

Special section

Measuring women's participation in international patenting

Introduction

Women contribute to all fields of creativity and intellectual endeavor, highlighting the importance of gender equality for scientific advancement and innovation. However, despite general improvements in gender equality around the world, gender gaps still persist, especially at senior levels.

Measuring the participation of women in science, technology and innovation activity has attracted considerable attention over the past two decades. A number of studies have attempted to quantify women's participation in science and technology by using information available in patent documents and scientific publications.¹ However, a key barrier to doing so is the fact that it is not customary for inventors or authors to provide information regarding their gender. This has required researchers to devise alternative methods for attributing gender to a given name. The two most common methods are to conduct surveys of inventors and authors, and to use name dictionaries to infer women's participation in patenting and publications.²

In order to extract gender statistics from patent documents at the global level, WIPO has developed a name dictionary to analyze around nine million inventors' and individual applicants' names recorded in international patent applications filed under the Patent Cooperation Treaty (PCT) – commonly referred to as the PCT System. Attributing gender to European/American names is challenging but less daunting than to Chinese and Korean names, partly because of the unavailability of original character and the relatively greater ambiguity inherent in names in these latter languages. WIPO has the advantage of being able to draw on the knowledge of its Chinese and Korean staff members, who are familiar with names in their respective languages. By using both publicly available information and staff members' inputs, WIPO has developed a World Gender-Name Dictionary (WGND) containing given names used in 182 countries. To our knowledge, this is the most comprehensive gender attribution exercise for patent documents undertaken so far.³

This section documents the participation of women in international patenting between 1995 and 2015, broken down by country of origin, field of technology and institutional sector.

How to extract gender statistics from patent documents?

In order to attribute gender to inventors' names recorded in Patent Cooperation Treaty (PCT) applications, WIPO produced a gender-name dictionary based on information taken from 13 different public sources. The final dictionary can be used to attribute gender to around 6.2 million names in 182 countries/economies. Note that gender is attributed to a given name on a country-by-country basis because certain names can be considered male in one country but female in another. For example, the name Andrea can refer to a male in Italy but to a female in Spain.

Using this dictionary, gender was attributed to 96% of the 8.8 million names of individuals recorded in PCT applications. However, the gender attribution percentage of applications is not equal across countries. Among applicants from the top 20 countries of origin of PCT applications, gender attribution is least complete for those from China (88%), India (89%), the Republic of Korea (92%) and Japan (94%). For applicants from each of the remaining top 20 countries of origin, gender could be attributed for 95% or more of names. This was also the case for applicants from the remaining 198 countries of origin.

Attributing gender to a name is not an exact science; there is no guarantee that gender has been attributed correctly, and so the gender attributed to a given name should be treated as the most likely gender associated with that name.

The detailed methodology and dictionary are described in Lax-Martinez et al. (2016), which is available for download at: www.wipo.int/econ_stat/en/economics.

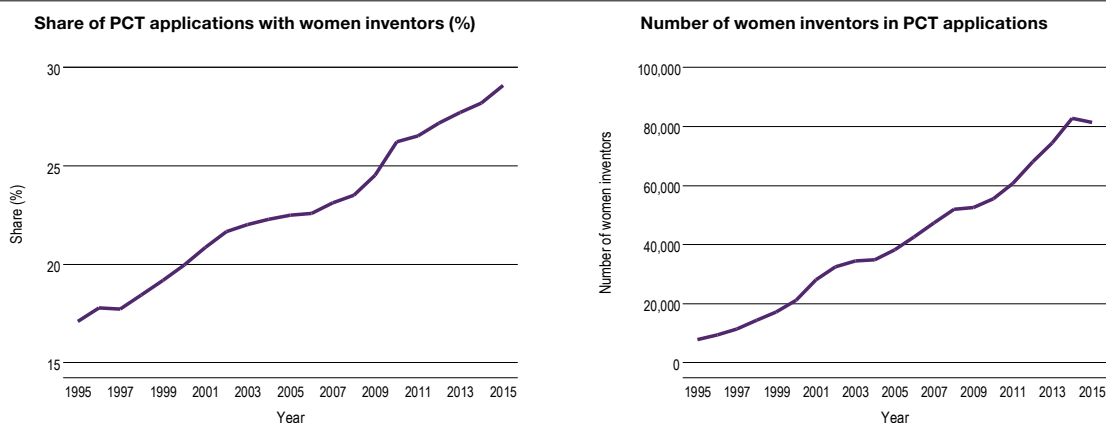
The overall share of women inventors in international patenting has been increasing

Figure 1 presents the annual shares of PCT international patent applications with at least one woman inventor (hereinafter, applications with women inventors).⁴ The share of PCT applications with women inventors increased from 17% in 1995 to 29% in 2015. Despite this increase, less than a third of all applications in 2015 included women. In terms of volumes, the total number of women inventors recorded in PCT applications increased from only 7,780 in 1995 to 81,316 in 2015, representing annual average growth of 12.5%.

1. See Frietsch et al., 2009; Naldi and Parenti, 2002; Sugimoto et al., 2015; UKIPO, 2016; among others.
2. See UKIPO (2016) as an example of the dictionary approach and Walsh and Nagaoka (2009) as an example of the survey approach.
3. The closest most recent work has been done by UKIPO (2016).

