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Research Paper

The Gender Patenting Gap: A Study on the Iberoamerican Countries

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Abstract

Purpose: This work presents a study on the female involvement in patent applications in all 23 Ibero-American countries that are WIPO members, in order to measure gender inequalities in institutional collaborations and technological fields, across time.

Design/methodology/approach: The data used in this paper come from EPO Worldwide Patent Statistical Database (PATSTAT). PATSTAT contains bibliographical data relating to more than 100 million patent documents from leading industrialized and developing countries, as well as legal event data from more than 40 patent authorities contained in the EPO worldwide legal event data (INPADOC). The extracted subset is composed of 150,863 patent applications with priority years between 2007 and 2016.

Findings: Our observations indicate that even in more dynamic economies such as Portugal and Spain, the participation of women per patent applications does not exceed 30%. Additionally, the distribution of female participation among institutional sectors and technological fields is consistent with previous studies in other regions and indicate a socio-cultural divide.

Research limitations: Unisex names were not considered and were counted as gender unknown, and patent applications for which no inventor information was available were discarded, but further effort of data analysis may provide more information about gender inequalities.

Practical implications: While patents are imperfect variables of inventive step and therefore should be considered as a variable proxy of innovation, our findings may help to guide the implementation of policies for balancing gender participation in innovative activities, as well as instigating research into the issues causing divisive participation along gender lines.

Originality/value: While there is a widespread effort into evaluating and improving the participation of groups recognized as minorities within state-of-the-art activities, research

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about women participation in the innovation sector is fragmented due to differing regional characteristics: industrial and academic segmentation, socio-economic disparities, and cultural factors. Thus, localized studies present an opportunity of filling the gaps of knowledge on societal participation in innovation activities.

Keywords Gender; Iberoamerica; Patent statistic

1 Introduction

In September 2015, Heads of State and Government met at the historic Summit of Sustainable Development in which they approved the 2030 Agenda. This Agenda contains 17 Sustainable Development Goals (SDGs) of universal application that, since January 1st, 2016, govern the efforts of countries to achieve a sustainable world in the year 2030. The fifth objective focuses on gender equality, being one of its goals to ensure the full and effective participation of women and equal leadership opportunities at all decision levels in political, economic and public life.

However, despite many good intentions and initiatives, gender inequality still abounds in science. Although there are more women undergraduate and graduate students than men in many countries, there are relatively few full-time teachers and gender inequalities persist in hiring, salary, financing, satisfaction, and patents (Larivière et al., 2013).

The main objective of this article is to answer to the following research questions:

(1) Is the average women inventorship ratio different among Iberoamerican countries? How so?
(2) Is the difference about female involvement in patenting more accute in private or public organizations?
(3) What are the technology sectors with more and less inequalities?

This work attempts to bring some light to these questions, with a study on the female involvement in patent applications in all 23 Ibero-American countries that are WIPO members, in order to measure gender inequalities in institutional collaborations and technological fields, across time.

2 Literature review

Many studies have sought to analyze women's participation in science, technology and innovation, using mainly statistics in patent documents and scientific publications (WIPO, 2018).

A comprehensive study of the patenting activity for women inventors, in the early period of intellectual/industrial property protection (1790–1895) was presented by Khan (2000). Using data from 4,196 patents filed in the United States in this period,

as well as city directory information, the author examines the growth of women's participation by combining economic, social, and political factors, bringing attention to the fact that female participation was responding to market demands that were particular to the sphere of influence in which they had the greatest experience at the time (domestic and rural technology). The study also highlights the tendency in previous analysis of overlooking the importance of such technologies when compared to industrial machinery inventions, which devaluated women's contributions. A later study using 4.6 million utility patents issued between 1976 and 2013 by the United States Patent and Trade Office (USPTO) (Sugimoto et al., 2015) found an increase of female-to-male ratio of patenting activity from 2.7% to 10.8% in that period, and that the female patentees were predominantly from academic institutions. Their results also indicated that the female inventors had higher interdisciplinarity, measured as a function of the number of different IPC codes, but had lower technological impact than male patentees, measured as a function of the number of citations per patent.

