The Researcher Journey Through a Gender Lens

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An examination of research participation, career progression and perceptions across the globe

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The Researcher Journey Through a Gender Lens

Foreword

At Elsevier, our mission is to advance science and to improve healthcare outcomes through quality information and analytics. The only way we, and others, can make a lasting impact on the societal challenges of our times is by harnessing the full contribution of all stakeholders in the global research and healthcare community. Promoting gender diversity and inclusion in research through an evidence-based, measurable approach is an important part of this ongoing effort. We have been applying this approach to achieve a better balance of gender participation in research and are increasingly focusing on how gender is factored into research.

In this light, I am pleased to share our latest report: *The Researcher Journey Through a Gender Lens.*

The past fifty years have seen enormous strides for and by women in research. Women now comprise a greater share of science, technology, engineering, mathematics (STEM) and medicine graduates than ever before, and there is increased focus and energy on balanced participation, factoring gender into research and research on gender itself.

Yet, our latest findings indicate that disparities still linger, with slower growth of articles published by women, higher numbers of women leaving research and understudied research areas. This report also highlights that women are not participating in collaboration networks at the same level as men, potentially impacting their career progression. On average, men have more co-authors than women, with a tendency to collaborate with those of the same gender across the subject areas and regions studied, demonstrating that we have more work to do to address issues that cut across diversity *and* inclusion.

As the first woman CEO in Elsevier's 140-year history, I am proud and privileged to play a role in examining the consequences of women's underrepresentation in research and to implement solutions to drive more inclusive research. We have the responsibility to combine quality content with the latest in data analytics to gain robust insights into areas of gender imbalance and develop targeted strategies, such as recalibrating conferences, editorial boards and the peer review process, so research is curated to be more inclusive.

This new study builds on our previous two reports—*Gender in the Global Research Landscape* and *Mapping Gender in the German Research Arena*—by examining critical aspects of contribution, performance and influence through a gender lens. The report includes quantitative analyses of new areas and themes not covered in our earlier reports and, for the first time, incorporates a qualitative survey. We feel accountable to continue to share powerful, data-driven insight with researchers, governments, funders and institutions worldwide to inspire targeted initiatives and to inform policy.

These reports are part of Elsevier's broader commitment to gender diversity and inclusion, as a member of the global research community and in support of the United Nations' Sustainable Development Goal 5 to achieve gender equality and empower all women and girls. Through our Gender Working Group, we are continually refining key processes, principles and systems so that we can support the most robust research in the most equitable and inclusive way. We are actively targeting greater gender diversity for our journal editorial boards, reviewers and invited conference speakers, and are seeking to address the various layers where implicit bias can come into

play throughout the peer review process. Across our portfolio of journals, we have significantly enhanced editorial policies and guidance to authors on reporting about sex and gender in research studies and the use of inclusive language.

We are deliberately working to foster an inclusive culture across Elsevier, including enhanced development paths for women into senior leadership roles and more flexible benefits to foster greater work-life balance. This effort is spearheaded by our Global Head of Inclusion & Diversity and supported by the energy and passion of our 7,500 employees around the globe.

I am also excited to share that we are launching an Inclusion and Diversity Advisory Board, which brings together the passion and thoughtful contributions of preeminent leaders from across the international research and healthcare community. It is a great privilege to work with such a distinguished group of independent leaders towards finding lasting solutions to unlock the full potential of academic and applied research through greater diversity.

I hope the findings of our latest report will provide useful insights and drive action, by also learning from disciplines and countries where there has been more success in making progress. I look forward to collaborating with all stakeholders who share our objective of enhancing gender equity in research.

Kumsal Bayazit
Chief Executive Officer, Elsevier

We feel accountable to continue to share powerful, data-driven insight with researchers, governments, funders and institutions worldwide to inspire targeted initiatives and to inform policy.

The Researcher Journey Through a Gender Lens

Executive Summary

Gender diversity and inclusion are of growing importance and focus in many sectors, including business, education, government and research. Increasing gender diversity has a positive impact on productivity, boosts problem-solving and increases innovation – all essential outcomes for tackling the great challenges of our time, from health to food security, from climate change to sustainable communities.

As part of Elsevier's ongoing efforts to promote gender diversity and advance gender equity in research using an evidence-based approach, we developed this latest report to understand how gender impacts the researcher journey. Drawing on robust data sets, we analyzed information about authors of academic publications, grant recipients and patent applicants to gain insights into trends in gender-based representation across 15 countries and the EU28.

In recent decades there has been significant progress in terms of women's participation in research and we are seeing an increased focus on factoring gender into research.

However, our latest report shows that disparities still exist, demonstrating that we have more work to do to address issues that cut across diversity as well as inclusion.

In research authorship, we are closer to gender parity now than a decade ago, with women continuing to publish for nearly as long as men over the course of their careers.

In all the countries and regions featured in this report, the increase in women authors is closing a gender gap in terms of participation. In some research areas, authorship is approaching gender parity, particularly among authors with a short publication history and in many subject areas within the life and health sciences. In some subjects, notably nursing and psychology, women now represent the majority of authors. Conversely, men are better represented among authors with a long publication history, across all subject areas within the physical sciences and as last and corresponding authors.

In addition to the general global trends, there were notable country-specific findings. For example, Argentina was the closest to gender parity among authors overall, while Japan had the lowest ratio of women to men among authors in all subject areas. Spain and Mexico had the largest increases in the proportion of women among inventors. In many countries, however, the proportion of women among grant recipients corresponds with women's underrepresentation as last and corresponding authors on papers. Moreover, among patent applicants, women were very poorly represented and little change was observed over time, suggesting high gain potential in this segment of the innovation pipeline.

However, the ratio of women to men as authors decreases over time, contributing to men publishing more, having greater impact as well as exposure to international career advancement.

The ratio of women to men declined from the time of first publication to 10 years later in all countries and regions, except for Portugal. Moreover, in every country, the percentage of women who continue to publish over time is slightly lower than for men. International experiences are associated with a higher retention of authors, and men are more likely than women to travel outside their home

country during their research careers. Among those who publish outside their home country, men are more likely to continue to publish than women, further reflecting a retention disparity. Among authors who traveled internationally, in most countries and in the EU28, men publish more and have a slightly higher citation impact than women.

Women have a smaller footprint in the research landscape and fall behind men among grant awardees and patent applicants.

While having a diverse workforce of researchers is important, it is equally important for individual career progression that the researcher footprint—including publications and citations, grant awards and patent applications—reflects growth in participation.

However, men have a larger research footprint in general: they publish more than women, are awarded more grants than women, and apply for more patents than women. This is a trend apparent in every country examined. Furthermore, on average, the citation impact of men's first author publications is higher than that of women's, intimating a gender bias in citation practice.

Collaboration approaches differ by gender as men have more direct collaborators than women, although women and men are equally central to their networks overall.

Broadly, across subject areas and countries, men tend to have more co-authors than women do, with the gap widening as publication history increases, which likely contributes to men having a higher publication output than women. However, women and men are equally connected to second-order collaborators and to international co-authors – except in the EU28, where men establish international collaborations slightly more than women do. Notably, both men and women preferentially collaborate with authors of the same gender.

Attitudes toward gender issues vary, necessitating tailored communication and action.

Researcher attitudes towards the role of gender in academia vary, guided by the importance they place on gender diversity and inclusion and by how fair they perceive the academic system to be. This was the case for several topics, from the impact of gender on recruitment and promotion to interventions aimed at increasing gender diversity. There was general agreement that family duties can negatively impact women's research careers. Differing opinions on the causes of gender bias were reflected in different interventions suggested by respondents. These findings speak to the need for institutions, organizations and policymakers to customize the communication strategies related to their gender diversity and inclusion initiatives to account for different perspectives, so that those initiatives can fully succeed.

Chapter 1

Research Participation

Assessing gender diversity among researchers

Key Findings

- *In all countries studied and the EU28, the ratio of women to men among all authors is closer to parity during a recent 5-year period compared with a decade ago.*

- *Men are more highly represented among authors with a long publication history while women are highly represented among authors with a short publication history.*

- *In most countries, the ratio of women to men among authors is lowest in the physical sciences and highest in the life and health sciences. Nursing and psychology stand apart with more women than men among authors. Japan has the lowest ratio of women to men among authors in every subject area.*

- *The greatest increase in the proportion of women among authors is seen in nursing and psychology and the smallest increase is seen in the physical sciences.*

- *Last authors and corresponding authors consist of proportionally more men than women compared with the overall author population in every country.*

- *In many countries, the proportion of women among grantees closely reflects the proportion of women among corresponding and last authors.*

- *The ratio of women to men among inventors and assignees is very low compared to the ratio observed for authors and grantees. Most countries show very modest changes in these ratios over time. Spain and Mexico stand apart for having the largest increases in the proportion of women among inventors.*

Research Participation

Introduction

Studies have shown that gender diversity in the workforce correlates with profitability and value creation[1], and that gender-diverse leadership improves productivity[2]. In an age when research must demonstrate return on investment, the benefits of gender diversity are increasingly important. Furthermore, research is increasingly collaborative, and studies have demonstrated that the proportion of women in a group is one of three key factors that correlate with the collective intelligence of that group.[3] Yet, the gender gap among researchers within the global scientific workforce persists across subject areas and geographic regions.[4] In 2018, 28.8% of researchers globally were women per the UNESCO Institute for Statistics.[5] Elsevier's 2017 report, Gender in the Global Research Landscape, reported that the proportion of women among researchers ranges from 20% to 49% across 12 countries and regions.[6] Participation in research by women also varies by subject area, with relatively higher proportions of women in the biomedical sciences and lower proportions in the physical sciences. Suboptimal gender balance among researchers increases the risk of suboptimal productivity, creativity and innovation within the global scientific endeavor.

1 McKinsey & Company. (2018). Delivering through Diversity. Retrieved from: www.mckinsey.com/~/media/mckinsey/business%20functions/organization/our%20insights/delivering%20through%20diversity/delivering-through-diversity_full-report.ashx. Accessed November 24, 2019.; Zhang, L. (forthcoming). An institutional approach to gender diversity and firm performance. Organization Science. Retrieved from: www.hbs.edu/faculty/Publication%20Files/Final_version_6cb1dbd5-9c48-4a1c-9afa-237da2a1a7b4.pdf. Accessed November 24, 2019.

2 Dezso, C. L., & Ross, D. G. (2011). Does female representation in top management improve firm performance? A panel data investigation (March 9, 2011). Robert H. Smith School Research Paper No. RHS 06-104. Retrieved from: papers.ssrn.com/sol3/papers.cfm?abstract_id=1088182. Accessed November 24, 2019.

3 Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. Science, 330(6004), 686-688. doi: 10.1126/science.1193147

4 Charlesworth, T., & Banaji, M. (2019). Gender in science, technology, engineering, and mathematics. Journal of Neuroscience, 39(37), 7228-7243. doi: 10.1523/JNEUROSCI.0475-18.2019; Fox, M., Whittington, K., & Linkova, M. (2017). Gender, (in)equity, and the scientific workforce. In: Handbook of Science and Technology Studies. Cambridge, MA: MIT Press.; Elsevier. (2015). Mapping Gender in the German Research Arena. Retrieved from: www.elsevier.com/research-intelligence/resource-library/gender-2015. Accessed October 28, 2019.; United Nations Educational, Scientific and Cultural Organization. (2015). UNESCO Science Report: Towards 2030. Retrieved from: unesdoc.unesco.org/in/documentViewer.xhtml?v=2.1.196&id=p::usmarcdef_0000235406&file=/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_871d5667-bd86-4feb-a045-f802628d2f48%3F_%3D235406eng.pdf&locale=en&multi=true&ark=/ark:/48223/pf0000235406/PDF/235406eng.pdf#%5B%7B%22num%22%3A647%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2Cnull%2Cnull%2C0%5D. Accessed November 24, 2019.

5 UNESCO. (2018). Women in Science. Fact Sheet No. 51. June 2018 FS/2018/SCI/51. Retrieved from: uis.unesco.org/sites/default/files/documents/fs51-women-in-science-2018-en.pdf. Accessed October 23, 2019.

6 Elsevier. (2017). Gender in the Global Research Landscape. Retrieved from: www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.

The reasons underlying the gender gap in the scientific workforce—and how to address it—is a topic of intense study. The She Figures 2018 report noted near gender parity among researchers at the graduate level, but far fewer women at top positions within their fields.[7] This under-representation of women in leadership positions has been attributed to various factors, from gender differences in STEM (science, technology, engineering and mathematics) education, to challenges with work-life balance and systemic gender bias in hiring, promotion, publishing and funding.[8]

Diversity within the scientific workforce, including gender diversity, brings unique perspectives, drives creativity and innovation and provides new contexts for understanding and applying research findings.[9] Acknowledgment of the gender gap in research and its negative impact on progress has led to various institutional, national and global efforts to address the factors that steer girls and women away from seeking or staying in a research career.[10] Although a gender gap persists in many fields and countries, and the gap is closing more slowly in certain subject areas and countries,[11] Elsevier noted in their 2017 report that the proportion of women among researchers increased from 1996–2000 to 2011–2015 in all subject areas and geographies studied.[12]

Understanding the dynamics of participation of men and women in research will help inform strategies to further reduce the gender gap in the global scientific workforce.[13] This chapter describes the scientific workforce and how it has changed over time across 15 countries and the EU28 in 26 subject areas, comparing the number of men and women among researchers who are authors of scientific publications, awardees of grants and inventors and patent holders. Using comprehensive data sources such as Elsevier's Scopus and Funding Institutional databases and the European Patent Office (EPO) Worldwide Patent Statistical Database, PATSTAT, this analysis provides a multifaceted view of the research community along three of the main activities that researchers undertake: publishing research (scholarly communication), obtaining grant support (research funding) and registering patents (research innovation).

