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Progress and Potential

2020 update on U.S. women inventor-patentees

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Progress and Potential

2020 update on U.S. women inventor-patentees

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KEY FINDINGS

- More women are entering and staying active in the patent system than ever before.
- Patenting by U.S.-based women grew between 2016 and 2019. Patents with at least one woman inventor accounted for 21.9% of patents through 2019, up from 20.7% in 2016.
- The women inventor rate (WIR)—that is, the share of women among all U.S. inventor-patentees—grew from 12.1% in 2016 to 12.8% by 2019.
- The percentage of new women inventor-patentees rose from 16.6% in 2016 to 17.3% by 2019.
- The gender gap in the number of inventor-patentees that stay active by patenting again is decreasing. In 2014, 46% of women patented again within five years of their first patent (by 2019), versus 52% of men. In 1980, the gap was 28% for women versus 38% for men.
- The District of Columbia had the highest average WIR for 2007-2019 at 19.2%, while North Dakota had the lowest at 8.3%.
- Wyoming showed the largest improvement in its average WIR, up from 9.6% over 2007-2016 to 11.2% for 2007-2019.
- Among the top patenting organizations, Proctor & Gamble had the highest average WIR at 29.3% for 2007-2019.
- 3M Company showed the largest improvement in the participation of women inventor-patentees: Their average WIR increased from 15.2% over 2007-2016 to 16.6% for 2007-2019.

Introduction

The U.S. patent system improves the lives of Americans by encouraging and strengthening innovation. For this system to be most effective, all Americans must have the opportunity to reap the personal and commercial benefits of applying for and receiving patent protection. In a 2019 report, "Progress and Potential: A profile of women inventors on U.S. patents," the United States Patent and Trademark Office (USPTO) investigated the participation of U.S.-based women inventor-patentees in the U.S. patent system.[1] It examined the trends and characteristics of women's participation and found that women were underrepresented.

This update improves our understanding of women's participation as inventor-patentees in two ways. First, it updates the findings from the 2019 report using three years of new data, covering January 2017 through December 2019. Second, it provides an analysis of entry by women into the patent system. In particular, it looks at the number and share of new women inventor-patentees and the degree to which those women remain active by patenting again within the next five years. The updates and new information presented in this report rely heavily on PatentsView—a free, online platform for visualizing, disseminating, and promoting a better understanding of U.S. patent data supported by the USPTO's Office of the Chief Economist.[2]

There has been continued improvement in the participation of women inventor-patentees

The participation of U.S.-based women in the U.S. patent system can be evaluated using two indicators. The first is the share of patents that include at least one woman inventor. This indicator counts patents and provides an "output" perspective on participation, but it is also influenced by other factors, such as the gender composition of inventor-patentee teams and the total number of patents those teams produce. The second indicator—called the women inventor

1 See U.S. Patent and Trademark Office, Office of the Chief Economist, "Progress and Potential: A profile of women inventors on U.S. patents," IP Data Highlights, no. 2 (February 2019), www.uspto.gov/sites/default/files/documents/Progress-and-Potential.pdf. "Inventor-patentees" are inventors who choose to pursue patent protection for their invention(s).

2 PatentsView (www.patentsview.org) uses a machine learning algorithm to assign unique person-specific IDs to inventor-patentees, thus permitting the tracking of inventor-patentees in U.S. patent data since 1976.

rate (WIR)—calculates the share of women among all inventor-patentees in a given period of time.[3] The WIR indicates the proportion of unique women who are engaged in the patent system and provides an "input" perspective on participation. Unlike the first indicator, the WIR is independent of team gender composition and team production because it identifies the number of unique women inventors within a given time period.