Whittington and Smith-Doerr (2005) investigated gender disparities in commercial activity, for life scientists in both industrial and academic sectors. The study considered commercial involvement in variables such as the amount of patent grants, time to first patent since completion of a Ph.D. degree and average position in the inventor list of patents, as well as citation metrics to account for the commercial impact of the inventions. Results indicated that the nature of gender disparity in commercial innovation cannot be easily depicted by a single measure or patent count, requiring also consideration of locational variables such as employment sector. Their findings also indicated that despite the lower involvement of women in patenting, quality and impact of female patents were on par with their male counterparts, which suggested that commercial science may be losing opportunities of value generation by not correcting disparities in support for the patenting process. Those findings were also shared by McMillan (2009), in a study using US biotechnology industry data, and by Colyvas et al. (2012), using US medical school faculty data.

Still, on academic life sciences, a statistical study on a random sample of 4,227 life scientists, over a 30-year period was presented by Ding et al. (2006). Interviews were also conducted with faculty members to determine the scope and causes of the gender gap in patenting among life scientists. Among their findings was that the female life science faculty members patent at a rate about 40% the rate of male ones, a corroboration of the lack of a supporting network for the patenting process and the change in attitude for the younger generations of researchers pointed by the interviews, which can be observed in the growth in female participation over time.

Murray and Graham (2007) examined the mechanisms in the institution and maintenance of the gender gap in commercial science between 1975 and 2005, based on bibliometric data and semi-structured interviews, with 56 of a possible 148 life science faculty members from one institution (38% of the population), being 34 male (29%) and 22 female (73%), that were active during 2004–2005. Their findings revealed that key determinants of gender stratification in commercial science can be traced to "when early buyers in the market activated traditional cultural stereotypes of women in science and business, and showed an initial gender bias in the opportunities available to women life scientists". Those were reinforced across generations by homophily in mentoring and networks, among other factors. While limited in generalizability, the study findings also concurred on the lack of a supporting network for the patenting process as the major factor in shifting the gender bias. Analysis of detailed data from a sample of academic and industrial life scientists working in the United States by Whittington and Smith-Doerr (2008) further highlighted the role of organizational settings in influencing gender disparities, suggesting that less bureaucratic, horizontal distributions of work relations might favor better female participation. The differences in involvement in academic publishing between mothers and childless women were analyzed by Whittington (2011), finding similar involvement between both groups if past involvement was considered, which pointed to a considerable barrier of entry, especially in the case of mothers.

For the engineering faculty, a study by Thursby and Thursby (2005) looked at the licensing disclosure activity of 4,621 science and engineering faculty at Georgia Tech., Harvard, Stanford, Utah, Cal Tech., Cornell University, MIT, University of Pennsylvania, Purdue University, Texas A&M University, and University of Wisconsin Madison over a 17-year period. They found a very low portion of licensing activity from female faculty (8.55%), but also that the tendency of convergence of disclosure activity over time. Sifontes and Morales (2014) studied gender participation in patenting activity in eight Latin American countries for the period 1990–2006: Argentina, Brazil, Mexico, Colombia, Cuba, Peru, Chile, and Venezuela. Through data from the USPTO, they found that 20% of the patents had female inventors. Peru, Mexico, and Uruguay were the countries with greater gender inequality. Finally, the technological fields with more female presence were Chemistry and Metallurgy.

Frietsch et al. (2009) investigated gender-specific patterns in patenting and academic publication, by systematically assigning gender to the names of inventors and authors from 14 countries. Results revealed substantial differences in female participation across countries, and that the higher performing nations in this regard had little improvement in the studied period (1991–2005). This study also

corroborated the findings of higher and faster increasing participation in biology, medicine, chemistry, and related technological fields from previous studies. Hunt et al. (2013) explained the gender gap in terms of the underrepresentation of women in engineering and in development and design careers, in their statistical study on the U.S. 2003 National Survey of College Graduates (NSCG). Another study, using a survey applied to inventors in 20 European countries, the USA, Israel, and Japan, who were listed on at least one European patent application with priority dates between 2003 and 2005 (Hoisl & Mariani, 2016), accounted for the difference in income between male and female inventors. The results indicated that women earned about 14% less than their male peers, even with control for several sources of heterogeneity, such as types of jobs and potential parenthood, despite quality of the inventions, measured by general requirement of patentability, citation numbers, and patent family size.

