

CLOSING DIVERSITY GAPS IN INNOVATION: GENDER, RACE, AND INCOME DISPARITIES IN PATENTING AND COMMERCIALIZATION OF INVENTIONS

Holly Fechner and Matthew S. Shapanka

Covington & Burling LLP, Washington, DC, USA

Women, people of color, and lower-income individuals patent inventions at significantly lower rates than their male, white, and wealthier counterparts. Fewer than 20 percent of all U.S. patents today list a woman as an inventor. Among college graduates, fewer than half as many African Americans and Hispanics hold patents, compared to their white counterparts. Moreover, a child born in the U.S. to a family living below the median income level is ten times less likely to receive a patent in his or her lifetime than a child born to a family in the top one percent of income.

These disparities hold back economic growth and U.S. leadership in innovation. Achieving greater gender, race, and income diversity in inventing and patenting would unlock a wealth of innovation, economic growth, and job creation that is now untapped, bringing new inventors, new ideas, and new technologies into the innovation pipeline.

The U.S. government, educational institutions, and private industry should adopt measures to promote broad participation in invention and patenting to ensure that women, people of color, and lower-income individuals can contribute equally to the innovation economy. U.S. public policy and private practice should reflect the imperative that broad participation in inventing and patenting drives continued U.S. leadership in the global innovation economy and promotes fundamental fairness. This article concludes with recommendations for policymakers concerning ways to close the gender, race, and income gaps that persist in the innovation ecosystem.

Key words: Diversity; Innovation; Patents; Inventors; Equality

INTRODUCTION

In 1791, decades before the abolition of slavery, Thomas Jennings became the first African American inventor to receive a patent for a dry cleaning process (1). In 1809, more than a century before women in the U.S. had the right to vote, Mary Kies became the first woman to earn a U.S. patent. Her invention for a method of weaving straw fueled the growth of the straw hat industry in the U.S. at a time when the U.S. had embargoed imports from Great Britain (2).

With the exception of individuals held in slavery, the U.S. patent system has always been open to all inventors, regardless of race, gender, or economic status. The Constitution itself empowers Congress to “promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive right to their respective Writings and Discoveries” (3). The Patent Act of 1790 implements the Intellectual Property (IP) Clause broadly, providing that “upon the petition of *any person or persons*

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Address correspondence to Holly Fechner, Covington & Burling LLP, One CityCenter, 850 Tenth Street NW, Washington, D.C. 20001, USA.
Tel: +1 (202) 662-5475. E-mail: hfechner@cov.com

... setting forth that he, she, or they hath or have invented or discovered any useful art, manufacture, engine, machine, or device, or any improvement therein not be for known or used,” such inventor is entitled to a patent (4).

Since its inception, the U.S. patent system has become a great engine of innovation. In exchange for disclosing their inventions to the public, all inventors receive the “the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States” for up to 20 years. Anyone wishing to make, use, sell, or import a patented invention must license the invention from the patent owner — usually for a monetary fee — or face legal liability for patent infringement.

The benefits of the patent system are myriad. The promise of exclusive rights for one’s invention provides inventors with the incentive to expend resources to research and develop new ways to communicate; new ways to move people, goods, and information; new cures for diseases; and countless other innovations. The ability to buy and sell IP rights facilitates the commercialization of new ideas, allowing entrepreneurs to bring new inventions from the classroom, laboratory, or garage to the marketplace.

This ecosystem has proven enormously lucrative for the U.S. Economic activity from patents is estimated at over \$8 trillion, more than one-third of the U.S. gross domestic product (GDP) (5). IP-intensive industries directly account for 27.9 million jobs and indirectly support 17.6 million more supply chain jobs throughout the U.S. economy. In total, IP-intensive industries directly and indirectly support 45.5 million jobs, or about 30 percent of all employment in the U.S. (6).

