

Challenges for Women Inventors and Innovators in Using the Intellectual Property System - A Literature Review¹

Prepared by Ms. Jozefina Cutura

July 2019

¹ The Literature Review has been prepared in the context of the Development Agenda Project on ["Increasing the Role of Women in Innovation and Entrepreneurship, Encouraging Women in Developing Countries to Use the Intellectual Property System"](#).

Contents

Introduction	2
The economic potential of women inventors and innovators.....	2
Women inventors: data and trends over time	3
Concentration of women inventors in particular technology categories and environments	7
Becoming women inventors and innovators: key influencing factors and barriers to success	8
Lower labor market participation.....	8
Lack of childhood exposure to female inventors	9
Under-representation on science, technology, engineering and math degrees	10
Lower female patenting rates	12
Lower participation and slower career advancement among women in research, authorship and academia	12
Under-representation in patent-intensive fields.....	14
Family and household burdens.....	18
Conscious or unconscious bias	19
Lack of strong professional social networks.....	21
Lack of access to public and private funding.....	22
Lack of understanding of the importance of IP registration	24
Financial and administrative barriers in the patenting process	24
Underlying gender-bias in IP law	25
Conclusions and recommendations.....	29
Improve the collection and use of sex-disaggregated data	29
Encourage increased female entry into patent-intensive STEM fields and careers	29
Increase women’s access to critical resources, especially funding	30
Address sociocultural issues and bias that inhibit women’s innovative potential	31
Support networking, collaboration and learning	31
Reduce the complexity and cost of the patenting process and strengthen national capacity to serve women inventors and innovators.....	32
Improve enforcement of rights in developing countries, including in female-dominated areas	33
Support proactive policies and more research.....	33
Resources.....	34
References.....	35

INTRODUCTION

Despite marked improvements in gender equality, gender gaps persist in patenting and in women's ability to commercialize their creative and innovative output. Under its Policy on Gender Equality, the World Intellectual Property Organization (WIPO) must integrate a gender perspective into its policies and programs. Given the gender disparities in patenting, WIPO is undertaking a project on increasing the role of women in innovation and entrepreneurship to encourage women in developing countries to use the intellectual property (IP) system. In line with this project and the Policy on Gender Equality, WIPO commissioned this literature review to improve the understanding of the challenges facing women inventors and innovators, and to recommend measures to address these challenges. The report is based on a review of academic work available in English that focuses on women inventors and innovators. References include books; academic research; journal articles; government, think-tank and non-profit organization reports; and case studies. Sources span a variety of disciplines, including law, medicine, anthropology, economics, political science and gender studies. For the purposes of this review, inventors and innovators are primarily defined as those who patent, although the review also draws upon related areas of interest, especially copyright and trademarks.

THE ECONOMIC POTENTIAL OF WOMEN INVENTORS AND INNOVATORS

A growing body of work has documented the value of focusing on women in the economy generally and among innovators and inventors specifically. Research by the International Monetary Fund (IMF) finds that men and women bring different skills and perspectives to the workplace and that greater gender diversity is associated with higher economic growth and productivity.² The McKinsey Global Institute has estimated that full female participation and integration into the labor force could boost global gross domestic product (GDP) by as much as 26 per cent.³

Diversity and gender equity have an impact on inventiveness, as variety among patent holders can lead to a wider range of solutions to a multiplicity of human challenges, and to more gender-inclusive product development. Moreover, diversity and international collaboration have been found to increase inventive output.⁴ A study by the National Center for Women and Information Technology of the United States found that information technology (IT) patents with mixed-sex teams are cited more often than those with single-sex teams in later patent applications.⁵ This suggests that greater diversity on teams may lead to the development of patents that are more useful and successful.

² IMF. 2018. "Economic Gains from Gender Inclusion: New Mechanisms, New Evidence." IMF Staff Discussion Note, SDN/18/06.

³ McKinsey Global Institute. 2015. *The Power of Parity: How Advancing Women's Equality Can Add \$12 Trillion to Global Growth*. McKinsey & Co.

⁴ Organization for Economic Cooperation and Development (OECD). 2018. *Empowering Women in the Digital Age: Where Do We Stand?* OECD. Available online: <https://www.oecd.org/social/empowering-women-in-the-digital-age-brochure.pdf>

⁵ Milli, Jessica, Barbara Gault, Emma Williams-Baron, Jenny Xia and Meika Berlan. 2016. "The Gender Patenting Gap." Briefing Paper no. IWPR #C441. Institute for Women's Policy Research (IWPR).

The under-representation of women among inventors has economic costs because the gender gap in patenting represents an inefficient use of female innovative capacity. Bell *et al.* have found that improving opportunities for certain groups, such as minorities, low-income families and women, would improve not only their own earnings but also economic growth by improving the allocation of talent to innovation.⁶ Researchers from the United States have calculated that closing the gender gap in engineering and in jobs involving development and design would increase United States GDP per capita by 2.7 per cent.⁷ The economic benefit from supporting women's innovative potential could therefore be substantial.

WOMEN INVENTORS: DATA AND TRENDS OVER TIME

Obtaining an accurate picture of women's global patenting activity is not straightforward for two primary reasons. Firstly, databases that track patent activity do not include sex-disaggregated information on inventors, requiring the usage of name-matching software. Secondly, the sources consulted for this study use different definitions to calculate female patenting activity, resulting in diverging figures. It is therefore important to keep in mind what specific aspect of patenting a study is measuring when examining its data and findings.

Patenting is characterized by a lack of systematic sex-disaggregated data collection. Legally, when filing a patent application, each inventor must be named, but the gender of each applicant does not need to be included on the application. This means that it has not been possible to easily identify and aggregate sex-disaggregated data on patent applications and patent holders. Instead, organizations have had to infer the applicant's gender by their name, a process that is not wholly reliable, especially for certain parts of the world. As the name-matching software is not perfectly accurate, the figures vary among the different sources, even when the sources use the same measure of patenting activity.

However, sources on patenting do not consistently use the same measure to assess women's participation. When calculating women's patenting activity, it is important to remember that patent applications can have one inventor or multiple inventors working collaboratively as part of a team. The United States Patent and Trademark Office (USPTO) distinguishes between three types of metrics illustrating the different ways that women participate in patenting and invention:

- 1) the women inventor rate, namely the percentage of unique women inventors across all patents granted in a given year;
- 2) the percentage of patents granted in a given year that have at least one woman inventor; and

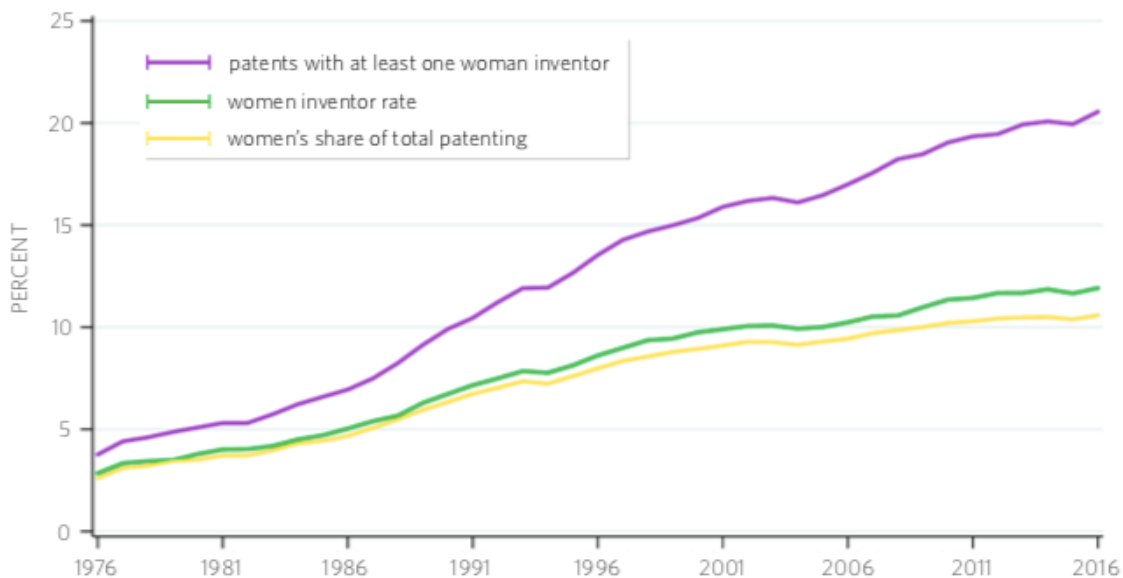
⁶ Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova and John Van Reenen *et al.* 2018. "Who Becomes an Inventor in America: The Importance of Exposure to Innovation." *The Quarterly Journal of Economics*, vol. 134(2), May 2019, pp. 647-713.

⁷ Hunt, Jennifer, Jean-Philippe Garant, Hannah Herman and David J. Munroe *et al.* 2012. "Why Don't Women Patent?" National Bureau of Economic Research. Working Paper no. 17888. Available online: <http://www.nber.org/papers/w17888.pdf>

- 3) women’s share of total patenting, whereby an equal share is attributed to each inventor when the patent has multiple inventors, and the resulting “fractions” of patents are summed across men and women to provide total patent output by gender for each year.

The figure below shows the trends in patenting among women for these three metrics in the United States.⁸ Depending on which measure is used, a slightly different picture of women’s patenting activity emerges. Although women in the United States are increasingly represented on patents with at least one female inventor, the woman inventor rate and women’s share of total patenting are much lower in comparison, with the gender gap closing at a slower pace.

Figure 1: Forty-year trends in patenting among women in the United States, 1976-2016



Source: USPTO. 2019. *Progress and Potential: A Profile of Women Inventors on US Patents*.

Across sources and regions of the world, the woman inventor rate remains low. The Organization for Economic Cooperation and Development (OECD) found that in the Group of Twenty (G20) area, the share of patents invented by women reached 8.4 per cent in 2014, compared to 5.6 per cent in 1994.⁹ In a study published in 2016, the United Kingdom Intellectual Property Office (UKIPO) found that women made up a little over 10 per cent of all inventors worldwide, with the numbers being higher than average in France and Russia and low in countries like Japan, Korea and Germany.¹⁰

In comparison, patents featuring at least one female inventor show more positive trends and higher female participation. WIPO data shows that women were listed in 31 per cent of some 224,000 international patent applications published in 2017, an increase from

⁸ USPTO. 2019. *Progress and Potential: A Profile of Women Inventors on US Patents*. USPTO. Available online: <https://www.uspto.gov/sites/default/files/documents/Progress-and-Potential.pdf>

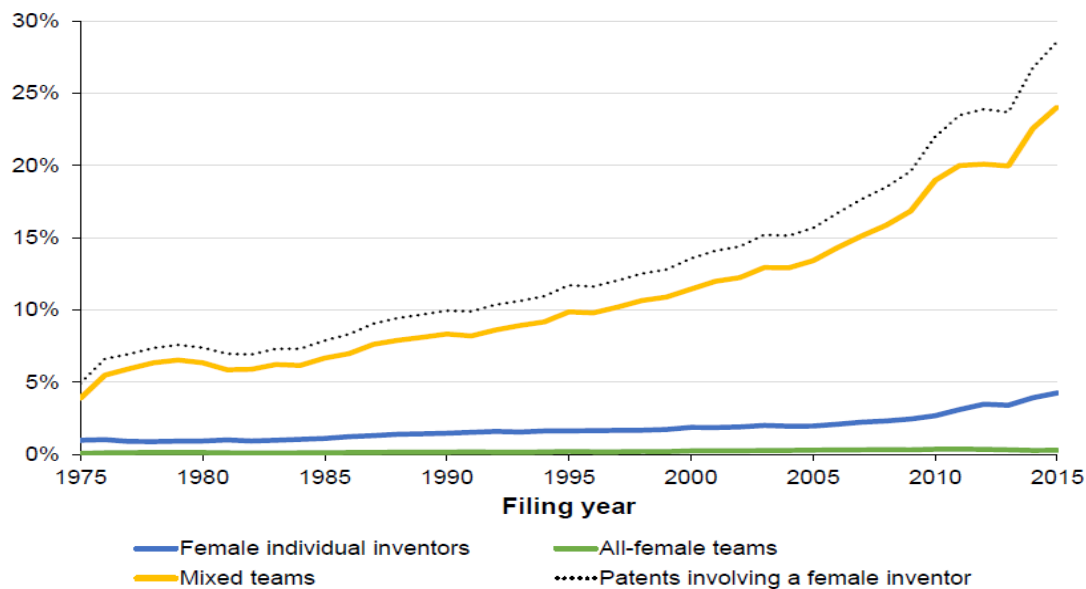
⁹ OECD. 2018. *Empowering Women in the Digital Age*.