4. Data reported in this section refer to PCT international applications, and the terms "PCT applications" and "international patent applications" are used interchangeably.

Figure 1. Women inventors in international patent applications



Source: WIPO Statistics Database, October 2016.

The combined total of male inventors recorded in applications stood much higher, at 455,624 in 2015, but represented more modest growth of 9.5% per year over the same period.

Women's participation rate of 29% at the global level masks considerable variation in participation rates across countries. Figure 2 presents data on the share of PCT applications with women inventors for some leading users of the PCT System. China and the Republic of Korea have the greatest gender equality in international patenting in that half of all PCT applications that originated in these countries between 2011 and 2015 included women inventors (figure 2). Singapore (36.6%), Spain (36.3%) and Poland (33.5%) also had high shares of PCT applications with women inventors. In contrast, Germany, Italy, Japan and South Africa have the greatest gender gaps among the listed countries of origin. Less than a fifth of all PCT applications from each of these countries included women inventors. Women inventors in PCT applications from the United States of America (U.S.) – the largest country of origin of PCT applications – were represented in 29% of these applications, which is on a par with the world average. However, in absolute terms the U.S (104,565) had the largest number of women inventors recorded in PCT applications, followed by China (63,365), Japan (43,957), the Republic of Korea (42,730) and Germany (23,905) (figure 3).

Middle-income countries such as Brazil and Mexico have a gender balance in PCT applications similar to that of some high-income countries such as Ireland and the Netherlands (figure 2). But in terms of volume,

the Netherlands has five times more women inventors than Brazil and 15 times more than Mexico (figure 3).

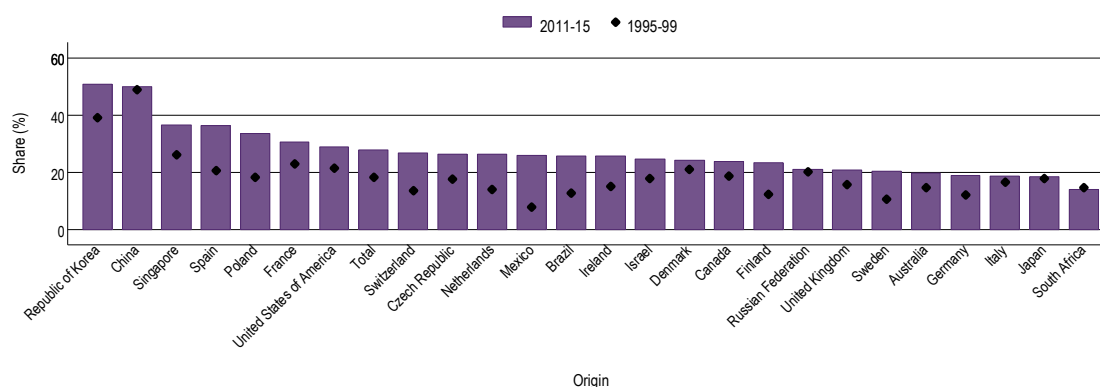
For all reported countries of origin except South Africa, gender balance improved when the five-year period of 1995-99 is compared with that of 2011-15. The fastest improvement was observed for Mexico, followed by Spain, Poland and Switzerland. Mexico's share of international patent applications with women inventors increased from 7.8% in 1995-99 to 25.8% in 2011-15. Spain, Poland and Switzerland saw similar magnitudes of increase – around a 15 percentage point improvement. South Africa saw a small decline in its share of patent applications with women inventors, while the shares for China, Japan and the Russian Federation remained largely unchanged.

Can technological specialization explain the gender gap in international patenting?

In order to better understand why women's participation rate is high in China, the Republic of Korea and Singapore but relatively low in Germany, Japan and the United Kingdom (U.K.), figure 4 presents PCT application data broken down by field of technology.⁵ Among the 35 fields of technology, biotechnology had the highest share of PCT applications with women inventors (57.6%), followed by pharmaceuticals (55.5%), organic fine chemistry (54.1%) and food chemistry (50.7%). In contrast, civil engineering; engines, pumps, turbines;

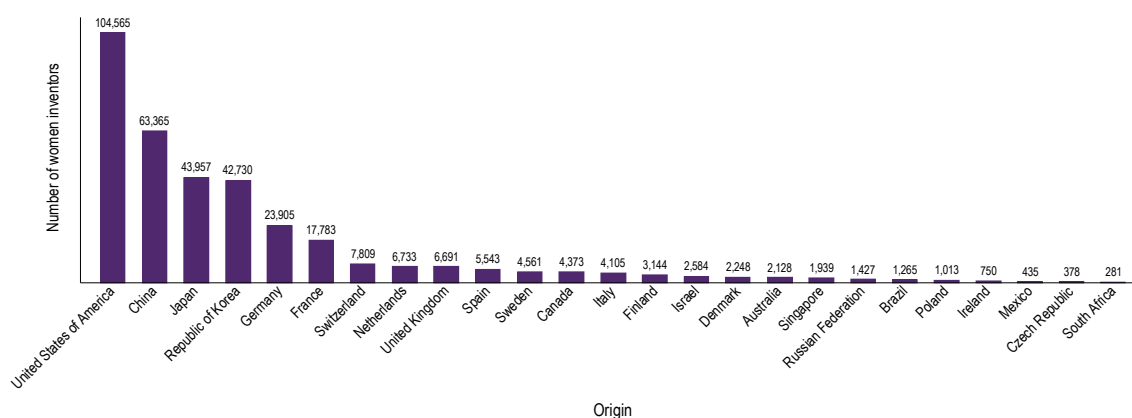
5. Participation rate is defined as the share of PCT applications with at least one woman inventor in total PCT applications.

