Where are U.S. women patentees? Assessing three decades of growth

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Where are U.S. women patentees? Assessing three decades of growth

Project team

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Michelle Saksena, PhD, Senior Research Economist, USPTO

Nicholas Rada, PhD, Deputy Chief Economist, USPTO

Lisa Cook, PhD, Professor, Michigan State University

Abstract

This report maps women's participation as inventor-patentees across U.S. counties from 1990 through 2019. It identifies counties with the most women patentees by technology field and assesses three decades of growth. Recognizing that increasing the number of women who patent is an important policy objective, the analysis explores characteristics of county economic environments that are correlated with having and increasing the number of women inventor-patentees. The results presented clarify the landscape and lay the foundation for evidence-based approaches to important questions such as how women's participation impacts county-level economic performance.

Introduction

Women are responsible for critical technologies that continue to influence U.S. economic growth and improve the quality of life for all Americans. Standing beside the likes of Charles Goodyear, Les Paul, and Steve Jobs—names synonymous with rubber tires, the electric guitar, and the Macintosh desktop computer—are the likes of Gertrude Belle Elion, Hedy Lamarr, and Barbara Liskov. Elion invented a leukemia-fighting drug and drugs that facilitated kidney transplants. Lamarr, the Hollywood actor, provided Allied forces in World War II with a critical advantage by creating a guidance system that launched torpedoes undetectable by radio frequencies. Her invention was a precursor to WiFi, GPS, and Bluetooth technologies. Liskov is a trailblazer in the design of computer programing languages. She developed key concepts and processes used in modern computer programming languages that enable advances in artificial intelligence technologies such as machine learning.

By 2019, nearly 230 years after the creation of the U.S. patent system, women made up only 13% of all inventor-patentees in the United

Key findings

- The number of counties with women inventor-patentees grew by 32% over the 30-year study period, an expansion of 411 new counties from 1990 through 2019.
- Growth in the number of women inventor-patentees was robust in counties where women were already patenting in the early 1990s. The average number of women inventors in the top 10% of counties was 34 in 1990. By 2019, the average was 209, a 515% increase.
- Among top women-patenting counties, Harris County, TX, showed strong growth in the field of fixed constructions (buildings, structures, earth drilling and related materials), rising by 2,045% in the 30 years studied.
- More women inventor-patentees were observed in counties with more highly educated women. Women's educational attainment of a bachelor's degree or higher was 52% greater in counties with women inventor-patentees.
- The importance of women's educational attainment carries over to counties with no previous women inventor-patentees: doubling the number of women college graduates correlates to a 61% increase in the likelihood that a county has its first woman inventor-patentee.

States.[1] This persistent underrepresentation of women has created an unnecessary drag on American innovation and prosperity.[2] Some economists suggest that if women were to patent at the same rate as men, commercialized patents could increase by 24% and per capita gross domestic product—that is, total economic output adjusted for the U.S. population—could increase by 2.7%.[3] Moreover, gender diversity boosts the inventive process in essential ways: women's experiences and viewpoints help inform, and thus improve, the quantity and quality of innovation;[4] gender diversity expands research into underserved topics, thereby filling overlooked technology gaps;[5] and women often help enhance communication and build external relationships, increasing team cooperation and productivity.[6]

Policymakers recognize that expanding women's participation in patenting is critical for growing and sustaining American innovation and economic competitiveness.[7] This report answers some of the basic questions needed for the policy formulation process. First, it maps the geography of women's participation as inventor-patentees across U.S. counties from 1990 through 2019. Second, it identifies counties with the most women patentees by technology field, comparing the scale of each technology field and assessing three decades of growth. Third, recognizing that increasing the number of women who patent is an important policy objective, the analysis delves deeper into the characteristics of county economic environments to assess how labor markets, per capita incomes, and educational attainment correlate with women's participation in patenting.[8]

Where are the women inventor-patentees?

Women's participation in patenting has more than doubled since the mid-1970s, but growth has varied widely among U.S. states.[9] A state perspective is broadly informative of national participation and growth, but innovation activity is highly diverse even within a state, and a county perspective is necessary to more accurately pinpoint the composition of women's growth in patenting over time and geography. This report assesses the extent to which new counties have become involved in the invention ecosystem, or whether the growth observed has been restricted to counties that already had women patentees.