¹⁰ UKIPO. 2016. *Gender Profiles in Worldwide Patenting: An analysis of female inventorship*. UKIPO, Newport.

23 per cent a decade earlier.¹¹ The UKIPO found that, globally, the overall proportion of patents involving a female inventor increased more than 500 per cent from 4.9 per cent in 1975 to over 28 per cent in 2015.¹² OECD research on G20 countries shows that over the last two decades, the number of patents featuring at least one woman on the team of inventors has increased more rapidly than the average of all patents.¹³

The UKIPO has analyzed whether female inventors are more likely to work on their own, as part of an all-female team or as part of a mixed team. In the dataset, 87 per cent of patents involved only men (48.5 per cent individual males and 38.5 per cent all-male teams), 2.2 per cent involved only women (2.0 per cent individual females and 0.2 per cent all-female teams) and the remaining 10.8 per cent involved mixed teams. Individual female inventors accounted for less than 1 per cent of patents between 1975 and 1985, but this has slowly increased to an average of 3 per cent since 2005. Despite the number of all-female teams having more than quadrupled since 1975, the absolute numbers remain very low, with 0.06 per cent of patents coming from all-female teams in 1975 and only 0.28 per cent in 2015.¹⁴

Figure 2: Female inventors by inventor type



Source: UKIPO. 2016. *Gender Profiles in Worldwide Patenting: An analysis of female inventorship*.

According to OECD research, almost 80 per cent of patents filed at key IP offices come from all-male teams, but the number of patents featuring at least one woman inventor has increased faster than the average of all patents, especially in patents related to information and communication technology (ICT).¹⁵ USPTO data shows that

¹¹ WIPO. 2018. "World Intellectual Property Day Celebrates Women's Accomplishments: New WIPO Figures Show Highest Ever Rate of Women Inventors, But Gender Gaps Persist." Press release, April 26, 2018. PR/2018/817.

¹² UKIPO. 2016. *Gender Profiles in Worldwide Patenting*.

¹³ OECD. 2018. *Empowering Women in the Digital Age*.

¹⁴ UKIPO. 2016. *Gender Profiles in Worldwide Patenting*.

¹⁵ OECD. 2018. *Empowering Women in the Digital Age*.

mixed-gender teams are driving most of the growth in granted patents having at least one female inventor.¹⁶

As the figure above illustrates, very few women patent as individual inventors, with this category showing the lowest female participation and the slowest progress over time. Women are most likely to be named on patents as part of a team of inventors, particularly mixed-gender teams. Researchers have hypothesized that women's tendency towards teamwork plays a role in this trend. Sugimoto *et al.* have found that female inventors have more co-inventors on average than male inventors in all International Patent Classification classes, for every type of assignee. They note that this heightened collaboration could be a behavioral difference, namely, women's higher propensity to work in groups, or a social difference.¹⁷ Individual case studies from the Philippines confirm this at the country level, finding that women inventors collaborated either with their husbands or work colleagues.¹⁸

Other researchers have pointed out that women inventor rates are higher in fields where teamwork matters more. In addition, they argue that higher female inventor participation at academic and publicly funded institutions suggests that women may specialize in more fundamental research, which tends to be concentrated in these types of organizations and requires larger collaborative teams. The trend towards teamwork among women points to the growing importance of understanding the relationship between gender and team dynamics and the impact of these factors on the professional performance and career trajectories of women.¹⁹

Regardless of the measure used, all sources and measures indicate a continued and significant gender disparity in patenting, although the gap has been narrowing over time. Researchers also agree that there is a lengthy timeline for closing the gender gap in innovation. According to Bell *et al.*, while the gender gap is indeed shrinking, it will take another 118 years at current rates to close it.²⁰ WIPO research is slightly more optimistic, calculating that the gender balance in patenting will not be reached until 2070, assuming current progression rates.²¹

¹⁶ USPTO. 2019. *Progress and Potential*.

¹⁷ Sugimoto, Cassidy *et al.* 2015. "The Academic Advantage: Gender Disparities in Patenting." *PLoS ONE* 10(5): e0128000

¹⁸ Zosa, Victorina. 2018. *Women and IP Commercialization in the Asian Region: The Case of Philippines*. WIPO. Unpublished.

¹⁹ USPTO. 2019. *Progress and Potential*.

²⁰ Bell *et al.* 2018. "Who Becomes an Inventor in America".

²¹ Lefeuvre, Bruno, Julio Raffo, Kaori Saito and Gema Lax-Martinez *et al.* 2018. "Women and the international patent system: encouraging trends." *WIPO Magazine*, April 2018.

CONCENTRATION OF WOMEN INVENTORS IN PARTICULAR TECHNOLOGY CATEGORIES AND ENVIRONMENTS

Looking at the participation of women in patents, it is clear that women cluster in particular fields. According to WIPO, the five fields with the highest shares of Patent Cooperation Treaty (PCT) applications with women inventors were biotechnology, pharmaceuticals, organic fine chemistry, food chemistry and analysis of biological materials. The five fields with the lowest shares of PCT applications with women inventors were civil engineering; engines, pumps and turbines; machine tools; mechanical elements; and transport.²²

The type of employer also matters. Women are more likely to patent in academia than in corporate or government environments. WIPO research has found that 51 per cent of all PCT applications filed by the academic sector included women inventors, compared to 30 per cent for the business sector, despite business accounting for the largest absolute number of women inventors.²³ Patents owned by universities had the highest share of women inventors (11 per cent, compared to 8 per cent in firms).²⁴ The figures differ between these sources because they use two different definitions of women's patenting activity.

In ICT-related patents featuring at least one female team member, the gender gap has been narrowing, suggesting a growing contribution by women to digital transformation.²⁵ A United States study confirmed this promising trend, noting that women's share of IT patents in the United States increased from 2 per cent in 1980 to 10 per cent in 2010.²⁶

In developing countries, the overall lack of economic advancement can influence the types of products that women patent. A WIPO-commissioned in-depth study of the Philippines found that patents generated by women tended to be in low-technology products and processes. They included human necessities, such as papaya-ripening control, or improved brown rice; operational improvements, such as a waste disposal machine; or physics-inspired inventions, such as a mobile online betting system.²⁷

²² WIPO. 2016. *World Intellectual Property Indicators 2016*. WIPO. Available online: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2016.pdf

²³ Lefeuvre *et al.* 2018. "Women and the international patent system".

²⁴ Sugimoto *et al.* 2015. "The Academic Advantage".

²⁵ OECD. 2018. *Empowering Women in the Digital Age*.

²⁶ Ashcraft, Catherine and Anthony Breitzman. 2012. *Who Invents IT? Women's Participation in Information Technology Patenting, 2012 Update*. National Center for Women and Information Technology.

²⁷ Zosa. 2018. *Women and IP Commercialization: The Philippines*.

BECOMING WOMEN INVENTORS AND INNOVATORS: KEY INFLUENCING FACTORS AND BARRIERS TO SUCCESS

Available literature points to a variety of complex and inter-related factors that have led to women's under-representation among inventors and innovators and have hindered their success. The extent to which each of these barriers may impact a particular woman's ability to patent and commercialize her inventive output will vary depending on a number of factors specific to her circumstances; for example, socioeconomic situation, country of birth, available economic resources and family circumstances. When considering how to remedy the gaps facing women in patenting, it is therefore important to be mindful of this complexity and the need for a comprehensive and tailored set of solutions. The different factors that have been found to influence women's patenting activity are discussed in detail below.

LOWER LABOR MARKET PARTICIPATION

Women participate in the labor market at lower rates than men, either as workers or as entrepreneurs. Rates of female labor force participation and employment serve as an overall indicator of women's economic activity and participation and also indicate what pool of female labor is available to potentially turn to innovation. Researchers have found that United States states with higher female labor force participation also have higher women inventor rates.²⁸ This indicates that the female labor force participation rate matters to innovation and points to the importance of broad-based policies to increase that rate.

Yet around the world, women are much less likely to participate in the labor market than men. The global female labor force participation rate stood at 48.5 per cent in 2018, compared to 75 per cent for men.²⁹ When women do work, they are less likely to be in the types of jobs and positions that lend themselves to innovation and are more likely to be in vulnerable employment or working informally, especially in developing countries.³⁰ They are also less likely to work in patent-intensive fields, a subject that is further discussed in a later section of this report.

Female entrepreneurship rates are also of particular relevance, as entrepreneurs are often the creators of innovation. However, women are less likely to be entrepreneurs. Men are twice as likely to be self-employed and, across OECD countries, are three times more likely to own businesses that have employees.³¹

²⁸ USPTO. 2019. *Progress and Potential*.

²⁹ International Labor Organization (ILO). 2018. *World Employment Social Outlook, Trends for Women 2018 Global Snapshot*. ILO, Geneva.

³⁰ *Ibid.*

³¹ OECD. 2018. *Empowering Women in the Digital Age*.

Researchers have found that female-owned businesses engage in research and development and produce innovative products at rates close to those of male-owned firms, but they are less likely to hold IP.³²

Women entrepreneurs face a variety of gender-specific challenges and are often disproportionately affected by the issues that many other entrepreneurs also deal with, such as limited access to finance. According to Mastercard, women entrepreneurs fare better in developed economies, where they can draw upon a greater pool of opportunities and resources.³³

In developing countries women often turn to entrepreneurship out of necessity rather than opportunity, to provide a source of additional, often informal, family income.³⁴ This pattern is likely to influence the growth and performance of their businesses and also suggests that women in developing countries may have an even greater uphill climb in making their entrepreneurial and innovative potential commercially viable and successful.

LACK OF CHILDHOOD EXPOSURE TO FEMALE INVENTORS

Childhood exposure has been identified as a critical early influencer of women's likelihood of patenting. Bell *et al.* have argued that exposure is a central determinant of innovation, and that exposure to female inventors in particular significantly affects the probability that a woman invents. Using de-identified data regarding 1.2 million inventors from patent records linked to tax records, they showed that children's chances of becoming inventors vary sharply with characteristics at birth, such as their race, gender and parents' socioeconomic class. Whereas exposure to male inventors had no impact on women's likelihood of innovating, familiarity with a technology class having many female inventors did have an impact. Lack of exposure to innovation may explain why talented children in low-income families, women and minorities are significantly less likely to become inventors.³⁵ These "lost Einsteins"³⁶ could have contributed valuable inventions had they been introduced to innovation and inventor role models early on. According to this research, if girls were as exposed to female inventors as boys are to male inventors, the gender gap in innovation would halve.³⁷ This suggests that tapping into the underexploited talent among children in low-income families, women and minorities should be a critical area of intervention.

In addition, as noted earlier, women's patenting activity tends to be concentrated in stereotypical, "female" fields and product types. Research, such as that by the USPTO,

³² Williams-Baron, Emma, Jessica Milli and Barbara Gault. 2018. *Innovation and Intellectual Property among Women Entrepreneurs*. Report no. IWPR C472. IWPR.

³³ Mastercard. 2018. *Mastercard Index of Women Entrepreneurs 2018*. Available online: https://newsroom.mastercard.com/wp-content/uploads/2018/03/MIWE_2018_Final_Report.pdf

³⁴ Minniti, Mari and Wim Naude. 2010. "Female Entrepreneurship in Developing Countries." *UN University Blogm UNU-WIDER*. Available online: <https://www.wider.unu.edu/publication/female-entrepreneurship-developing-countries>

³⁵ Bell *et al.* 2018. "Who Becomes an Inventor in America".

³⁶ *Ibid.*

³⁷ *et al. Ibid.*

has shown that women specialize in technology fields and sectors where female predecessors have patented before, rather than entering male-dominated fields or firms.³⁸ This reinforces the important influence that exposure to female role models has on female patenting.

UNDER-REPRESENTATION ON SCIENCE, TECHNOLOGY, ENGINEERING AND MATH DEGREES

The under-representation of women in science, technology, engineering and math (STEM) fields is often cited as a key reason for the gender disparity in innovation and patenting.³⁹ Prior research has shown that an increase in the number of STEM degrees is associated with an increase in patenting activity. In addition, there is a correlation between the increase in the share of STEM degrees awarded to women and the increase in female patenting rates over the last few decades.⁴⁰ Nevertheless, women remain under-represented in the fields of study and degrees that are rich in innovation. The available talent pool of women that could turn to innovation therefore narrows early.