Such evidence-based findings are a crucial step towards greater gender diversity: by understanding where we stand, based on where we have come from and how we have achieved progress, we can determine how to continue on our journey towards even greater gender balance in the world of research.

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7 European Commission Directorate-General for Research and Innovation. She Figures 2018. (2019). Brussels, Belgium: European Union. doi: 10.2777/936; National Research Council. (2010). Gender differences at critical transitions in the careers of science, engineering, and mathematics faculty. Retrieved from: doi.org/10.17226/12062. Accessed October 23, 2019.; Gibney, E. (2016). Women under-represented in world's science academies. Nature. February 26. Retrieved from: www.nature.com/news/women-under-represented-in-world-s-science-academies-1.19465. Accessed October 23, 2019.

8 Charlesworth, T., & Banaji, M. (2019). Gender in science, technology, engineering, and mathematics. Journal of Neuroscience, 39(37), 7228-7243. doi: 10.1523/JNEUROSCI.0475-18.2019; Association of Women in Science. (2019). Transforming STEM Leadership Culture. Retrieved from: www.awis.org/leadership-report/. Accessed October 28, 2019.

9 Nielsen, M., Bloch, C., & Schiebinger, L. (2018). Making gender diversity work for scientific discovery and innovation. Nature Human Behavior, 2(10), 726-724. doi: 10.1038/s41562-018-0433-1

10 Beeler, W., Smith-Doody, K., Ha, R., Aiyar, R., Schwarzbach, E., & Solomon, S. (2019). Forum institutional report cards for gender equality: lessons learned from benchmarking efforts for women in STEM. Cell Stem Cell, 25(3), 306-310. doi: 10.1016/j.stem.2019.08.010

11 Holman, L., Stuart-Fox, D., & Hauser, C.E. (2018). The gender gap in science: how long until women are equally represented? PLoS Biology, 16(4), e2004956. doi: 10.1371/journal.pbio.2004956

12 Elsevier. (2017). Gender in the Global Research Landscape. Retrieved from: www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.

13 Coe, I., Wiley, R., & Bekker, L. (2019). Organizational best practices toward gender equality in science and medicine. Lancet, 393(10171), 587-593. doi: 10.1016/S0140-6736(18)33188-X

Research Participation

Authors of Research Publications

Authorship of research publications is one way that researchers contribute to the advancement of knowledge. The demographics of the author pool may reflect gender differences if research does not appeal to women and men to the same degree. The appeal of research to women compared to men can differ because of cultural differences in how research is portrayed or perceived, or how welcoming the research environment is to women compared to men. This difference in the appeal of research ultimately manifests as differences in who is recruited and retained as part of the research workforce. In 2019, Elsevier's Customer Insights team conducted a survey to examine the perceptions of active researchers (self-identified as spending at least 20% of their academic/work activity conducting research on an ongoing basis) around career progression and gender balance in scholarly research. The survey revealed that 37% of active researchers think that gender imbalance in their field may be due to a lack of encouragement of women to pursue education or careers in that field starting from an early age. In addition, 42% of women surveyed described their workplace culture as gender-biased, and 38% of women reported bias or discrimination in recruitment, hiring and promotion processes (Appendix C, Figure C.1).

To provide greater insight into who participates in research as an author, we analyzed the active author populations for 15 countries and the EU28 during the periods 1999–2003 and 2014–2018.

We found a trend towards gender parity among authors when comparing active authors in 2014–2018 to those in 1999–2003 in all countries studied and the EU28 (Figure 1.1 and supplemental data Table B.1). This finding is consistent with the global research community's perceptions, with 61% of active researchers surveyed by Elsevier indicating that there are more women in research now compared to 10 years ago (Appendix C, Figure C.2). For most countries, the ratio was higher in 2014–2018 compared to 1999–2003 by approximately 20 women for every 100 men. Portugal showed the greatest increase in the ratio of women to men authors, from 63 women per 100 men in 1999–2003 to 94 women per 100 men in 2014–2018. Japan showed the smallest change over time, from 11 women per 100 men in 1999–2003 to 18 women per 100 men in 2014–2018. Among the countries analyzed, Argentina stood out for being the closest to parity among its authors in the period 2014–2018, with 104 women per 100 men.

As previously noted, cultural differences can explain the appeal of research to women compared to men and it is therefore striking that while Argentina shows a larger number of women in research than men, the Global Gender Gap Report 2020 from the World Economic Forum (http://www3.weforum.org/docs/WEF_GGGR_2020.pdf) shows Argentina in 30th position with a Gender Gap Index of 0.746. As a point of comparison, the index for Germany, which is ranked 10th, is 0.877 but shows lower proportion of women in research in our analysis. Similarly, while our findings show a higher proportion of women in research in Portugal, the country's Gender Gap Index is 0.744 (ranked 35th). Further investigation might reveal an explanation for this difference between the research world and wider society. On the other hand, Japan's low Gender Gap Index of 0.652 (ranked 121st) is consistent with the low proportion of women in research identified in our analysis.

FIGURE 1.1

Gender ratio among active authors during the periods 1999–2003 and 2014–2018 in each country and the EU28.

KEY

- 1999–2003
- 2014–2018

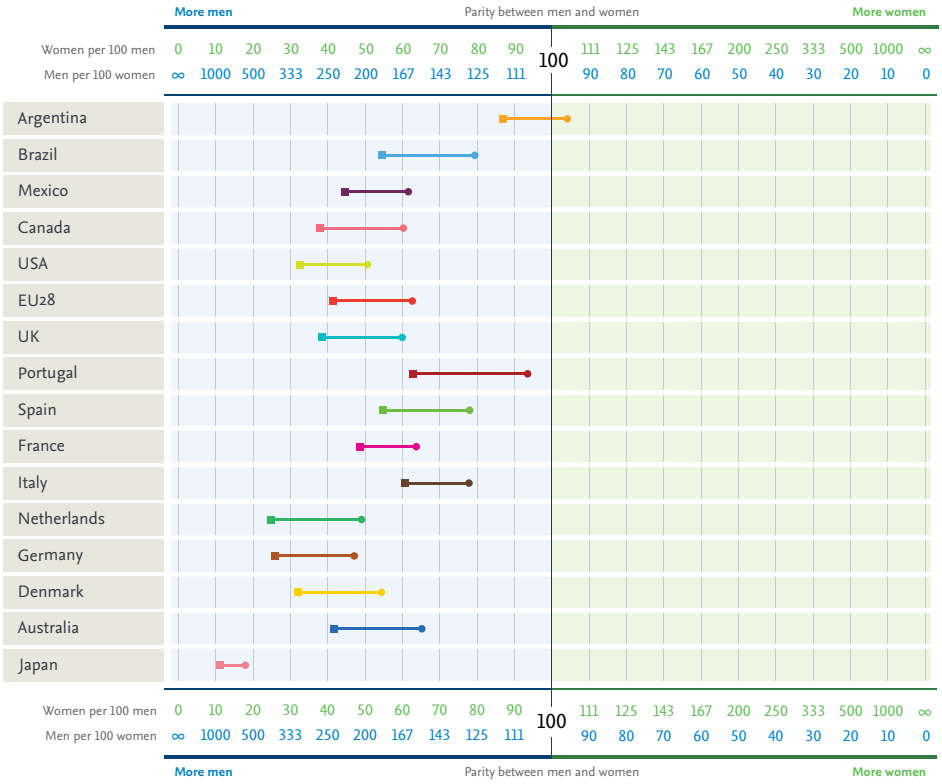


FIGURE 1.1 TAKEAWAY:

In all countries and the EU28, the ratio of women to men is closer to parity in the period 2014–2018 compared to 1999–2003.

HOW WE CONDUCTED THE AUTHOR-LEVEL ANALYSES

For each period analyzed, we defined active authors as those who authored at least two publications during the study period. To ensure that we did not exclude junior authors, we included any author who had their first publication during the period 1999–2003 if they had at least one more publication in the five years after the first publication, and any author who had only one publication during the period 2014–2018 if their first publication was published during that period. Authors were counted towards a country's author count if more than 30% of their publications during the period indicated an affiliation with that country (through the institutional affiliations associated with that author on the publication). Countries included in these analyses had at least 30,000 active authors from 2014 to 2018 for whom a gender could be inferred. Detailed methods are available in Appendix A.

The findings in Figure 1.1 reflect the total author population in each country regardless of field of study or time since first publication. However, we expected to find considerable differences across these parameters even within the same country. To clarify whether author ratios vary among authors with different publication start dates, we disaggregated the authors based on when they first published. This approach allowed us to assess how generational effects contribute to author parity by using publication start date as a proxy for age, with the assumption that, for example, if an author is actively publishing during the period 2014–2018 and their first publication was in 1999, they are likely older than someone whose first publication was in 2010.

We assigned the active authors from the period 2014–2018 into four defined categories, from those with the longest publication history (group A) to those with the shortest publication history (group D) according to the following parameters: group A – first publication in 2003 or prior; group B – first publication in 2004–2008; group C – first publication in 2009–2013; group D – first publication in 2014–2018.

In every country analyzed, the ratio of women to men authors was closest to parity among those with the shortest publication history (group D; likely the youngest group of authors), and furthest from parity among those with the longest publication history (group A; likely the oldest group of authors), with groups C and B in between (Figure 1.2). Those with the shortest publication history also represented the largest group of authors in each country and the EU28 (supplemental data Figure B.1), indicating that author ratios at the most junior levels are an important underlying factor driving the overall author ratios seen at the country level. In some countries, particularly those countries at or close to gender parity overall, such as Argentina and Portugal, the most junior groups consisted of more women than men authors. For most countries, there were 30-40 more women per 100 men in the most junior group compared to the most senior group of authors. The least difference in gender balance among the four author groups was seen in Argentina, which was also closest to gender parity overall, and in Japan, which had the lowest ratio of women to men authors regardless of author publication history. These results suggest generational differences in the numbers of women and men authors. In Chapter 3, we assess whether there are differences in how many authors continue to publish over time and whether the rate of continued authorship differs for women compared to men.

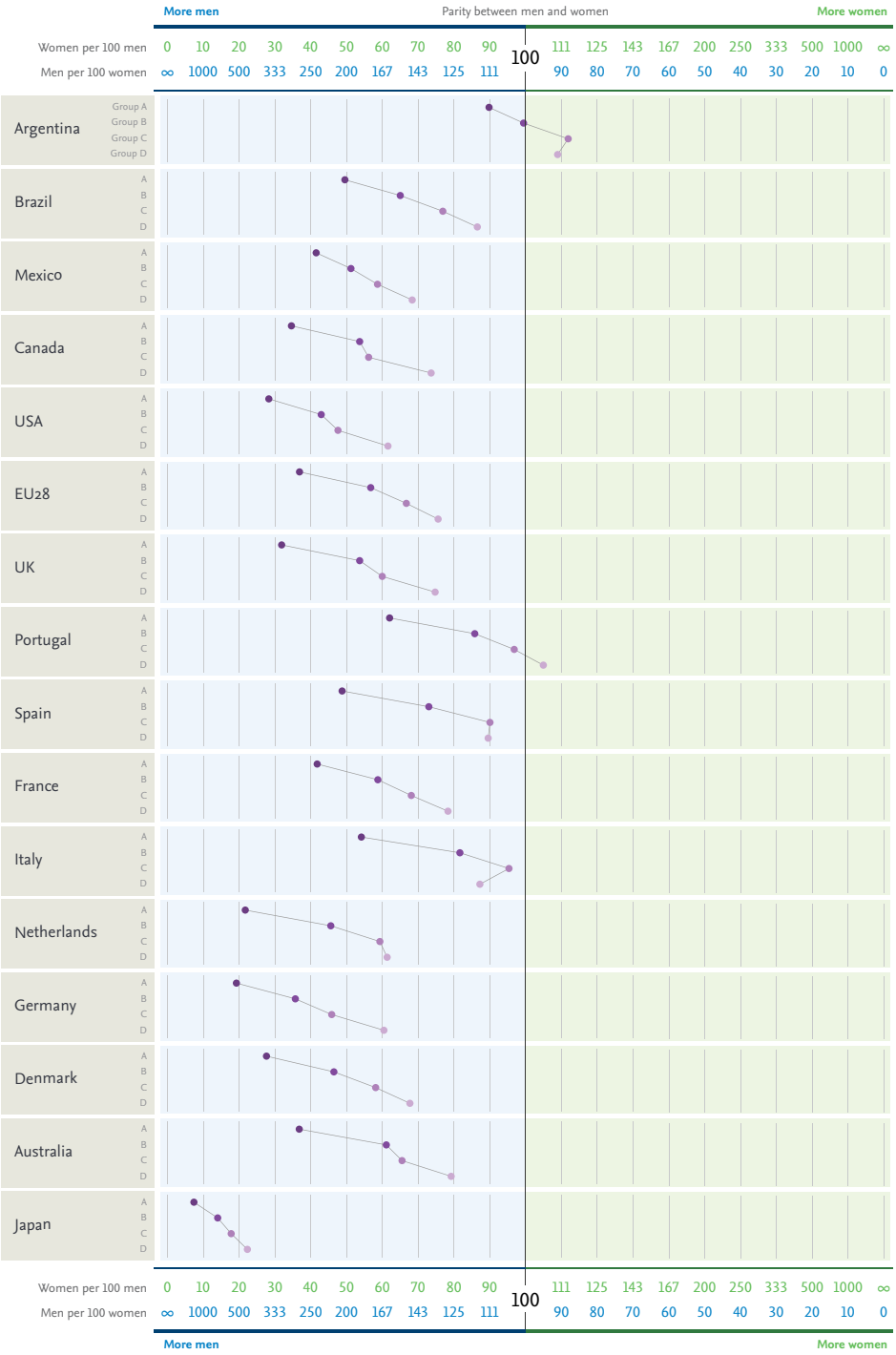
FIGURE 1.2

Gender ratio among active authors during the period 2014–2018 in each country, grouped based on year of author's first publication.