Localized studies on demographic patterns in intellectual production were conducted in Sweden (Jung & Ejermo, 2014), using gender, age, and education factors; in Italy (Lissoni, F., Montobbio, F., & Zirulia, L., 2013), analyzing the social and economic dynamics of attribution rights to inventions and academic publications; and in the USA (Brauneis & Oliar, 2018; Meng, 2016), on industry collaboration differences, and on the ethnicity, age, and gender of copyright registrants, respectively. Research on the European Union member states by Busolt and Kugele (2009) found female participation ranged between 5% and 25%, also showing a considerable gap between female academic productivity and patent output, indicating an underutilized potential of women inventors. Bastian et al. (2019) examined how social factors played an important role in the entrepreneurship development in the Middle Eastern and North African MENA countries and discussed the limitations to human development indicators brought by gender inequalities. Mauleón et al. (2013) analyzed the female involvement in Spanish patent applications to the European Patent Office between 1990 and 2004. The 15-year period showed a positive trend, particularly at universities and in research teams with men and women presence. In continuity, Mauleon and Bordons (2014) examined inter-gender differences by institutional sectors and technological fields in a macro-level analysis of 6,860 patents applied by Spanish inventors during 1999–2007 at the European Patent Office (EPO). The female involvement in patents was only 20%, with a higher presence in Public Research Organizations (PROs) and chemistry.

While corroborating to the general findings of gender disparities and growing female participation, those studies indicated different degrees in which such phenomena happen, and point to specific social, economic and cultural circumstances that affected regional patenting landscapes.

On another hand, de Melo-Martín (2013) called into question the assumptions of appropriateness of the use of patent metrics to measure researcher productivity and that patenting in the academic setting was beneficial to society. Those concerns were shared by Otero-Hermida and García-Melón (2018) in their study on research and innovation indicators with focus on Spain.

This study follows previous efforts on investigating regional differences in gender participation with sectorized data but focused on the countries in Latin America and the Iberian region (Portugal and Spain).

3 Data and methodology

The data used in this paper came from the EPO Worldwide Patent Statistical Database (PATSTAT EPO, 2019). PATSTAT contains bibliographical data relating to more than 100 million patent documents from leading industrialized and developing countries, as well as legal event data from more than 40 patent authorities contained in the EPO worldwide legal event data (INPADOC). The extracted subset is composed of the 150,863 patent applications with priority years between 2007 and 2016 for which at least one applicant was resident in an Iberoamerican country at the time of the application. The extraction was done on November 20, 2019.

We analyzed women's participation in all 23 Ibero-American countries that are WIPO members: Argentina, Bolivia, Brazil, Belize, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Spain, French Guiana, Guatemala, Guyana, Honduras, Haiti, Mexico, Nicaragua, Panama, Peru, Portugal, Paraguay, Suriname, Uruguay, and Venezuela.

PATSTAT contains information regarding the inventors: name, address, and whether the applicant is a person or an organization, as well as a sector categorization (individual, company, university, etc.) for each applicant. However, it does not include the applicants' gender. To obtain this information, a heuristic was applied in which the inventors' first names where matched against a name-gender list and classified as male or female. Unisex names were not considered and were counted as "gender unknown". Some applications also contain only a company as the applicant, but no inventor information, and were counted as "inventor unknown".

For each patent in the aforementioned period, the names of inventors were collected and the first names matched against the name-gender list, being counted as male, female, or unknown. Unknown gender classifications accounted for 3.2 percent of all the inventors collected.

The name-gender list was obtained from a combination of two name lists: 40,000 Namen (Michael, 2007) for Europe and Gênero dos nomes (Justen, 2018) for Brazil, Portugal, and Latin America. The success rate for gender checking was 96.8 percent.