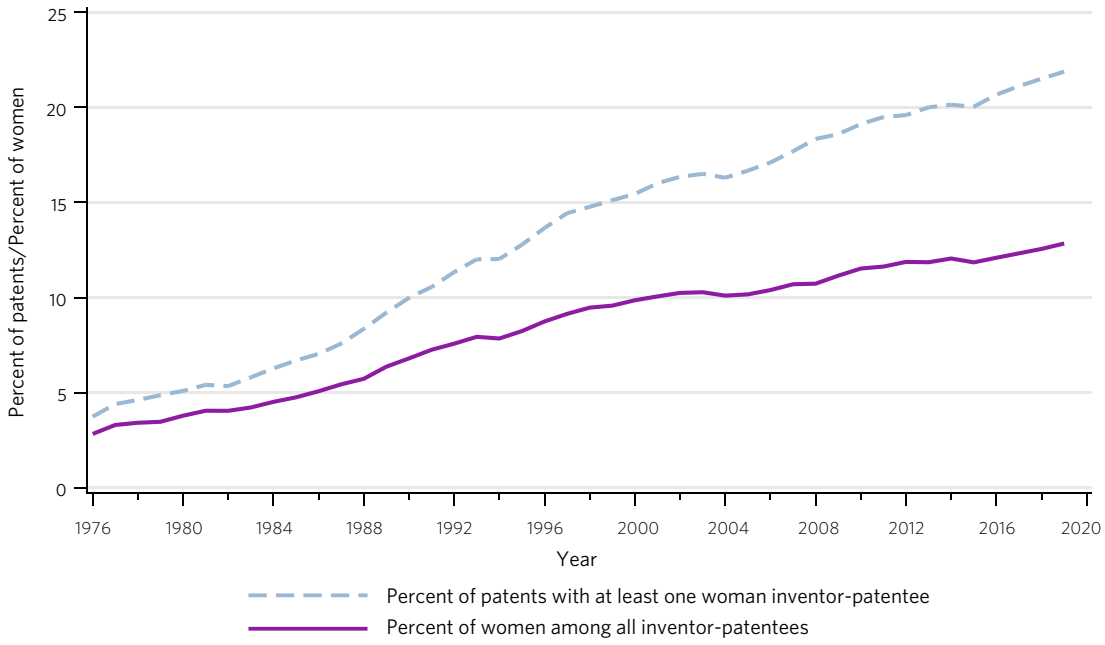
Both indicators have improved substantially since 1976 (Figure 1). The share of patents with at least one woman inventor grew from 20.7% in 2016 to 21.9% by the end of 2019 and is growing faster than in the prior period.[4] Observing faster growth in patent output is certainly positive, but it is unclear whether this trend reflects the contributions of women inventor-patentees because the dominant share of this output comes from mixed-gender teams.

The WIR improved from 12.1% in 2016 to 12.8% by 2019. This shows that more women are active as inventor-patentees. However, a WIR of 12.8% is substantially lower than other benchmarks of women's education and employment as scientists and engineers.[5] In 2017, women held about 2 million science and engineering jobs, but only 27,000 women were inventor-patentees in that year. The share of male science and engineering job holders who are inventor-patentees was three times higher. These data suggest that expanding the pipeline through education and science and engineering jobs, while necessary, is not sufficient to increase the participation of women as inventor-patentees.

More women are entering and staying active in the patent system

Bringing new women into the patent system is one of the most important channels for expanding women's participation as inventor-patentees. Using unique identifiers for inventor-patentees available through PatentsView, this

Figure 1: Patenting and participation by U.S.-based women inventor-patentees, 1976–2019



Source: Authors' analysis of PatentsView data, 1976–2019

3 WIR is calculated for a single year (such as 2019) as the number of unique women inventors divided by the total number of unique inventors for that year. The *average* women inventor rate (AWIR) is calculated over several years, such as 2007-2019, as the sum of unique women inventors in those years combined, divided by the sum of all unique inventors for those same years.

4 From 2010 to 2016, the share of patents with at least one woman inventor grew at an average annual rate of 1.3%. This rate increased to 2% for 2016 through 2019.

5 Recent figures from the National Science Board (NSB) show that women make up about 52% of the U.S. college-educated workforce and hold 29% of all U.S. science and engineering jobs (NSB 2020).