KEY	GROUP	YEAR OF FIRST PUBLICATION
●	A	2003 or prior
●	B	2004–2008
●	C	2009–2013
●	D	2014–2018

FIGURE 1.2 TAKEAWAY:

Men are more highly represented among authors with a long publication history while women are highly represented among authors with a short publication history.



Country-level gender statistics are greatly influenced by author and gender distribution across subject areas. Across the countries and region studied, authors in medicine are the most highly represented group, representing 15% (in Germany) to 23% (in Italy) of all authors (supplemental data Figure B.2). Authors in biochemistry, agricultural sciences and engineering represent 10-13% of authors in some countries. Authors in all other subject areas represent less than 10% of authors in the country.

Figure 1.3 shows that among active authors during the period 2014–2018, the lowest ratio of women to men was observed in the physical sciences (median ratio among countries ranged from 20 women per 100 men in mathematics to 51 women per 100 men in environmental science). In many life sciences and health sciences subject areas, the median ratio among the countries analyzed was close to parity. Nursing was an exception among the health sciences subject areas, in that women predominated. Among the social sciences, psychology was the exception in that women predominated in most countries. In all other social sciences subject areas, the median ratio of women to men was below parity but was still above the median observed for subject areas in the physical sciences. These data are consistent with the research subject area demographics reported in Elsevier's 2019 survey of active researchers in the global research community (Appendix C, Figure C.3). We also found that broad observations made at the country level were reflected within each subject area, with the highest ratio of women to men observed for Argentina and the lowest ratio observed for Japan across all subject areas.

In every subject area, among the countries analyzed, the median ratio of women to men among active authors in 2014–2018 was higher than the median ratio among authors in 1999–2003 (supplemental data, Figure B.3). The smallest increase in median ratio was seen for subject areas in the physical sciences, where the median in 2014–2018 was 6 to 8 more women per 100 men than in 1999–2003 in several subject areas (computer science, mathematics, physics & astronomy, materials science, engineering, energy). Among the physical sciences, environmental science showed the greatest increase in the proportion of women, with 18 more women per 100 men in 2014–2018 than in the previous period (based on median ratio among countries analyzed). In contrast, the life and health sciences showed the greatest increase in women as a proportion of men, with medians ranging from 20 more women per 100 men in biochemistry to 64 more women per 100 men in nursing in 2014–2018 compared with 1999–2003. The changes observed in nursing were interesting given that, in most countries, even though women predominated as authors in 1999–2003, the proportion of women among authors in nursing was even higher in 2014–2018 for each country. For example, among the countries analyzed, Australia had the highest proportion of women among active authors in nursing in 1999–2003, with 171 women per 100 men. This increased to 245 women per 100 men in 2014–2018.

HOW WE DID THE SUBJECT-LEVEL ANALYSES

To examine how author gender distribution varies within research disciplines, we assessed gender ratios using the Scopus journal classification system, All Science Journal Classification (ASJC). In this system, titles in Scopus are classified under four broad subject clusters (life sciences, physical sciences, health sciences and social sciences), which are further divided into 27 major subject areas, which in turn are composed of more granular subcategories. Journals are classified into one or more of these subcategories based on their content. Journals that are not discipline-specific such as Nature and Science fall under the classification "multidisciplinary."

For our analyses, publications in "multidisciplinary" journals were re-classified into the appropriate subcategories based on the text in their titles and abstracts using Elsevier fingerprinting technology. Authors were counted towards a subject area/subcategory if more than 30% of their publications during the period were published in a journal with that classification. Authors who published 30% or more of their publications in journals classified in multiple subject areas/subcategories will count towards more than one subject area/subcategory.

FIGURE 1.3

Physical sciences

Gender ratio among active authors during the period 2014–2018, disaggregated according to subject area.

KEY

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

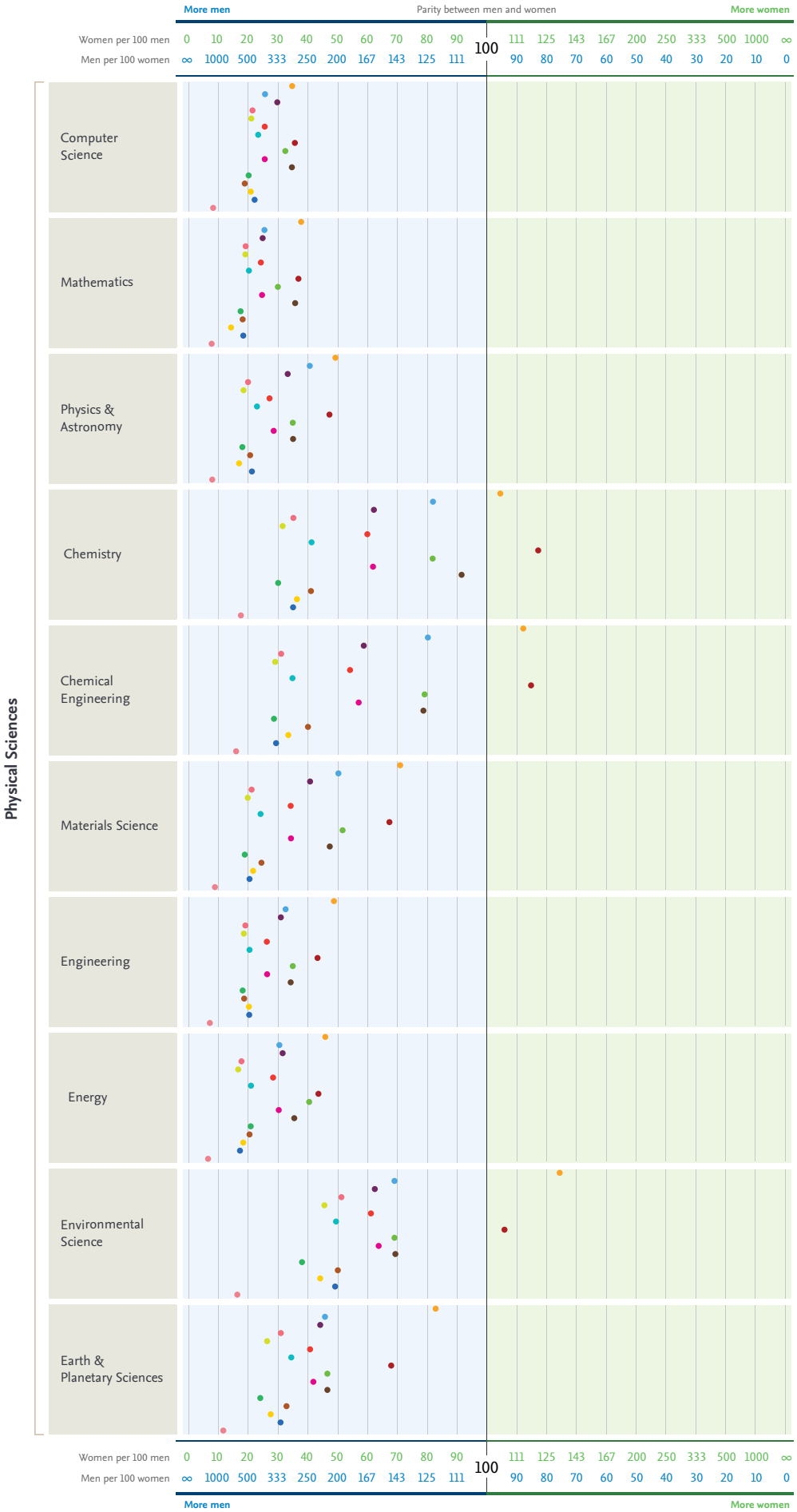


FIGURE 1.3 (CON'T)

Health and life sciences

Gender ratio among active authors during the period 2014–2018, disaggregated according to subject area.

KEY

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

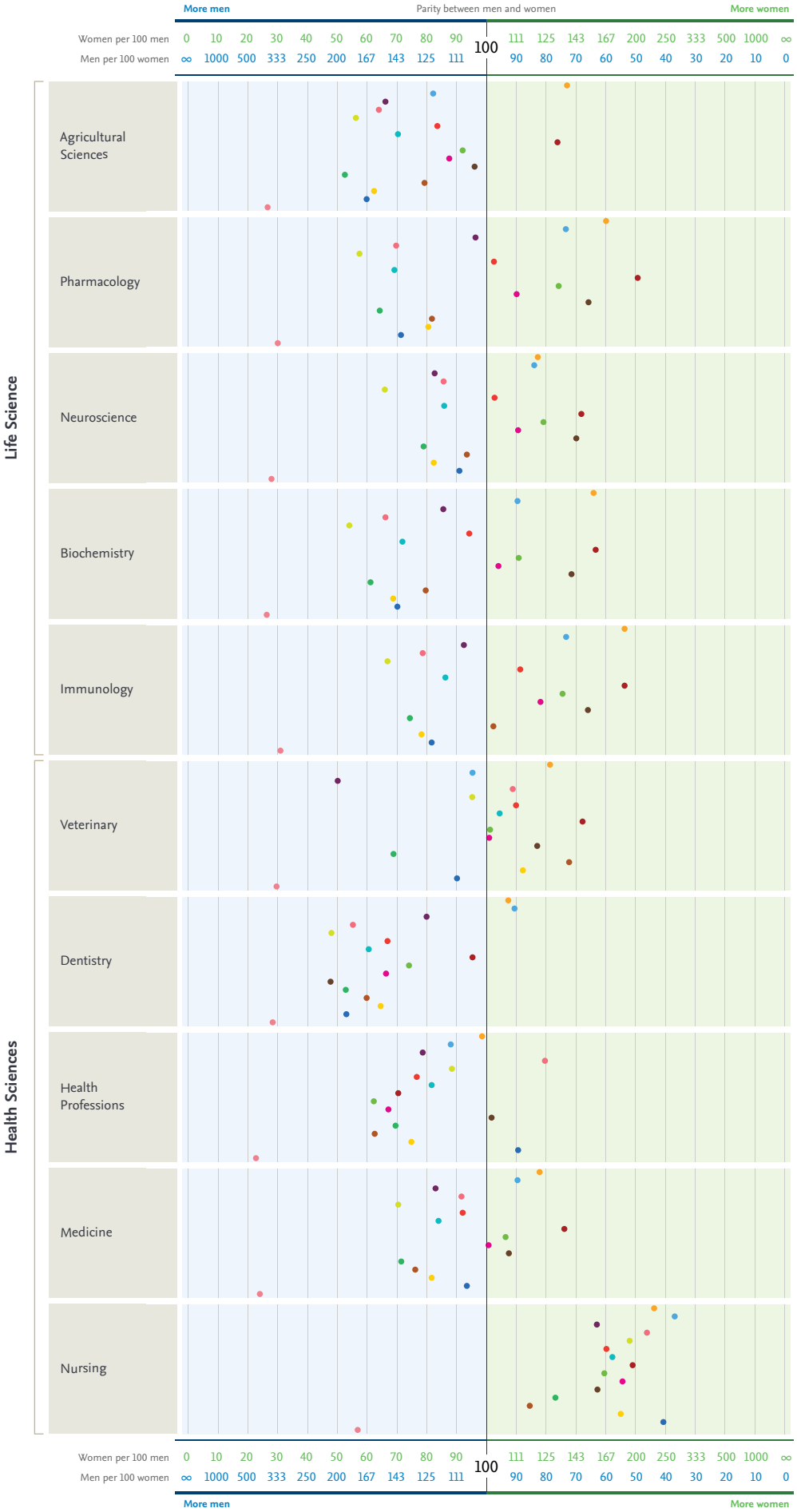


FIGURE 1.3 (CON'T)

Social sciences

Gender ratio among active authors during the period 2014–2018, disaggregated according to subject area.

KEY

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

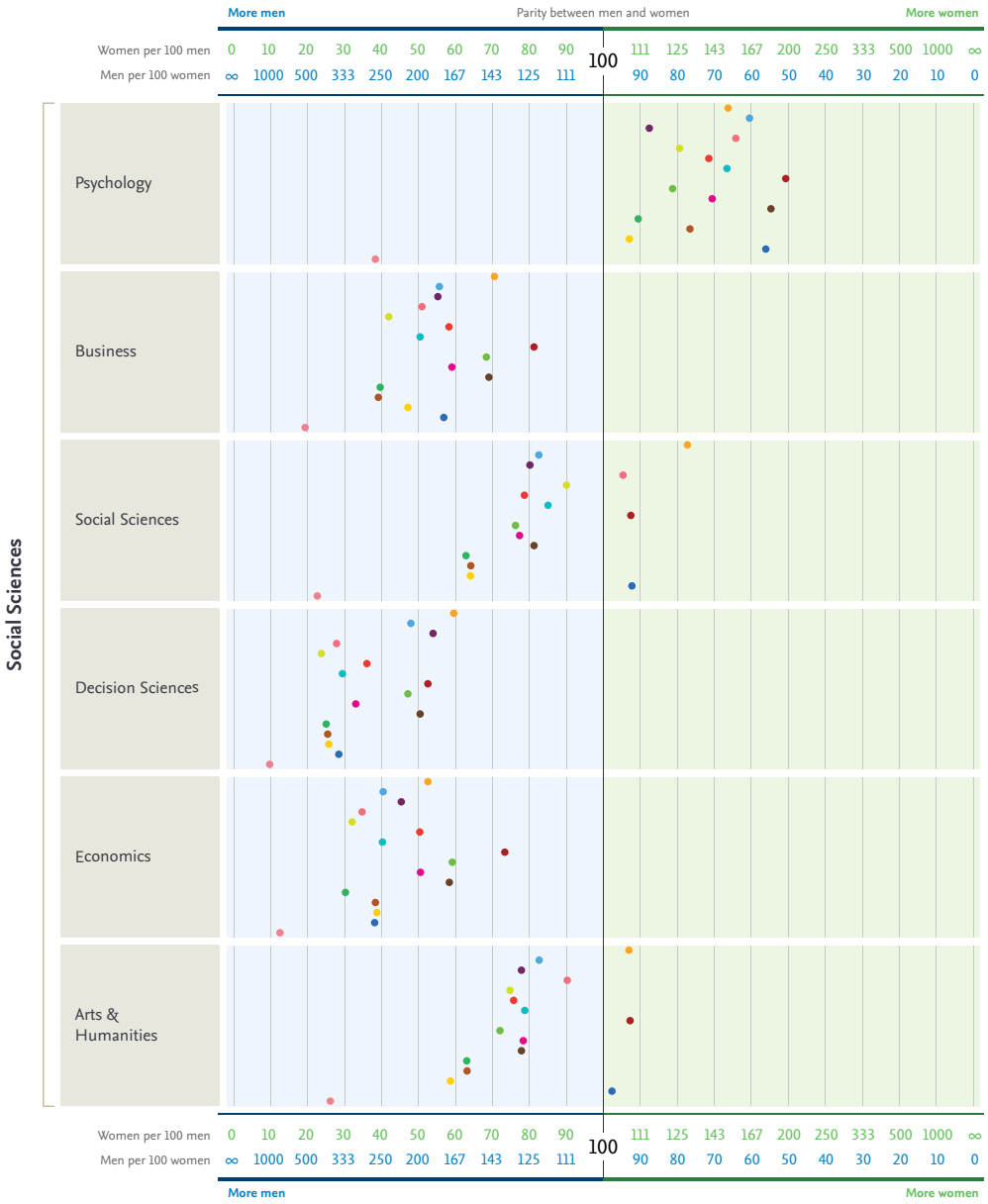


FIGURE 1.3 TAKEAWAY:

For most countries, the ratio of women to men is lowest in the physical sciences and highest in the life and health sciences. Nursing and psychology stand apart with more women than men in most countries. Japan has the lowest ratio of women to men in every subject area.