Figure 2. Share of international patent applications with women inventors by origin



Source: WIPO Statistics Database, October 2016.

Figure 3. Number of women inventors in international patent applications by origin, 2011-15



Source: WIPO Statistics Database, October 2016.

machine tools; mechanical elements; and transport had the largest gender disparities. Women’s participation rates were less than 15% in each of these five fields.

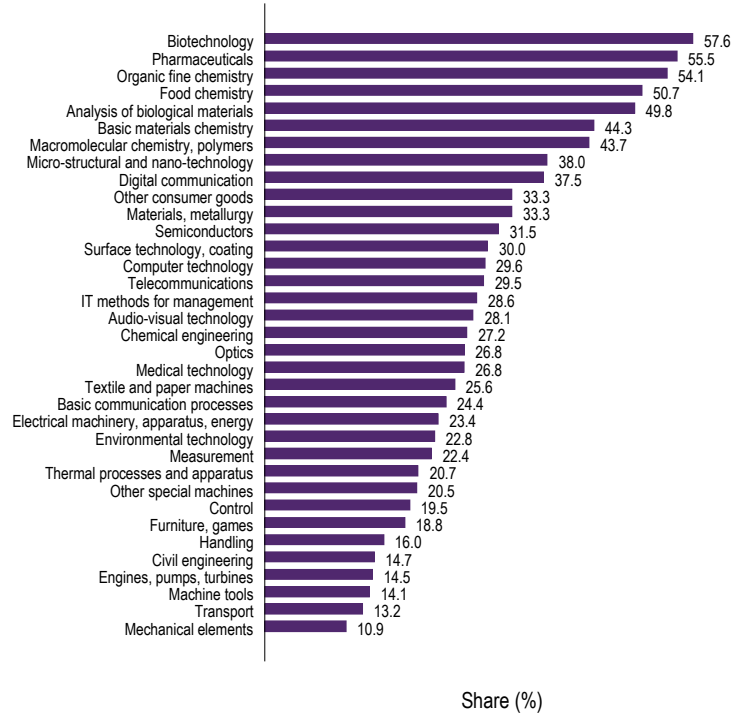
Figure 5 shows trends in women’s participation rates for each of the top five fields of technology alongside the top five fields that saw the fastest improvement in gender balance. For all fields of technology presented in this figure, there was a sizable increase in the shares of PCT applications with women inventors. For example, digital communication and telecommunications both saw a narrowing of the gender gap between 1995 and 2015. This was partly due to the fact that a large proportion of PCT applications filed in these two fields originated in China, which as mentioned earlier has a

good overall gender balance (see figure 2).⁶ Gender disparity also narrowed markedly in the fields of food chemistry and organic fine chemistry as well as in other consumer goods categories.

As shown in figure 2, Germany, Japan, South Africa and the U.K. have some of the largest gender disparities. This could be due in part to the fact that these countries of origin have high numbers of patent filings in fields of technology in which women’s participation rates are low. For example, only 13% of all transport-related PCT applications had female inventors. Applicants from Germany filed a high share of their applications in this sector (around one-tenth of all PCT applications),

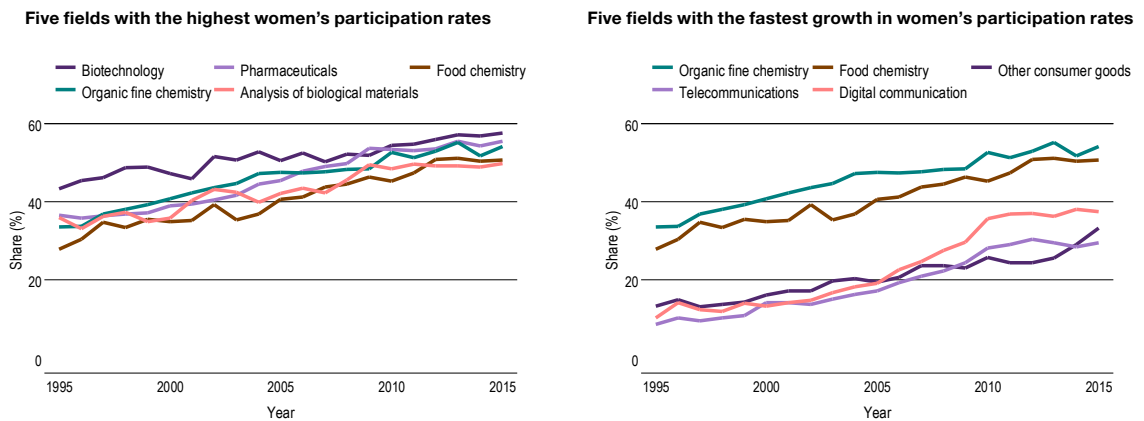
6. Computer technology accounted for 13% of China’s PCT applications, while digital communication accounted for 23.7%.