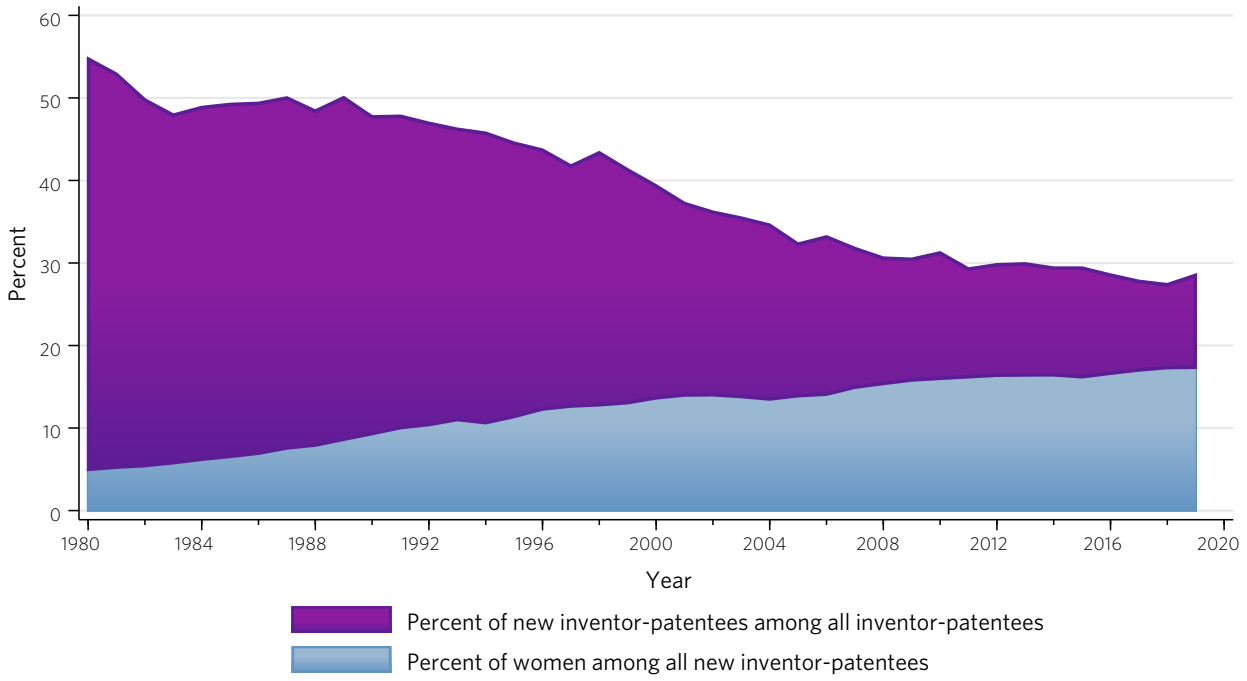
report extends the scope of the USPTO's 2019 "Progress and Potential" report by shedding light on the flow of new U.S.-based inventors into the patent system.

In 1980, there were approximately 44,550 unique inventor-patentees. This number grew to about 241,800 by 2019. During that same period, the share of new inventor-patentees among this group fell (the purple area in Figure 2). To some degree, this downward trend is expected, given that the number of inventor-patentees who patented again increased over time relative to the entry of new inventor-patentees. However, after growing at an average rate of 9.6% from 2009 to 2014, the number of new inventor-patentees grew at just 2.7% per year (on average) from 2014 to 2019. In 2019, there were about 69,080 new inventor-patentees.

Similar to the trend in the WIR, the share of women among all new inventor-patentees increased from about 5% in 1980 to 17.3% by the end of 2019 (the blue area in Figure 2). In the five-year period from 2009 to 2014, the number of new women inventor-patentees grew by an average of 10.8% each year. In the next five years ending in 2019, this growth slackened to 4% per year. Nevertheless, a 4% annual growth in the number of new women inventor-patentees is notably higher than the growth observed for new men inventor-patentees, which was 2.5% from 2014 through 2019. From 2014 to 2019, the average number of new women inventor-patentees per year was about 10,340.[6]

Similar to the trend in the WIR, the share of women among all new inventor-patentees increased from about 5% in 1980 to 17.3% by the end of 2019.

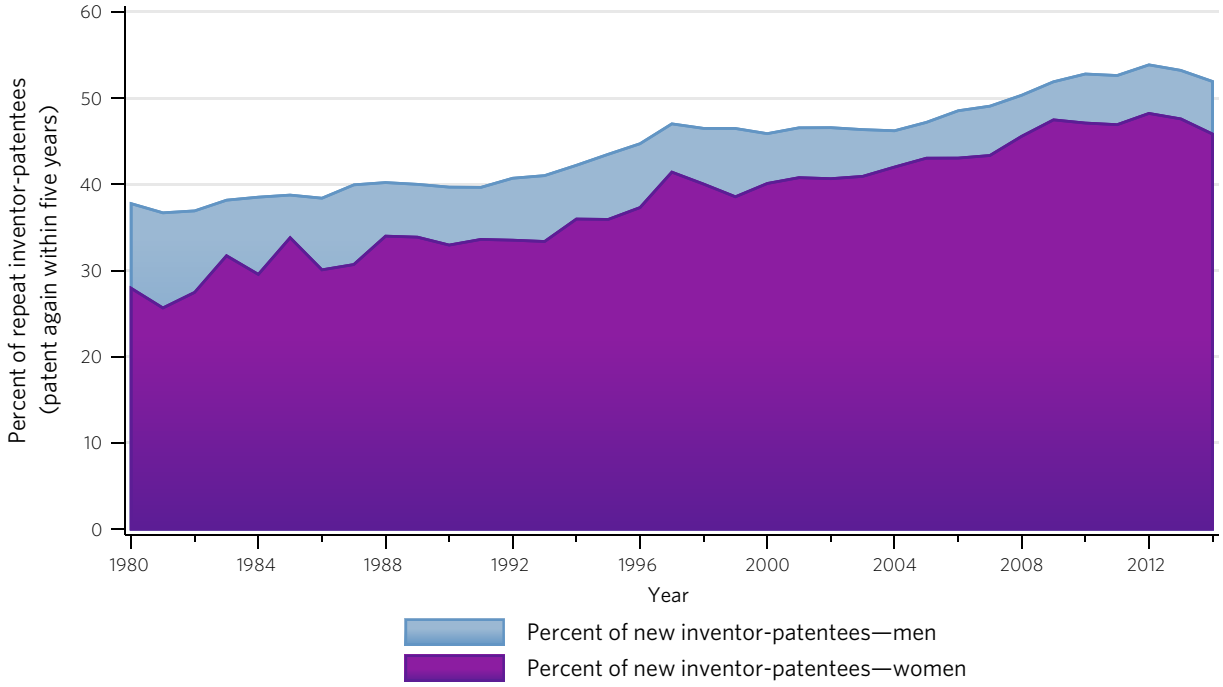
Figure 2: New inventor-patentees as a percentage of all inventor-patentees, and corresponding women's percentage, 1980–2019