1 Inventor-patentees are those inventors who seek patent protection for their inventions. See Toole et al. (2020). This rate is significantly lower than other benchmarks of women's education and employment as scientists and engineers (NCSES, 2021).

2 See Rothwell et al. (2013); Bell et al. (2019).

3 See Bell et al. (2019); Hunt (2016).

4 See Milli et al. (2016); Xie et al. (2020).

5 See Koning et al. (2021).

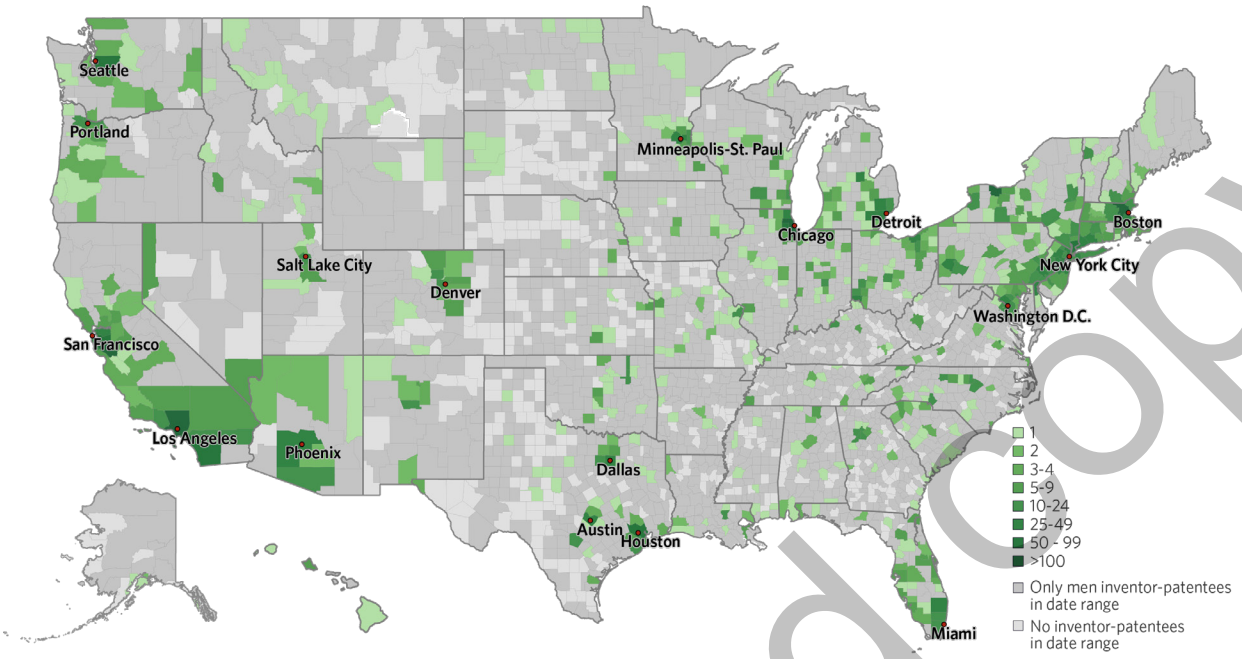
6 Xie et al. (2020) show that gender diversity in research and development teams enhances innovation efficiency by generating social benefits that help improve intra- and inter-team communication.

7 Despite notable growth in the last 40 years, women remain underrepresented at all points in the intellectual property lifecycle (SUCCESS Act, 2018), from applying for and being granted a patent, to staying active by inventing again (Toole et al., 2019; Toole et al., 2020), to seeking commercialization for their patents (Shaw and Hess, 2018).

8 The findings reported are not causal estimates of these relationships. They are estimates based on combining a novel dataset with a statistical model and estimation method that account for the count data nature of women's participation in patenting and for a number of county-level factors that might influence the participation of women patentees. Not all possible factors are considered, and no randomized control trial was conducted. The data and statistical approach are described in the supplementary materials available at www.uspto.gov/sites/default/files/documents/oce-women-patentees-supplement.pdf.