Figure 4. Share of international patent applications with women inventors by field of technology, 2015



Source: WIPO Statistics Database, October 2016.

Figure 5. Share of international patent applications with women inventors for selected fields of technology



Source: WIPO Statistics Database, October 2016.

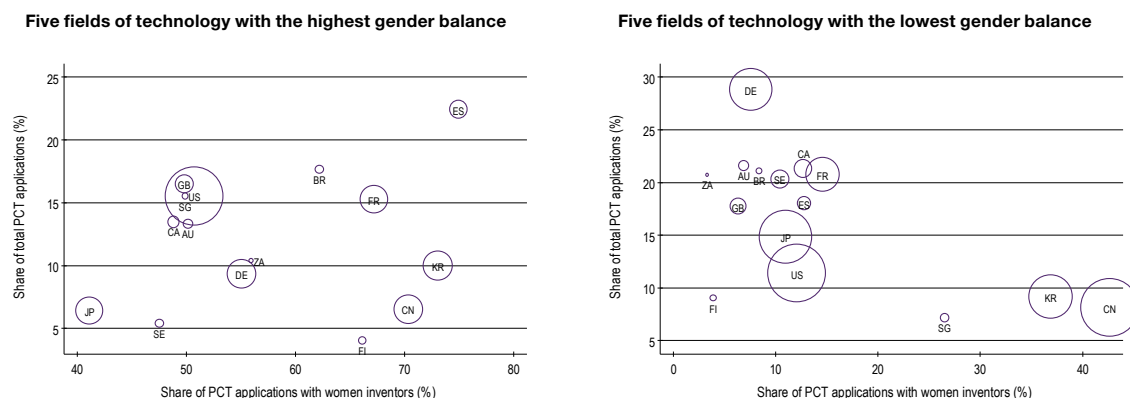
whereas applicants from China – which had a high women’s participation rate in all PCT applications combined – filed only 2% of all their PCT applications in this sector.

Figure 6 illustrates this point by presenting the share of women’s participation rates in the five fields of technology with the highest and the lowest women’s participation rates, together with the shares of these five fields in total PCT applications for selected countries of origin. Countries whose applicants file high shares of their PCT

applications in the five fields with the lowest women’s participation rates, such as Germany, Japan and the U.S., tend to have wider gender disparities. Similarly, countries whose applicants file high shares of their PCT applications in the five fields with high women’s participation rates, such as Spain, tend to have greater gender balance.

There were women inventors in more than 70% of PCT applications filed by applicants from Poland, Spain,

Figure 6. Women’s participation rates by field of technology and origin



Note: The five fields with the highest shares of 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, turbines; machine tools; mechanical elements; and transport. See figure 4. Country codes are as follows: AU (Australia); BR (Brazil); CA (Canada); CN (China); DE (Germany); ES (Spain); FI (Finland); FR (France); GB (United Kingdom); JP (Japan); KR (Republic of Korea); SE (Sweden); SG (Singapore); US (United States of America); and ZA (South Africa).

Source: WIPO Statistics Database, October 2016.

the Republic of Korea and China in the five fields of technology with the greatest gender balance (figure 7). In contrast, less than half of PCT applications in these fields from Canada, Japan, New Zealand, Singapore, Sweden and the U.K. included women inventors.

As for the five fields of technology with the largest gender disparities, China (43%), the Republic of Korea (37%) and Singapore (26%) had the largest shares of PCT applications with women inventors. But for the majority of the reported countries of origin, less than one-tenth of PCT applications filed in these fields of technology featured women inventors.

Is there gender disparity in international patenting across institutional sectors?

The academic sector, which includes universities and public research organizations, tends to have a higher share of PCT applications with women inventors than the business sector. In 2015, around 48% of all PCT applications filed by the academic sector included women inventors compared to only 28% for the business sector.⁷ The shares of women inventors in both

7. Sectorial allocation of PCT applications is based on the first applicant named in an application. For example, in a PCT application with two applicants, if the first applicant named is a university followed by the name of a company, the application will be allocated to the academic sector.