Source: Authors' analysis of PatentsView data, 1976–2019

6 For top universities, Delgado and Murray analyze the participation of new female inventors. (See Delgado, M., and F. Murray, "Catalysts for Gender Inclusion in Innovation: The Role of Universities and Their Top Inventors," unpublished paper, Massachusetts Institute of Technology, February 2020.)

Figure 3: Percentage of new inventor-patentees who remained active in the patent system by patenting again within five years, by gender, 1980–2014



Source: Authors' analysis of PatentsView data, 1976–2019.
Note: Cohorts were constructed by grouping inventor-patentees by the year they received their first patent and then following them for five subsequent years.

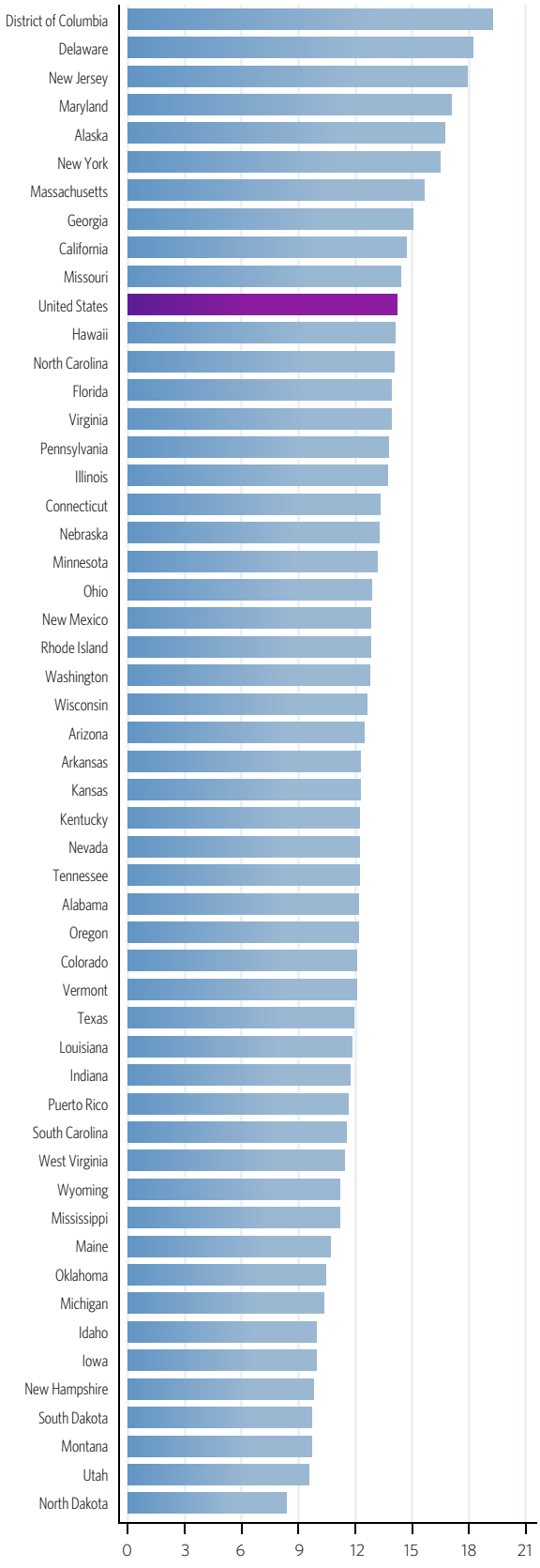
Another aspect that characterizes participation as inventor-patentees is whether they stay active in or drop out of the patent system. One form of staying active is to patent multiple inventions over time. For this report, we measure engagement for each new inventor-patentee by assessing whether that person obtained at least one more granted patent in the five years following his or her first patent.

