



Women in Argentine Science, Technology, and Innovation system: a deceiving equality

Daniela Belén Risaro

*PhD in Ocean and Atmospheric Sciences,
Class of 2021, Universidad de Buenos Aires*

María del Milagro Urricariet

BA in Oceanography, Universidad de Buenos Aires

Camila Prudente

*PhD Candidate in Atmospheric and Ocean Sciences,
Universidad de Buenos Aires*

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ABSTRACT

The gender gaps in the field of Science, Technology, Engineering, and Mathematics (STEM) Research in Latin America and the Caribbean seem not to exist in terms of the number of female and male researchers. However, there is significant horizontal disaggregation, as well as other dimensions of inequality that have not been exhaustively quantified and investigated. To explore this disparity in one country of the region, we analysed gender differences in staff productivity in the Argentine Science, Technology, and Innovation system between 2011 and 2018, considering age, seniority level, as well as the number of patent applications and those granted. We found that, on average, men produce more papers than women in most age ranges. This productivity gap is observed after their 30s, a stage in which women carry out child-rearing and maternity activities. In most of the ranks that make up a research career, the gender gap is in favour of men, except for at Senior Researcher level where the difference is reversed, suggesting that only female researchers with a very competitive profile reach higher ranks. The number of patent applications by men and those granted to them is double that of women. These differences show significant gender inequality in the workplace of the Argentine Science, Technology, and Innovation system. This information is fundamental and necessary to design and implement new evidence-based gender policies, as well as to redesign existing public policies.

INTRODUCTION

Despite the progress made in gender parity in recent decades, worldwide the number of female researchers in the field of science continues to be small. According to the Institute of Statistics of the United Nations Educational, Scientific and Cultural Organisation, in July 2019, the global average rate of female researchers was only 29.3%. Former authors suggest gender inequality may be evident at phases before the research career, such as university courses and even schooling (Marchionni et al., 2019). Women tend to drop out of university studies in a higher proportion than men, and the gender gap widens in the transition between university and entering the labour market (Bello, 2020).

In Latin America and the Caribbean, the gender gap is narrowing in the field of Science, Technology, and Innovation (STI), and it is one of the two regions of the world that has achieved gender parity in the proportion of researchers, where women represent between 45% and 55% of all researchers (Bello, 2020). However, the distribution of female researchers is heterogeneous across different fields, with females being underrepresented in STEM subjects (López-Bassols et al., 2018). This disproportion is associated with an evident gap in the stages of schooling and in subsequent career choices (Marchionni et al., 2019). Within the last decades, the gradual increase in the percentage of women in STEM was followed by an increase in the gender disparities in productivity (Huang et al., 2020). Furthermore, data from the World Intellectual Property Organisation on women's participation in patenting activities reveal that in most Latin American and Caribbean countries, less than one in three patents include at least one woman as an inventor (López-Bassols et al., 2018).

The Argentine Science, Technology and Innovation system is mainly composed of institutes of public universities, and the

National Scientific and Technical Research Council (CONICET, in Spanish) (Baringoltz et al., 2018) that concentrates most of the human resources in STI. Research centres show both vertical and horizontal segregation in the workplace. This vertical segregation, phenomenon known as the “glass ceiling”, is understood as the invisible institutional obstacles faced by women, in conjunction with an unequal distribution of responsibilities for care and housework. This reality creates enormous difficulty for women to access hierarchical and decision-making jobs, particularly in the field of STI in Argentina (Szenkman and Lotitto, 2020).

The horizontal segmentation that occurs in the labour market, an effect known as “glass walls”, also affects Argentina, leaving women underrepresented in STEM areas. This is observed within CONICET research categories where women are majority in biological and health sciences (61.3%) and social sciences and humanities (57.6%) but are under-represented in exact and natural sciences (41.7%) and engineering and technologies (9.7%) (Szenkman and Lotitto, 2020).

The disparity in terms of leadership and decision-making positions between women and men is notable within the Argentine Science, Technology, and Innovation system (MinCyT, 2020). The distribution of the high percentage of women based on the four research categories, suggested by the latest edition of the Frascati Manual (OECD, 2018), shows this phenomenon. Even though there are more women than men in CONICET staff (Szenkman and Lotitto, 2020), their access to the highest research seniority level is lesser than men.