We collected patent information based on the country of each applicant. For example, for accounting Spanish participation, we collected all documents in the specified period (2007–2016) that had at least one Spanish inventor. Therefore, in this study we analyze the participation by nationality, instead of by patent office. This allows considering inventors that apply for patents in foreign markets but not in their own country as part of the same social/cultural group. After removal of gender unknown inventors and applications with unknown inventors, we were left with a subset of 103,914 patent applications, which were used for the statistics.

The statistics collected comprise patent document counts, inventor and gender counts, and the ratios of those globally and over time, per year of the analyzed period. The ratios obtained for female applicants are presented next in descriptive and visual forms.

4 Female participation in patenting

Firstly, we analyze the average women inventorship ratio, i.e. the average ratio between the number of women and the number of inventors in a patent, as it represents a way of measuring female participation in the patenting activity. Table 1 presents the data obtained for the analyzed countries. Although the women inventor ratio may be relatively high for some countries (e.g. French Guyana), their small number of patent applications in the analyzed period makes it impossible to draw further conclusions for them. However, several countries as Costa Rica, Guatemala, Nicaragua, and Paraguay, with the lowest ratio of women inventorship ratio, should be taken into account these inequalities and make gender equality policies in patenting.

When analyzing the ratio of women in patent applications, we noticed that in patents owned by companies the participation of women is still small (27%). It is in the academic (40%) and governmental (41%) that the number of women per patent has higher percentage (see Table 2). For the fields with higher female participation, on the one hand, if we look at the distribution of applicants by technological sectors over institutional sectors (Figure 1), the top 3 technological sectors at universities and governments are Instruments, Chemistry, and Others, which includes technological fields such as nanotechnology. On the other hand, company patents are focused on Electrical and Mechanical Engineering.

In Figure 2, we can observe that the Biotechnology, Pharmaceutical, and Organic Fine Chemistry fields also have the highest female participation in the Ibero-American regions, like the global tendency presented in previous studies, despite their typical sector distribution. This points to factors like institutional culture as the source of this difference.

Table 1. Female involvement in patent applications with priority years (2007–2016) for which the applicant was resident in an iberoamerican[1] country.

Country	# of patents	percent	# of inventors	Avg. women p/patent[2]	Avg. women invt. ratio[3]
Argentina	2,019	1.2338	4,741	0.486	0.207
Bolivia (LA)	16	0.0098	73	0.500	0.109
Brazil (LA)	18,632	11.3859	28,099	0.352	0.233
Belize	145	0.0886	26	0.062	0.360
Chile (LA)	3,521	2.1517	5,180	0.348	0.237
Colombia (LA)	1,547	0.9454	2,847	0.451	0.245
Costa Rica (LA)	173	0.1057	689	0.358	0.090
Cuba (LA)	1,018	0.6221	1,556	0.672	0.440
Dominican Republic (LA)	76	0.0464	148	0.487	0.250
Ecuador (LA)	365	0.2230	481	0.266	0.201
Spain (IB)	63,128	38.5771	95,002	0.426	0.283
French Guyana (LA)	1	0.0006	12	5.000	0.417
Guatemala (LA)	18	0.0110	91	0.500	0.099
Honduras (LA)	7	0.0043	35	1.571	0.314
Mexico (LA)	6,569	4.0143	13,731	0.428	0.204
Nicaragua (LA)	7	0.0043	36	0.143	0.028
Panama (LA)	613	0.3746	302	0.132	0.268
Peru (LA)	211	0.1289	484	0.588	0.256
Portugal (IB)	5,242	3.2034	9,129	0.465	0.267
Paraguay (LA)	23	0.0141	44	0.174	0.091
Suriname (LA)	5	0.0031	10	0.600	0.300
Uruguay (LA)	324	0.1980	649	0.346	0.172
Venezuela (LA)	254	0.1552	791	0.779	0.250
Latin America	35,544	0.342	60,016	0.678	0.228
Iberian countries	68,370	0.658	104,131	0.446	0.275
Ibero-America	103,914	100.0	164,156	0.658	0.232

[1]Latin american countries are indicated with (LA) next to their names, and Iberian countries with (IB).
[2]The Avg. women per patent shows the average number of women listed as inventors in each application.
[3]The Avg. women inventor ratio shows the mean ratio of *women/men* inventors for the appications analyzed.