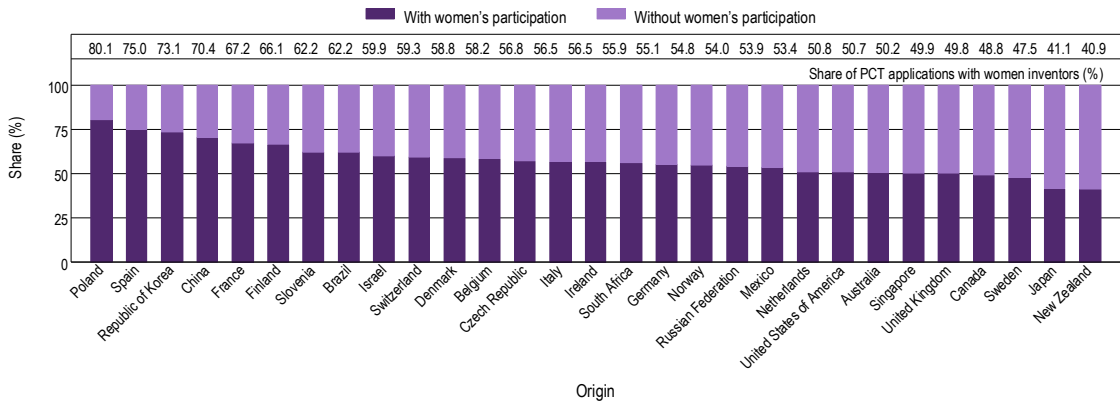
sectors have followed upward trends between 1995 and 2015. Although the academic sector has the highest women’s participation rate, the business sector had the largest number of women inventors in terms of absolute numbers – by a factor of five. The total numbers of women inventors recorded in PCT applications between 1995 and 2015 amounted to 702,764 for the business sector and 121,087 for the academic sector (figure 8). This is to be expected considering that the business sector accounted for 85% of all PCT applications in 2015, compared to just 7% filed by the academic sector.

China, Mexico, Brazil and Spain had the highest shares of PCT applications with women inventors in the academic sector. Around two-thirds of PCT applications filed by the academic sector in each of these countries of origin included women inventors. This is in contrast to Japan and Sweden, where the shares were less than 30% (figure 9). The largest gender disparities between the academic and business sectors were observed for Brazil, Italy, Mexico and South Africa. For example, the share of PCT applications with women inventors originating from Mexico was 69% for the academic sector and 26% for the business sector. In contrast, the Netherlands, the Republic of Korea, Sweden and Switzerland had the lowest gender disparities between the two sectors.

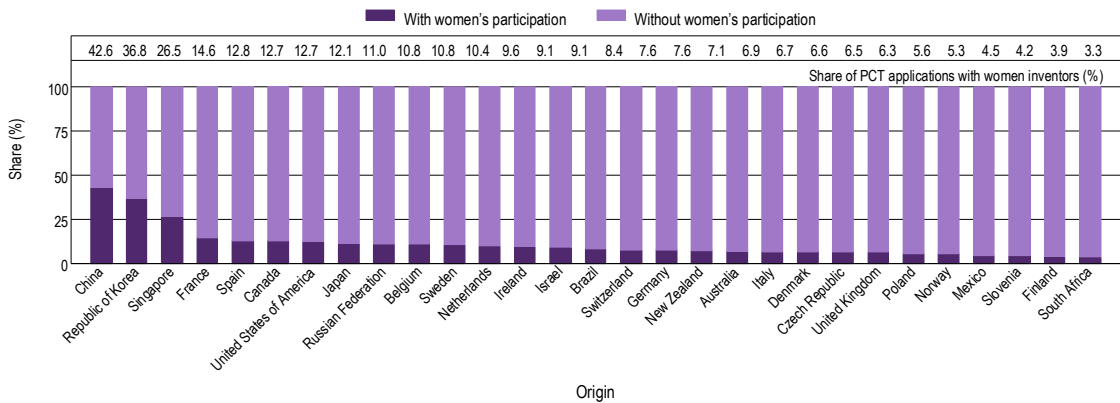
Differences in women’s participation across institutional sectors can partly be explained by the fact that

Figure 7. Share of international patent applications with women inventors by field of technology and origin, 2011-15

Five fields of technology with the highest gender balance



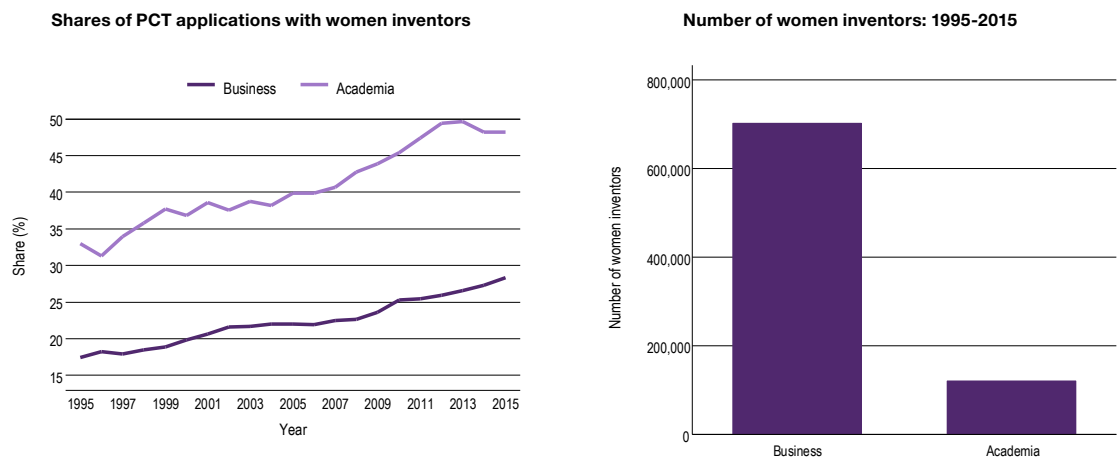
Five fields of technology with the lowest gender balance



Note: As shown in figure 4, the five fields with the highest shares of PCT applications with women inventors were: biotechnology, pharmaceuticals, organic fine chemistry, food chemistry and analysis of biological materials, while the five fields with the lowest shares of PCT applications with women inventors were: civil engineering; engines, pumps, turbines; machine tools; mechanical elements; and transport.