Given the advances in female educational attainment in recent decades, women now often outnumber men at the bachelor's and master's degree levels. Yet there are fewer women in areas that matter to innovation. At the PhD level globally, men make up 57 per cent of the total.⁴¹ While growing numbers of women are studying in scientific fields at the tertiary level, they constitute just 30-46 per cent of the graduates in those fields and are especially under-represented in engineering, manufacturing, construction and computer science.⁴² In computer science, there has even been a steady decrease in female graduates since 2000, a problem that is especially pronounced in developed countries.⁴³ Interestingly, countries that are generally considered as models for gender equality, such as Sweden, Norway or Finland, have lower levels of female STEM graduates than countries with less perceived equality, such as Albania or Algeria, which have higher percentages of women in STEM.

An OECD report found that girls aged 15 are two times less likely to aspire to a career as an engineer, scientist or architect, and that women account for only 20 per cent of graduates at the tertiary level in ICT fields (see figure 3 below).⁴⁴ According to the report, the career paths of boys and girls already start to diverge by the age of 15, before important career choices are made.

³⁸ USPTO. 2019. *Progress and Potential*.

³⁹ Shaw, Elyse, M.A. and Cynthia Hess. 2018. *Closing the Gender Gap in Patenting, Innovation, and Commercialization: Programs Promoting Equity and Inclusion*. Report no. IWPR C471. IWPR.

⁴⁰ Milli, Jessica, Emma Williams-Baron, Meika Berlan, Jenny Xia and Barbara Gaultet *al.* 2016. *Equity in Innovation: Women Inventors and Patents*. Report no. IWPR C448. Washington, DC. IWPR.

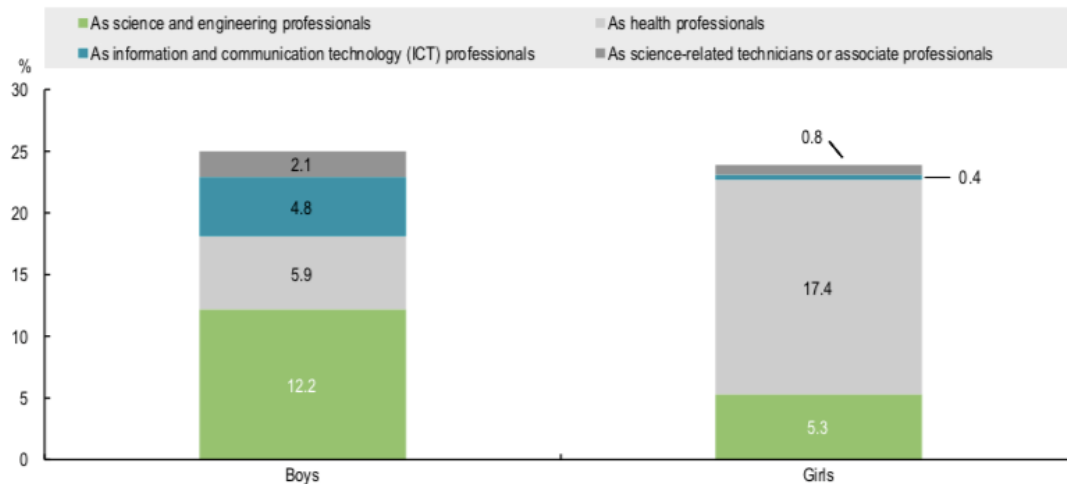
⁴¹ UNESCO. 2015. *UNESCO Science Report*.

⁴² *Ibid.*

⁴³ *Ibid.*

⁴⁴ OECD. 2018. *Empowering Women in the Digital Age*.

Figure 3: Proportion of 15-year-olds who expect to work in a science-related occupation by the age of 30, by type of science professional, OECD average, 2015



Notes: ICT = information and communication technology. OECD PISA 2015 asked students what occupation they expected to be working in by the time they reached the age of 30. Students could enter any job title or description in an open-entry field; their answers were later classified according to the International Standard Classification of Occupations, 2008 edition (ISCO-08). These coded answers were used to create an indicator of science-related career expectations, defined as those whose realisation requires the study of science beyond compulsory education, typically in formal tertiary education. Within this large group of science-related occupations, the following major groups were distinguished: science and engineering professionals; health professionals; science technicians and associate professionals; and ICT professionals.

Source: OECD (2016b). *Education at a Glance 2016*, <http://dx.doi.org/10.1787/eag-2016-en>.

Despite the focus on women in STEM as a critical constraint, research on how educational paths contribute to the gender disparity in patenting is mixed. For example, Hunt *et al.* do not find that women with science or engineering degrees are any more likely to patent than women without. They argue that patenting rates among women with science and engineering degrees are so low that increasing their representation in science and engineering would not have much effect. They also observe that only 7 per cent of the gender gap in patenting is attributable to women's lower probability of holding any science or engineering degree. Bell *et al.* have also found that the gains in participation in science and engineering occupations and entrepreneurship have not broadly increased the numbers of female inventors.⁴⁵

Other work has zeroed in on patenting rates among women with PhDs. Researchers have pointed out that at the PhD level, women are 40-66 per cent as likely to patent as men, compared to 8 per cent for college graduates as a whole. They have calculated that the lower share of doctorates among women accounts for about 10 per cent of the patenting gap.⁴⁶ Therefore, women's low participation in STEM, while important for providing a talent pool of potential innovators, must be examined alongside other factors that hinder women's innovation.

⁴⁵ Bell *et al.* 2018. "Who Becomes an Inventor in America".

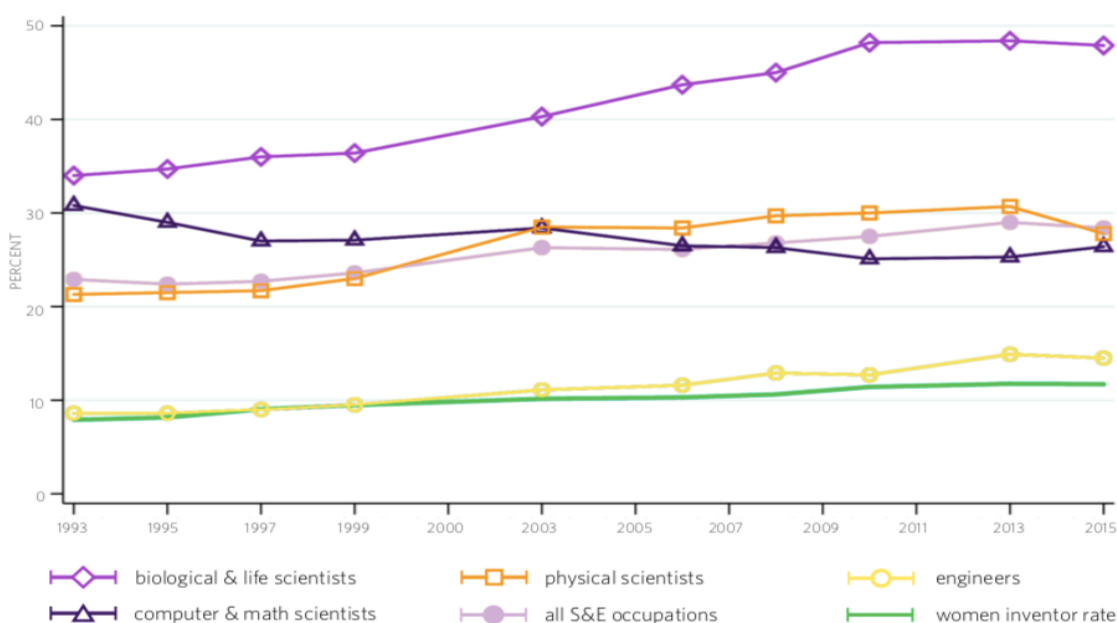
⁴⁶ Kenny, Charles and Megan O'Donnell. 2017. "Expanding Women's Role in Developing Technology: Increasing Productivity, Improving Lives." *CGD Notes*. Center for Global Development.

LOWER FEMALE PATENTING RATES

Women patent at lower rates, even when they are in STEM fields, and they face numerous challenges in these disciplines. The USPTO has compared women's participation in relevant careers with the total female patenting rate in the USA. They found that in 2015, women made up about 28 per cent of the total science and engineering workforce, but only 12 per cent of inventors named on granted patents. Across nearly all science occupations, women participate as employees at a much higher rate than they invent patented technology, except for engineering (figure 4).

In light of these figures, women's under-representation in STEM careers alone cannot provide the full explanation for the disparity in patenting. The USPTO suggests that there is a potential underutilization of high-skilled, innovative talent, and that women are disproportionately affected by the various factors that prevent scientific professionals and entrepreneurs from becoming patent inventors.⁴⁷ These other factors are discussed in the sections that follow.

Figure 4: Women patent inventors vs. women in science and engineering occupations in the USA



Source: USPTO. 2019. *Progress and Potential*.

Lower participation and slower career advancement among women in research, authorship and academia

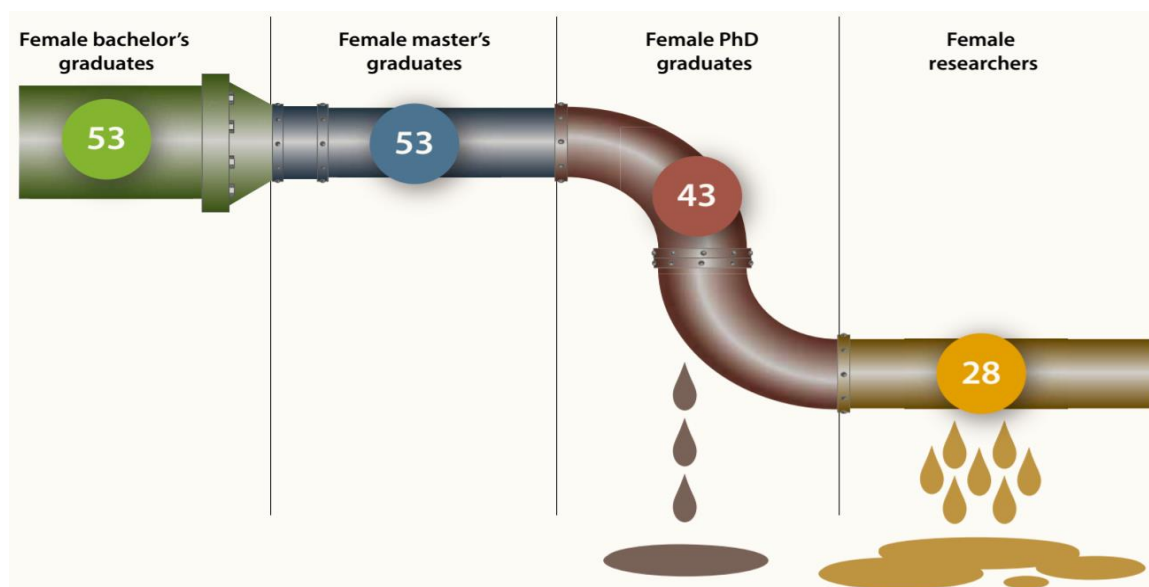
One argument put forward for women's lower patenting rate is that they progress more slowly into the roles in which patenting is more likely to occur. Critical areas where gender gaps persist include research roles, authorship and academia.

⁴⁷ USPTO. 2019. *Progress and Potential*.

Women make up just 28 per cent of the world’s researchers, a group that represents an important source of talent for innovation.⁴⁸ This is despite the fact that women make up more than half of the world’s bachelor’s and master’s degree students. Female participation in research declines with each step up the ladder of the scientific research system.⁴⁹ The high attrition rate for women in STEM and research has been termed “the leaky pipeline”, illustrated in figure 5.

Even when women work in research, they meet various challenges. They are less likely to work as researchers in the private sector, which accounts for the majority of all patents. In the European Union (EU), for example, women represent just 20.2 per cent of researchers in the private sector and 42.5 per cent of researchers in government. Women researchers in the EU are more likely to work part time, under contract arrangements, and they earn less than their male counterparts.⁵⁰

Figure 5: The leaky pipeline: Percentages of women in higher education and research



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO). 2015. *UNESCO Science Report, Towards 2030*.

Other aspects of scientific decision-making show similar trends, with women under-represented as peer reviewers, on editorial boards and on research councils. A survey of 10 relevant and highly regarded journals found that women made up 16 per cent of subject editors, 14 per cent of associate editors and 12 per cent of editors-in-chief.⁵¹

OECD research on similar measures shows a problematic lack of gender equality in scientific publishing and team leadership. It found that women comprised just 21 per cent of scientists identified as “corresponding authors”, a proxy term for leadership in the

⁴⁸ UNESCO. 2015. *UNESCO Science Report*.

⁴⁹ *Ibid.*

⁵⁰ Directorate-General for Research and Innovation (European Commission). 2019. *She Figures 2018*. Publications Office of the European Union.