Disaggregating active authors from the period 2014–2018 within each subject area according to year of first publication, we observed similar trends as those seen for all researchers in aggregate: there were more women among authors who started publishing recently (presumably younger authors) compared to those with a longer publication history, regardless of subject area (supplemental data, Figure B.4).

Authorship position can indicate an author's contribution to the research in some fields. We assessed gender balance among active authors in the position of corresponding author, first author and last author (as provided by the authors at the time of publication, as captured in Scopus) over the two time periods and examined differences in gender balance for each author position compared to the overall author population.

Across all countries, the population of corresponding authors and last authors consisted of slightly more men compared to the total author population (Figure 1.4). First authors tended to be similar in gender distribution to the author population as a whole. To determine what factors underlie this trend, we assessed the publication history of authors within each authorship position group. We found that in every country, the total population of active authors and first authors mostly consisted of those who first published between 2014–2018 while corresponding authors and last authors have been publishing for a longer time (supplemental data Figure B.5). This suggests a relationship between authorship position and author seniority.

Consistent with the data on all authors, the ratio of women to men in these positions (corresponding author, first author and last author) in the 2014–2018 cohort was higher than in the 1999–2003 cohort, across all countries (supplemental data Figure B.6), suggesting that differences in gender ratio observed over time apply to authorship positions as well.

When we normalized the ratio of women to men in specific authorship positions to the ratio overall, we found that the greatest divergence in ratio based on authorship position occurred in the life sciences and the health sciences (supplemental data Figure B.7). In these fields, we observed that the ratio of women to men was lower among corresponding authors compared to the overall author population and was lower among last authors compared with corresponding authors. Immunology stood out in this regard, with 97 women per 100 men overall (median among countries) compared to only 68 women per 100 men as corresponding authors and 52 women per 100 men as last authors. The ratio of women to men among first authors was frequently the same as the overall author ratio. Together, these data suggest that in these fields, first authors generally have a shorter publication history and are more likely to be women, while corresponding and last authors generally have a longer publication history and are less likely to be women. These observations are consistent with the idea that, in the life sciences and health sciences, the last author is more likely to be the lead Principal Investigator (PI) responsible for securing funding and the first author is more likely to have less experience and be more junior. Thus, our results suggest that in the life and health sciences, the proportion of women among PIs is low, while the proportion of women among junior researchers, though still below parity in most countries, is higher.

Men are more highly represented among authors with a long publication history while women are highly represented among authors with a short publication history.

FIGURE 1.4

Gender ratio among active authors in 2014–2018 disaggregated based on author position.

KEY

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

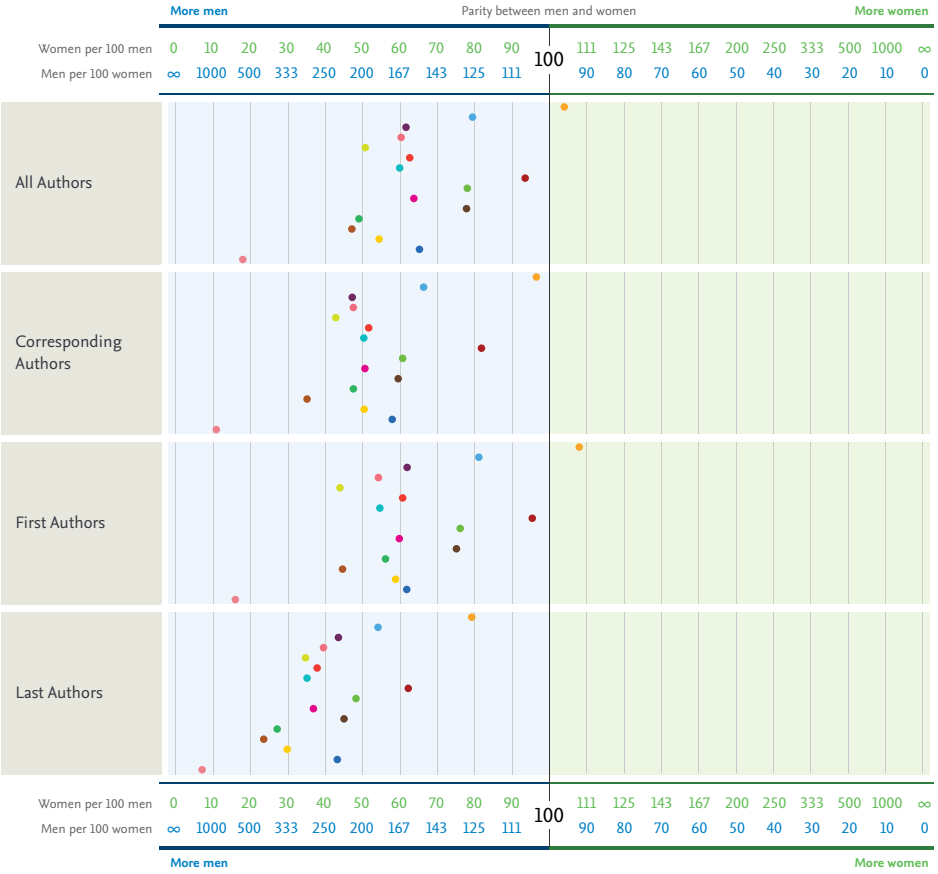


FIGURE 1.4 TAKEAWAY:

Last authors and corresponding authors consist of proportionally more men than women compared with the overall author population in every country.

Case Study:

Gender diversity within subfields of medicine

For the subject area-level analyses shown throughout chapter 1, we assessed the ratio of women to men within 26 major subject areas. Because the subject area of medicine is broad and includes several subfields, we further disaggregated the data within the subject area of medicine to provide insight on gender diversity across the subfields within medicine. These subfields are based on a combination of subcategories as explained in Appendix A, section "Subject areas and subfields included in the analysis."

We observed that within the subject area of medicine, the subfield of fertility & birth saw the greatest increase in representation of women among authors: during the period 1999–2003, the median ratio among countries was 73 women per 100 men, whereas during the period 2014–2018, the median was 161 women per 100 men (Figure 1.5). This increase in the median between periods was greater than the increase seen in the subject areas of nursing and psychology (supplemental data, Figure B.3). Pediatrics saw a similarly large increase in the proportional representation of women among active authors, with the median ratio increasing to 150 women per 100 men during the period 2014–2018, from 75 women per 100 men during the period 1999–2003.

Among active authors during the period 2014–2018, the median ratio of women to men among the countries studied was highest in the subfield of fertility & birth, followed by pediatrics (Figure 1.5, Figure B.8). The lowest ratio of women to men was observed in the subfields of surgery followed by cardiology & pulmonology. General clinical medicine, cancer and infectious diseases & allergy had a ratio of women to men that was similar to the subject area of medicine overall. In all subfields of medicine, Japan had the lowest ratio of women to men while Portugal often had the highest ratio of women to men among authors.

As observed at the country and subject area levels, we noted a higher ratio of women to men among authors with a shorter publication history (Figure 1.6). In many subfields of medicine, the median ratio of women to men was observed to be notably higher among those who first published in 2004–2008 compared with authors who first published in 2003 or prior. However, in emergency medicine, surgery, radiology & imaging and cardiology & pulmonology, the ratio of women to men increased more gradually among authors with a shorter publication history.

Together, these data show that although women's representation as authors has increased in all subfields of medicine analyzed, the pace of change in emergency medicine, surgery, radiology & imaging and cardiology & pulmonology has lagged the pace seen in medicine overall. In contrast, a high pace of change in fertility & birth and pediatrics has resulted in the underrepresentation of men in these subfields.

FIGURE 1.5

Gender ratio among active authors during the period 1999–2003 and 2014–2018 in the subject area of medicine and its subfields. Data for selected subject areas within the life sciences are shown for comparison.

KEY

■ 1999–2003 ● 2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE 1.5 (CONT)

Gender ratio among active authors during the period 1999–2003 and 2014–2018 in the subject area of medicine and its subfields. Data for selected subject areas within the life sciences are shown for comparison.

KEY

1999–2003 ● 2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

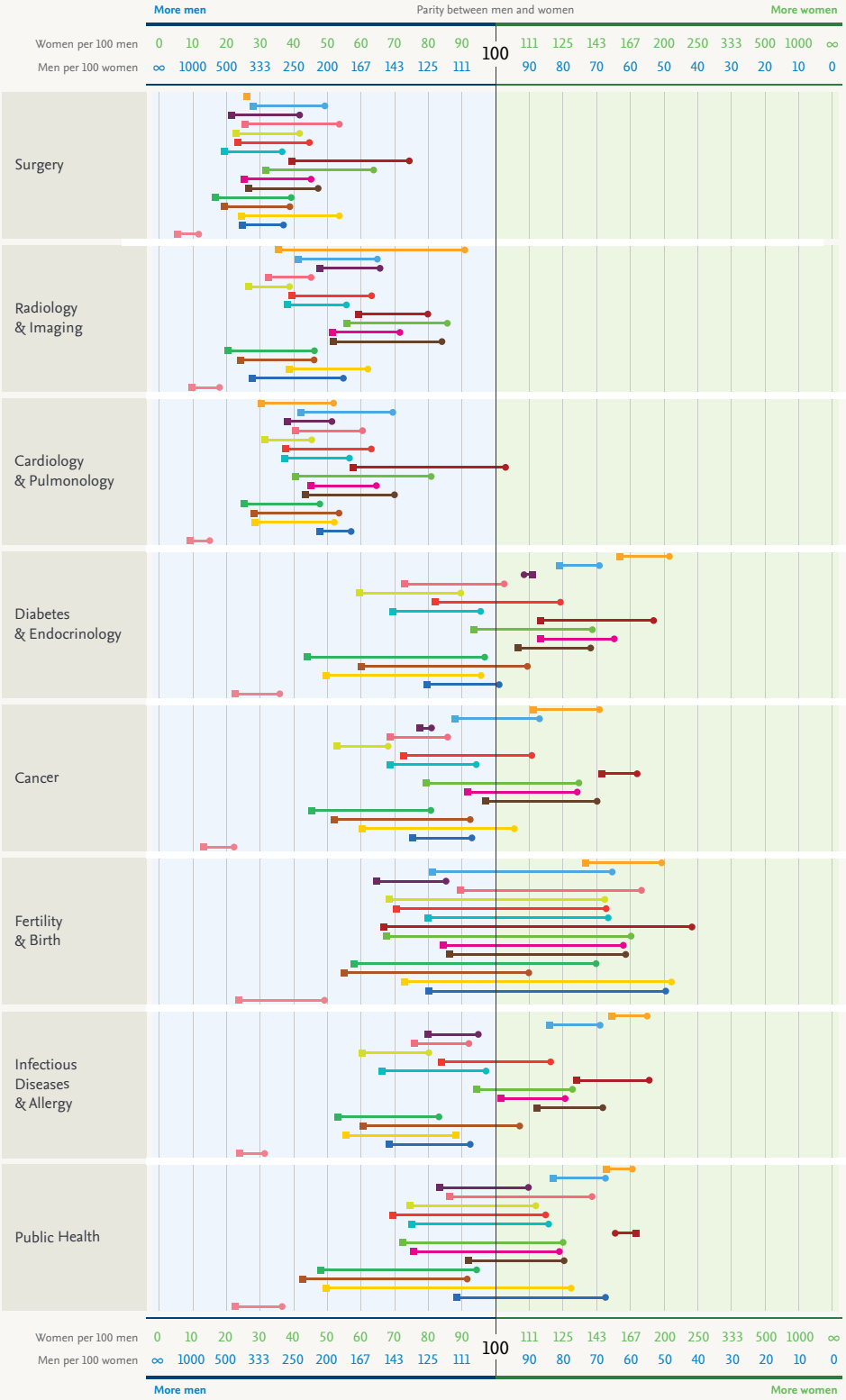


FIGURE 1.6

Gender ratio among active authors during the period 2014–2018 in each country in the subject area of medicine and its subfields, grouped based on year of author's first publication.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE 1.6 (CONT)

Gender ratio among active authors during the period 2014–2018 in each country in the subject area of medicine and its subfields, grouped based on year of author's first publication.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

Research Participation

Grant Awardees

Assessment of grant awardees provides insight into the gender composition of those who are successfully competing for research funding and contributing to funding agencies' research portfolios and missions. Many factors contribute to the composition of grant awardees. The composition of the available pool of individuals who are qualified to apply, whether the research proposed fits the research priorities of the funding institution, and the quality of the application itself are just a few such factors. Gender-based differences may reflect gender differences in who applies for awards and/or who is awarded.