For groups of new inventor-patentees from 1980 through 2014, Figure 3 shows the percentage who remained active in the patent system within the next five years. For instance, of the group of new men inventor-patentees in 1980, about 38% of those individuals stayed active by patenting again within the next five years. This percentage rose over time. For new men inventor-patentees in 2014, about 52% remained active. The results for women inventor-patentees indicate that women are less continuously engaged in the patent system as inventors, but that engagement is improving over time. For the 1980 group of new women inventor-patentees, about 28% remained active within the next five years. By 2014, this percentage increased to nearly 46%. Although the factors driving these trends are not yet known, women inventor-patentees are decreasing the gender gap in the number of active inventor-patentees in the patent system.

The U.S. and most states show an improved AWIR

For the nation, women's participation as inventor-patentees improved. The average women inventor rate (AWIR) for 2007-2019 was 14.2%, up from 13.6% for 2007-2016. However, national-level improvements in AWIR do not reveal state level variation in women's participation (Figure 4). A strong national AWIR could be driven by a handful of states, potentially masking important differences in the geography of women's participation. The USPTO's 2019 "Progress and Potential" report revealed a more than 10 percentage point difference between the highest and lowest state AWIRs (Delaware 18.3%; North Dakota 8.2%). In that same time period, about 42% of all U.S.-based women inventor-patentees were located in four states: California, Massachusetts, New York, and Texas. Three states had fewer than 50 women inventor-patentees (Wyoming, North Dakota, and Alaska), four states had between 50 and 100, and 18 states plus the

Figure 4: Average women inventor rate (AWIR) by state, 2007–2019



Source: Authors' analysis of PatentsView data, 2007–2019

About 41% of all U.S.-based women inventor-patentees are located in four states: California, Massachusetts, New York, and Texas.

District of Columbia had between 101 and 500 women inventor-patentees.[7]

With the updated data used in this report (2017–2019), the range of AWIR values across states increased slightly to 11%, underlining how geographic location shapes opportunities differentially for women to become inventor-patentees.[8] Among the four states with the most women inventor-patentees, Texas is the only one ranked below the national AWIR of 14.2%.[9]

Figure 5 illustrates how state AWIRs have changed since 2016. Forty-five states and the District of Columbia improved their AWIRs for 2007-2019 relative to 2007-2016. Wyoming (darkest purple in Figure 5) showed the largest improvement, rising from 9.6% to 11.2%. This is an increase of 1.6 percentage points.[10] However, because Wyoming has a small number of inventor-patentees, this change represents a relatively small increase in the absolute number of women inventor-patentees. The AWIRs for 15 states increased between 0.001 and 0.500 percentage points, while 30 states plus the District of Columbia improved between 0.501 and 1.500 percentage points. Alaska, Hawaii, North Dakota, Alabama, and Mississippi all experienced small reductions in their AWIRs.