9 See Toole et al. (2019); Toole et al. (2020).

Figure 1: Women Inventor-Patentees by County, 1990–1992



Source: Authors' estimates using PatentsView data (https://patentsview.org/). A larger map for Figure 1 is available for download.

Women inventor-patentee participation in 1990-1992

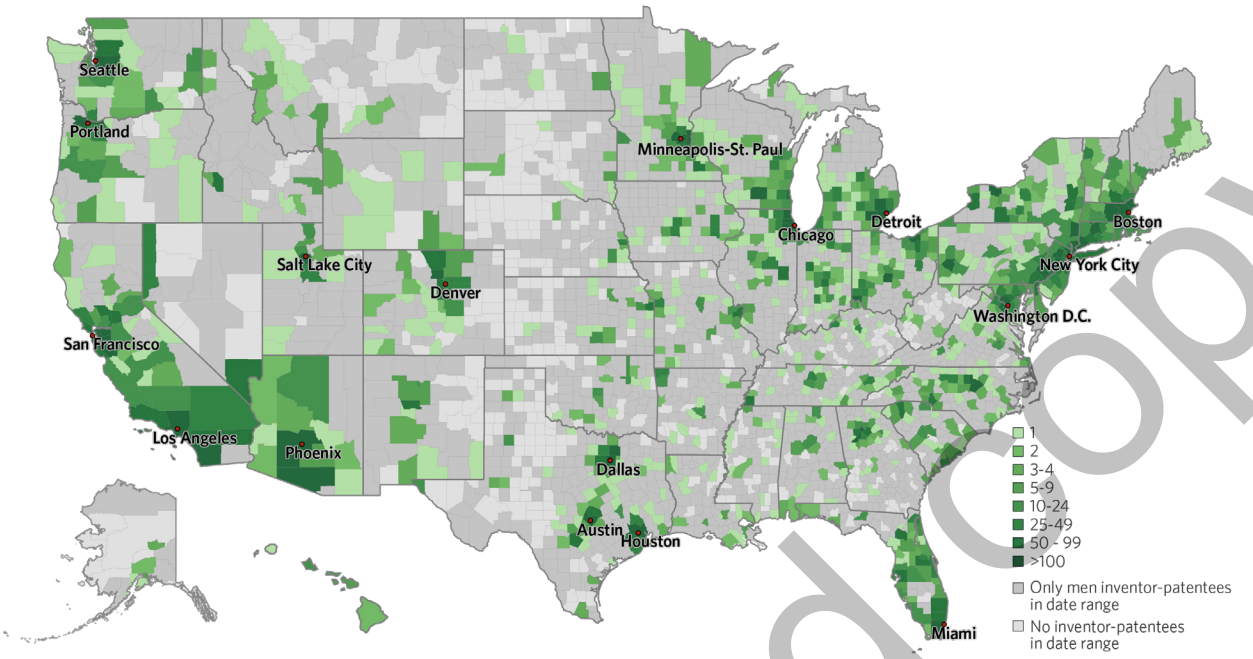
Figure 1 maps the average number of women inventor-patentees in each U.S. county between 1990 and 1992 (darker green represents greater numbers). Counties with only men inventor-patentees are gray, and counties with no inventor-patentees are dark gray. The map provides a county-by-county visualization of women inventors' participation in the patent system during that period.

Consistent with the research by Delgado et al. (2014) and others, metropolitan areas tend to have more women inventor-patentees (the darkest green counties in 1990-1992).[10] On the East Coast, counties along the Boston-Washington, D.C., corridor and in south Florida have high numbers of women patentees. Likewise, on the West Coast they reside around Seattle, Portland, San Francisco, Los Angeles, San Diego, and Phoenix. These concentrations are consistent with historical strengths in technologies such as medicine and chemistry on the East Coast and computer science on the West Coast.

The number of gray counties with no women inventor-patentees is prominent in Figure 1. In 1990-1992, a total of 2,117 counties—or 80% of all U.S. counties—had only men inventor-patentees. The few dark gray counties, reflecting no inventors named on patents, primarily appear in the Great Plains region of the U.S. These dark gray counties accounted for 1% of all U.S. counties.