We assessed the ratio of women to men among research grant awardees during the period 2014–2018 by examining awards data from Elsevier's Funding Institutional solution. Detailed methods on how awardees were identified are provided in the Appendix A. Analyses were limited to those countries with at least 5,000 awardees for whom a gender could be inferred.

Consistent with our findings based on author data, we observed fewer women awardees than men in all awarding countries included in the analysis (Figure 1.7). Canada had the highest representation of women among grantees, with 50 women per 100 men awarded a research grant, while Japan was the furthest from parity with 10 women per 100 men. All other countries and the EU28 in aggregate had a ratio between 25 to 45 women awardees per 100 men. Contrasting these data with author data, we noted that the proportion of women among awardees in the USA, EU28, the UK, Germany and Japan was below the ratio seen for corresponding authors and above the ratio seen among last authors. This is consistent with the notion that research awardees are frequently senior investigators and suggests that the awardee population closely reflects the pool of available recipients (i.e., senior investigators). In Canada, the ratio of women to men among awardees was slightly higher than the ratio of corresponding authors (by 5 women per 100 men). One possible explanation for this could be the presence of mechanisms in Canada to award research grants to those who have never been in a leadership position. In contrast, the gender ratio observed among grant awardees in Australia was lower than the ratio of women to men among corresponding authors (by 21 women per 100 men) and last authors (by 6 women per 100 men). This may be due to different practices in taking the last or corresponding author position in Australia or it may indicate gender bias against women in grant award systems. Alternatively, differences in the gender ratios of grant awardees compared to authors may reflect differences in the distribution of authors across subject areas compared to the distribution of awardees across subject areas in each country. For example, a difference might be seen if a country's author pool is predominantly composed of researchers in the health and life sciences (which is the case for all countries analyzed) but the awardee pool consists of proportionally more social and physical scientists (both fields in which the gender ratio among last and corresponding authors is more similar to the ratio for the overall author population).

FIGURE 1.7

Gender ratio among research grant awardees receiving an award during the period 2014–2018 compared to author ratios among all active authors, first authors, last authors and corresponding authors active during the same period.

KEY

- Canada
- USA
- EU28
- UK
- Germany
- Australia
- Japan

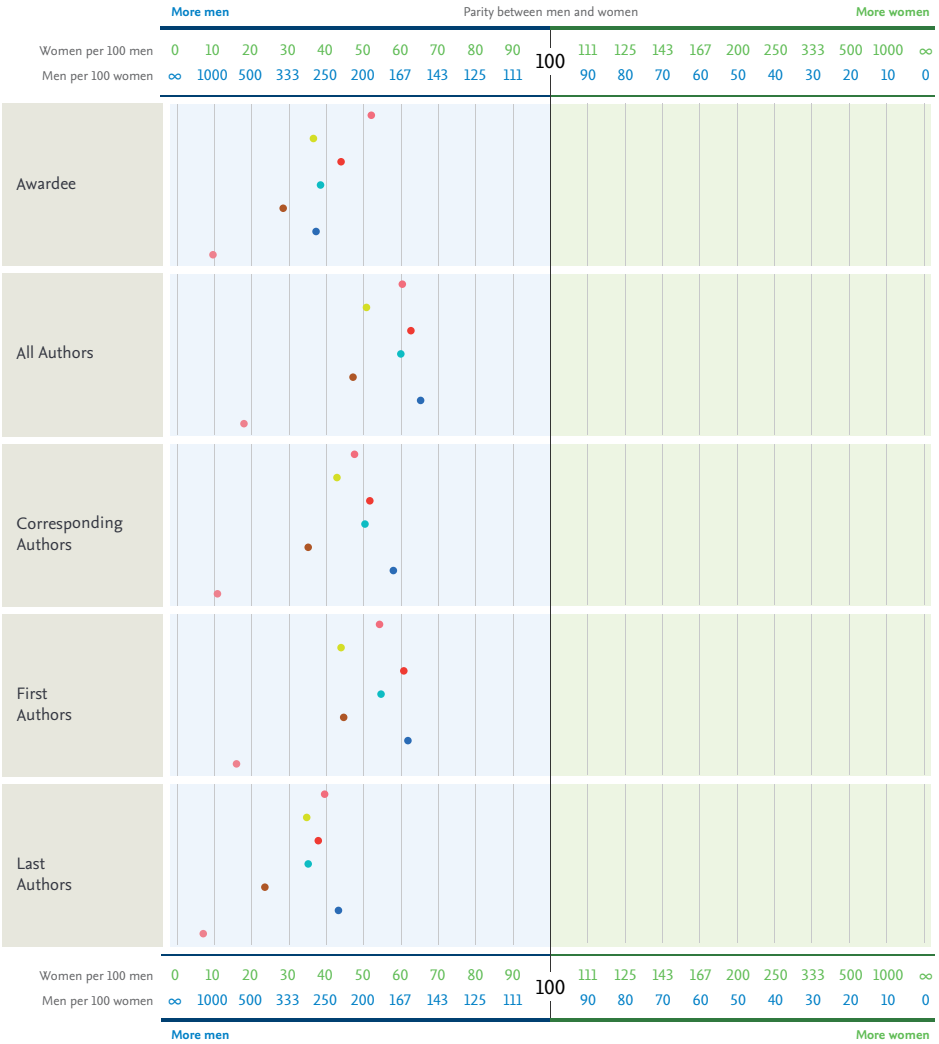


FIGURE 1.7 TAKEAWAY:

In many countries, the proportion of women among grantees closely reflects the proportion of women among corresponding and last authors.

Research Participation

Inventors and Patent Assignees

Individuals submitting patents for research discoveries are actively turning their research into practical applications with potential for commercial value. To understand the proportional representation of women and men among inventors (those who contribute to the claims of a patentable invention) and patent assignees (the subset of inventors who own intellectual property rights to patents), we analyzed PATSTAT patent data for the United States Patent and Trade Office (USPTO) and the European Patent Office (EPO). Data from the China National Intellectual Property Administration (CNIPA), Japan Patent Office (JIPO) and Korean Patent Office (KIPO) were evaluated but excluded because too few patents included the country of the inventor and because the gender of the inventors could not be inferred accurately for a sufficient number of inventors to generate a robust data set using the approach employed in this report. Individuals included in this analysis are those who appeared as inventors or assignees in any patent applications filed in 1999–2003 or 2012–2016 at either the USPTO or EPO, regardless of when the patent was granted. We assessed patents from 2012 to 2016 rather than from 2014 to 2018 because patent applications must first be published before they appear in PATSTAT, resulting in a lag of up to 18 months for the EPO. The methods employed to select these patent offices and to assign inventors and assignees to a country are described in more detail in the Appendix A. Briefly, inventors or assignees were counted towards a country's count if more than 30% of their patents during the period indicated that country as the inventor or assignee country. We limited this analysis to countries with a minimum of 1,400 inventors for whom a gender could be inferred.

In all countries studied, women inventors represented a small minority of inventors. Spain had the highest ratio of women to men among inventors during the period 1999–2003, with 17 women per 100 men, placing it above France (15 women per 100 men) and Brazil (14 women per 100 men; Figure 1.8). The ratio of women to men among inventors in the EU28 was 9 per 100 men, reflecting the relatively lower ratios observed in the UK (9 women per 100 men) and Germany (6 women per 100 men). With only 5 women per 100 men, Japan had the lowest proportion of women among inventors across all countries. All countries showed an increase in the ratio of women to men among inventors in 2012–2016 compared with 1999–2003, with the exception of Canada, in which the ratio was stable. The largest increases in ratio between the two time periods were seen in Mexico (16 women per 100 men, up from 9 women per 100 men) and Spain (24 women per 100 men, up from 17 women per 100 men). Spain maintained its rank from the 1999–2003 period, followed by both France and Brazil (17 women per 100 men), Mexico (16 women per 100 men) and Italy (15 women per 100 men). The ratio of women to men among inventors in the EU28 increased in 2012–2016 to 12 women per 100 men, up from 9 women per 100 men in 1999–2003.

Large gaps between the ratio for assignees and inventors may indicate a loss of intellectual property (IP), as inventors do not hold the rights (and thus lose the market value) of their inventions. We observed that, for the majority of countries analyzed, the ratio of women to men among patent assignees mirrored the ratio observed for inventors (Figure 1.8). Spain, Brazil and Mexico stood apart in that there were fewer women per 100 men among assignees than among inventors (7 fewer women per 100 men among assignees compared to inventors in Spain, 4 fewer in Brazil and 3 fewer in Mexico).

FIGURE 1.8

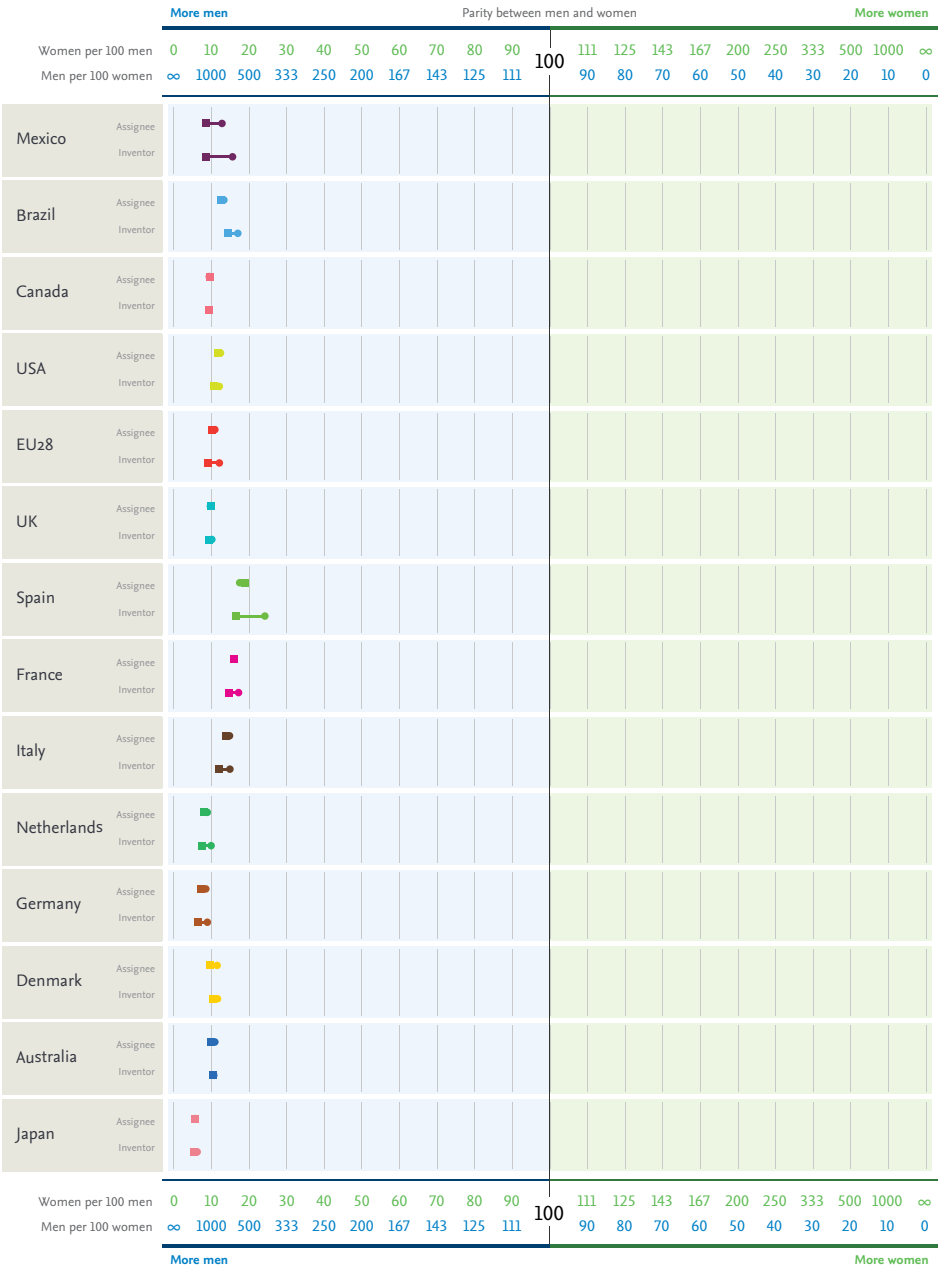
Gender ratio among inventors and assignees during the periods 1999–2003 and 2012–2016 for each country and the EU28.

KEY

- 1999–2003
- 2012–2016

FIGURE 1.8 TAKEAWAY:

The ratio of women to men among inventors and assignees is very low compared to the ratio observed for authors and grantees. Most countries show very modest changes in these ratios over time. Spain and Mexico stand apart for having the largest increases in the proportion of women among inventors.