⁵¹ UNESCO. 2015. *UNESCO Science Report*.

world of research, and that women only accounted for around 20 per cent of peer reviewers and editorial board members. This drops to less than 15 per cent when these activities are remunerated. Moreover, in 2015, only 17 per cent of scientists earning more than 105,000 US dollars were women. The representation of women among corresponding authors is highest in the social sciences, especially in the arts and humanities (slightly above 30 per cent of corresponding authors). It is lowest in patent-intensive physics, followed by materials science and chemical engineering, at 15 per cent or less.⁵²

The inequality in authorship mirrors the gender gaps in academia. Globally, women are under-represented at more senior levels of academia. Data from the United States shows that 19 per cent of assistant professors are women, falling to 4 per cent for full professors. Data from other countries show similar disparities. In South Africa, for example, women make up 19 per cent of heads of science councils and national science facilities, 22 per cent of the Academy of Science of South Africa, 17 per cent of heads of universities and 21 per cent of full university professors.⁵³ In the EU, women represent 48 per cent of doctoral students and graduates, 46 per cent of grade C academic positions, 40 per cent of grade B academic positions, and just 24 per cent of grade A positions, which decreases to 15 per cent in STEM.⁵⁴ These gender gaps are important, as seniority is correlated with innovation. For example, Hunt *et al.* have pointed out that PhDs hold 29 per cent of patents and academics just 7 per cent of patents.⁵⁵

Research on grant applications among medical school faculty in particular has concluded that women's lower academic rank was the primary reason for the gender gaps noted.⁵⁶ At the same time, Sugimoto *et al.* have argued that academic environments are more conducive to female patenting than government or corporate organizations, pointing to the higher share of patenting among women in academia than in business.⁵⁷

However, even when women are in the right types of jobs and roles, they still encounter obstacles and patent at lower rates. Ding *et al.* have shown that female academics patent at 40 per cent the rate of men.⁵⁸ This suggests that while promoting women's entry into academia is important, it is equally important to ensure that they can advance to higher ranks of academia and succeed in these roles.

Under-representation in patent-intensive fields

Women are both less likely to enter and more likely to exit STEM careers. However, their under-representation in patent-intensive fields of study and jobs is particularly relevant.

⁵² OECD. 2018. *Empowering Women in the Digital Age*.

⁵³ UNESCO. 2015. *UNESCO Science Report*.

⁵⁴ Directorate-General for Research and Innovation (European Commission). 2019. *She Figures 2018*.

⁵⁵ Hunt *et al.* 2012. "Why Don't Women Patent?"

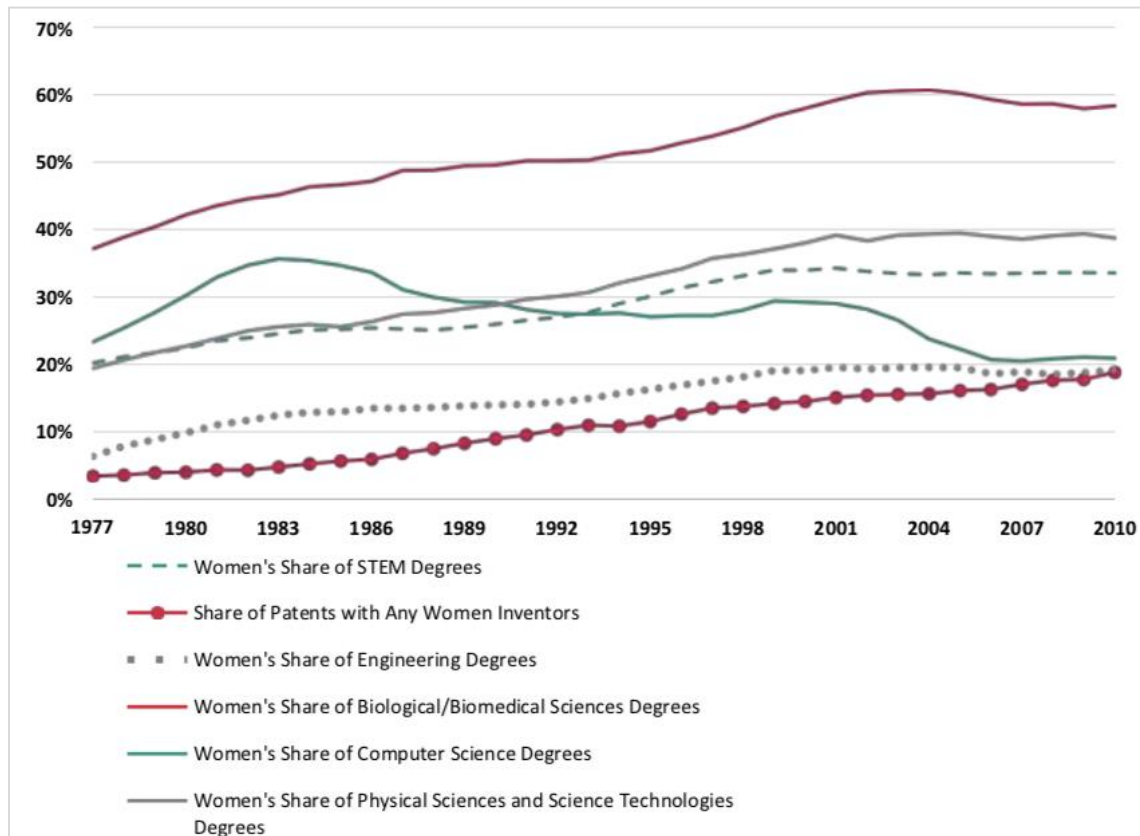
⁵⁶ Weisbren, SE *et al.* 2008. "Gender differences in research grant applications and funding outcomes for medical student faculty." *Journal of Women's Health*, 17(2), pp. 207-14

⁵⁷ Sugimoto *et al.* 2015. "The Academic Advantage".

⁵⁸ Ding *et al.* 2006. "Gender Differences in Patenting in the Academic Life Sciences." *Science*, 313(5787), pp. 665-7.

The figure below illustrates the gender gap in patent-intensive fields of study, and how women's share of different STEM degrees compares to their patenting rate. It shows that women are the majority of degree holders in biological sciences but hold much lower shares of degrees in patent-intensive engineering, computer science and physical sciences in the United States.⁵⁹

Figure 6: Share of STEM degrees received by women in the United States, 1977-2010



Source: Institute for Women's Policy Research (IWPR) analysis of Delixus, Inc. National Women's Business Council (2012); USPTO (2016a); and Snyder, Brey, and Dillow (2016).

Hunt *et al.* have argued that the most important determinant of the gender gap among science and engineering degree holders is women's under-representation in patent-intensive fields of study, especially electrical and mechanical engineering, and in patent-intensive job tasks, especially development and design. Using a United States dataset of national college graduates, the authors calculated what specific characteristics contribute to the gender gap in patenting. They found that women's younger age and lower likelihood of having a PhD were less important contributors to the gap than the specific fields of study within science and engineering and the particular job tasks. They argue that the most important steps towards increasing female patenting

⁵⁹ Milli *et al.* 2016. "The Gender Patenting Gap".

rates are to increase women's representation in electrical and mechanical engineering compared to life sciences, and in jobs involving design and development.⁶⁰

Unsupportive organizational culture, stereotyping, sexism and discrimination hinder women's advancement in STEM careers, especially in private firms. Even when women enter STEM careers and work in patent-intensive fields, they do not succeed as well as men, especially in private firms. As noted above, women are more likely to hold patents granted to public or non-profit organizations,⁶¹ despite the total number of patents being higher in industry. In engineering, women account for 20 per cent of paper authorship in universities and governmental institutes, but only 13 per cent in industry.⁶² These data trends point to possible greater gender-specific challenges facing women in private firms. The trends suggest that certain factors in private firms make it harder for women to contribute to innovation and invention, compared to academia and government.

While women start out well represented among lower ranks of scientists, engineers and technologists in private firms, they drop out at very high rates. Women in business roles in tech-intensive industries leave for other industries at higher rates than men (53 per cent compared to 31 per cent for men).⁶³

Data on women's patenting patterns in IT show wide disparities between companies. For example, in some companies, 20–30 per cent of patents have at least one female inventor, while in others the figure is less than 5 per cent. According to a study on women in IT, this suggests that individual organizational environments matter and can influence women's patenting patterns.⁶⁴

Research points to a confluence of negative factors in corporate culture that impacts women's likelihood of staying and advancing in private firms. Women in science, engineering and technology report being marginalized by a 'macho culture.' Being a solo female on a team or site can be isolating. In addition, the time-intensive nature of the jobs and the risk-and-reward system can disadvantage women, who are often more risk averse. In a study on why women are leaving science, engineering and technology careers, 40 per cent reported feeling stalled. The study also found that attrition rates among women spike 10 years into their careers. This is often a critical time for advancement, but also a time when family pressures for women may intensify.⁶⁵

⁶⁰ Hunt *et al.* 2012. "Why Don't Women Patent?"

⁶¹ Sugimoto *et al.*, 2015; Martinez *et al.*, 2016. Also USPTO. 2019. *Progress and Potential*.

⁶² Ghiasi, Gita, Vincent Larivière and Cassidy Sugimoto. 2015. "On the Compliance of Women Engineers with a Gendered Scientific System." *PLoS ONE* 10(12): e0145931.

<https://doi.org/10.1371/journal.pone.0145931>

⁶³ Catalyst. 2019. "Quick Take: Women in Science, Engineering, Technology and Mathematics (STEM)." Catalyst. Available online: https://www.catalyst.org/research/women-in-science-technology-engineering-and-mathematics-stem/#footnote2_rc46tgt

⁶⁴ Ashcraft and Breitzman. 2012. *Who Invents IT?*

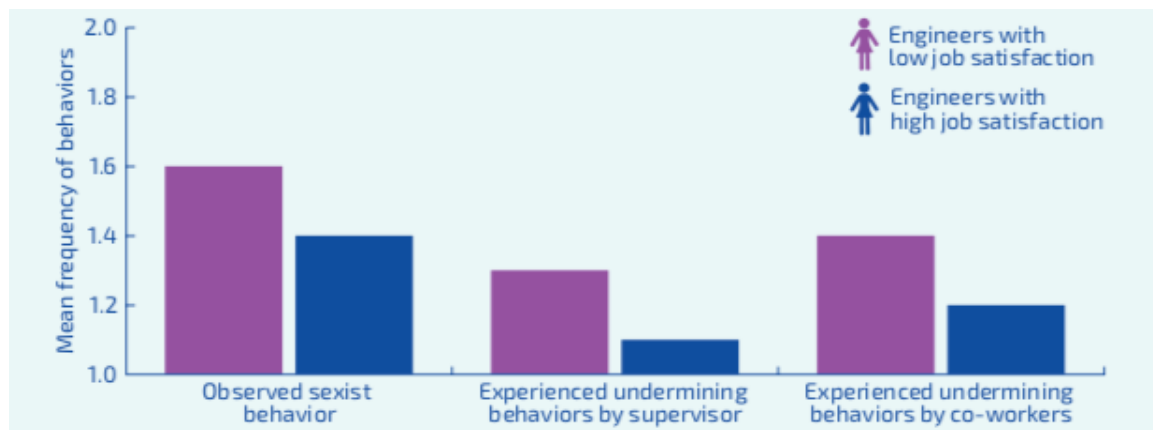
⁶⁵ Hewlett, Sylvia Ann *et al.* 2008. *The Athena Factor: Reversing the Brain Drain in Science, Engineering and Technology*. HBR Research Report, Harvard Business Review.

Women also often have less work stability. Data from the Republic of Korea, for example, shows that just 19 per cent of women working in science and technology are appointed with permanent contracts, compared to 81 per cent of men.⁶⁶

A recent United States study found that only 12 per cent of engineers are women, and the number of women in computing has fallen from 35 per cent in 1990 to just 26 per cent. According to the study, the problem for women in the field starts before they even get the job because hiring employers rated male candidates higher on critical dimensions, even when male and female candidates had identical resumes. This indicates that stereotypes hold women back from the outset.⁶⁷

Once women are hired, they continue to encounter challenges. Looking at job satisfaction among female engineers, the same study found that women who reported low job satisfaction were more likely to have experienced sexist behavior or undermining by their supervisors or co-workers (see figure below).⁶⁸ Lower pay, slower professional advancement and discrimination may also lead women to leave the field.⁶⁹

Figure 7: Job satisfaction of women engineers in the workforce



Source: Corbett, Christianne and Catherine Hill. 2015. *Solving the Equation: The Variables for Women's Success in Engineering and Computing*.