10 Delgado et al. (2014) find that concentrations of economic activity reflect local amenities that help inventors by providing richer opportunities to share knowledge, to access larger product and service markets, to engage with a research community through colleges and universities, and to access other businesses like legal services that support the drafting and examination of patents and subsequent commercialization activities. Such amenities are, as indicated by Delgado et al. (2019) and Kulis and Sicotte (2002), of particular relevance to women inventors, as they tend to be less mobile than male inventors (e.g., parental obligations tie them to a geographic area).

Figure 2: Women Inventor-Patentees by County, 2017–2019



Source: Authors' estimates using PatentsView data (https://patentsview.org/). A larger map for Figure 2 is available for download.

Growth in women's participation in patenting between 1990-1992 and 2017-2019

Figure 2 portrays women's participation in patenting in 2017-2019, and illustrates the two ways in which growth has occurred since the early 1990s.

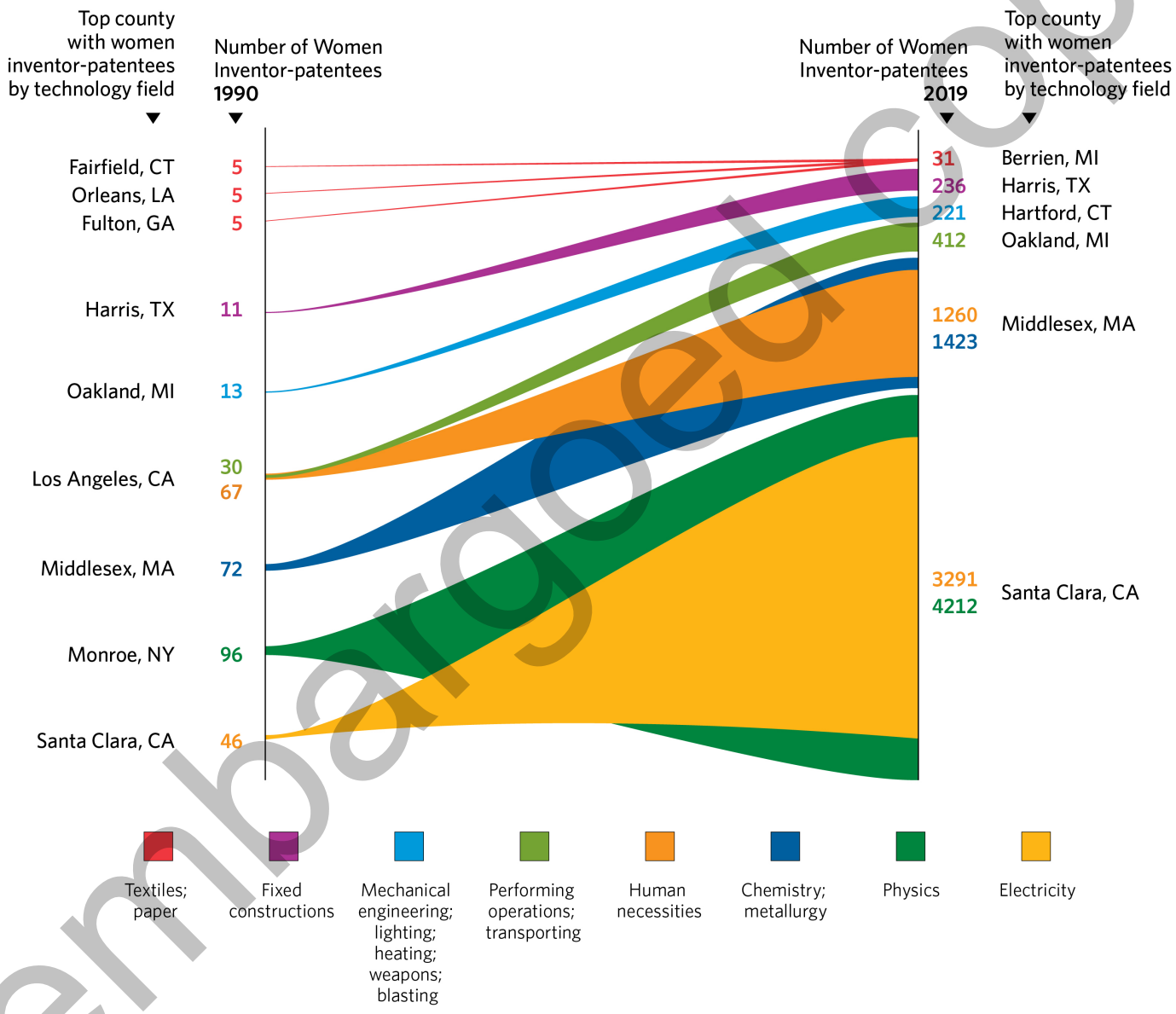
First, the number of counties with women inventor-patentees increased by nearly a third between 1990-2019. Specifically, 411 new counties were added—a 32% increase—to the patenting ecosystem during this time period. As shown in Figure 2, county expansion centered around cities and spread outward. What is noticeably different in Figure 2 is that women's representation occurs in parts of the country that were not necessarily synonymous with innovation in the early 1990s. While it is evident that there is considerable growth outward from very large, economically bustling cities like New York City and San Francisco, midsize cities such as Austin also experienced significant growth in the number of women inventor-patentees. Detroit, which has a storied history of economic decline and recent rebound, also showed appreciable growth in women patentees.[11] Additionally, places with strong educational and research networks but relatively smaller populations, like the research triangle in North Carolina (Raleigh, Durham, and Chapel Hill), also had compelling growth.