Although some of the earliest inventors in American history were women and people of color, today not every American has equal opportunity to share in the benefits of the innovation ecosystem. Patents are awarded without regard to race, gender, or income, but women, people of color, and lower-income individuals patent inventions at significantly lower rates than their male, white, and wealthier counterparts. Achieving greater gender, race, and income diversity in inventing would unlock a wealth of innovation and economic growth that is now untapped. Patent law and policy should reflect

the imperative that broad participation in inventing and patenting drives continued U.S. dominance in the global innovation economy and promotes fundamental fairness.

THE PATENT DIVERSITY GAPS

Recent academic research has identified at least three major gaps in patenting. Women, especially African American and Hispanic women, obtain patents at significantly lower rates than men; people of color obtain patents at significantly lower rates than whites; and individuals from lower-income families are significantly less likely to obtain a patent than individuals who grew up in wealthier families. Studying each demographic characteristic brings its own data challenges. The USPTO does not collect demographic data about patent applicants. As a result, each study in this field was conducted differently, using different data sets to compile as much information as possible concerning the relevant population. Despite those limitations, researchers have documented that each of these disparities is significant and represents billions — if not trillions — of dollars in lost economic activity.

The Gender Patent Gap

According to the Institute for Women’s Policy Research (IWPR), only 18.8 percent of all U.S. patents in 2010 list one or more women as an inventor (7). That is an advance over 1977 when only 3.4 percent of patents listed a woman inventor, but, at current rates of patenting, women will not reach parity with men until the year 2092 (7).

The gender gap is slightly smaller, though still significant, for people of color. For example, white men patent at nine times the rate of white women, while Hispanic men patent at five times the rate of Hispanic women, and African American men patent at 2.6 times the rate of African American women. However, with the exception of Asian men, who patent at nearly twice the rate of white men, white men patent at significantly higher rates than African American and Hispanic persons of both genders (7).

Much of the gender gap results from a disparity in patent applications rather than patent awards. From 2000 to 2016, women inventors filed only one-third as many patent applications as men (7). Over the same

period, the USPTO “allowed” — meaning the patent was granted — 67.2 percent of applications from women inventors, compared with 73 percent from men inventors (7). In other words, among inventors who apply for patents, the gender gap is significantly smaller than among the general population.

The gender gap is made even more stark by the fact that women hold only 5.5 percent of commercialized patents, which “are more important for economic growth,” according to a study by the National Bureau of Economic Research (NBER) (8). Even women who do patent are not necessarily bringing those inventions to market.

One major study offers three reasons to explain why women are so much less likely to hold commercialized patents. First, women hold a smaller share of mechanical and electrical engineering degrees among all holders of science, technology, engineering, and math (STEM) degrees (8). Second, women are under-represented in engineering jobs, particularly the patent-intensive electrical and mechanical engineering fields, and in other jobs that involve research and development or design (8). Third, women hold a smaller share of doctorates (8).

However, education is not the only cause of the gender gap in patenting. As discussed further below, mentorship, corporate culture, and academic culture all contribute to the gap in commercialized patents by excluding women from the jobs, networks, and research teams that are most likely to invent.

The gender patent gap is hardly a problem for the U.S. only, but some countries are better than others at promoting women’s patenting. According to the World Intellectual Property Organization (WIPO), only 29 percent of international patent applications (PCT) worldwide have at least one female inventor listed (9). Although the U.S. is the largest user of the PCT patent system, only slightly more than 29 percent of U.S. PCT applications list a female inventor (9). While many countries rank below the U.S. in terms of their share of women inventors, some of the U.S.’s largest competitors fare much better. For example, in China and Korea, nearly 50 percent of PCT applications list a woman inventor, and Singapore, Spain, Poland, and France all rank above the U.S.

The Race Patent Gap

African Americans patent at even lower rates than women. One study found that from 1970 to 2006, African American inventors were awarded just six patents per million people, compared to over 40 patents per million for women and 235 patents per million for all U.S. inventors (10).

Among college graduates, African Americans and Hispanics hold nearly half as many patents as whites—about one percent each (7). African Americans and Hispanics also apply for patents at nearly half the rate of whites as compared with Asian American and Pacific Islanders, who seek patents at nearly double the rate of white men (7). African Americans, Hispanics, and white women apply for patents at comparable, and much lower, rates (0.3, 0.3, and 0.5 percent of women college graduates within each racial/ethnic group) (7).