This paper aims to detect and quantify gender gaps in the Argentine Science, Technology, and Innovation system for the design of strategies and public policies with a gender perspective that adequately approaches the gender differences in the area. To achieve this, we determined the following specific objectives: (1) quantitatively identify scientific production based on: gender, age range, researcher category; and (2) estimate the type of scientific

production and the number of patent applications and patents granted, in order to (3) detect an order of priority in the gender gaps observed to focus on inequalities in a staggered way.

This paper is divided into four sections. Section 1 provides a description of the data and the methods used in the analysis, while Section 2 exposes its limitations. The results and discussions about the data analysis conducted to achieve the objectives were included in Section 3. Finally, the conclusion and final remarks are drawn in the last section.

DATA AND METHODOLOGY

The data used to carry out this study is available on the Argentine Science and Technology Information Portal (MinCyT, 2020). We analysed an annual database of observations differentiated by gender between 2011 and 2018, composed of 39,525 women and 29,027 men. The fields analysed were “Total number of papers published”, “Seniority level”, “Age”, “Patent applications” / “granted patents”, and “Type of publication”. The databases referred to faculty who self-identified as women or men, considering the static registration of gender as binary, and therefore do not consider diversities or non-binary identities.

The total number of papers published was disaggregated by the type of publication made. This category included articles in scientific journals indexed according to the SCImago Journal Rank (SJR), which groups academic journals according to their degree of impact. The journals were classified according to the number of citations received in the past three years and were arranged in quartiles: Q1, Q2, Q3 and Q4, where Q1 is occupied by the top 25% of journals in the list, Q2 is the next 25% and so on. In addition, we considered other types of publications such as book chapters, books, and publications in the Basic Core of Argentine Scientific Journals (NBR, in Spanish). The NBR is

a program designed to prioritise the Argentine scientific and technological publications by CONICET.

Databases included both researchers and technical or support staff. However, we used only human resources categories specifically dedicated to research and development - i.e., in increasing hierarchy: Fellows (doctoral and postdoctoral), and all researcher seniority levels (Assistant, Associate, Independent, Principal and Senior). All these categories generally refer to different ages and stages of the career of each researcher. In addition, we studied age ranges grouped in 10-year intervals from 20 years of age, distributed in five study groups (21-30, 31-40, 41-50, 51-60 and 61+ years old).

Since the Argentine Science, Technology and Innovation system has a greater number of women than men in its database, we normalised several of the indicators studied and expressed them per capita. To facilitate the understanding and comparison of the data and due to the low number of patents in the database, this variable was expressed in quantity per thousand people of each gender.

To perform the statistical analysis of the databases, we estimated descriptive measures of both central tendency (mean, median, quartiles) and dispersion (standard deviation, maximum and minimum). The inferential analysis of the estimators calculated on the analysed sample consisted in studying the confidence intervals for the mean considering a confidence level of 95%.

LIMITATIONS

The present study has only addressed some indicators, so the picture is thus still incomplete. In this regard, the number of projects directed and the tenure of a teaching position could be added to future analysis, to complement our findings. Another aspect to consider would be the presence of gender bias in the

evaluation committees that are responsible for granting patents, passing projects and funding them.

Other limitations we find in carrying out this work lead us to open new horizons for debate. Firstly, gender binary data do not allow us to distinguish and quantify gender differences within the female and male genders. This can be addressed in previous instances, such as survey preparation, data collection and analysis. Nonetheless, in order to highlight the gender discrepancies shown by the data, the findings of this study are classified as binary.

Secondly, the database does not indicate the order of authors in the publications and the collaboration between them. Therefore, it is not possible to evaluate whether women have a more collaborative profile when publishing. Thus, it is necessary to implement a gender perspective in the creation of the public indicators of the Argentine Science, Technology, and Innovation system since this information could further reveal inequality to the detriment of women.

Finally, the main areas of STEM were considered in the analysis, without taking into account the horizontal disaggregation within them. It is expected that the gaps will be greater in masculine disciplines where women are underrepresented. For this, a specific public policy design is necessary to promote the insertion of women and gender and sexual diversities.

RESULTS AND DISCUSSION

We carried out a descriptive statistical analysis of the number of published papers by the STI staff between 2011 and 2018. The most common measures of central tendency and dispersion are shown in Table 1. Mean values indicate that the number of papers per capita is greater in men (3.51) than women (2.79). Higher

standard deviations are obtained in men (7.14) compared to women (5.17), indicating women are more assertive than men in the number of published papers. The coinciding median values of both distributions indicate that both the mean and the standard deviation are biased by outliers.