Second, the number of women inventor-patentees continued to grow in counties where women were already patenting in the early 1990s. Focusing on the top 10% of counties with women inventors who patent, their average number per county in 1990-1992 was 34. By 2017-2019, the average number per county increased to 209. In some instances, counties experienced dramatic gains. For example, Benton County, located southwest of Little Rock,

11 See Bunting et al. (2014).

Arkansas, had one woman patentee in 1990-1992. By 2017-2019, Benton County had 26 women inventors who held patents, a 2,500% gain. Hendricks County, adjacent to Indianapolis, Indiana, had 13 women inventor-patentees in 2017-2019, up from only one in 1990-1992.

Figure 3. Top counties with women inventor-patentees by technology field, 1990 and 2019



Source: Authors' estimates using PatentsView data (https://patentsview.org/)

In which technology fields do women patent?

Figure 3 identifies U.S. counties with the greatest number of women inventor-patentees in eight technology areas in 1990 and in 2019. The change between 1990 and 2019 for each technology area is represented by the left-to-right "flow" of shaded regions. Wider flows represent more women inventor-patentees, and each technology area is represented by a different color.[12] We label counties as inventive "hubs" if they had the most women inventor-patentees within a technology field. For example, Santa Clara County, California, was the national hub for the field of electricity in 1990 with 46 women inventor-patentees.

In 1990 and in 2019, the field of physics had the largest technology hub (Figure 3). Findings from the USPTO report "Progress and Potential: 2020 update on U.S. women inventor-patentees" showed that women's participation in patenting as a rate—that is, calculated relative to all patentees in that technology field—was highest in the field of chemistry.[13] The present report emphasizes the importance of also considering the absolute size of women's participation to better portray women's representation in technology overall. In the present report, for example, the chemistry; metallurgy technology hub (Middlesex County, MA) had the highest women's participation rate (21%), but notably ranked third as of 2019 in terms of the total number of women inventors named on patents. More women patented in the physics (4,212) and in the electricity (3,291) technology hubs despite having lower participation rates (12% in both as of 2019).

Figure 3 emphasizes the substantial growth in women inventor-patentees between 1990 and 2019 by technology hub. As indicated by the changing size of the shaded regions, growth in the number of women inventor-patentees increased across all technology fields, but varied widely. For example, the fixed constructions (buildings, structures, earth drilling and related materials) technology hub grew 2,045% over the 30 year span. In 1990, only 11 women inventors were listed on issued fixed constructions patents in Harris County, but by 2019, there were 236. Other examples of growth in technology hubs include the field of human necessities (grew by 1,781%), physics (4,288%), and electricity (7,054%) during the same period.