Research Participation

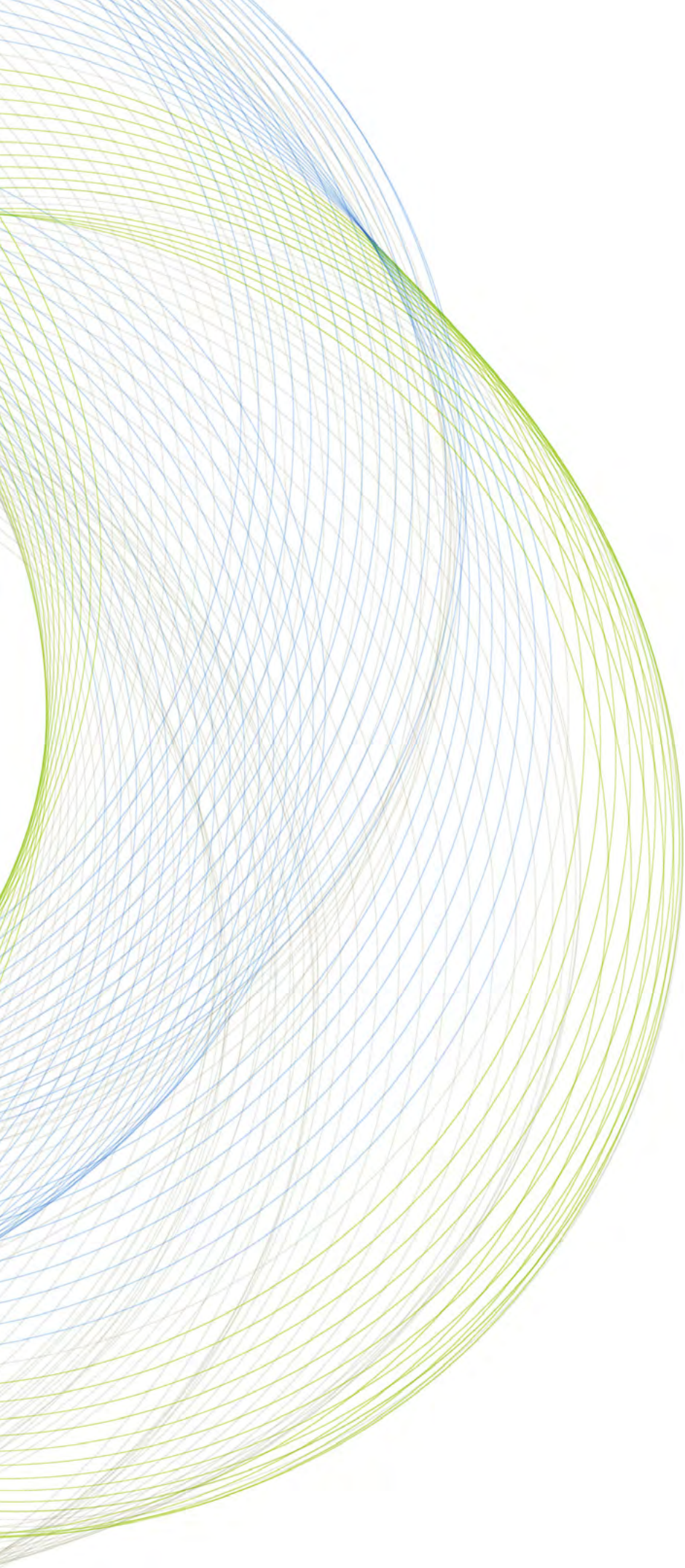
Conclusion

Overall, our analysis reveals incremental improvements in women's representation among researchers along three of the key core activities that they undertake: authoring publications, securing research funding and applying for patents. The rate and magnitude by which the gender gap has decreased within these activities differs across countries and the EU28. Among authors, differences in the ratios of women to men researchers are observed across subject areas, with a lower representation of women observed in the physical sciences. Notably, the lower proportion of women in the physical sciences may in part explain the lower representation of women among patent applicants, given that patenting activity is higher in physical sciences subject areas. In nursing and psychology, the gender gap has increased as men's representation has decreased over time in these fields. Beyond country/region and subject area-based differences, we also observed differences in the proportional representation of women and men that correlated with author publication history and authorship position. The largest gender gap is observed among authors with a long publication history and those who have authored as corresponding or last authors. These insights offer good context for Chapter 2, in which we provide further information on men and women in the world of research by examining their research footprint in terms of publications, grants, patents and citation impact.

Chapter 2

Research Footprint

Measuring the research footprint of women and men



Key Findings

- *In every country, on average, women researchers author fewer publications than men, regardless of authorship position. The least difference is observed among first authors while the biggest difference is observed among all authors.*
- *Among first authors, the average FWCI of men is higher than that of women, suggesting gender bias in citation practice.*
- *Among grantees, on average, men tend to win more grants than women.*
- *Among inventors, men tend to apply for more patents than women. This difference in average number of patents applied for by men compared to women is greater among assignees.*

Research Footprint

Introduction

Ensuring that the research workforce is diverse is an important first step to ensuring diverse perspectives are reflected in and inform research. Active engagement by participants from that workforce across a range of research activities—publishing, applying for funding and seeking patents—is also critical. Here, we examine the outcomes of these research activities, which form a researcher's "footprint" and have a significant impact on both the researcher's career and the resulting research portfolio overall. Understanding whether gender-associated differences in the researcher footprint exist offers the opportunity to reflect on potential causes of gender gaps, likely obstacles that prevent both men and women to thrive equally and the possible biases that affect success. Such insights are crucial to a more comprehensive understanding of the global research environment, enabling an evidence-based approach towards achieving equal opportunities for all researchers regardless of gender and for the research enterprise to reap the benefits of a diverse workforce.

Research publications are an important research output. They are a means of communicating research findings to the academic community. Several studies have described gender disparity in terms of scholarly output—the number of articles, reviews, and abstracts—published by men and women researchers, showing that, on average, women author fewer publications than men, with differences in scholarly output varying by subject area, geography, journal type and authorship position.[14] Citations of research publications are a means of crediting the originators of an idea or finding, as well as recognizing expertise. The number of citations received by a publication is indicative of uptake of knowledge[15] and can serve as a proxy for the academic impact of the publication. Several studies have noted a gender difference in how citations accrue, with work authored by women cited less often than that by men, and variations in the citation gap across subject areas[16] and authorship position[17] that may be related to gender-based differences in self-citation and journal prestige.[18] The gender gap in scholarly output and

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18 Andersen, J. P., Schneider, J. W., Jagsi, R., & Nielsen, M. W. (2019). Gender variations in citation distributions in medicine are very small and due to self-citation and journal prestige. ELife, 8, 1–17. doi: 10.7554/elife.45374; King, M. M., Bergstrom, C. T., Correll, S. J., Jacquet, J., & West, J. D. (2017). Men set their own cites high: gender and self-citation across fields and over time. Socius, 3. doi: 10.1177/2378023117738903

citation accrual has been attributed to various factors. Recent studies have described a "Matilda effect"—the perception that the scholarly work of women is lower quality than that of men—which leads to fewer citations or invitations to collaborate and has a negative effect on future scholarly output.[19] Women are also more likely than men to take career breaks or switch to a part-time position to achieve work-life balance or care for a family member; these breaks can reduce productivity.[20] Successfully publishing again after returning to research can be difficult, particularly if institutional support structures are lacking. As publication output is often used to measure performance in academic research, gender-based differences in the number of publications, as well as the impact of those publications, can have a significant effect on the career progression of women researchers.[21]

Gender disparities have also been noted in terms of research funding, another benchmark of success for researchers that factors into tenure and promotion decisions.[22] A recent study found that a smaller percentage of women than men who apply for high-risk, high-reward awards at the National Institutes of Health (NIH) in the United States go on to win these awards.[23] Another study reported significant gender differences in the size of awards to first-time NIH grant awardees, particularly for the highest-funded grant types.[24] Top prizes in science, such as those awarded by professional societies, are won more often by men, who also receive more money and prestige as a result of winning.[25]

Like research publications, patents are an important outcome of research. Through patents, researchers claim the rights to the application of intellectual property. However, similar to the observation for publication output, there is evidence that women have a lower patent counts than men.[26]

In this chapter, we expand on the body of literature related to the gender gap in research footprint, using advanced methodologies to examine the average number of publications, grant awards and patents, as well as the impact of publications as measured by citations, across 15 countries and the EU28, overall and in 26 subject areas.

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Research Footprint

Author Publication Output

In this section, we assessed the average number of publications that were authored by women and men. We calculated the average number of publications for each gender by first counting the number of publications by each author and then determining the average across authors of the same gender. To get a sense of authors' output as both contributing authors and as lead authors, we assessed authors based on authorship position and calculated the average output among authors who have been in: 1) any authorship position, 2) the corresponding author position, 3) the first author position and 4) the last author position. Publications in which authors are listed in alphabetical order and publications with two or fewer authors were not included among the counts of first and last author papers. We limited the analysis to output during a five-year period: the publication output during the period 1999–2003 was assessed for authors who were active during those same years and the publication output during the period 2014–2018 was assessed for authors who were active during those years. Authors were considered active if they published at least two publications during the defined period of interest. To avoid excluding "new authors," that is, those authors who first published during the period of interest, we applied different criteria for inclusion of these authors. "New authors" were included in the 1999–2003 cohort if they subsequently published within five years of their first publication. "New authors" whose first publication appeared during the period 2014–2018 were unconditionally included in the 2014–2018 cohort. Detailed methods are available in Appendix A.

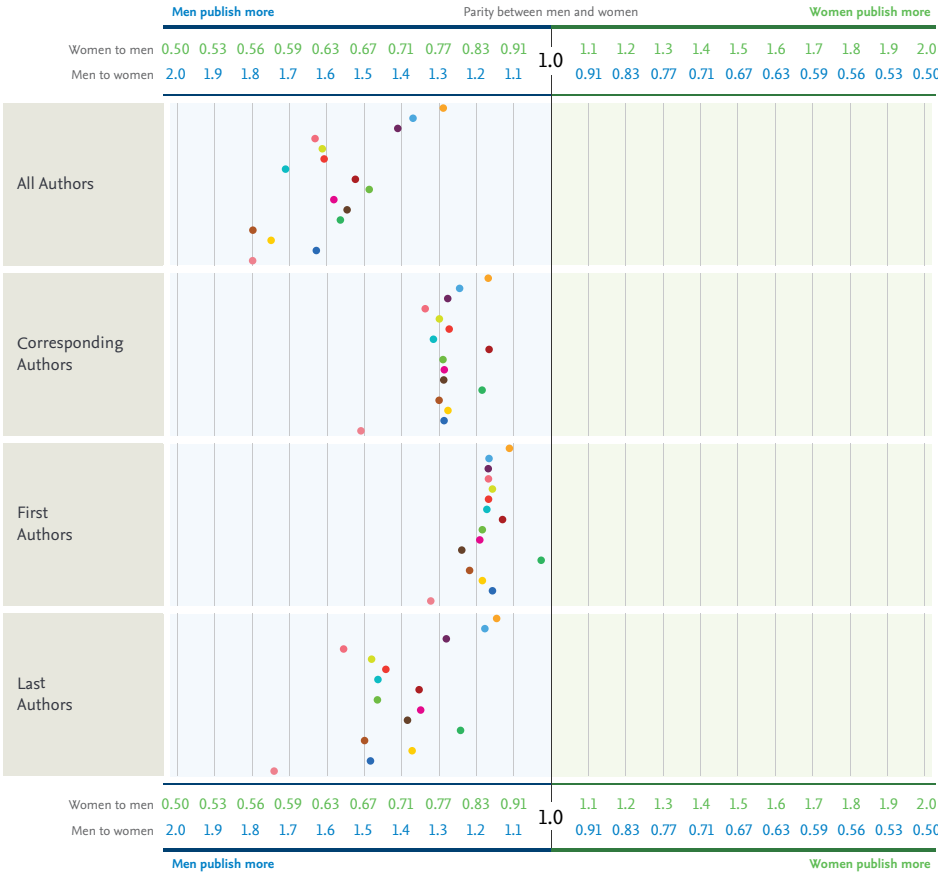
Our data show that, on average, women published less than men in a five-year period in every country assessed, regardless of authorship position (Figure 2.1, supplemental data Table B.2). The same trends were observed for authors active during the period 1999–2003 (supplemental data Table B.2). The average publication count was most similar between women and men for first author publications, ranging from no difference in the average publication output by men compared to women in the Netherlands to 1.3 times more publications by men compared with women in Japan. The greatest difference in average publication output was seen among those in any authorship position, with men on average authoring 1.5 times more publications than women in 11 of the 15 countries (along with the EU28 as a whole). The difference in publication output among those in last author position ranged from 1.1 times more (i.e., 10% more) on average by men than women in Argentina to 1.7 times more by men than women in Japan. The difference in publication output among those who were corresponding authors ranged from 1.2 times more on average by men than women in Argentina, Portugal, the Netherlands and Brazil to 1.5 times more by men than women in Japan. Argentina stood out for having the least difference between men and women in publication output across various authorship positions, while Japan stood out for having the greatest difference in publication output among first authors, last authors and corresponding authors. This suggests a relationship between gender ratio and gender-related differences in publication output. When we assessed whether there was a correlation between the gender ratio among authors and the ratio of average output among countries, we observed a slight correlation among corresponding authors ($R^2 = 0.69$; $p < 0.0001$; supplemental data Figure B.9).

To assess the role of author publication history in contributing to the difference in publication output of men compared with women, we disaggregated the authors based on the year of first publication. We observed that, for most countries, the gender related difference in publication output was higher among authors with a longer publication history and minimal among authors with the shortest publication history (supplemental data Figure B.10). This trend was most apparent among all authors but also observed among last authors and corresponding authors. Among those who published as first authors, the greatest difference in publication output was observed among authors whose first publication was published in the period 2009–2013.

In every country, on average, women researchers author fewer publications than men, regardless of authorship position. The least difference in the average number of publications by women compared to men is observed among first authors and the biggest difference is observed among all authors.

FIGURE 2.1

Ratio of the average number of publications by women to men and men to women, as shown. Data are based on average number of publications by active authors in the period 2014–2018 in each country, disaggregated according to author position.



- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE 2.1 TAKEAWAY:

On average, women author fewer publications than men, regardless of authorship position. The least difference in the average number of publications by women compared to men is observed among first authors and the biggest difference is observed among all authors.

When disaggregating the data by subject area, we observed that, within most subject areas, the difference in publication output between women and men mirrored the pattern seen for all research in aggregate: the greatest difference in output of men compared to women was seen among all authors in any position, followed by those in last and corresponding author positions, and the least difference was seen among first authors. Author publication history appeared to explain part of the difference observed among last and corresponding authors, as the difference in output was greatly diminished when the data were disaggregated by subject area and publication history. However, when assessing output of all authors (i.e., regardless of authorship position), we observed that, in the life sciences and health sciences, a large gender gap in publication output persists among authors with the longest publication history. This may be due in part to the broad range of years included in this group (all authors whose first publication was in 2003 or prior). If the first year of publication among most women in this group was more recent than the first year of publication among most men in this group, this difference in publication history could account for the difference in publication count. Further statistical analyses would provide greater clarity on the relationship between gender differences in publication output and author country, subject area, publication history and authorship position.

From the available data, it wasn't possible to directly assess whether a difference in child-care responsibilities among men and women contributed to the observed gender difference in publication output. We could not identify any studies that document when most authors have children relative to their first publication. We hypothesized that a substantial population of post-doctoral researchers who have young children may be represented among the first author researchers who first published in 2009–2013 in the life and health sciences. Additional family responsibilities that more often fall to women, including taking time off for pregnancy and childcare, may have led to a decrease in research activity and a lower publication output among women in this group.[27] However, further sociological data are required to make a definitive link. The data do, however, suggest a relationship between the gender gap in publication output and publication history, particularly among those in any authorship position, which suggests that gender differences in networking and collaborations may drive this difference. Consistent with this, our 2019 survey of the global research community (described in Appendix A) found that, on average, men report that they are invited to collaborate on a research project that could lead to a publication more often than women (mean number of invitations to collaborate/year: men = 3.52, women = 3.04; Appendix A, Figure C.4). This suggests that men may have greater opportunities than women to be named as a co-author. We explore the role of women and men's co-author networks further in Chapter 4.

27 Fox, M. F. (2005). Gender, family characteristics, and publication productivity among scientists. Social Studies of Science, 35(1), 131-150. doi: 10.1177/0306312705046630; Hunter, L. A. & Leahey E. (2010). Parenting and research productivity: new evidence and methods. Social Studies of Science, 40(3), 433-451. doi: 10.1177/0306312709358472; Kyvik, S. (1990). Motherhood and scientific productivity. Social Studies of Science, 20, 149-160. doi: 10.1177/030631290020001005; Kyvik, S. & Teigen M. (1996). Child care, research collaboration, and gender differences in scientific productivity. Science, Technology and Human Values, 21(1), 54-71. doi: 10.1177/016224399602100103; Long, J. S. (1990). The origins of sex differences in science. Social Forces, 68(4), 1297-1315. doi: 10.1093/sf/68.4.1297; Stack, S. (2004). Gender, children and research productivity. Research in Higher Education, 45(8), 891-920. doi: 10.1007/s11162-004-5953-z; Miller, S. (2019). To improve gender equality, help men take parental leave. Society for Human Resource Management. Retrieved from https://www.shrm.org/resourcesandtools/hr-topics/benefits/pages/help-men-take-parental-leave.aspx. Accessed December 3, 2019.; Cerrato, J., & Cifre, E. (2018). Gender inequality in household chores and work-family conflict. Frontiers in Psychology, 9, 1330. doi: 10.3389/fpsyg.2018.01330; Pew Research Center. (2015). Raising Kids and Running a Household: How Working Parents Share the Load. November 4. Retrieved from https://www.pewsocialtrends.org/2015/11/04/raising-kids-and-running-a-household-how-working-parents-share-the-load/. Accessed December 3, 2019.; Bianchi, S. (2011). Family change and time allocation in American families. Annals of the American Academy of Political and Social Science, 638(1), 21-44. doi: 10.1177/0002716211413731

Research Footprint

Field-Weighted Citation Impact

Citations accrued by publications can provide insight into the academic impact of publications, as researchers cite each other's work to signal that they are further building on that work. We used a field-weighted metric in which citation count is normalized to account for the publication type, publication year and subject area because these three variables greatly impact the accrual of citations by a publication. This metric, field-weighted citation impact (FWCI), was calculated for each publication. To compare average FWCI for women and men, we first calculated the mean FWCI for each active author based on their publications during the five-year period 2014–2018 and then calculated the mean for each gender based on the author-level average FWCI (detailed methods are available in Appendix A). Different factors can influence whether research is cited. We expected that if differences in how publications were cited are related to the gender of the authors of the article, these differences would be most apparent when assessing based on the gender of the first author, last author and/or corresponding author.

Our analyses revealed that, among the countries studied, the average FWCI for men compared to women when assessing all authors, regardless of authorship position, was close to equivalent in all countries and the EU28, with a ratio of FWCI for men to women that ranged from 0.96 in the UK to 1.04 in Argentina, and a median of 1.01 among countries studied (Figure 2.2, supplemental data Table B.3). The difference between average FWCI among men and women was slightly higher when assessing last authors and ranged from a ratio of 0.97 in Argentina to 1.12 in Portugal, with a median ratio of 1.05 among the countries studied. The trend among last authors was similar to that of corresponding authors (ratio of average FWCI of men to that of women ranged from 1.01 in Mexico to 1.14 in France, with a median of 1.06 among countries). The greatest difference in average FWCI was observed among first authors. Among first authors, men's average FWCI was greater than women's by 1.1 times or more in 12 of the 15 countries studied along with the EU28. Together, this suggests that gender influences citation behavior on the basis of authorship position, particularly among first authors. Among active authors during the period 1999–2003, we observed that the ratio of average FWCI was closer to parity among first and last authors but not corresponding authors, suggesting that for some author positions, gender differences in how research is cited decreases as research becomes older (supplemental data Table B.3). Overall, and consistent with the previous Elsevier analysis,[28] differences in FWCI of publications by men and women remained small. It has been suggested that self-citations and journal prestige may play a role in this discrepancy, as has been observed in the field of medicine.[29]

28 Elsevier. (2017). Gender in the Global Research Landscape. Retrieved from: www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.

29 Anders, J. P., Schneider, J. W., Jagsi, R., & Nielsen, M. W. (2019). Meta-research: gender variations in citation distributions in medicine are very small and due to self-citation and journal prestige. eLife, 8, e45374. doi: 10.7554/eLife.45374

FIGURE 2.2

Ratio of the average FWCI of publications by women to men and men to women, as shown. Data are based on publications by active authors during the period 2014–2018 in each country, disaggregated according to author position.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

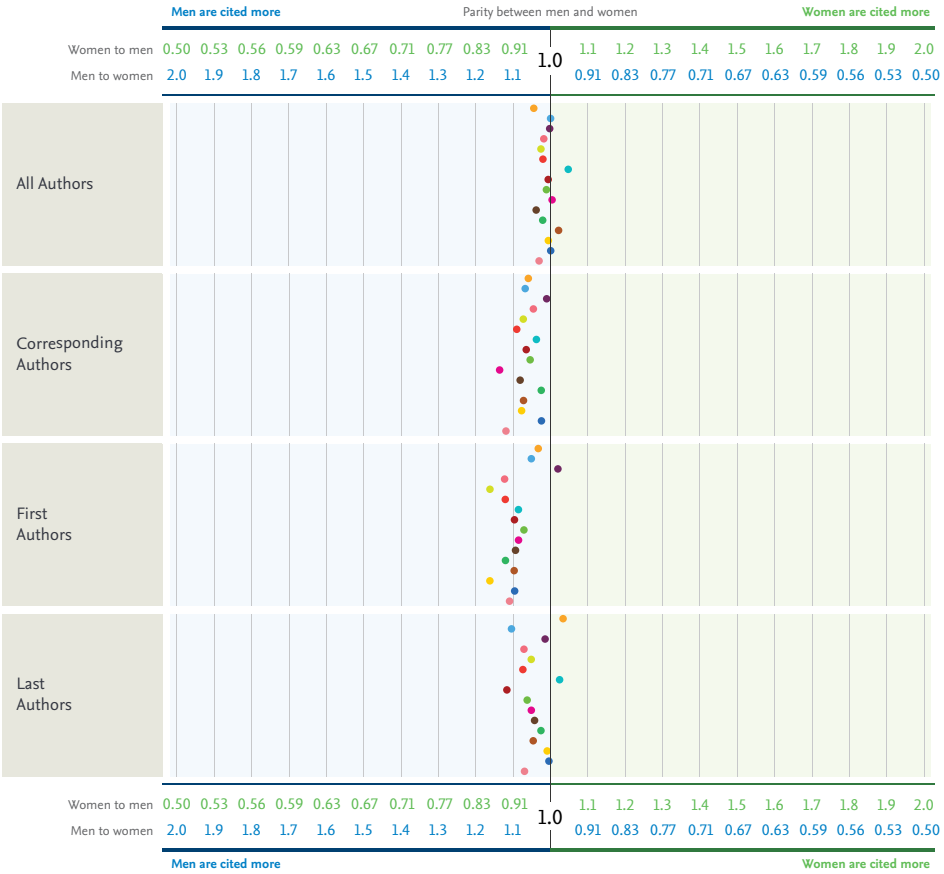


FIGURE 2.2 TAKEAWAY:

Among first authors, the average FWCI of men is higher than that of women, suggesting gender bias in citation practice.

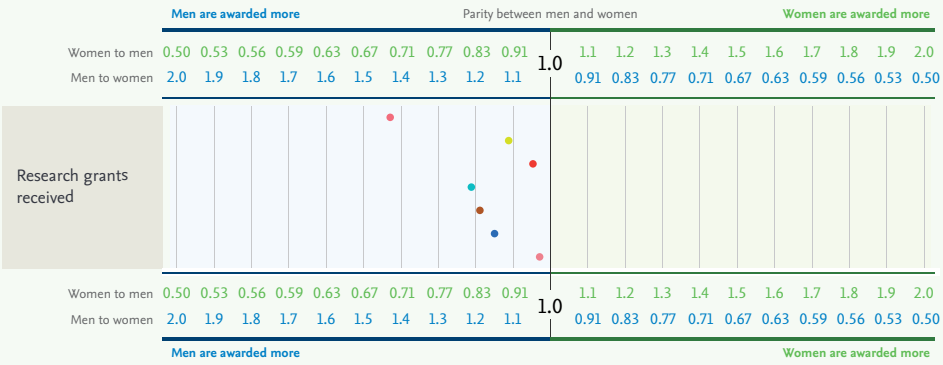
Research Footprint

Grants Awarded

The number of research grants awarded to researchers can vary depending on the number of proposals submitted, the quality of a researcher's grant proposals and the track record of the researcher. However, there are other factors that can also influence whether a researcher is awarded a grant. For example, researchers may be awarded more grants if they lead a large research group or if they frequently collaborate with researchers who have a high award success rate. Biases in awarding systems can impact both who receives grant awards and how many awards and award dollars are received. In this section, we assessed the average number of awards received by individuals in each country and the EU28. Figure 2.3 (supplemental data Table B.4) shows the average number of awards granted to women compared to men during the period 2014–2018. In Japan and the EU28, the average number of grants awarded to women and men was almost equal. The observation of near parity for grants received by women and men in Japan contrasts with the very low ratio of women to men awardees in Japan shown in Figure 1.7. Canada had the highest proportion of women among awardees and saw the largest gender-based difference in average number of awards received: men in Canada were awarded 1.4 times (40%) more grants than women. In all other countries, the average number of awards received by men was 1.1–1.2 times greater than the average received by women.

FIGURE 2.3

Ratio of the average number of research grants received by women to men and men to women in each country during the period 2014–2018.



- Canada
- USA
- EU28
- UK
- Germany
- Australia
- Japan

Among grantees, on average, men tend to win more grants than women.

Research Footprint

Number of Patent Applications

Various factors can influence whether individuals apply for patents. In addition to having an invention that is suitable for patenting, individuals are more likely to apply for a patent if they have support throughout the patenting process, are aware of what support is available and are encouraged to apply. We determined the number of patent applications from individual inventors (those who contribute to the claims of a patentable invention) and assignees (the subset of inventors who own intellectual property rights to patents), and calculated the average number of patent applications across men and women from each country and the EU28.

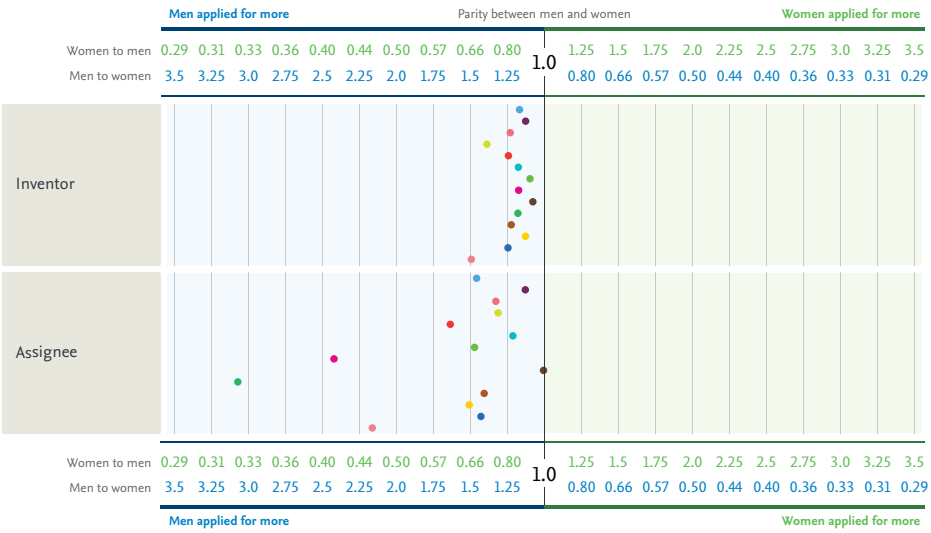
During the period 2012–2016, women inventors and assignees appearing on European Patent Office (EPO) and United States Patent and Trade Office (USPTO) patent applications were contributors on fewer patent applications than men on average in every country and the EU28 (Figure 2.4; supplemental data Table B.5). Among inventors, the average number of patents that men applied for ranged from 1.1 times more than women (in Italy, Spain and Denmark) to 1.5 times more than women (in Japan). Among the countries studied, the median ratio of the average number of patent applications by men compared to women was 1.2. The trend for assignees was slightly higher, with a median ratio of 1.4 among the countries studied. Italy was at the lowest end, with no difference in the average number of patent applications by men and women assignees. The greatest difference in the average number of patent applications by men compared to women assignees was seen for the Netherlands (on average, men applied for 3.1 times more patents than women). Along with the Netherlands, France and Japan were far above the median, with men assignees in these countries applying for 2.4 and 2.1 times more patents, respectively, than women.