Other factors that seem to have a negative impact include stereotypes that portray women as lacking qualities needed to be a scientist, or work–life conflict owing to their caregiving roles.⁷⁰

This is confirmed by data from the UK, where 13 per cent of engineers are women and female retention in the profession is a significant problem. Just 30 per cent of women who earn bachelor's degrees in engineering are still in the profession 20 years later, and 30 per cent of women who have left the profession cite the organizational climate as the

⁶⁶ UNESCO. 2017. "10 Facts about Girls and Women in STEM in Asia." Available online: <https://bangkok.unesco.org/content/10-facts-about-girls-and-women-stem-asia>

⁶⁷ Corbett, Christianne and Catherine Hill. 2015. *Solving the Equation: The Variables for Women's Success in Engineering and Computing*. American Association of University Women.

⁶⁸ *Ibid.*

⁶⁹ Hunt *et al.* 2012. "Why Don't Women Patent?"

⁷⁰ Shaw and Hess. 2018. *Closing the Gender Gap*.

reason. Sixty-one percent of women in engineering report that they have to prove themselves repeatedly to get the same level of respect and recognition as their male colleagues.⁷¹

Another small study of female engineers at two UK companies in petrochemicals and in manufacturing, identified supportive organizational culture as critical to women's interest in keeping the job. The study interviewed women engineers about what encouraged them to stay on in their roles. Critical factors cited included support from colleagues, performance feedback, being given responsibilities and opportunities and having positive role models. These all made the female engineers feel valued and improved their confidence and belief that they could combine work and family life.⁷²

This suggests that it is critical to encourage companies to improve their organizational culture and be receptive to women's specific needs and concerns, to ensure female retention in male-dominated arenas like engineering.

Family and household burdens

Women's career progress and patenting potential are hindered by family and domestic concerns. Around the world, working women still assume greater reproductive and household responsibilities than men do. This influences their ability not only to participate equally in the labor market, but also to become successful inventors. These challenges come into play early on, influencing the course of study and job choices, for example, and continue throughout a woman's career.

Women's career progression can be significantly affected by gender expectations resulting from their reproductive and domestic roles. For example, it is often expected that a woman will take time off and leave her career to have children. Often, when she returns, it may be for part-time or temporary work, leaving her with a less stable career trajectory.⁷³

A research study of graduate chemistry students from the UK found that 72 per cent of women planned to become researchers at the beginning of their studies, but only 37 per cent still had that goal at the end of their studies. Discouraging factors included greater problems with supervisors, feeling isolated from their research groups, and being more uncomfortable with the research culture of their group, including work patterns, working hours and competition among peers. Female students felt that the academic career would require too much of a personal sacrifice. Many also spoke of being advised against pursuing a scientific career because of the challenges they would face as a woman.⁷⁴

⁷¹ Rincon, Roberta. 2018. "SWE Research Update: Women in Engineering by the Numbers." *Society of Women Engineers*. Available online: <https://alltogether.swe.org/2018/09/swe-research-update-women-in-engineering-by-the-numbers/>

⁷² Fernando, D. L, Cohen and J. Duberley. 2018. "What Helps? Women Engineers' Accounts of Staying On." *Human Resources Management Journal* 28(3), pp. 479-495.

⁷³ UNESCO. 2015. *UNESCO Science Report*.

⁷⁴ *Ibid*.

A recent study from Sri Lanka asked why female academics are less engaged in commercializing their IP rights. Gender-specific household burdens were a significant culprit. The primary reason cited by respondents was lack of time, primarily because of family responsibilities, and difficulties balancing family responsibilities and work. Other reasons included gender-based and cultural constraints, lack of respect for women entrepreneurs, lack of technical and business knowledge, and lack of access to funding.⁷⁵

Other challenges can include issues with women feeling like they need to fit in and be 'one of the boys' rather than benefit from flexible working arrangements to accommodate their life situations and caregiving responsibilities. In East Africa, barriers facing female researchers include difficulty in travelling to conferences or in participating in fieldwork, on the assumption that they are the primary domestic caregivers.⁷⁶

Conscious or unconscious bias

Bias, whether conscious or not, can also influence outcomes for women and manifests itself in many ways; for example, by affecting decisions on funding or on hiring and promotions.

Funding is critical for women's innovation. However, research has found that venture capitalists prefer pitches by men, even when the same content is delivered by males as by females. Similarly, investors have been found to ask male investors and female investors different and gender-biased questions (for example, asking a male investor how he plans to scale up, while asking a female investor how she plans to manage risk).⁷⁷ This type of bias directly affects women's innovative potential, as it leads to them receiving less funding for their ventures.

Bias can affect women's ability to secure positions in male-dominated STEM careers. A study found that both male and female faculty rated a male applicant for a laboratory position significantly higher than a female applicant and offered him a higher starting salary and more career mentoring.⁷⁸

The process of obtaining a patent can also be colored by gender bias. Data has shown that women are less likely to be granted patents. For example, Hunt *et al.* have found that female inventors commercialize 17 log points fewer patents than men.⁷⁹

According to a report by the Institute for Women's Policy Research (IWPR), of the patents filed between 2000 and 2016 in the US, 67 per cent of applications filed by women were eventually accepted, compared to 73 per cent of those filed by men. But male primary inventors submitted significantly more applications than female primary inventors (see figure 8).⁸⁰ The report argued that one reason for the lower acceptance

⁷⁵ Kariyawasam, Kanchana [no date]. *Women and IP Commercialization in the Asian Region: The Case Study of Sri Lanka*. WIPO. Unpublished.

⁷⁶ UNESCO. 2015. *UNESCO Science Report*.

⁷⁷ Williams-Baron *et al.* 2018. *Innovation and Intellectual Property*.

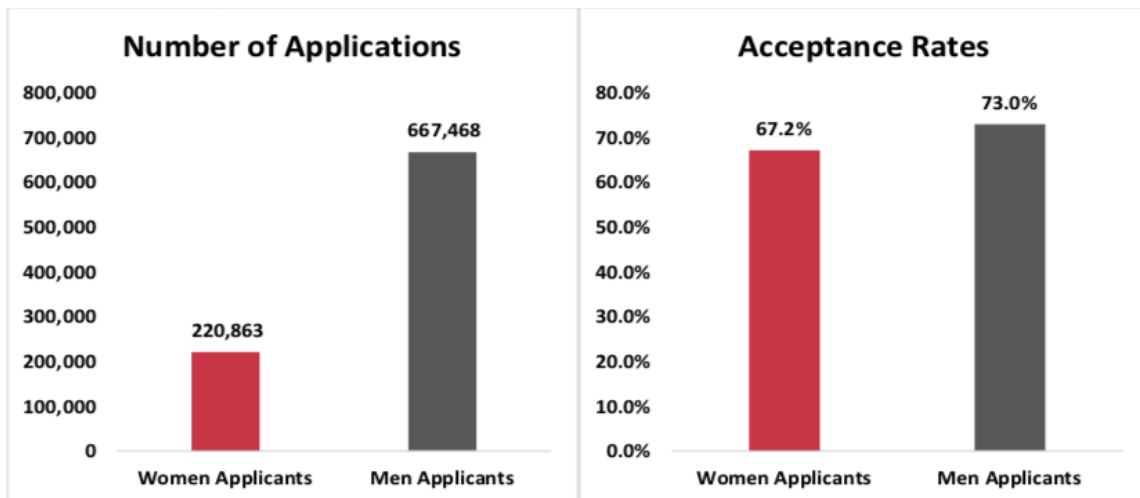
⁷⁸ UNESCO. 2015. *UNESCO Science Report*.

⁷⁹ Hunt *et al.* 2012. "Why Don't Women Patent?".

⁸⁰ Milli *et al.* 2016. *Equity in Innovation*.

rates among women was their concentration in fields that had lower acceptance rates, such as medical and chemistry fields. It also maintained that women may be less likely to negotiate with patent examiners than men, and more likely to abandon their applications. The IWPR also found that women who were ultimately successful had a higher number of office actions before their patent was granted, indicating that they had to jump through more hoops before their applications succeeded.

Figure 8: Number of patent applications and acceptance rates by applicant gender in the United States, 2000-2016



Note: Patents are classified by gender based on the sex of the first-named inventor on the application. Acceptance rates are calculated based on the total number of patents that were either accepted or abandoned and do not include patent applications whose evaluations are still ongoing. Patent applications are considered “abandoned” when inventors do not respond to a USPTO office action within the six-month timeframe. However, applicants can re-open their evaluation at any time, but it is impossible to determine in the data which applicants will re-open their evaluations. Thus, there may be some margin of error associated with the acceptance rates presented.

Source: IWPR calculations based on Garber (2016) in Milli, Jessica *et al.* 2016. *Equity in Innovation: Women Inventors and Patents*. Report no. IWPR C448. Washington, DC. IWPR.

Taking a closer look at the process, researchers from Yale University found that not only were women less likely to be granted patents, but their applications were 2.5 per cent less likely to be appealed. When granted, their patents had more words added that reduced the scope of their patents, potentially weakening the protection. When approved, women’s patents were maintained less by their assignees and received fewer citations from other inventors and patent examiners.⁸¹

This suggests that while, on the surface, the patenting process appears to be gender neutral, in practice gender bias can influence outcomes for women. The authors of the Yale study have found some proof that gender bias plays a role. While patent applicants do not include their gender on the application, it is possible to infer their gender by the names. The authors found that women with common names had 8.2 per cent less chance of obtaining patent approval, compared to just 2.8 per cent less for women with rare names, where it would be more difficult for an examiner to guess the applicant’s

⁸¹ Jensen, Kyle, Balazs Kovacs, and Olav Sorenson. 2018. “Gender Differences in Obtaining and Maintaining Patent Rights.” *Nature Biotechnology*, vol. 36, pp. 307-309.

gender. They conclude that women inventors are confronted with a greater degree of scrutiny based on their gender. It is therefore important to closely examine and review patenting processes and requirements to uncover hidden, often unintended bias and to devise solutions to erase it.

Lack of strong professional social networks

Female patenting activity is further constrained by limited professional networks. Research has found that women life scientists have smaller and lower-level professional networks than men. Sugimoto *et al.* have argued that one reason that female patenting is more prevalent in academia is due to the less hierarchical organization of academic institutions, which is useful for helping to build social networks.⁸² Wittington and Smith-Doerr suggest that biotechnology is an exception to the low female participation in patenting because biotechnology tends to have more flexible, flatter and networked organizational structures, where women do better than in hierarchical structures.⁸³

Existing research also suggests that having industry contacts is a strong predictor of patenting involvement. Women have fewer such contacts than men.⁸⁴ Using data from a national study of academic scientists in the United States, Meng found that having industry contacts was the most important factor in patenting involvement for women.⁸⁵ The author argued that the lack of collaboration with industry explains the considerable difference in patenting between male and female academics, and that only improved collaboration with industry would significantly increase the probability of patenting for female academic scientists. A recent WIPO study on women inventors in Sri Lanka confirms that the lack of networks is an issue, with women citing the lack of opportunity to form networks as a critical constraint to their professional advancement (see Box 1 below).

The patterns of female patenting seem to confirm the importance of networks and teams, as females are much more likely to patent on teams, as was discussed in the earlier section of this report.

⁸² Sugimoto *et al.* 2015. "The Academic Advantage".

⁸³ Wittington, Kjersten and Laurel Smith-Doerr. 2005. "Gender and Commercial Science: Women's Patenting in the Life Sciences." *The Journal of Technology Transfer*, vol. 30(4), pp. 355-270.

⁸⁴ Milli *et al.* 2016. *Equity in Innovation*.

⁸⁵ Meng, Yu. 2016. "Collaboration Patterns and Patenting: Exploring Gender Distinctions." *Research Policy* 45(1), pp. 56-67.

Box 1: Lack of networks hinders women from becoming inventors in Sri Lanka

Social barriers play an adverse role in relation to the potential and career prospects of female scientists in Sri Lanka. In particular, as 'their male counterparts have more freedom to move in the scientific community', 'they can easily form links with other parties that assist them to climb up their social ladder, while a large proportion of women scientists lack this opportunity.' As a result, female scientists who 'happen to do it in their own time and the hard way', take a longer time to reach the same level as their male counterparts. Traditional and cultural ethics in Sri Lanka also hinder women from taking part in research projects that involve extensive fieldwork and laboratory work at late hours.

Excerpted from: Kariyawasam, Kanchana [no date]. *Women and IP Commercialization in the Asian Region: The Case Study of Sri Lanka*. WIPO. Unpublished.