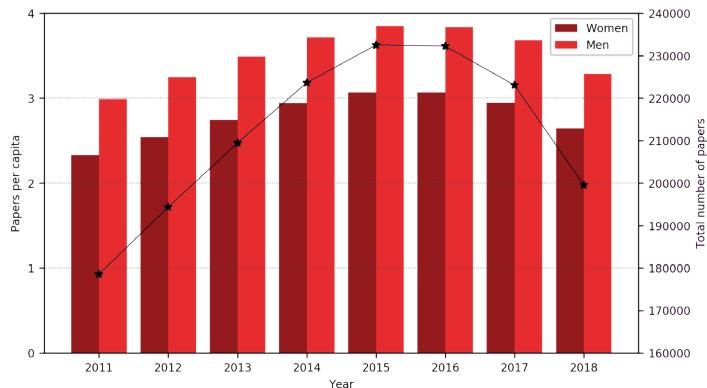
TABLE 1: STATISTICS PARAMETERS OF THE NUMBER OF PAPERS PER CAPITA

	Women	Men
Mean	2.79	3.51
Median	1	1
Standard deviation	5.17	7.14
Minimum	0	0
Maximum	474	454

Source: Argentine Science and Technology Information Portal (MinCyT, 2020).

We analysed the temporal evolution of the papers published through the years of study (Figure 1). The number of papers per capita by men and women shows a difference that is maintained from 2011 to 2018, which varies between 0.64 and 0.78. Figure 1 also shows the total number of papers published by men and women for each year of study. This time series shows an increase between 2011 and 2015 in the number of papers published by both men and women and a monotonous decrease thereafter. The value increased 30% between 2011 and 2015, and then decreased to 11% in the last year of study. This decrease from 2015 could coincide with the budget cut that STI suffered during the 2015-2019 period in Argentina, which was exhaustively reported in previous studies (e.g. Aliaga, 2019).

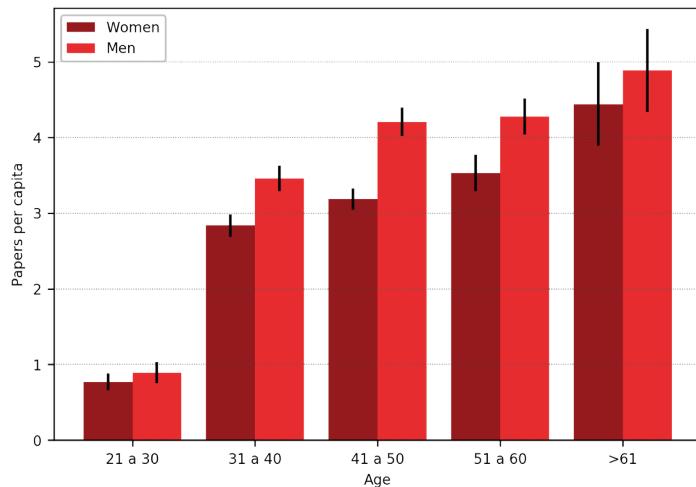
FIGURE 1: TEMPORAL EVOLUTION OF PAPERS PER CAPITA PUBLISHED BY MEN AND WOMEN BETWEEN 2011 AND 2018. THE LINE REPRESENTS THE ANNUAL NUMBER OF PAPERS PUBLISHED.



Source: Argentine Science and Technology Information Portal (MinCyT, 2020)

Figure 2 shows the papers per capita according to the age distribution of the authors, together with the confidence intervals (CI) associated with each indicator. In people aged between 20 to 30 the CIs between women and men overlap, which is also observed over 60 years old, while for the rest of the ranges there is no overlap between the intervals. This shows a significant difference at the 95% confidence level in the papers per capita in favour of male researchers between the ranges of 30 to 60 years old. The largest gap is observed between the ages of 40 and 50, where women publish an average of 3.18 (CI: [3.04; 3.32]) papers per capita and men 4.21 (CI: [4.02; 4.40]). For people over 60 years of age, the gender gap is shortened. Here is an overlap between the CIs and, therefore, the difference is no longer statistically significant. This result could suggest that female researchers over 60 years old had to demonstrate greater achievements to progress in their professional careers.