These hubs also shifted geographically over time. For example, Los Angeles County, California, had the largest number of women inventor-patentees of any field in 1990 (97 women inventor-patentees in the combined areas of human necessities and performing operations; transporting), followed closely by Monroe County, New York. By 2019, Los Angeles County lost its standing as the top women inventor-patentee county in the U.S. to Santa Clara County, which had a consolidated total of 7,503 women inventor-patentees.[14] Notably, Santa Clara County had 180% more women inventor-patentees than the second largest women inventor-patentee hub, Middlesex County, Massachusetts (2,683 women inventors named on patents in 2019).[15]

12 The USPTO classifies patents into at least one technical area using the Cooperative Patent Classification (CPC) system. Within the CPC system, there are eight top-level sections corresponding to the International Patent Classification (IPC), plus a "Y" section to tag emerging and cross-referenced technologies. (Note: Y classified patents are excluded in this analysis.) Each patent is assigned to a classification that best captures the invention as a whole for the patent family; this classification is designated as the "CPC First" classification. See www.uspto.gov/web/patents/classification/cpc/html/cpc.html.

13 See Toole et al. (2020).

14 By 2019, Los Angeles County was not a top county for women patentees in any technology field. It was last listed as a top county of human necessities patents in 2006.

15 When accounting for population, Santa Clara County (1,927,470 residents in 2019) had 38 women inventor-patentees per 1,000 residents compared to Middlesex County (1,600,842 residents in 2019), which had 17 women inventor-patentees for every 1,000 residents. Thus, in 2019, Santa Clara County had 124% more women inventor-patentees per capita than Middlesex County.

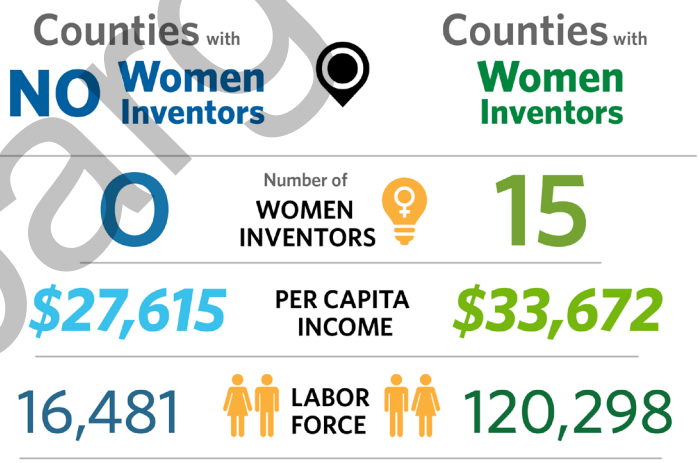
Are women inventor-patentees in counties with large labor markets and high incomes?

This section explores characteristics of county economic environments that correlate with having and increasing the number of women inventor-patentees. Figure 4 quantifies the maps exhibited earlier by separating counties into two groups: counties with women inventor-patentees and counties with only men inventor-patentees. Counties with women inventor-patentees have larger labor markets (630% more laborers) and higher incomes (22% greater) than those counties without them.

The analysis for this report shows a positive correlation between the size of a county's labor force and its growth in the number of women inventor-patentees (see online supplement for details). Prior literature suggests that large labor markets offer advantages to local inventors that are likely to be important for women's participation.[16] For instance, opportunities to build networks and trust relationships may be more abundant in larger labor markets. Another possible advantage could result from the presence of low-skilled labor.[17] For example, because women are still the predominant household caregivers,[18] they are likely more sensitive to the local availability of childcare. Readily available childcare may attract women inventors with children by affording them the option to secure help, thereby freeing up time to devote to innovation.[19]

Statistical tests further show a positive empirical relationship between local per capita incomes and the presence of women inventor-patentees: on average, if the size of the labor market and other factors stayed the same, an increase in a county's per capita income by

Figure 4. Economic statistics of counties with and without women inventor-patentees, 1990-2019 average



Source: Authors' estimates. See online supplement for data details.