Lack of access to public and private funding

Poorer access to funding compared to men is a pervasive problem for women that crops up across many areas of their creative and innovative pursuits. The lack of access to finance has been well documented as a critical limitation for women entrepreneurs globally. According to the World Bank, 70 per cent of female-owned small and medium enterprises in developing countries are not able to get the capital they need, creating a credit deficit of almost 1.5 trillion US dollars.⁸⁶ The inability of women entrepreneurs to obtain capital stifles their entrepreneurial and innovative potential and the growth of their businesses.

The gender financing gap has not closed, despite many global and national initiatives to expand access to finance for those that lack it, regardless of gender. Various funders have found that in order to close this gap, women need specific and female-focused encouragement and programs. The persistent gender biases and additional sociocultural and gender-specific hurdles facing women have necessitated separate and female-specific initiatives to broaden female participation in sectors or domains from which women have traditionally been excluded. Many finance-focused organizations provide female-specific lending products to encourage increased access to finance by women. Organizations such as the International Finance Corporation, the World Bank, the European Bank for Reconstruction and Development or the African Development Bank have launched access-to-finance facilities targeting women in developing countries. These have increased the amount of finance available to women and have supported female entrepreneurs to grow their business ventures. This example suggests that simply offering a service without female-specific targeting or marketing may not be enough to ensure female participation. It is important to offer female-specific technical assistance, programs and products to encourage women to participate, especially in domains and fields where they have historically faced exclusion and bias.

With increasingly digitalized innovation, how women are able to raise funds for their start-ups is of particular interest. According to the OECD, female-owned start-ups

⁸⁶ Women Entrepreneurs Finance Initiative Program website. Accessed April 10, 2019. Available online: <https://we-fi.org/>

receive 23 per cent less funding and are 30 per cent less likely to have a positive exit – i.e., to be acquired or issue an initial public offering – compared to male-owned businesses. According to the same research, only 11 per cent of innovative start-ups seeking venture capital investments are founded by women.⁸⁷ They fare even worse when one looks at the amount of funding actually received: in 2018, female-founded startups in the United States received just 2.2 per cent of venture capital investment.⁸⁸

Data on research funding confirms the negative trends. Examining the recipients of research awards from the United States National Institutes of Health, researchers have calculated the relative probability that female-owned firms attract private investments to fund the transition of technology developed under the program into a marketable innovation. They found that female-owned firms were as much as 16 percentage points less likely to attract private investment than male-owned firms.⁸⁹

Research funding also tends to be more limited for women, although the evidence points to complex reasons for this. Analysis of sex-disaggregated data from the United States National Institutes of Health shows that women comprise 31 per cent of research grantees. Further examination into trends has shown that women individually held fewer grants, submitted fewer applications and were less successful in renewing grants.⁹⁰

Other work has looked at gender differences in grant applications among medical school faculty. Significant gender differences were found in the mean number of submissions per applicant (women 2.3, men 2.7); success rate (women 41 per cent, men 45 per cent); number of years requested (women 3.1, men 3.4); median annual amount requested (women 115,325 US dollars, men 150,000 dollars); mean number of years awarded (women 2.9, men 3.2); and median annual amount awarded (women 98,094 dollars, men 125,000 dollars). Yet, after controlling for academic rank, grant success rates were not significantly different between women and men, even though female submission rates were significantly lower at the lowest faculty rank. Women's lower average academic rank therefore emerged as critical issue, although it manifested in unequal access to grant funding.⁹¹

Nevertheless, women's overall lower access to capital and financial resources is a significant barrier, since the development of IP, especially patents, tends to require significant financial commitments. Without equal access to finance, women will not be able to either invest sufficiently in their product development or make other required financial investments along the way, such as covering the costs of a patent attorney.⁹²

⁸⁷ OECD. 2018. *Empowering Women in the Digital Age*.

⁸⁸ Clark, Kate. 2018. "Female founders have brought in just 2.2% of US VC this year." *TechCrunch*. Available online: <https://techcrunch.com/2018/11/04/female-founders-have-brought-in-just-2-2-of-us-vc-this-year-yes-again/>

⁸⁹ Gicheva, Dora and Albert Link. 2013. "Leveraging entrepreneurship through private investments: does gender matter?" *Small Business Economics*, February 2013, vol 40(2), pp. 199-210.

⁹⁰ Hechtman, Lisa *et al.* 2018. "NIH funding longevity by gender." *PNAS*, July 31, 2018, 115(31), pp. 7943-7948.

⁹¹ Weisbren *et al.* 2008. "Gender differences".

⁹² Shaw and Hess. 2018. *Closing the Gender Gap*.

Lack of understanding of the importance of IP registration

A lack of understanding of the value and benefits of IP may also hinder women from pursuing protection for their innovations. A study undertaken to address women's under-representation in innovation, which examined a large number of programs established to remedy this gender disparity, found that the women whom the programs served had little information or education that would equip them to pursue patenting and entrepreneurship. They also did not see the commercialization of innovation as a part of their career paths.⁹³ This finding reinforces the need for improved education of women about patenting and commercialization through a variety of channels.

In developing countries, research on women in business confirms this, as women often do not understand the value and benefit of patenting or commercializing their inventions. Focusing on 'market women' entrepreneurs in Ghana, a researcher found that many of these women are not aware of how IP law can help them gain strategic advantages in the marketplace. These women may not know how to develop their brand by using trademarks to distinguish their businesses from competitors, and they may be unaware that their creative works could be protected by copyright and patents. The author argues that the first step is for the African market woman to recognize that she has created something of value that she could protect, market and sell.⁹⁴ Such studies point to the importance of raising awareness about the available legal protections as a critical step in increasing patenting rates, as well as copyright and trademark protection, among women.

Financial and administrative barriers in the patenting process

Registering patent rights can be very time-consuming and costly, and women can struggle to obtain the necessary resources and to navigate the often complex and lengthy process. For women in developing countries, the time and cost burdens can be especially burdensome, often requiring trips to the capital city and significant investment of time, effort and funds. For women who are more likely to be time and cash poor, these costs can be prohibitive, discouraging innovation and registration of their rights.

A recent WIPO-commissioned report focusing on Sri Lanka found that the cost of obtaining a patent was cited as the biggest obstacle by female inventors, with complicated legal requirements associated with patent applications and legal regulations also being a significant obstacle.⁹⁵

An examination of how women are able to protect their IP rights in the United Republic of Tanzania identified similar challenges. While the country conforms to international standards and, in principle, provides adequate IP protection, in practice, women interviewed for the study deemed the costs associated with registration as prohibitive. With registration facilities under-resourced, short-staffed and confined to the capital

⁹³ Ibid

⁹⁴ Osef-Tutu, Janewa. 2018. "Using Intellectual Property Law to Promote Human Flourishing for 'Market Women.'" *Landslide*, March/April 2018. American Bar Association.

⁹⁵ Kariyawasam [no date]. *Women and IP Commercialization: Sri Lanka*.

Dar es Salaam, these constraints were especially onerous for women, who tend to have less time and mobility.

Interviews with women lawyers in Tanzania revealed that very few entrepreneurs knew how to register a copyright or even that registration was available under the law. While copyright exists immediately upon the creation of a work, registration can be important for protecting the copyright holder in case of copyright infringement or disputes.⁹⁶ The study also argued that IP law was not easily reconciled with traditional beliefs in communal property, a subject further discussed below.⁹⁷

Underlying gender-bias in IP law

Although IP law is ostensibly gender neutral, it can result in gender-biased outcomes and distinct disadvantages for women. Feminist authors have taken issue with both the policies and legal framework that govern IP, asserting that the legal definitions of “inventor”, “author”, “works” and “invention” can reinforce persistent gender disparities in copyright and patent registration.⁹⁸ If IP is defined as focused on protecting an individual’s abstract knowledge in order to monetize a creation, female creativity may be excluded from protection. This is because women often hold knowledge that is created and shared through informal social networks and is often motivated by the desire to care for community, rather than by profit.⁹⁹

Feminist authors have pointed out that gender bias can play a role determining what types of contributions are seen as valuable and worthy of legal protection or recognition. They have questioned, for example, why the male-dominated fields of science and research are deemed more worthy of protection than the more female-dominated domains of traditional knowledge and traditional cultural expressions (see also Box 2).¹⁰⁰

Several authors have argued that IP law has traditionally excluded creative endeavors historically dominated by women, such as domestic crafts, cooking and sewing.¹⁰¹ Feminist authors have contended that copyright laws have been written and enforced to help largely men to retain control over resources, and that copyright infrastructure has helped to maintain material and economic inequality between women and men.¹⁰² Female creative output commands less attention and money than creative works by men, and male writers, composers, producers and authors of almost any form of copyrightable work dominate culture and receive a majority of financial resources from their creative output. It has been argued that this is because copyright law was written by

⁹⁶ See, for example, the following website for explanation of the importance of registering copyrights: <https://www.copyright.gov/help/faq/faq-general.html#register>

⁹⁷ Ellis, Amanda, Mark Blackden, Jozefina Cutura, Fiona MacCulloch and Holger Seebens. 2007. *Gender and Economic Growth in Tanzania: Creating Opportunities for Women*. World Bank, Washington DC.

⁹⁸ Swanson, Kara. 2018. “Cat Ladies, Quilters, and Creativity.” *Landslide*, March/April 2018. American Bar Association.

⁹⁹ *Ibid.*

¹⁰⁰ Gearhart-Sema, Terra. 2009. “Women’s Work, Women’s Knowing. Intellectual Property and the Recognition of Women’s Traditional Knowledge.” *Yale Journal of Law and Feminism*, vol. 21(2), article 4.

¹⁰¹ Swanson. 2018. “Cat Ladies, Quilters, and Creativity”.

¹⁰² Bartow, Ann. 2006. “Fair Use and the Fairer Sex: Gender, Feminism and Copyright Law.” *Journal of Gender, Social Policy & the Law*, vol. 14(3) [2006], article 4.

men, and it therefore embodies a male version of how creativity and commerce should intersect.¹⁰³

At the same time, lack of copyright law enforcement can have a negative gender impact. Women in creative industries, such as arts, entertainment and music, can disproportionately feel the impact of failure to enforce copyright law, especially in developing countries.¹⁰⁴ For example, in Tanzania women are estimated to constitute 75 per cent of the paid people in the music industry. The country has received international recognition for its “coastal poetic melodies of Taarab”, which is estimated to be 98 per cent female, as well as gospel music, which is estimated to be 80 per cent female. Yet with very weak copyright enforcement and counterfeit issues, musicians are deprived of their royalties and protections.¹⁰⁵

Box 2: What type of creative output is worthy of legal protection? Does it exclude female creativity?

[C]opyright law has traditionally excluded recipes and clothing from protection. Cooking and sewing are areas of creative endeavor historically dominated by women, as are other domestic crafts, such as knitting, quilting, and embroidery. As applied to these crafts, copyright can feel both underprotective and overinclusive. Categorically excluding types of creation from the legal status of authored works—like recipes—is an indication that such creation is lesser, lacking even that modicum of originality that copyright requires.

Yet ..., applying copyright protection to the “pictorial” aspects of a useful article like a quilt, or treating a knitting pattern like a copyrighted architectural drawing, also disturbs the norms of crafting creation, failing to acknowledge or support the communal ways in which such creativity is generated. Quilting and knitting have long been social endeavors, done in bees and circles, in which women admired, copied, and adapted each other’s designs, and passed along patterns as part of folk traditions that lacked identifiable single authors. Some members of craft communities have sought to move their creations into the marketplace, and to use copyright to define and protect their productions as commodity creativity. Other members of such craft communities have found such claims bewildering or even harmful, threatening the constant cycle of copying and adaptation that has created the rich array of options that are the basis of any new pattern.

Excerpted from: Swanson, Kara. 2018. “Cat Ladies, Quilters, and Creativity.” *Landslide*, March/April 2018. American Bar Association.

Some have argued that the problem is not even just the law itself, but also women’s lower socioeconomic status, which prevents them from gaining equal access to the law and its protections.¹⁰⁶ Even if the law were drafted to account for how women’s creative output is produced and manifested, their lower status in society, lack of a voice, poor knowledge about the IP system and limited access to resources such as a lawyer, could still prevent them from gaining the benefits of any legal protection.

It can be difficult to reconcile IP rights with traditional beliefs about communal property, and women’s traditional knowledge (knowledge and practices that they have held and

¹⁰³ *Ibid.*

¹⁰⁴ Ellis *et al.* 2007. *Gender and Economic Growth in Tanzania*.