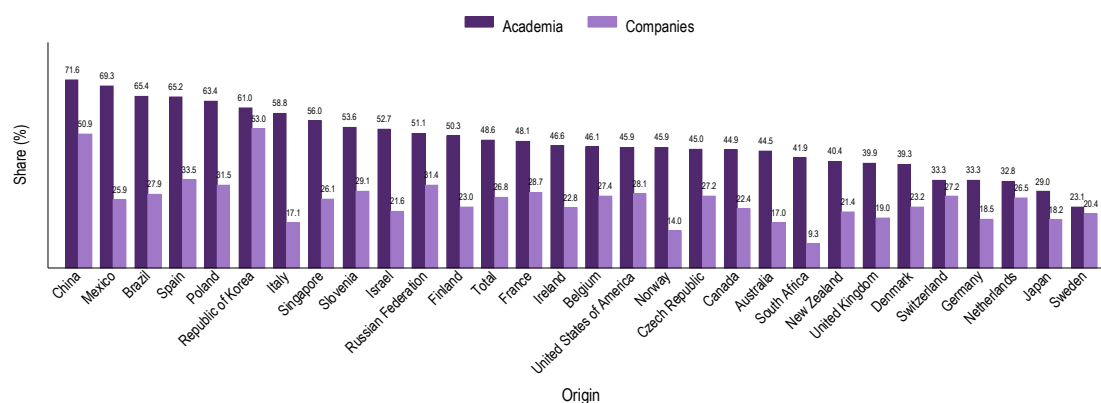
Source: WIPO Statistics Database, October 2016.

Figure 8. Shares of international patent applications with women inventors by institutional sector



Source: WIPO Statistics Database, October 2016.

Figure 9. Share of international patent applications with women inventors by institutional sector and origin, 2011-15



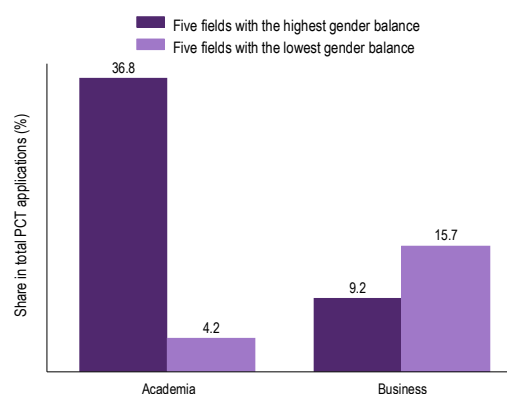
Source: WIPO Statistics Database, October 2016.

the distribution of applications from the academic sector by fields of technology is skewed towards fields that have a good gender balance (figure 10). For example, in 2015 the top five fields of technology for women’s participation rates accounted for 36.8% of total applications filed by the academic sector, while the five fields of technologies with the largest gender disparities accounted for 4.2%. In contrast, for the business sector, the top five fields accounted for 9.2% and the five fields of technologies with the largest gender disparities accounted for 15.7%.

Gender gaps among top PCT applicants

Among the top 100 PCT applicants, LG Chem Limited of the Republic of Korea had the highest share of PCT applications with women inventors for the period of 2011-15. It was followed by L’Oréal of France, Henkel of Germany, Novartis and F. Hoffmann-La Roche, both of Switzerland, and Merck Patent GmbH of Germany. For each of these companies, around three-fifths of their PCT applications included women inventors. Three of these companies specialize in pharmaceuticals, while one is active in chemistry and two in the manufacture of beauty products. In this list of top PCT applicants, Bosch-Siemens of Germany, Nokia Corporation of Finland and two Japanese companies – Daikin Industries and Hitachi Limited – had the lowest shares of PCT applications with women inventors, at less than a quarter each. Apple and Google, both of the U.S., also had low shares of PCT applications with women inventors.

Figure 10. Distribution of international patent applications by institutional sector and field of technology, 2015



Note: The five fields with the highest shares of PCT applications with women inventors were: biotechnology, pharmaceuticals, organic fine chemistry, food chemistry and analysis of biological materials, while the five fields with the lowest shares of PCT applications with women inventors were: civil engineering; engines, pumps, turbines; machine tools; mechanical elements; and transport. See figure 4.

Source: WIPO Statistics Database, October 2016.

ZTE Corporation and Huawei Technologies of China are the top two PCT applicants overall. For both, around 50% of their PCT applications included women inventors, putting them in 14th and 15th position respectively in terms of gender balance. However, in absolute numbers, ZTE had the largest number of women inventors (9,298) in PCT applications for the period of 2011-15, followed by Huawei Technologies (8,531). The majority of the reported companies saw increases in their shares of PCT applications with women inventors between the periods 1995-99 and 2011-15.