Table 2. Female involvement by institutional sector in patent applications with priority years (2007–2016) for which the applicant was resident in an iberoamerican country.

Sector	Avg. women invt. ratio				
	# of patents	percent	# of inventors	Avg. women p/patent	Avg. women invt. ratio
COMPANY	119,364	0.730	150,866	0.347	0.274
GOVERNMENT	12,991	0.079	21,126	0.679	0.418
INDIVIDUAL	6,453	0.039	6,412	0.194	0.193
UNIVERSITY	17,712	0.108	28,006	0.635	0.404

Note. The institutional sectors indicate the institutional origin or affiliation of the inventors. Only the applications pertaining to one of the four sectors: Company, Government, Individual, University, are listed in this table. Thus the total number of patents is different from Table 1. The sectorization methodology is descibed in previous PATSTAT research (Van Looy, Du Plessis, & Magerman, 2006).

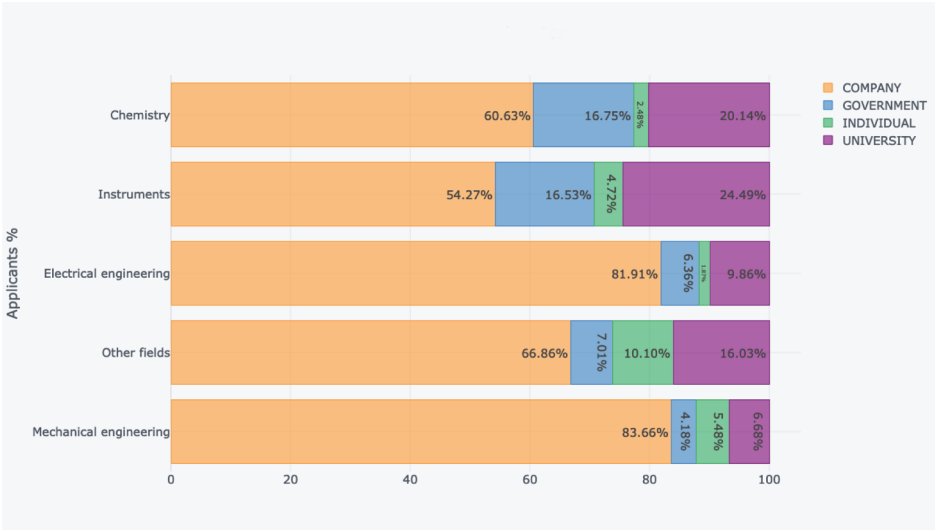

Figure 1. Distribution of applicants by technological sectors over institutional sectors in patent applications with priority years (2007–2016) for which the applicant was resident in an iberoamerican country.

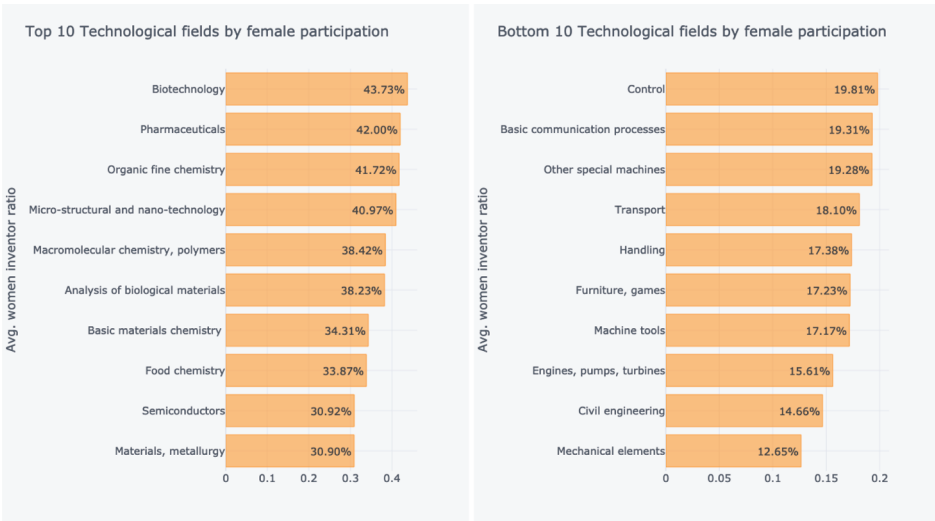

Figure 2. Average women inventor ratio (*women/men*), highest and lowest 10, per technological field in patent applications with priority years (2007–2016) for which the applicant was resident in an iberoamerican country.