¹⁰⁵ *Ibid.*

¹⁰⁶ Gearhart-Sema. 2009. “Women’s Work, Women’s Knowing”.

passed on for generations) and traditional cultural expressions (expressions of traditional culture and knowledge). Female inventors and innovators may be especially disadvantaged in seeking protection under the law for their traditional knowledge and traditional cultural expressions. Rural entrepreneurs, who are often female, may have difficulty obtaining the expertise needed to protect local plants and designs.¹⁰⁷ In addition, women's traditional knowledge and traditional cultural expressions may not be widely known, as they are often undocumented. This could leave them vulnerable to exploitation. While some women have managed to combine their cultural knowledge and traditions with innovative ideas to make products for which they have received protection, many other women have not been able to do so. Women's lack of access to education and careers, which was discussed earlier, along with weak institutionalization of IP enforcement and biases in local justice systems may present particular challenges for women.¹⁰⁸

Box 3: Traditional knowledge and traditional cultural expressions from Kenya are being appropriated elsewhere

Since 2002, Kenyan knitwear, handwoven baskets, wood carvings, and stone curios have yielded significant export earnings [in Kenya.]... But competition in production has increased because of the development of synthetic substitutes and machine-made crafts that are being manufactured more cheaply by other countries, particularly in South Asia. A particular challenge is the protection of intellectual property. Products based on traditional knowledge and traditional cultural expressions that belong to communities are not easily protected under the conventional intellectual property system.¹⁰⁹ Consequently, some Kenyan products have been copied and granted intellectual property protection elsewhere. One example is traditional handwoven Kenyan baskets: the machine used to produce them has been patented in Korea.

Excerpted from: Ellis *et al.* 2007. *Gender and Economic Growth in Kenya: Unleashing the Power of Women*. World Bank, Washington DC.

Various authors have documented instances of how cultural heritage and indigenous knowledge are not being capitalized upon by women in developing countries and have been instead appropriated elsewhere (see Box 3). It has also been asserted that the IP system has been used to rob women of the traditional knowledge and traditional cultural expressions that they hold.¹¹⁰

While not all traditional knowledge and traditional cultural expressions by women lend themselves to IP protection, some of the products based on them have entered the world market, such as Rwandan woven baskets.

Researchers have argued that women's knowledge needs to be documented, for example, through traditional knowledge libraries and registers, so that external entities seeking to patent the women's products or processes would be less likely to have such

¹⁰⁷ Ellis *et al.* 2007. *Gender and Economic Growth in Tanzania*.

¹⁰⁸ Gearhart-Sema. 2009. "Women's Work, Women's Knowing".

¹⁰⁹ WIPO. 2019. *The Protection of Traditional Knowledge: Updated Draft Gap Analysis* (WIPO/GRTKF/IC/40/7). Also see WIPO. 2019. *The Protection of Traditional Cultural Expressions: Updated Draft Gap Analysis* (WIPO/GRTKF/IC/40/8).

¹¹⁰ Gearhart-Sema. 2009. "Women's Work, Women's Knowing".

patents granted. Patent offices would then need to use traditional knowledge registers when researching prior art for patent applications.¹¹¹ However, the mere documentation of traditional knowledge or traditional cultural expressions cannot stand alone as an effective strategy for protection. Concerns and questions have been raised regarding documentation and its potential effects on rights, cultures and livelihoods. These include concerns about placing traditional knowledge and traditional cultural expressions in the public domain and/or making them publicly available, the loss of control over them, and the disappearance of the secret nature of some traditional knowledge and traditional cultural expressions. Any project that seeks to document traditional knowledge would therefore need to consider these complex factors, since traditional knowledge could be either strengthened or lost, depending on how documentation is carried out.¹¹²

¹¹¹ *Ibid.*

¹¹² WIPO. 2017. *Documenting Traditional Knowledge – A Toolkit*. WIPO, Geneva.

CONCLUSIONS AND RECOMMENDATIONS

As this research illustrates, a multitude of complex challenges hold women back from patenting at greater rates. The research does not identify one single top constraint, nor does it suggest a ranking of constraints in order of importance. Instead, the extent to which any of the issues identified will affect a particular woman will vary according to her life circumstances and environment. For some women, access to finance may be the top constraint. For others, it could be the lack of networks or the lack of advancement within the profession. Moreover, no single action alone would likely make a substantial difference in improving female patenting rates. Instead, a concerted and consistent effort over time across a number of inter-related dimensions and areas is required to make a meaningful difference.

The recommendations provided below are targeted primarily at WIPO and its Member States. They are organized around the critical challenges hindering women's patenting, which this paper discussed. Some recommendations suggest collaborative efforts between multiple types of organizations, such as governments, the United Nations (UN) system, business and academia.

IMPROVE THE COLLECTION AND USE OF SEX-DISAGGREGATED DATA

- The ability to track sex-disaggregated information on patent filings needs to be improved by adding a gender box to the patent application. WIPO should also encourage Member States to adopt the gender box for applicants who file in their own countries. This will reduce time burdens and the possibilities for error associated with using name dictionaries.
- Both WIPO and Member States should continue to use the sex-disaggregated data currently collected through PCT applications to systematically analyze and track progress over time in applications by gender, as a means of understanding trends and whether efforts to address gender-specific barriers are bearing results.

ENCOURAGE INCREASED FEMALE ENTRY INTO PATENT-INTENSIVE STEM FIELDS AND CAREERS

- Greater labor force participation rates among women are associated with greater innovation. Member States should therefore continue to implement a variety of labor market policies that stimulate women's labor market participation generally, as both workers and entrepreneurs, and their entry into STEM careers more specifically. These would include, for example, removing gender-specific policy and regulatory restrictions on women's work, encouraging flexible work arrangements, affordable childcare and parental leave, or supporting change in cultural attitudes.
- Member States and academic institutions should provide scholarships and fellowships specifically for women to study patent-intensive STEM fields.
- International development organizations and donors can support efforts to promote STEM studies and careers among women by funding scholarships and

internships for girls in patent-intensive fields as a core component of their educational and workforce development programs.

- Member States, through their education systems, should implement age-appropriate and targeted awareness raising campaigns to encourage girls to pursue STEM studies and careers, including by showcasing stories and examples of female role models. These can be done in collaboration with various partners, such as non-profit organizations working with girls, industry organizations and associations. WIPO can support such efforts by developing campaigns and materials that can be customized and rolled out in different country environments.
- Various initiatives exist to offer STEM-specific training to girls, such as the 3-week intensive science, technology, engineering, art and mathematics (STEAM) training offered through UN Foundation Girl Up campaign for girls in developing countries. WIPO should explore partnerships with such programs to expand their training curriculum and include specific modules on innovation.
- Member States should require academic institutions, especially those that are government funded, to: (a) review their academic staff promotion policies for signs of unintended bias or disadvantage towards women, and (b) establish programs to support women's advancement to higher academic ranks.
- WIPO should encourage Member States to work with academia and industry to develop programs that provide internships for girls studying STEM, with a particular focus on internships in patent-intensive fields. This will increase girls' hands-on exposure to innovation, which is critical to innovation in later age.
- Member States should encourage industry to improve organizational culture so that it is more welcoming and responsive to women's concerns, to improve hiring and retention of women in male-dominated careers, such as engineering. WIPO could support such efforts by organizing seminars and exchanges among companies working in patent-intensive industries on best practices in female-friendly organizational culture, or through other relevant seminars it organizes, such as those on PCT.

INCREASE WOMEN'S ACCESS TO CRITICAL RESOURCES, ESPECIALLY FUNDING

- Member States should support greater access to funding and resources for women inventors by:
 - establishing grant facilities and/or grant windows to provide awards specifically for women's research and innovation;
 - rewarding grant applications that are gender responsive and feature female innovators and inventors on teams by making the involvement of women a grant selection criterion included in evaluation criteria; and
 - including a specific focus on funding women's research as part of international cooperation efforts through which developed countries support developing country research and scientific development.

- WIPO can highlight, showcase and otherwise promote good practice initiatives that support and fund women researchers such as the L’Oreal-UNESCO For Women in Science program.
- Women’s venture funds and access-to-finance initiatives should continue to offer targeted access to funding for women’s startups and entrepreneurial activity. WIPO should engage in dialogue with international financial organizations such as the International Finance Corporation or the African Development Bank, which have funded such efforts, to encourage and support them to design and offer specific funding windows within programs for women seeking to market innovative products or commercialize their inventions.
- WIPO should consider partnering with umbrella organizations that promote women’s access to finance, such as the Global Banking Alliance for Women, to introduce a focus on women inventors and innovators in the topics on which they support and educate their members.
- WIPO should partner with organizations that promote women’s access to finance and venture capital to address implicit bias in funding decisions. Funders have a major role to play in providing women with the capital needed to realize their innovative pursuits. They should closely scrutinize their processes to eliminate bias; for example, by ensuring that all applicants are asked the same set of questions. WIPO should work to raise awareness of these issues among Member States and funders.

ADDRESS SOCIOCULTURAL ISSUES AND BIAS THAT INHIBIT WOMEN’S INNOVATIVE POTENTIAL

- Member States should encourage industry and academia to offer female-friendly policies, such as flexible hours, or part time work in labs, classrooms and patent-intensive industry.
- WIPO should encourage and support Member States to develop tools to reduce gender bias in granting patents to women inventors. This could include developing and providing training on unconscious bias for examiners, ensuring anonymous reviews of applications whereby the applicant is only identifiable by their initials, and restricting exchanges between applicants and examiners to a platform that assures anonymity.

SUPPORT NETWORKING, COLLABORATION AND LEARNING

- Educational institutions in Member States should partner with research institutions and businesses to sponsor opportunities for girls to be exposed to and interact with inventors from an early age through, for example, summer campsite visits to their work sites.
- WIPO should continue to support campaigns and educational awareness to promote female role models in patenting, with a particular focus on school-aged girls.
- WIPO should establish a mentoring initiative specifically for women researchers in business and academia. WIPO would develop rosters of women mentors who

are more established and those still seeking to patent and commercialize their work. Mentoring can be carried out within and between countries and would pair more successful women mentors with women who are in earlier stages of development. WIPO could facilitate mentoring through in-person meetings, workshops, site visits and remote-based interactions.

- Member States should encourage both public and private employers to value time women spend cultivating professional networks by, for example, including this in their performance evaluations.
- Member States that have higher than average shares of women inventors should present their approaches and lessons to serve as models for other countries. WIPO can facilitate these exchanges by hosting events and learning sessions.

REDUCE THE COMPLEXITY AND COST OF THE PATENTING PROCESS AND STRENGTHEN NATIONAL CAPACITY TO SERVE WOMEN INVENTORS AND INNOVATORS

- Reducing the complexity and cost of patenting in developing countries is important for addressing gender-specific constraints of registering patents, given women's mobility and time challenges. WIPO should support Member States to ensure that as much of the process as possible can be carried out online and from home rather than requiring expensive and time-consuming trips to capital cities to register. This would help reduce the time and cost of the process for women.
- WIPO should support Member States to design specific measures and outreach programs for women inventors and innovators by:
 - supporting the establishment of dedicated units and building the capacity of national personnel working in patent offices or at other relevant institutions, such as chambers of commerce or business associations, to respond to gender-specific concerns. These units would offer targeted capacity building for women entrepreneurs and scientists seeking to patent. Although WIPO carries out similar capacity building already, tailoring this to women's situations and circumstances is important, as prior experience has shown that gender-specific targeting makes a difference in domains where women are traditionally under-represented;
 - developing and rolling out webinars targeting women in Member States to educate them on processes and explain the importance and benefits of patenting as part of women's outreach efforts; and
 - partnering with national bodies such as women's business associations, chambers of commerce, women lawyers' associations or non-profit organizations serving girls, to promote innovation and invention. For example, such bodies could offer the above webinars to their members as a learning opportunity. They could also help to conduct outreach and campaigns on innovation among school-aged girls, delivering important messaging to them at a formative and critical age.

- WIPO Academy should continue to offer customized courses for women scientists and to ensure gender balance and high rates of female participation in its general course offering.

IMPROVE ENFORCEMENT OF RIGHTS IN DEVELOPING COUNTRIES, INCLUDING IN FEMALE-DOMINATED AREAS

- WIPO and its Member States should assist women in effectively using the IP system to protect their traditional knowledge and traditional cultural expressions. For example, women could use trademarks to brand their traditional handicrafts, such as Taita baskets from Kenya. Women should be encouraged to use the patent system to protect their innovations based on traditional knowledge.¹¹³
- Member States should consider, on a case-by-case basis, carefully documenting women's traditional knowledge, in a manner that protects their rights, minimizes risks associated with documentation and is part of a broader IP strategy.
- International legal instruments for the protection of traditional knowledge and traditional cultural expressions should be drafted in way that adequately captures and recognizes women's traditional knowledge and cultural expressions.