Moreover, science and engineering fields are dominated by white men. In 2015, nearly half of all scientists and engineers in the U.S. were white men, with white women coming in second at 18 percent, Asian men at 14 percent, and Asian women at seven percent (7). Hispanic men made up just four percent of scientists and engineers, African American men made up just three percent, and Hispanic and African American women made up just two percent each (7). Significantly lower participation by people of color in patent-intensive fields contributes to lower participation in the patenting system altogether.

The Income Patent Gap

Researchers have also shown the effects of income on an individual’s propensity to patent. Individuals born to wealthier parents are far more likely to patent than individuals born to poorer parents. Specifically, for every 10,000 children born to families in the top one percent, 22.5 will receive a patent in adulthood. In contrast, only 2.2 of every 10,000 children born to families with incomes below the U.S. median income will receive a patent as an adult (11).

CLOSING THE GAPS: RECOMMENDATIONS FOR ACADEMIA, INDUSTRY, AND POLICYMAKERS

No simple solution exists to increase gender, race, and income diversity in inventing and patenting, but many steps interplay with one another, each of which

contributes to greater inclusion in the innovation ecosystem.

STEM Education

Ensuring that women, people of color, and lower-income individuals have access to high quality education is an important first step. Encouraging more gender, race, and income diversity in the most patent-intensive STEM fields in colleges and graduate schools — mechanical engineering and electrical engineering — helps close the portion of the patent gaps attributable to gaps in education. STEM education in primary and secondary schools also plays an important role. Moreover, private programs that promote exposure to STEM fields are a key component. For example, the Qualcomm Thinkabit Lab offers daylong STEM programs for elementary and secondary school classes, free of charge, to expose children to careers in science and engineering, “careers they may not know exist” (12). Programs like Thinkabit, Girls Who Code, and Girl Develop It are key to ensuring that children of all backgrounds learn about STEM opportunities early.

Mentorship and Social Networking

However, education is only part of the solution. Mentorships and social networks also play significant roles in encouraging the commercialization of invention. Social networks are key to helping inventors “evaluat[e] whether it would be worthwhile to pursue a patent” in the first place since an inventor is likely to first seek advice from his or her own peers (7). Moreover, for women in particular, the relative “exclusion from STEM fields” has led to limited available mentorship opportunities and networks. Because women tend to seek other women as mentors, and females in positions to act as mentors for inventors are limited in supply, it is harder for women to find other women inventors to advise them (7). Another study found that children are more likely to patent in the technology area in which their parents work, suggesting that “the network of people in the firm and industry could influence what careers young people are interested in studying and pursuing later in life” (11).

Institutional Structures

Differences between academic structures and industry networks also influence patenting behavior. Academic organizations tend to be more top-down. Tenure and promotion decisions, research opportunities, grants, and opportunities to collaborate with other researchers are often determined based on status, title, and seniority. By contrast, certain industry networks tend to be more collaborative, with industry inventors more able to expand or form new relationships on their own without “permission” or explicit support from their institutions. This positions certain industry inventors, in particular, to expand their networks and increase the potential universe of partners for research and development projects that could lead to patented inventions (13).

In the university context, much of the bandwidth that women academics devote to research is expended on academic publishing rather than patenting efforts. Including patents as a key part of tenure and promotion decisions for STEM faculty will likely encourage more women and faculty of color to patent. Relatedly, inventors should actively seek to work on mixed-gender research and development teams. Beyond promoting inclusion in innovation, mixed gender teams produce higher-quality patents as measured by patent citations (7).

Truly closing the gaps will require conscious effort and institutional change in academia, industry, government, and other institutions that support inventors. At the university level, technology transfer offices exist to help researchers patent and commercialize their inventions. For women and people of color, whose access to social networks is more limited, technology transfer offices can prove especially valuable to help navigate the patenting process and grow their networks (17). Both universities and industries need to do more to build collaborative networks that encourage inclusive inventing teams.