5 Evolution of participation over time

If we take into account the growth on women inventorship (Table 3), the 3 top positions are for Chile, Ecuador, and Colombia. Interestingly, Brazil shows a higher growth in female involvement of patenting than Spain in the period 2007–2016. In 2007, the countries with most women inventors were Dominican Republic, Spain, and Brazil, respectively. However, in 2016, the first and third position were occupied by the same countries, and Chile held the position of Spain.

Table 3. Ranking of Ibero American countries in female participation growth on patenting (2007–2016).

Rank	Country	Avg. women invt. ratio		
		2007	2016	growth
1	Chile	0.199	0.308	0.108
2	Ecuador	0.062	0.154	0.091
3	Colombia	0.170	0.259	0.088
4	Portugal	0.228	0.302	0.074
5	Dominican Republic	0.437	0.500	0.062
6	Costa Rica	0.071	0.131	0.060
7	Mexico	0.165	0.206	0.040
8	Brazil	0.223	0.257	0.033
9	Spain	0.273	0.275	0.001

As a way of measuring the difference between the different countries that form Iberoamerica, the Latin American countries are considered on the one hand and the Iberian countries (Spain and Portugal) on the other hand. Spain and Portugal are the only countries in Europe in which there is a 100 percent exemption of patent fees for public universities (Martinez & Bares, 2018).

In Figure 3 we consider the evolution of average women inventorship ratio over the period 2007–2016. The 3 areas (Ibero-America, Latin America, and Iberian Countries) have an irregular trend, with slight grow over the period of time. The Iberian region is the leader in female participation through the entire period, but the Latin American area shows greater change.

6 Conclusion

The objective of this paper is to shed light on the female involvement in patenting in Iberoamerican countries, as part of an effort to increase the regional information landscape for gender disparities.

Even in more dynamic economies such as Portugal and Spain, the participation of women per patent applications does not exceed 30%, in terms of an average female-to-male ratio. According to Hosler (2018), the gender equality in innovation was more than 75 years away.

Figure 3. Average women inventor ratio (*women/men*) over time, per region in patent applications with priority years (2007–2016) for which the applicant was resident in an iberoamerican country.

However, the average women inventorship ratio in Cuba overtakes 40%, despite its minor level of inventorship. Compared with other Iberoamerican countries like Costa Rica, Guatemala, Nicaragua, and Paraguay, there is a greater distance. A closer look at the Cuban patenting environment can help to understand this phenomenon.

In Iberoamerican countries, the highest concentration of women per patent applications happens in government institutions and universities. Although the number of women in Science, Technology, Engineering, and Mathematics (STEM) fields are low, the average women inventor ratio are highest in Biotechnology, Pharmaceuticals and Organic fine Chemistry, and lowest in Civil and Mechanical engineering fields, which is consistent with previous studies in other regions and indicates a socio-cultural divide.

Overcoming gender inequality in Science, Technology, and Innovation activities should be the subject of public policies, that can be better formulated with access to up-to-date regional information regarding the evolution of gender differences and results of current and past efforts to reduce them. Several policy recommendations include offering assistance with patenting costs, fostering the inclusion of women in STEM or improving the networking with the industry (Milli et al., 2016).

Advances have been reached in the countries under review, but the challenges are still latent and require participation from women, especially when governments do not see the importance and interpret inclusion as an underdevelopment problem.

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Author contributions

Danilo S. Carvalho (danilo.silva@cdts.fiocruz.br) performed the collection, processing and analysis of the data, implemented the experiment, wrote and revised the manuscript. Lydia Bares (lydia.bares@uca.es) designed the research framework, wrote and revised the manuscript. Kelyane Silva (kelyaneal@gmail.com) proposed the research problems, wrote and revised the manuscript.

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