SUPPORT PROACTIVE POLICIES AND MORE RESEARCH

- WIPO should commission additional global research on seemingly gender-neutral national IP policies and laws that may, in practice, inadvertently discourage female patenting or erode women's traditional knowledge and rights. This research should have a particular focus on developing countries. It should aim to understand what specific laws, processes and regulations could result in unintended negative consequences and propose measures to rectify them.
- WIPO should review existing international treaties and national policies for possibilities to include proactive language on gender, such as targets for women's participation in research or tax incentives for women's innovation. It should then support governments that are interested in revising their national policies to ensure that such proactive language and targets are included and implemented.
- Member States should consider adopting specific target percentages of overall research funding to be made available to women inventors through national research grant schemes, similar to existing targets on inclusive sourcing (e.g. 5 per cent target for sourcing from female-owned businesses in the United States).
- Member States should consider structuring research tax incentives and breaks for companies in a way that encourages greater female participation, such as by providing additional incentives for research conducted by teams comprising at least 50 per cent female scientists.

¹¹³ More examples are included in the WIPO publication *Protect and Promote Your Culture: A Practical Guide to Intellectual Property for Indigenous Peoples and Local Communities*, available online at: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1048.pdf.

RESOURCES

This section includes a small sample of web links to organizations and resources for women inventors and innovators.

Anita Borg Institute: a wealth of resources, research and networking for women in technology. <https://anitab.org>

Girl Up: a UN-led movement of young women leaders, with specific programming on STEM. <https://www.girlup.org/>

Girls Who Code: offers free programs for girls learning to code. <https://girlswhocode.com/>

Global Banking Alliance for Women: a global consortium of financial institutions dedicated to reaching the women's market. <http://www.gbaforwomen.org/>

Lean In "50 Ways to Fight Bias" card game: an interactive, downloadable card game to help fight gender bias in the workplace. <https://leanin.org/gender-bias-cards>

Springboard Enterprises: a network of innovators, influencers and investors dedicated to supporting high-growth tech companies led by women. <https://sb.co/>

TED: a collection of TED talks by women in STEM. https://www.ted.com/playlists/253/11_ted_talks_by_brilliant_wome

37 Angels: a curated list of resources for female founders, including on funding. <http://www.37angels.com/female>

European Union Women Inventors and Innovators Network: an organization promoting support, tools and information to help women achieve growth in their businesses and workplaces. <http://www.euwiinternational.eu>

Society of Women Engineers: an organization dedicated to women in engineering. <http://societyofwomenengineers.swe.org/>

UN Women's Empowerment Principles: provides concrete guidance for companies to increase gender equality and opportunities for women in the workplace, marketplace and community. <https://www.empowerwomen.org/en/weps/about>

Women Inventors Network: a network to encourage collaboration and activities in support of women inventors and to celebrate them. <https://www.ifa.com/women-inventors/>

Women in Global Science and Technology: a non-profit organization promoting women's development of science, technology and innovation internationally. <http://wisat.org/>

REFERENCES

- Ashcraft, Catherine and Anthony Breitzman. 2012. *Who Invents IT? Women's Participation in Information Technology Patenting, 2012 Update*. National Center for Women and Information Technology.
- Bartow, Ann. 2006. "Fair Use and the Fairer Sex: Gender, Feminism and Copyright Law." *Journal of Gender, Social Policy & the Law*, vol. 14(3) [2006], article 4.
- Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova and John Van Reenen . 2018. "Who Becomes an Inventor in America: The Importance of Exposure to Innovation." *The Quarterly Journal of Economics*, vol. 134(2), May 2019, pp. 647-713.
- Catalyst. 2019. "Quick Take: Women in Science, Engineering, Technology and Mathematics (STEM)." *Catalyst*. Available online: https://www.catalyst.org/research/women-in-science-technology-engineering-and-mathematics-stem/#footnote2_rc46tqt
- Corbett, Christianne and Catherine Hill. 2015. *Solving the Equation: The Variables for Women's Success in Engineering and Computing*. American Association of University Women.
- Clark, Kate. 2018. "Female founders have brought in just 2.2 per cent of US VC this year." *TechCrunch*. Available online: <https://techcrunch.com/2018/11/04/female-founders-have-brought-in-just-2-2-of-us-vc-this-year-yes-again/>
- Ding, Waverly W., Fiona Murray, and Toby E. Stuart. 2006. "Gender Differences in Patenting in the Academic Life Sciences." *Science*, 313(5787), pp. 665-67.
- Directorate-General for Research and Innovation (European Commission). 2019. *She Figures 2018*. Publications Office of the European Union.
- Ellis, Amanda, Mark Blackden, Jozefina Cutura, Fiona MacCulloch and Holger Seebens. 2007. *Gender and Economic Growth in Tanzania: Creating Opportunities for Women*. World Bank, Washington DC.
- Ellis, Amanda, Jozefina Cutura, Nouma Dione, Ian Gillson and Clare Manuel. 2007. *Gender and Economic Growth in Kenya: Unleashing the Power of Women*. World Bank, Washington DC.
- Fernando, D. L, Cohen and J. Duberley. 2018. "What Helps? Women Engineers' Accounts of Staying On." *Human Resources Management Journal*, 28(3), pp. 479-495.
- Gearhart-Sema, Terra. 2009. "Women's Work, Women's Knowing. Intellectual Property and the Recognition of Women's Traditional Knowledge." *Yale Journal of Law and Feminism*, vol. 21(2), article 4.
- Ghiasi, Gita, Vincent Larivière and Cassidy Sugimoto. 2015. "On the Compliance of Women Engineers with a Gendered Scientific System." *PLoS ONE*. 10(12): e0145931. <https://doi.org/10.1371/journal.pone.0145931>
- Gicheva, Dora and Albert Link. 2013. "Leveraging entrepreneurship through private investments: does gender matter?" *Small Business Economics*, February 2013, vol. 40(2), pp. 199-210.
- Hechtman, Lisa *et al.* 2018. "NIH funding longevity by gender." *PNAS* July 31, 115(31), pp. 7943-7948.

- Hewlett, Sylvia Ann *et al.* 2008. "The Athena Factor: Reversing the Brain Drain in Science, Engineering and Technology." *HBR Research Report*, Harvard Business Review.
- Hunt, Jennifer, Jean-Philippe Garant, Hannah Herman, and David J. Munroe. 2012. "Why Don't Women Patent?" National Bureau of Economic Research. Working Paper no. 17888. Available online: <http://www.nber.org/papers/w17888.pdf>.
- International Finance Corporation, Banking on Women Program website. Accessed April 10, 2019. Available online: https://www.ifc.org/wps/wcm/connect/Industry_EXT_Content/IFC_External_Corporate_Site/Financial+Institutions/Priorities/Banking_on_Women/
- International Labor Organization. 2018. World Employment Social Outlook, Trends for Women 2018 Global Snapshot. ILO, Geneva.
- International Monetary Fund. 2018. "Economic Gains from Gender Inclusion: New Mechanisms, New Evidence." IMF Staff Discussion Note, SDN/18/06.
- Jensen, Kyle, Balazs Kovacs, and Olav Sorenson. 2018. "Gender Differences in Obtaining and Maintaining Patent Rights." *Nature Biotechnology*, vol. 36, pp. 307-309.
- Kariyawasam, Kanchana [no date]. *Women and IP Commercialization in the Asian Region: The Case Study of Sri Lanka*. WIPO. Unpublished.
- Kenny, Charles and Megan O'Donnell. 2017. "Expanding Women's Role in Developing Technology: Increasing Productivity, Improving Lives." *CGD Notes*. Center for Global Development.
- Leeds Beckett University. 2018. "Countries with greater gender equality have fewer STEM graduates." Available online: <https://phys.org/news/2018-02-countries-greater-gender-equality-percentage.html>
- Lefevre, Bruno, Julio Raffo, Kaori Saito and Gema Lax-Martinez. 2018. "Women and the international patent system: encouraging trends." *WIPO Magazine*, April 2018.
- Mastercard. 2018. *Mastercard Index of Women Entrepreneurs 2018*. Available online: https://newsroom.mastercard.com/wp-content/uploads/2018/03/MIWE_2018_Final_Report.pdf
- Meng, Yu. 2016. "Collaboration Patterns and Patenting: Exploring Gender Distinctions." *Research Policy*, vol. 45(1), pp. 56-67. [doi:10.1016/j.respol.2015.07.004](https://doi.org/10.1016/j.respol.2015.07.004)
- Milli, Jessica, Ph.D., Barbara Gault, Ph.D., Emma Williams-Baron, Jenny Xia, and Meika Belran. 2016. "The Gender Patenting Gap." Briefing Paper no. IWPR C441. Institute for Women's Policy Research.
- Milli, Jessica, Emma Williams-Baron, Meika Belran, Jenny Xia and Barbara Gault. 2016. *Equity in Innovation: Women Inventors and Patents*. Report no. IWPR C448. Washington, DC. IWPR.
- Minniti, Mari and Wim Naude. 2010. "Female Entrepreneurship in Developing Countries." *UN University Blogm UNU-WIDER*. Available online: <https://www.wider.unu.edu/publication/female-entrepreneurship-developing-countries>
- McKinsey Global Institute. 2015. *The Power of Parity: How Advancing Women's Equality Can Add \$12 Trillion to Global Growth*. McKinsey & Co.

- Organization for Economic Cooperation and Development. 2018. *Empowering Women in the Digital Age: Where Do We Stand?* OECD.
- Osef-Tutu, Janewa. 2018. "Using Intellectual Property Law to Promote Human Flourishing for 'Market Women.'" *Landslide*, March/April 2018. American Bar Association.
- Rincon, Roberta. 2018. "SWE Research Update: Women in Engineering by the Numbers." *Society of Women Engineers*. Available online: <https://altogether.swe.org/2018/09/swe-research-update-women-in-engineering-by-the-numbers/>
- Shaw, Elyse and Cynthia Hess. 2018. *Closing the Gender Gap in Patenting, Innovation, and Commercialization: Programs Promoting Equity and Inclusion*. Report no. IWPR C471, IWPR.
- Sugimoto, Cassidy et al. 2015. "The Academic Advantage: Gender Disparities in Patenting." *PLoS ONE* 10(5): e0128000
- Swanson, Kara. 2018. "Cat Ladies, Quilters, and Creativity." *Landslide*, March/April 2018. American Bar Association.
- UK Intellectual Property Office. 2016. *Gender Profiles in Worldwide Patenting: An analysis of female inventorship*. UKIPO, Newport.
- UNESCO. 2015. *UNESCO Science Report, Towards 2030*. UNESCO Publishing, Paris.
- . 2017. "10 Facts about Girls and Women in STEM in Asia." Available online: <https://bangkok.unesco.org/content/10-facts-about-girls-and-women-stem-asia>
- US Patents and Trademarks Office. 2019. *Progress and Potential: A Profile of Women Inventors on US Patents*. . Available online: <https://www.uspto.gov/sites/default/files/documents/Progress-and-Potential.pdf>
- Weisbren, SE et al. 2008. "Gender differences in research grant applications and funding outcomes for medical student faculty." *Journal of Women's Health*, 17(2), pp. 207-14
- Williams-Baron, Emma, Jessica Milli and Barbara Gault. 2018. *Innovation and Intellectual Property among Women Entrepreneurs*. Report no. IWPR C472, IWPR.
- Wittington, Kjersten and Laurel Smith-Doerr. 2005. "Gender and Commercial Science: Women's Patenting in the Life Sciences." *The Journal of Technology Transfer*, vol. 30(4), pp. 355-270.
- World Intellectual Property Organization. 2016. *World Intellectual Property Indicators 2016*. Available online: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2016.pdf
- . 2017. *Documenting Traditional Knowledge: A Toolkit*. WIPO, Geneva.
- . 2018. "World Intellectual Property Day Celebrates Women's Accomplishments: New WIPO Figures Show Highest Ever Rate of Women Inventors, But Gender Gaps Persist." Press Release, April 26, 2018. PR/2018/817.
- . 2019. *The Protection of Traditional Knowledge: Updated Draft Gap Analysis (WIPO/GRTKF/IC/40/7)*.
- . 2019. *The Protection of Traditional Cultural Expressions: Updated Draft Gap Analysis (WIPO/GRTKF/IC/40/8)*.

Women Entrepreneurs Finance Initiative Program website. Accessed April 10, 2019.
Available online: <https://we-fi.org/>

Zosa, Victorina. 2018. *Women and IP Commercialization in the Asian Region: The Case of Philippines*. WIPO. Unpublished.