FIGURE 2: NUMBER OF PAPERS PER CAPITA ACCORDING TO AGE AND GENDER OF THE RESEARCH STAFF BETWEEN 2011 AND 2018. THE VERTICAL LINE IN BETWEEN EACH BAR REPRESENTS THE CONFIDENCE INTERVAL (CI).



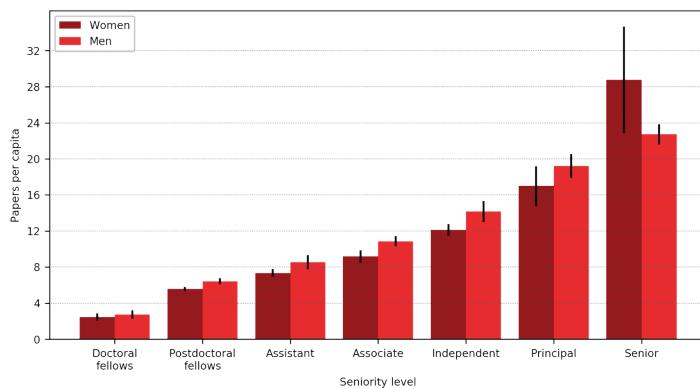
Source: Argentine Science and Technology Information Portal (MinCyT, 2020)

In terms of the number of published papers, there is a large gender disparity in favour of males beginning at the age of 30. This might be related to the care labour that women do while breastfeeding, as well as before and during the schooling of the children for whom they are responsible. In the scientific career, the period during which women perform care labour overlaps with the time when scientists begin to specialise, lead research groups, publish and/or produce patents. As a result, women's professional development in science is slowed down, which is difficult to reverse.

When disaggregating the papers per capita by seniority level and by gender, there is a greater number of papers published by men than by women, in almost all the categories considered

(Figure 3). The differences between doctoral fellows (i.e. PhD candidates) are not significant, however, they increase as the seniority level rises. The gaps in Postdoctoral Fellows, Assistant, Associate, and Independent Researchers are significantly in all cases. The major gap is presented in the latest category, always in favour of men. However, this significance no longer exists at the Principal level and the difference is reversed upon reaching the Senior level, meaning that women publish more papers than men in this category. A difference of 6.02 is observed, which indicates a trend of greater scientific production by women at this stage of their career. The reversal of the difference at the last level is striking.

FIGURE 3: NUMBER OF PAPERS PER CAPITA ACCORDING TO SENIORITY LEVEL FOR MEN AND WOMEN BETWEEN 2011 AND 2018. THE VERTICAL LINE IN BETWEEN EACH BAR REPRESENTS THE CONFIDENCE INTERVAL (CI).



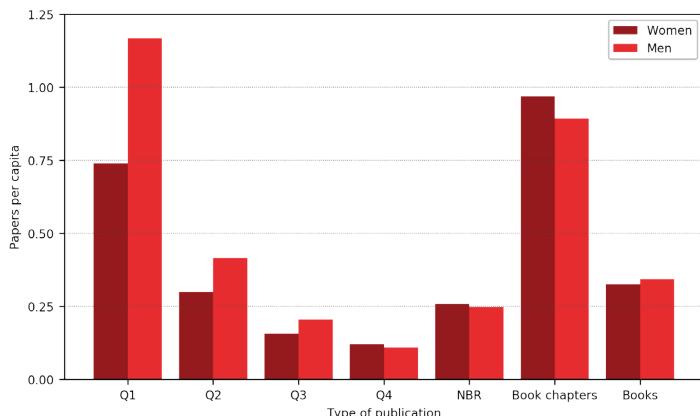
Source: Argentine Science and Technology Information Portal (MinCyT, 2020)

The remarkable difference found in the number of papers published by Senior Researchers shows that women are overqualified compared to men at this seniority level. This result suggests that only those women who have a very competitive profile reach the highest rank. An example of this enormous inequality is the number of people of each gender that occupy Senior level in 2018. Only 64 of 238 researchers are women, reflecting an alarming gap.