Table 1. Shares of international patent applications with women inventors for top PCT applicants in the business sector

Applicant	Share of PCT applications with women inventors (%)		Number of women inventors	Number of PCT applications
	2011-15	1995-99	2011-15	2011-15
LG Chem Ltd	71.3	73.2	2,849	2,288
L'Oréal	69.4	63.8	1,737	1,530
Henkel KGaA	65.8	37.8	1,346	1,174
Novartis AG	61.4	35.1	1,168	1,019
F. Hoffmann-La Roche AG	60.7	32.2	1,024	935
Merck Patent GmbH	59.8	43.6	858	935
Samsung Electronics Co Ltd	59.3	38.7	5,007	5,689
BOE Technology Group	56.2	n.a.	1,543	2,045
LG Electronics Inc	56.2	42.9	4,387	5,642
Dow Global Technologies Inc	54.7	n.a.	1,576	1,993
Tencent Technology (Shenzhen) Co Ltd	52.0	n.a.	1,984	2,419
Procter & Gamble Company	51.4	37.0	1,909	2,288
BASE SE	51.2	31.1	3,005	3,646
ZTE Corporation	51.1	n.a.	9,298	13,076
Huawei Technologies Co Ltd	50.5	n.a.	8,531	12,770
NESTEC SA	49.9	n.a.	1,084	1,208
Huawei Device Co Ltd	46.8	n.a.	980	1,615
DSM IP Assets	46.8	n.a.	615	949
Corning Inc	40.7	24.0	807	1,423
Qualcomm Incorporated	40.3	15.6	5,003	9,721
Shenzhen China Star Optoelectronics Technology Co Ltd	38.6	n.a.	1,274	2,651
Applied Materials Inc	38.0	28.9	888	1,689
E.I. Du Pont de Nemours and Company	37.9	25.3	863	1,693
Microsoft Corporation	36.9	21.8	1,969	3,602
Intel Corporation	36.0	15.2	2,682	5,556
International Business Machines Corporation	35.9	15.6	1,243	2,624
Nitto Denko Corporation	35.2	29.5	812	1,604
3M Innovative Properties Company	34.9	26.7	1,580	3,139
Uni-Charm Corporation	32.9	25.0	365	923
Hitachi High-Technologies Corporation	32.9	n.a.	398	979
Nokia Siemens Networks	31.4	n.a.	416	1,203
Alcatel Lucent	30.6	18.5	941	2,467
General Electric Company	30.1	15.7	885	2,222
Koninklijke Philips Electronics	28.9	9.1	2,403	6,502
Hewlett-Packard Development Company	28.9	18.9	1,514	4,089
Toray Industries Inc	28.6	19.6	392	1,166
Mitsubishi Chemical Corporation	28.3	45.4	302	884
Compagnie Générale des Etablissements Michelin - Michelin & Cie	28.0	5.5	395	1,039
Thomson Licensing	27.5	24.6	552	1,461
Société Nationale d'Etude et de Construction de Moteurs d'Aviation	26.2	25.0	296	916
Kabushiki Kaisha Toshiba	26.0	16.8	859	2,766
Telefonaktiebolaget LM Ericsson	26.0	7.6	2,076	6,703
Asahi Glass Company Ltd	25.7	27.7	440	1,537
Google Inc	25.4	n.a.	935	2,892
Terumo Kabushiki Kaisha	25.0	17.6	314	1,132
Apple Computer Inc	24.6	19.1	649	2,146
Nokia Corporation	24.1	25.0	846	2,885
Daikin Industries Ltd	23.5	9.0	352	1,077
Hitachi Ltd	22.7	21.9	1,102	4,293
Bosch-Siemens Hausgeräte GmbH	22.6	7.6	454	1,471

Note: The top 100 PCT applicants were selected based on the numbers of PCT applications they filed between 2011 and 2015. The table reports data for the 50 business applicants with the highest women's participation rates. n.a. indicates not applicable.

Source: WIPO Statistics Database, October 2016.

Table 2. Shares of international patent applications with women inventors for the top PCT applicants in the academic sector