Exposure to Innovation

Mere exposure to other inventors is another way to help close the gaps. The children of inventors are nearly ten times more likely to become inventors than children of non-inventors (11). Likewise, children who grow up in “innovation-intensive” areas, such as Northern California, New England, New York City,

and parts of Michigan, Minnesota, and Wisconsin, are significantly more likely to become inventors (11). The exposure effects hold true for gender too—areas of the country that score well on indices of gender bias (i.e., regions that generally have a more positive view of women) tend to also have more female inventors (11).

Exposure to, and engagement with, inventive teams works. Lisa Seacat DeLuca, a technology strategist at IBM, has written,

On my first job, I was surrounded by inventors. Rather than being intimidated, I found a group of engineers who met a couple times a month to discuss patents. I quickly discovered just how addicting it was to brainstorm about cutting edge technologies, write up our ideas, and pitch them to our company's patent review boards (14).

Since that first job, DeLuca has filed over 600 patent applications on technology ranging from cloud and mobile computing to the Internet of Things and has been issued 250 U.S. and global patents to date. She has been recognized as the most prolific inventor in IBM history and was inducted into the Women in Technology Hall of Fame in 2017 (15).

Access to Venture Capital

More reliable venture capital (VC) funding would also help close the gaps. Currently, fewer than five percent of all VC deals—and only about two percent of all VC funding—goes to women, and only seven percent of partners at VC firms are women (16). This massive funding gap penalizes women inventors, who are less likely to receive venture backing for their ideas than their male counterparts. Funding to bring their research and development ideas to market would only further spur women to invent.

Assistance Programs for Entrepreneurs

Some programs are available to help provide the tools inventors need to be successful entrepreneurs and to help them build their networks. For example, the Empowering Women in Technology Startups (Ewits) program at the University of Florida provides women with hands-on entrepreneurial training to help them pursue leadership roles in technology businesses (18). Universities and industries should

identify the strongest programs that empower women and entrepreneurs of color and replicate them across the country and across disciplines. Bias training and inclusion programs for “gatekeepers,” such as grant makers or tenure and promotion committee members, are additional tools to encourage greater diversity in invention. Programs that provide innovators with assistance in applying for grants and other government programs, such as the Department of Energy's “Phase 0 Assistance Program” (19), help encourage women and people of color to seek funding for their innovative enterprises.

Public Policy

Public policy changes also play an important role. Congress and the Administration should further study the problem and promote institutional best practices; provide technical and programmatic assistance to inventors; support policies that advance STEM education; incentivize VC firms to support a more diverse set of inventors; strengthen the patent system; and prevent and remedy discrimination.

Congress should direct the USPTO to collect demographic data on patent applicants and recipients to better understand the gaps and to evaluate the effectiveness of efforts to reduce them. Today, the USPTO collects no data on race, gender, or income from patent applicants, requiring researchers to use name-matching software and other techniques to study disparities in patenting. Reliable studies of both the patent gaps and their remedies require a comprehensive data source that the USPTO can create and publish to maintain accountability for equity in patenting. As with other government programs, the collection of this data would be segregated and would not be known or considered in the decision about whether to grant a patent (20).

Researchers and practitioners need to learn more about best practices that maximize patenting and commercialization among diverse communities. To that end, Congress should commission a study of best practices that lead women, people of color, and lower-income populations to engage in innovation.

Agencies across the government have a role to play in engaging diverse inventors. The USPTO provides technical assistance with patenting. The Small Business Administration offers grants and technical

assistance for women starting small businesses. The National Science Foundation, National Institutes of Health, and White House Office of Science and Technology Policy all have the resources and expertise to help promote diversity in invention and entrepreneurship across industries and disciplines through grant-making, education, and policy recommendations to the White House and Congress.

Congress and the USPTO can also directly reduce some disparities in patenting. For example, Congress and the USPTO can unilaterally lower the high costs associated with patenting that create barriers to entry. High fees associated with filing and defending a patent can pose a substantial barrier since people from under-represented groups earn less, on average, than white men (21). Attorney fees alone for filing a patent application can cost \$5,000 to \$16,000, excluding other associated costs (22). Programs like the USPTO Pro Bono Assistance Program, which matches qualified low-income applicants with volunteer patent attorneys, and the USPTO Pro Se Assistance Program, which provides advice to inventors who wish to pursue patents without the help of an attorney, can help to mitigate the high costs of patenting an invention, but they could be expanded to help small businesses and others for whom attorneys' fees are a major barrier to entry.