We also analyse gender gaps along with the different types of papers published (Figure 4). The greatest difference is found in the publications made in Q1 journals, with a per capita average of 1.17 for men and 0.78 for women. This difference decreases in those papers published in lower hierarchy journals (Q2 and Q3), and it is reversed in Q4 journals and NBR publications. Likewise, book chapters are mostly published by women while books are mostly by male authorship. This shows a differential productivity gap along with the publication type. Papers published in Q1 journals are the most relevant for the scientific career of the authors, allowing them to be more successful in submitting to faculty positions, project funding, or even seniority-level promotions.

We do not have the submission information to compare these results. However, even if the largest difference is due to women submitting fewer papers to Q1 journals than men, this also shows a relevant gender gap. The journals in which these publications appear are also not included in the database, so we do not have information on blind review processes.

FIGURE 4: NUMBER OF PAPERS PER CAPITA ACCORDING TO THE SJR INDEX FOR MEN AND WOMEN BETWEEN 2011 AND 2018.



Source: Argentine Science and Technology Information Portal (MinCyT, 2020)

Regarding patenting, a total of 5,626 patent applications were registered throughout the study period, of which 2,234 correspond to women while 3,392 to men. These values represent 39.7% and 60.3%, respectively, of all patent applications. This difference is also notable in the case of granted patents, with a total of 1,655 patents throughout the period and percentages of 38.6% and 61.4%, for women and men, respectively. Therefore, we choose to express the number of patents per thousand people and in the percentages that these amounts represent. It can be seen from Table 2, that by normalising these values, the number of patent applications by men (67.4%) is more than double than those of women (32.6%). This difference increases in the case of granted patents, with percentages of 68.4% and 31.6%, respectively.

TABLE 2: NUMBER OF PATENT APPLICATIONS AND GRANTED FOR MEN AND WOMEN IN THE TOTAL STUDY PERIOD.

	Women		Men	
	Number per thousand	Percentage (%)	Number per thousand	Percentage (%)
Patent applications	56.6	32.6	117.1	67.4
Granted patents	16.2	31.6	35.1	68.4

Source: Argentine Science and Technology Information Portal (MinCyT, 2020).

The comparison about patent applications and granted patents between both genders also shows a notable dissimilarity in favour of male researchers. Twice as many patents are requested by and granted to men. This difference could be due to gender inequality in terms of the incentives (will, initiative or self-esteem) of those able to patent their work. Also, competition within work teams could be in favour of men.

CONCLUSION

This work identifies apparently hidden gender inequalities in the scientific workforce of the Argentine Science, Technology, and Innovation system. Our results show that there is a significant gender gap, observed through several indicators, which describe the multifaceted nature and complexity of the issue: women are still underrepresented in scientific production. This can be seen, firstly, in the number of publications for each gender. The articles and books published by researchers are predominantly written by men, implying the construction of new scientific knowledge is dominated by a male perspective. Moreover, the same disparity is observed in patent applications and granted

patents, suggesting that innovative ideas in science are still more likely to be associated with men than with women.

Gender inequality becomes even more relevant when age groups and seniority level are analysed. Our analyses show that the gender gap in the number of publications is greater between the ages of 30 and 60. This difference narrows for researchers over 60 years old, which is consistent with the variations observed between categories of researchers. The discrepancy in publications in favour of men is widened in intermediate categories but is reversed for senior researchers. This suggests that the age of female researchers affects the number of hours they can dedicate to their professional careers. And this may be related to workload due to housework or caring for dependents.

At this point, the gender gap in Argentina's scientific and technological system is undeniable. We consider that the role of the Argentine state in reducing gender disparity in the promotion and production of science is relevant and crucial. Therefore, it is essential to further evaluate public support programs for research, as they can be crucial tools to reduce gender gaps in STI. As we have seen, horizontal disaggregation leads to a shortage of female researchers, especially in engineering and technology, due to multiple socio-cultural causes. For this reason, we recommend promoting women's careers in STEM through comprehensive public programs that address the issue in an interdisciplinary way.

Finally, this study was able to be conducted due to the availability of a public database. Although it would be ideal to have non-binary databases in terms of gender, the existence of free public information and indicators disaggregated by gender is very useful. This information is crucial for making gender gaps in science visible through reports and research. Therefore, we promote the implementation and preparation of surveys, data collection and analyses with a gender perspective.

It is extremely important to continue research such as that conducted in this study to produce robust statistical results that will enable the design and implementation of evidence-based policies to reduce gender gaps in science.

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