16 See Delgado et al. (2014).
17 See AARP (2021); Dush et al. (2018).
18 Ibid.
19 See Coser (1974).

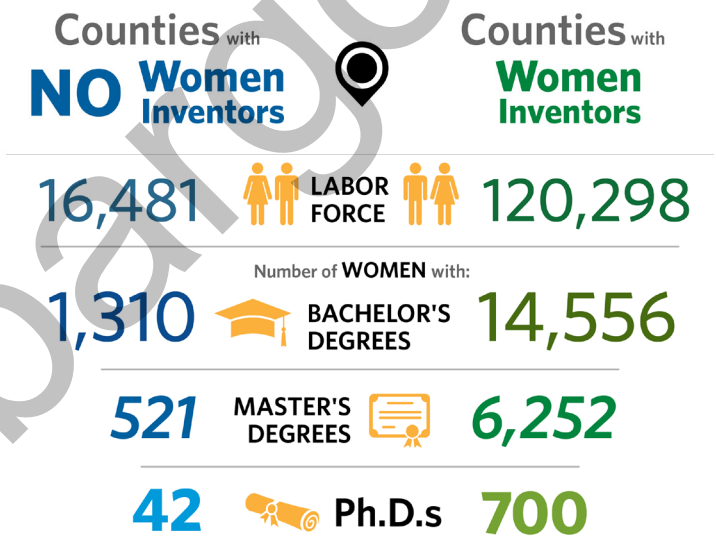
$50,000 correlates to an additional woman inventor-patentee.[20] These findings support existing evidence from the literature that the size of local labor markets and the level of income are important environmental economic considerations for policymakers and others who seek to expand the number of women inventor-patentees in the innovation ecosystem.[21]

Is women's educational achievement associated with a county attaining its first woman inventor-patentee?

Figure 5 shows that counties with more women inventor-patentees also have more women with higher-education degrees compared to counties with no women inventor-patentees. Because places with larger labor forces also tend to have more highly educated people, the number of women graduates in Figure 5 is divided by the labor force size in each county.[22] For every 100 workers, there are 12 women with a bachelor's degree in counties with women inventor-patentees. In counties with no women inventor-patentees, there are only eight women with bachelor's degrees for every 100 workers. These findings show that after adjusting for higher population density, there are 52% more highly educated women in counties with women inventor-patentees.

Our analysis also found a positive empirical relationship between the number of women college graduates and the likelihood that a county attains its first woman inventor. Specifically, a doubling of the number of women college graduates correlate with a 61% increase in the likelihood that a county has its first woman inventor-patentee. There was a positive relationship with graduate degrees as well: a doubling of a county's number of women with

Figure 5. Education statistics of counties with and without women inventor-patentees, 1990-2019 average



Source: Authors' estimates. See online supplement for data details.

20 It should be kept in mind that local labor markets and per capita incomes are expected to increase when more women participate in invention and innovation. The statistical model presented here does not examine this direction of influence.

21 See Bell et al. (2019).

22 Educational attainment rates were normalized by the labor force to account for the different sizes of counties. In addition, master's and Ph.D. graduates were also normalized and found to have a similar pattern; counties with women inventor-patentees had more advanced-level graduates than counties with no women inventors named on patents.

Ph.D.s correlates with a 20% chance of having a first woman patentee (see online supplement for these calculations). For a county with no women inventors, doubling the number of women with bachelor's degrees has a greater total effect compared to doubling the number of women with Ph.D.s because there are far more women with bachelor's degrees than Ph.D.s. However, on a person-to-person basis, the addition of one woman with a Ph.D. is equivalent to adding 10 women with bachelor's degrees in a county in terms of increasing the likelihood of having a first woman patentee.

Looking forward

To help inform policies that expand the innovation ecosystem to historically underserved populations, this report uses a novel dataset on U.S. counties covering three decades to identify where women inventors patent, pinpoint major concentrations of women's patenting by technology field, and explore characteristics of county economic environments that correlate with having and increasing the number of women inventor-patentees. The maps reveal that women inventor-patentees are expanding their geographic representation over time. Interestingly, and consistent with the broader regional hub phenomenon (e.g., Silicon Valley), U.S. counties where women patented in the early 1990s show a technological "deepening," suggesting complementarities between women's patenting and local economic conditions. Turning to those local economic conditions, the analysis found significant and positive correlations between women's participation and the size of local labor markets, per capita incomes, and education levels.

Overall, the report highlights the importance of local economic conditions for expanding women's participation in patenting. But, building local capacity for innovation and expanding participation need not happen in isolation. Future research could explore how participation and economic outcomes respond to greater connectedness between local economies, perhaps by creating virtual spaces for people in underserved communities to connect with others.

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