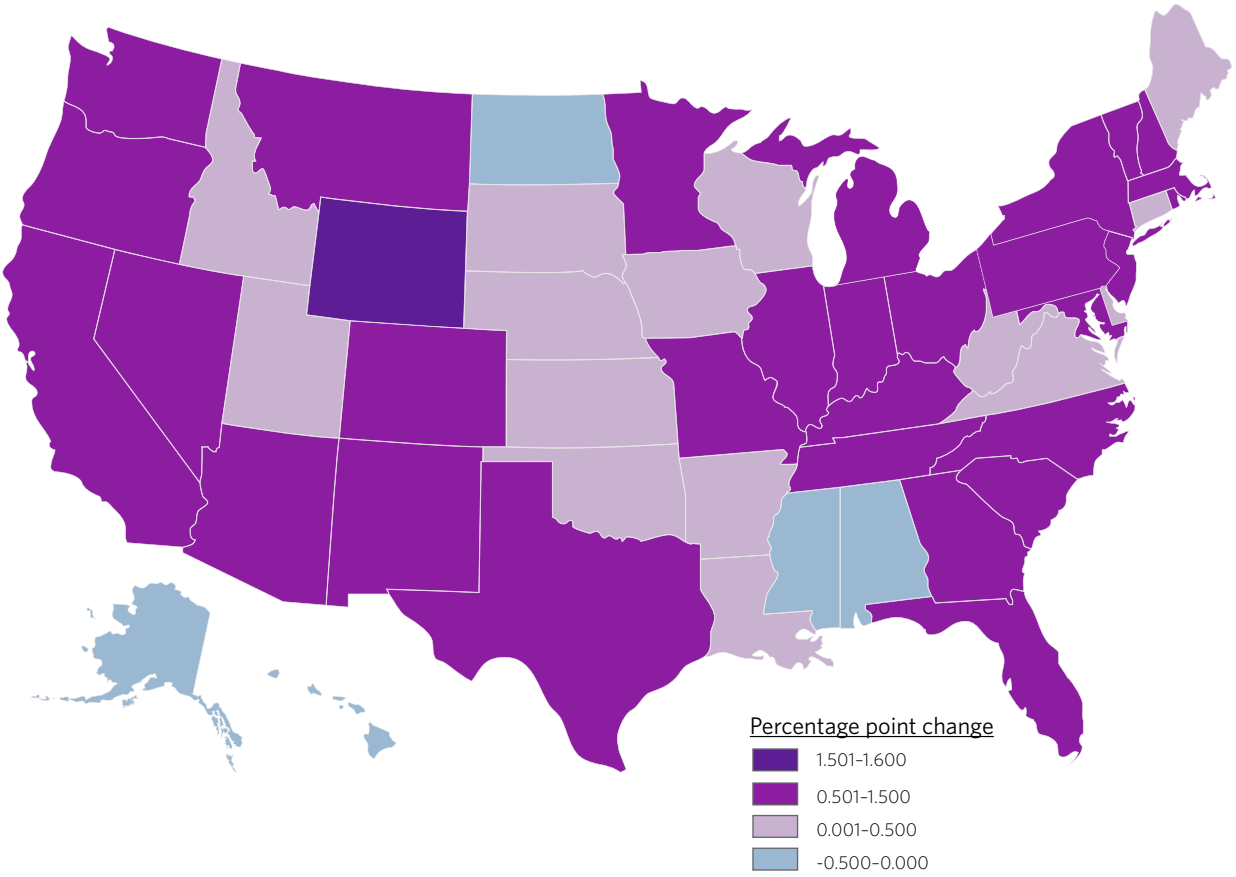
7 See USPTO, "Progress and Potential" (February 2019).

8 In this update, the period of coverage was expanded to include five earlier years of data preceding 2012, adding 2007–2011. This change was made to provide consistency with other figures in this report, but it does not influence the results in a meaningful way. Using an average over 2007-2019 helps to smooth year to year variation.

9 Note that the national AWIR of 14.2% is higher than all WIR values reported in Figure 1. This is due to the fact that the AWIR in Figure 4 is an average calculated over a longer time interval, from 2007 through 2019, and thereby retains unique inventor-patentees who may have patented in only one year. The WIR reported in Figure 1 only counts unique inventor-patentees appearing annually.

10 A change in percentage points is not equivalent to a percentage change. For instance, the percentage point change will be 5 when values go from 10% to 15% whereas the percentage change would be 50%.

Figure 5: Percentage point change in the average women inventor rate (AWIR) by state between the time periods 2007–2016 and 2007–2019



