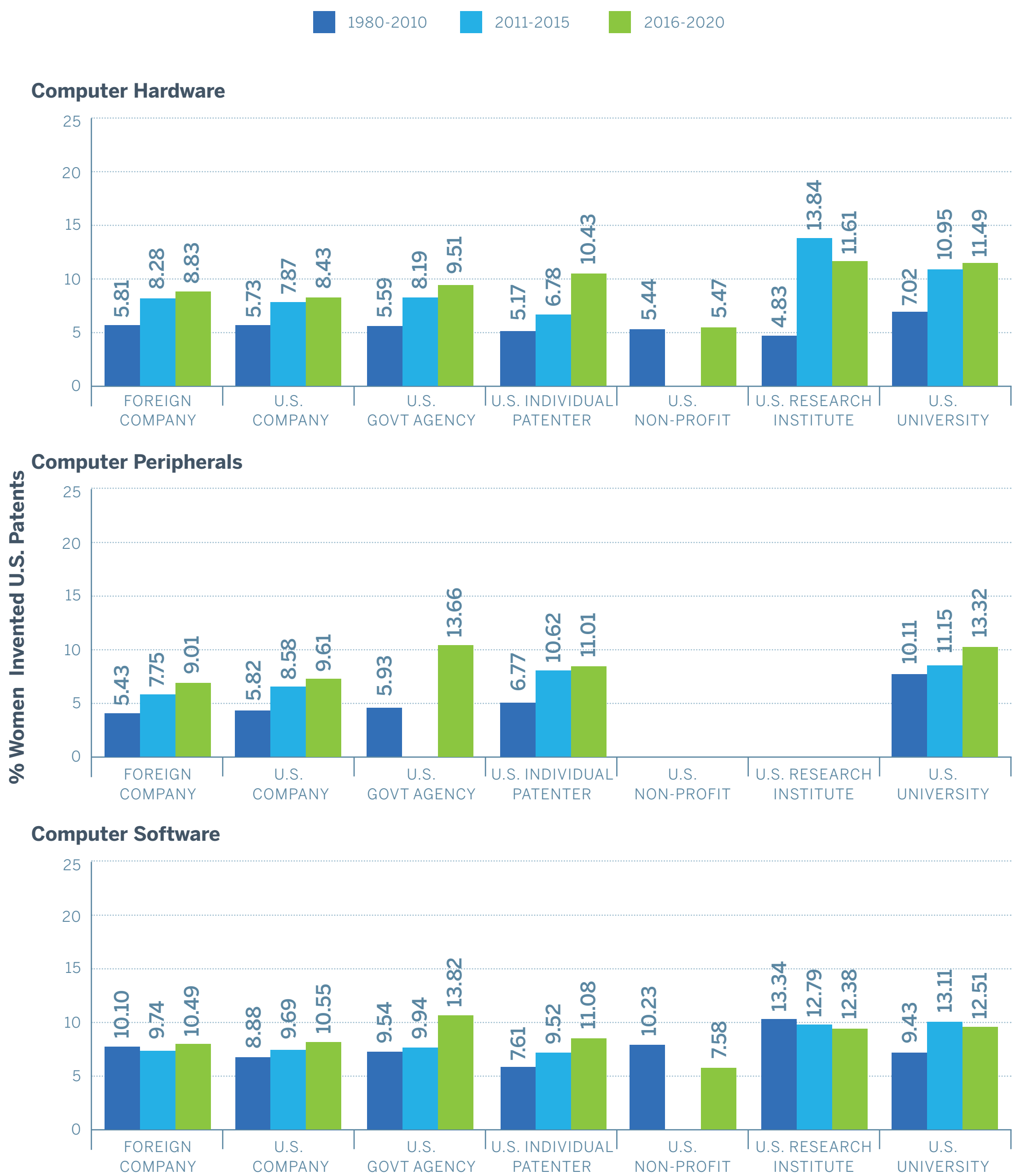


Figure 19 and **Figure 20** show the percentage of U.S. Information Technology patents invented by women by sector and technology category. If we look at the overall combined category, we see that U.S. universities have the highest percentage of women inventorship in each time-period. For 2016-20 12.25% of U.S.-invented IT patents from universities were invented by women, compared to 8.91% for women in U.S. firms and 9.0% for women in foreign-owned firms with U.S. operations.

FIGURE 19. **Percentage of Women U.S.-Invented Patents by Sector and Technology Category (Patents 1980-2020 - Sectors with Fewer than 50 Patents Omitted)**

FIGURE 20. **Percentage of Women U.S.-Invented Patents by Sector and Technology Category (Patents 1980-2020 - Sectors with Fewer than 50 Patents Omitted)**



IV. Conclusion

The National Center for Women & Information Technology, with funding from its Workforce Alliance, commissioned this study to provide insight into the current state of affairs regarding the rate and progress of women's patenting. The bad news is that the overall rate of patenting by women in IT is still relatively low in the U.S. The good news is that the trends are positive with a growing share of women inventorship in a fast-growing field. The news is even better in some subcategories of IT such as Artificial Intelligence and Software.

Likewise, the finding that mixed-gender teams are more frequently cited than either men-only or women-only teams is still an interesting finding. While this advantage seems primarily related to size of team, future research would do well to explore the relationship between size, gender, and citation rates.

Additional good news emerges in the finding that the level of women inventorship in IT is quite high at some companies. This suggests that systemic factors, such as company environment, can make a difference. As such, women could continue to gain greater shares of IT invention, especially if we identify and replicate the conditions and practices that foster women's increased patenting efforts. This report then serves as a call for additional research to identify the conditions and practices that would make this possible.

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