Applicant	Share of PCT applications with women inventors (%)		Number of women inventors	Number of PCT applications
	2011-15	1995-99	2011-15	2011-15
Korea Research Institute of Bioscience and Biotechnology	83.1	100.0	639	261
Consejo Superior de Investigaciones Cientificas	81.2	55.6	734	426
Electronics & Telecommunications Research Institute of Korea	80.5	75.0	606	395
Korea Research Institute of Chemical Technology	77.9	59.2	284	181
China Academy of Telecommunications Technology	75.2	n.a.	1,152	875
Tsinghua University	74.5	50.0	522	329
Korea Institute of Science and Technology	74.5	78.9	194	141
Peking University	74.1	50.0	416	351
Institut National de la Santé et de la Recherche Médicale	70.4	73.1	701	595
Korea Institute of Energy Research	66.5	n.a.	361	245
Yeda Research and Development Co Ltd	64.9	39.7	192	188
Kyunghee University	64.4	n.a.	132	132
Korea Institute of Industrial Technology	63.0	n.a.	302	276
Chonbuk National University	62.9	n.a.	133	132
Korea Advanced Institute of Science and Technology	62.0	33.3	399	408
Korea Research Institute of Standards and Science	61.9	n.a.	110	134
Korea Electronics Technology Institute	61.8	n.a.	175	199
Nanyang Technological University	60.4	n.a.	227	298
Kyungpook National University	60.2	n.a.	147	166
Hanyang University	60.2	n.a.	218	246
Seoul National University	59.5	n.a.	467	462
Ajou University	59.4	n.a.	123	133
USA as represented by The Secretary Dept. of Health and Human Services	59.4	40.4	445	453
Centre National de la Recherche Scientifique	58.7	46.0	825	846
Agency of Science Technology and Research	58.6	n.a.	618	681
Yonsei University	57.9	n.a.	259	278
Gwangju Institute of Science and Technology	57.7	n.a.	114	142
Korea Institute of Machinery & Materials	53.9	n.a.	150	167
Leland Stanford Junior University	53.6	35.1	414	491
Duke University	53.5	36.0	159	228
New York University	53.2	37.1	203	267
University of Rochester	53.1	35.0	108	147
Hebrew University of Jerusalem	53.0	45.5	152	198
State University of New Jersey	53.0	42.0	104	151
Yale University	52.7	35.1	128	182
Postech Foundation	52.7	n.a.	173	245
Tel Aviv University	52.5	32.4	177	179
Korea University	52.1	n.a.	228	292
Massachusetts Institute of Technology	51.5	28.4	720	1,010
Johns Hopkins University	51.2	42.1	504	664
Council of Scientific and Industrial Research	50.6	n.a.	370	443
University of Pennsylvania	50.3	33.5	246	346
University of California	50.1	33.6	1,305	1,800
Wisconsin Alumni Research Foundation	50.0	38.9	156	192
Sloan-Kettering Institute for Cancer Research	50.0	50.6	125	166
Purdue University	49.0	45.0	120	196
Northeastern University	48.8	40.9	112	172
Columbia University	48.6	38.1	338	521
Max-Planck-Gesellschaft Zur Forderung Der Wissenschaften	48.3	34.3	159	232
University of Colorado	48.1	39.1	138	208

Note: The top 100 PCT applicants from the academic sector were selected based on the numbers of PCT applications they filed between 2011 and 2015. The table reports data for the 50 applicants with the highest women's participation rates. n.a. indicates not applicable.

Source: WIPO Statistics Database, October 2016.

As for the top PCT applicants in the academic sector, at least 80% of PCT applications filed by the Korea Research Institute of Bioscience and Biotechnology (the Republic of Korea), the Consejo Superior de Investigaciones Científicas (Spain) and the Electronics & Telecommunications Research Institute of Korea (the Republic of Korea) included women inventors. Eight of the top 10 academic applicants with the highest shares of PCT applications with women inventors are located either in China or the Republic of Korea. The two exceptions are the Consejo Superior de Investigaciones Científicas of Spain and the Institut National de la Santé et de la Recherche Médicale of France.

Conclusions

We are able to produce reliable data on the number of women inventors worldwide based on information available in international patent documents and a name dictionary assembled from 13 public sources. From this data, we can confidently conclude that there has been considerable improvement in women's participation in patenting. Despite this improvement, only 29% of all PCT applications filed in 2015 involved women inventors, which suggests that a significant gender gap persists.

Women's participation in patenting is not equally distributed across countries. Countries such as China and the Republic of Korea have contributed substantially to the improvement in gender balance over the past 20 years. Germany, Japan and the U.S., although home to a large number of women inventors, each have low shares of women inventors relative to their total numbers of inventors. Improvement in gender balance in these countries will determine the rate of progress at the global level over the coming decades.

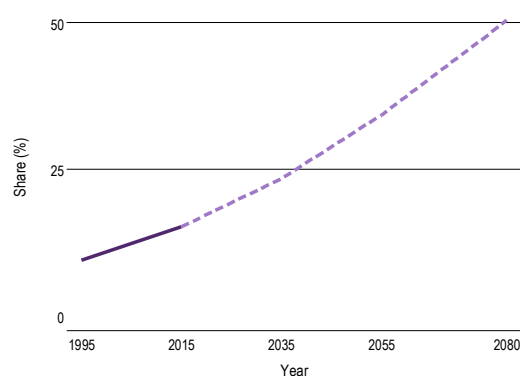
Some fields of technology have seen more progress than others. In particular, fields related to the life sciences, such as biotechnology and pharmaceuticals, are among those with higher gender balance scores. In addition, movement toward gender balance in fields related to ICTs, such as digital communication and telecommunications, has been faster than average. To a certain extent, improvement in a country's gender balance score will depend on the level of patenting activity in the life sciences and in fast-growing technological fields.

Participation of women inventors in international patenting tends to be higher in the academic sector, which includes universities and public research organizations, than in the business sector. Countries with high shares

of PCT applications filed by the academic sector will have a better gender balance. However, the share of academic sector PCT applications in total PCT applications remains small.

Overall, the proportion of women inventors relative to men remains far from balanced. At the current rate of progress, we will not reach gender balance until 2080 (figure 11).

Figure 11. Forecast trend in gender balance



Source: WIPO.

Gender balance/disparity in patenting activity is determined by various factors such as the participation of women in science and engineering, education and the labor market. In addition, the propensity to use the patent system varies across countries and fields of technology. Therefore, one should draw on other gender-related indicators – beyond patenting – to make any general conclusion about gender balance for a country, institutional sector or field of technology.

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