Source: Authors' analysis of PatentsView data, 2007–2019

Few top patent assignees surpass the national AWIR

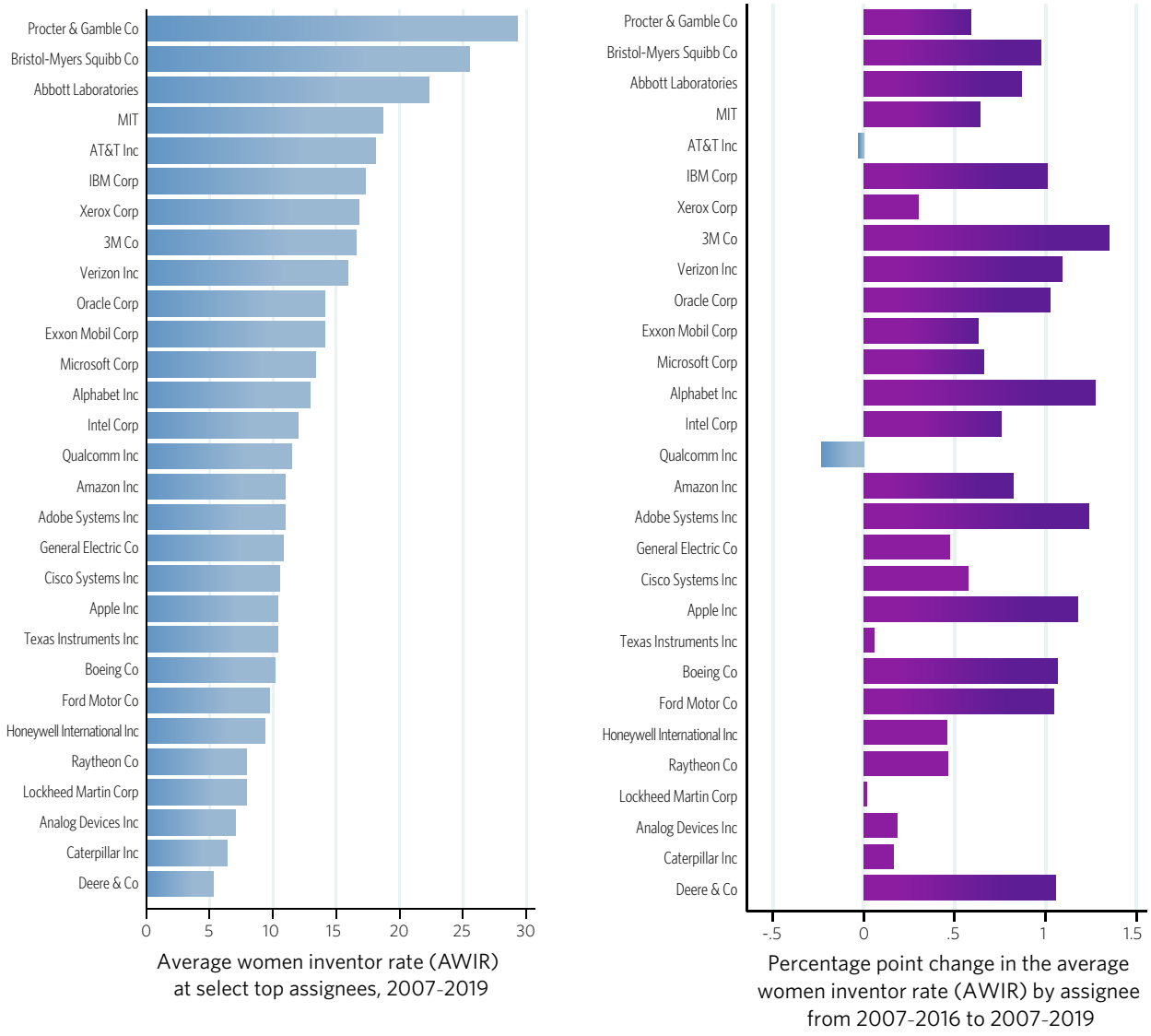
Due to the volume of annual patent filings, the organizations that are the top patent assignees have a disproportionate influence on women's participation in the U.S. patent system.[11] For the 29 top assignees listed in Figure 6 (left bar chart), only 11 had AWIRs above the 14.2% national AWIR. Continuing a long-running trend, Procter & Gamble led the group with over 29%. The three companies with the highest AWIR values produce diversified healthcare products and pharmaceuticals, which is consistent with the concentration of women in chemistry, biology, and related STEM (science, technology, engineering, and mathematics) fields and jobs.[12] In contrast, women make up the smallest share of inventor-patentees at companies more focused on electrical and mechanical engineering technologies, such as Deere & Co. (5%), Caterpillar (6%), and Analog Devices (7%).

Women's participation as inventor-patentees varies considerably across U.S. companies, both within and across industrial sectors.

11 When a patent is granted, a company or other entity is assigned ownership and identified as the "assignee" of the patent.

12 National Science Board, Science & Engineering Indicators, 2020. "The State of U.S. Science & Engineering." Washington, D.C.: NSB-2020-1. ncses.nsf.gov/pubs/nsb20201.

Figure 6: Average women inventor rate (AWIR) at 29 top patent assignees



Source: Authors' analysis of PatentsView data, 2007–2019

Figure 6 (right bar chart) shows the percentage point changes in the AWIRs for top assignees between two time periods, 2007–2019 compared to 2007–2016. 3M Company showed the largest gain in women's participation, rising by 1.4 percentage points to 15.2% in 2007-2019. The increase for Procter & Gamble, which is first in the AWIR rankings, was about half as large (0.59 percentage points). The AWIR values for 9 of the top 29 assignees listed in Figure 6 increased by more than 1 percentage point, and 18 others exhibited some improvement. AWIR values were flat or slightly down for Qualcomm and AT&T.