Congress should also maintain a strong patent system to help people from under-represented communities invent and patent. A strong patent system will help women and inventors of color license their inventions for a fair return and secure capital support for their businesses. Over three-quarters of VC investors report that they consider patents in funding determinations (23). However, women, people of color, and lower-income individuals have less access to capital associated with start-up success. To the extent that inventors from under-represented communities can more easily obtain and defend their innovations, they can access additional funding to grow their businesses, expand employment, and commercialize their innovations for public use.

Finally, discrimination against women and people of color in the workplace, cultural inertia in academia and industry, and gender and racial stereotypes all contribute to the patent gaps. Policy efforts to promote equality in innovation must ensure that

nondiscrimination laws are fully enforced and that employment and staffing decisions in academia, industry, and government are made on their merits and not based on gender, race, or other characteristics. It is also essential to promote paid family and medical leave and work-life balance to ensure that everyone can contribute to the innovation economy while participating fully in both their personal and professional lives.

THE ECONOMIC IMPERATIVE OF CLOSING PATENTING GAPS

The under-representation of women, people of color, and lower-income individuals in the patent system presents both a social and an economic challenge. In addition to failing to funnel large swaths of society into the innovation pipeline, persistent gender, race, and income gaps result in the U.S. foregoing the opportunity for substantial economic growth and job creation.

The benefits of closing the gap are tangible—and significant. For example, one study found that “eliminating the patenting shortfall of female holders of science and engineering degrees would increase GDP per capita by 2.7%” (8). Another study found that including more women and African Americans in the “initial stage of the process of innovation” would increase GDP somewhere between 0.64 percent and 3.3 percent per capita (10).

In addition to the specific GDP potential, the patent gaps are depressing new business creation, job growth, and innovation. Structural barriers that result in lower participation in patenting activities by segments of the U.S. population erect another barrier to entry in business and entrepreneurship. For example, a report by the Center for Equitable Growth found that the rising inequality in the patent system is linked to the decline in the number of new start-ups in the U.S. economy and the decline in the number of new innovations (25). Noting that firms younger than five years old made up only 39 percent of all businesses in the U.S. just before the Great Recession, the report points to lower patenting rates among low-income individuals to underscore “just how far out of reach entrepreneurial success is for the vast majority of children born into low-income families in the U.S.” (24).

Patents help start-ups grow by encouraging capital investment, creating jobs, and generating follow-on innovations that create more useful and accessible products for consumers. Indeed, patents are essential for start-ups to obtain funding, whether from VC firms or other investors (7). Companies with at least one patent application filed typically receive venture funding faster than companies with no patents (25), and patents factor into the funding decisions of both commercial and investment banks, angel investors, and even friends and family looking to invest in a business (23).

The connection between patents and start-ups is important for the broader economy: Start-ups generate 10 percent of all new jobs in the U.S. each year. Allowing more people access to the patent system will only increase these economic benefits (23).

Greater inclusion in the innovation ecosystem means more perspectives and more ideas in the innovation pipeline. For example, Jessica Matthews, the

CEO of Uncharted Play, invented a soccer ball that can harness energy and power lamps—an invention inspired by a power outage during a family wedding in Nigeria. Today, Uncharted Play holds 15 patents for technology that can be installed in any device that “can harness kinetic energy,” such as baby strollers, floor panels, and furniture (26). Without broader perspectives and experiences, innovative ideas to solve significant problems might not emerge.

Increasing participation in invention and patenting will ensure that persons of all backgrounds can participate fully in the culture of innovation and entrepreneurship that the framers of the IP Clause envisioned at the nation’s founding. Equal opportunity to invent, patent, and commercialize innovative ideas will drive the U.S. innovation economy ever forward, creating countless new products and cures that will create jobs, stimulate economic growth, and improve the quality of life for millions of people.

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