Appendix I: Gender attribution validation

After publication of the 2019 "Progress and Potential" report, we undertook an evaluation of the quality of the gender attribution algorithm used in that report and in this update. The algorithm's accuracy was assessed on a test set of USPTO examiners whose genders are known from internal USPTO human resources data.[13] First, patent examiner names were extracted from public data on U.S. patents hosted by PatentsView (www.patentsview.org). Second, examiner genders were attributed to each patent examiner using the algorithm. There were more than 3 million patent-examiner pairs. For these, a gender was attributed in about 90% of the cases. For these successful attribution cases, the algorithm correctly predicted gender in 94.3% of the cases. This number, however, is likely a lower bound for the algorithm's accuracy due to instances of incomplete information or data inconsistencies. For example, some observations contained only the initials of the examiner's name rather than his or her first name, which is not enough information to infer the person's gender.

Appendix II: The AWIR for top patent assignees

To generate the set of organizations reviewed, we relied on the list of selected top assignees used in the 2019 "Progress and Potential" report.[14] We pre-processed the top patent assignee names[15] for matching to the population of all assignee names on U.S.-granted patents between 1976 and 2019.[16] Using software, we applied various fuzzy matching methods to the pre-processed names of top assignees and the population of all patent assignees.[17] The software generated scores for each potential match based on the co-occurrence of words, where words were weighted by their inverse frequency. We retained all potential matches with a score greater than or equal to 95 (out of a possible score of 100).

Next, manual reviews were performed to validate the accuracy of matched candidates. This process involved identifying matches to joint ventures, subsidiaries, or international branches of the companies and other entities in our sample. Inaccurate or low-quality matches were removed. Despite these efforts, some inaccuracies in the grouping of assignee names may still be present.

Two sets of matched assignee names were generated for each entity: (1) assignee names of the entity itself as well as any related IP branch or holding company, excluding joint ventures, subsidiaries, and international branches; and (2) all matching assignee names. The second set, while more expansive, does not represent a company's entire corporate structure because subsidiaries with names that are different from the corporate name could not be identified without comprehensive information on corporate ownership structures and any changes in those structures over time. For this reason, AWIR values may differ if the entire corporate structure is considered.

13 Appendix II of the USPTO's "Progress and Potential" (February 2019) report explains the gender attribution algorithm in detail.

14 Appendix III of the USPTO's "Progress and Potential" (February 2019) report provides more background.

15 We manually searched the patent assignee data for possible variants of the official name of each entity in our sample. An individual firm's name can appear in a variety of ways on different patents. For example, International Business Machines may be abbreviated as "IBM," or Massachusetts Institute of Technology as "MIT." We compiled a list of such name variants for each entity and then cleaned and standardized the variants using a firm name standardization software package (stnd_comp) in Stata.

16 We restricted the PatentsView assignee file to all organizational assignees (that is, no individuals) with at least one patent granted between 1976 and 2019 and then cleaned and standardized each assignee name using a firm name standardization software package (stnd_comp) in Stata.

17 We used the publicly available Doherr Search Engine to perform matching. See Doherr, Thorsten, "Inventor mobility index: A method to disambiguate inventor careers," ZEW Discussion Paper, no. 17-018 (2017).

For each of the two sets of matched assignee names, granted patents were linked and retained for the period of interest, 2007 through 2019. For each matched patent in sets 1 and 2, we retrieved PatentsView's unique inventor ID and associated gender to calculate the AWIR for the set of unique inventors. The AWIRs were consistent across the matched patents in sets 1 and 2 because the vast majority of matched patents fall into both groups. Given this similarity, throughout the report, we provide only the AWIR for the patents linked to assignees matched in set 1, which excludes joint ventures, subsidiaries, and international branches.

For Figure 6, we calculated the AWIR across two periods: 2007–2016 and 2007–2019. To ensure internal consistency, we reestimated the AWIR for the 2007–2016 period instead of relying on the data from the previous report. Analyzing these two periods allowed us to assess changes in the top assignee AWIRs. Although the methods remained largely the same as those in the previous report, the input data changed in several ways, leading to assignee-level differences between the AWIR in the previous report and the reestimated 2007–2016 AWIR in this report. Most notably, the assignee and inventor disambiguation algorithms were improved, which led to higher-quality data, but also to variations in the set of inventors and patents associated with each assignee. As a quality check, we manually compared the selected assignees' patent portfolios generated for both reports, including only those patents granted between 2007 and 2016, to ensure consistency. The differences in patent portfolio composition across reports was driven by the erroneously linked patents in the previous report because of a lower-quality disambiguation algorithm. Our results will also be influenced by differences in the share of inventors with missing gender attributions across assignees.

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