Overall, the trends seen for the average number of patent applications by women and men inventors and assignees during the period 2012–2016 were similar to those observed for the period 1999–2003 (supplemental data Table B.5). Assessing assignees, the median ratio for average number of applications by men compared to women among countries was 1.5 in 1999–2003 and 1.4 in 2012–2016. Among inventors, the median ratio among countries studied was slightly greater in 2012–2016 (at 1.2) compared with 1999–2003 (at 1.1). Unlike what was observed for 2012–2016, there were a few countries in 1999–2003 in which women inventors applied for slightly more patents on average than men. Australia stood apart from other countries in 1999–2003 in that, among assignees, women applied for 2.6 times more patents than men, and among inventors, women applied for 1.3 times more patents than men. This higher average application count for women in Australia was not seen in 2012–2016.

When comparing the data on the average number of patent applications submitted with the data on the number of women and men among inventors, we observed that, in many cases, countries with a lower proportion of women among inventors (Japan, Germany and the Netherlands) also had the greatest difference in the average number of applications, with women applying for far fewer applications than men. This was similar to the relationship observed for authors and publication output. However, we did not find any correlation between the ratio of women to men among inventors compared with the ratio of average number of patent applications by women and men ($R^2 = 0.25$; $p = 0.08$). The inclusion of more countries in the dataset may reveal a more robust relationship.

FIGURE 2.4

Ratio of the average number of patent applications by women to men and men to women in each country during the period 2014–2018.



- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

Among inventors, men tend to apply for more patents than women. This difference is greater among assignees.

Case Study:

Assessing gender balance among China's authors

The methods for inferring author gender in this report were based on author names as they are written using the Roman alphabet. However, this approach delivered poor results for authors from China: we did not obtain gender approximation for a sufficient number of authors to pass the same thresholds applied to other countries included in the report. We found that the gender disambiguation methods used could be more reliably applied to author names written in Mandarin than to those same names transliterated using the Roman alphabet. This is because Mandarin is a tonal language: a name spelled in the same way using the Roman alphabet can be spelled and pronounced differently using Chinese characters, with some versions referring to names associated with men and others referring to names associated with women. Recently, efforts have been made to include alternate non-Roman text names for authors whose names are written in a text other than the Roman alphabet in the author byline. We capitalized on these efforts and retrieved the names of authors that had submitted their name in Mandarin. This typically occurs in Mandarin language journals. For this case study analysis, we assessed statistics related to authors who provided a Mandarin name for any publication during the period 2014–2016 because Mandarin language author names have only been collected for this period thus far. We then inferred the gender of these authors using NamSor and used the authors' Scopus author profiles to identify their publication history and output. We used a threshold for the Gender Probability Score that was lower than the score used elsewhere in this report to increase the recall and ensure a sufficient number of authors for analysis. Detailed methods on how this cohort of authors were defined and their gender was inferred are available in Appendix A, section "Analysis of authors for case study on China."

A total of 76,627 active authors with a Mandarin name were identified using this approach. Of those authors, 8,019 (10.5%) were predicted by NamSor to be women, 23,131 (30.2%) were predicted to be men and the gender of the remaining 45,477 (59.4%) could not be determined. Our approach in the following analyses was based on the assumption that the authors of unknown gender were distributed among men and women according to the same distribution observed for those for whom gender could be predicted.

Our analysis revealed that the ratio of women to men in this cohort was 0.34, meaning that there were 34 women per 100 men in the group (Figure 2.5). We assigned authors to subject areas based on their publication record during the period 2014–2018: authors were assigned to a subject area if at least 30% of their publications were in a journal within that subject area. The majority of authors in the cohort were in the physical sciences, particularly engineering (51% of authors), materials science (24% of authors) and physics & astronomy (22% of authors). Note that because some journals are categorized under more than one subject area, authors could be assigned to multiple subject areas. However, even considering that some authors counted towards multiple categories, the representation of authors in the physical sciences was higher than expected based on China's publication output across all subject areas. This was likely due to sampling bias. That is, the set of authors whose names were available in Mandarin for this study were not a representative sample of all authors in China and authors from the life sciences, health sciences and social sciences were underrepresented in the cohort. This high representation of authors from three subject areas in this cohort should be considered when assessing statistics provided at the level of "all subject areas," and data at this level should not be assumed to represent China's entire research workforce. Hence, results from this case study need to be interpreted with care and should not be compared directly with findings from other countries reported on here.

Disaggregating this cohort of authors based on their publication history resulted in similar trends seen for other countries, in that the group of authors with the shortest publication history (group D, first publication in 2014) was closer to gender parity than the group of authors with the longest publication history (group A, first publication in 2003 or prior; Figure 2.6).

As observed for other countries, women in this cohort of authors published fewer publications than men within the five-year period of 2014–2018 (Figure 2.7). This difference in publication output was greatest among those with the longest publication history and decreased among those with shorter publication histories. One possible reason for this difference could be that, among those with a longer publication history, men had more collaborations, resulting in a higher publication count than women. Time taken off by women due to childcare, eldercare and other family care responsibilities may also account for the difference in publication count.[30]

30 Cook, S. (2013). Women's paid work and unpaid care responsibilities in China. A Planet For Life. Retrieved from http://regardssurlaterre.com/en/womens-paid-work-and-unpaid-care-responsibilities-china. Accessed December 3, 2019.; Hewlett, S. A. (2011). Elder care, child care, and the struggles of Chinese women. Harvard Business Review, April 8. Retrieved from https://hbr.org/2011/04/eldercare-childcare-and-the-st. Accessed December 3, 2019.

FIGURE 2.5

Gender ratio among the cohort of Chinese authors (authors active during the period 2014–2018).

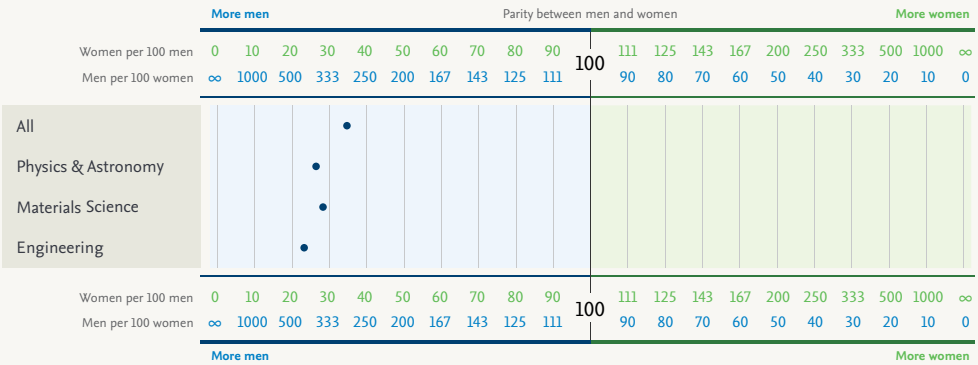
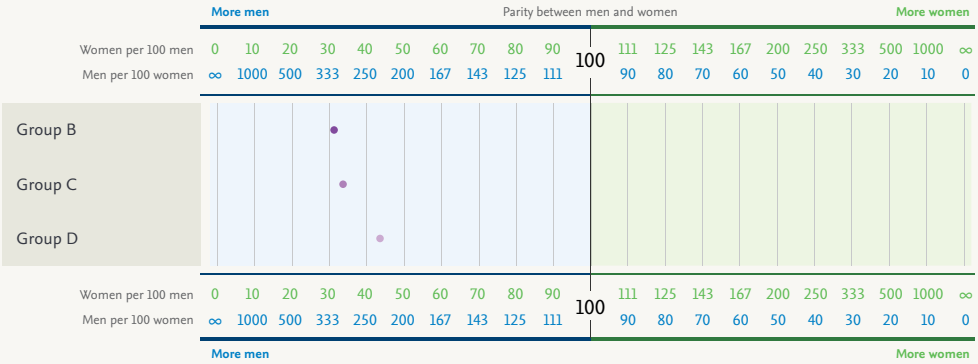


FIGURE 2.6

Gender ratio among the cohort of Chinese authors (authors active during the period 2014–2018), grouped based on the year of the author's first publication.



GROUP	YEAR OF FIRST PUBLICATION
B	2004–2008
C	2009–2013
D	2014–2018

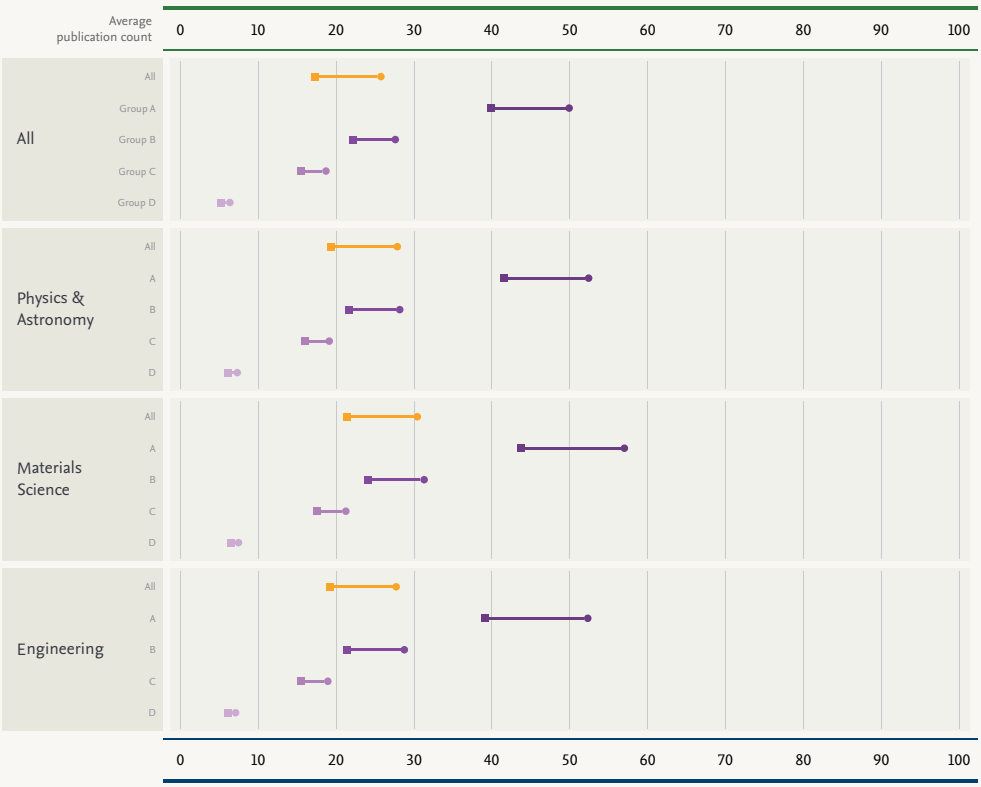
FIGURE 2.7

Average publication count during the period 2014–2018 of men and women in the cohort of Chinese authors, disaggregated according to publication history.

KEY	GROUP	YEAR OF FIRST PUBLICATION
●	All	2018 or prior
●	A	2003 or prior
●	B	2004–2008
●	C	2009–2013
●	D	2014–2018

■ **Women**

● **Men**



Expert Interview

Charlina Vitcheva, MA, MS

Acting Director-General, Joint Research Centre (JRC)
European Commission (EC)

How would you describe the current state of gender diversity in research, compared with 5 years ago, and its impact on research and/or researchers globally and/or in your region in particular?

The gender balance in research is improving in the EU, but at a slow pace. Women in research remain significantly underrepresented — around one-third of all EU28 researchers are women. The scientific quality and societal relevance of produced knowledge, technologies and innovation increases when they reflect the needs, behaviors and attitudes of both women and men. Things are moving in the right direction, but we need to do more if we want to achieve a good gender balance in the near future.

On average, women today outnumber men at student and graduate levels and there is broad gender balance at PhD level; however, their distribution in uneven across scientific fields of study, especially STEM fields, revealing a persistence of gender stereotypes. On a positive note, the latest "She Figures" report indicates that the EU is integrating the gender dimension in the content of scientific literature slightly better than the world average.

Are there initiatives, policies, or interventions that have emerged within your region and/or field in the last 3-5 years that you feel have impacted progress and should be monitored to assess impact?

Gender equality and the integration of a gender perspective in the preparation and evaluation of policies in academic research is a priority for the EU. One action worth mentioning is the Declaration on Women in Digital, signed earlier this year by 26 EU Member States. Its purpose is to encourage women to play an active role in the digital and technology sectors. One commitment by the signatories is to monitor the evolution of women' engagement and participation in digital jobs, careers and entrepreneurship through a Women in Digital scoreboard. The demand for skills in artificial intelligence (AI) is expanding in several industries and AI specialists are becoming some of the highest paid experts. If the gender gap persists, it may widen the existing pay disparities between men and women. Concrete policy actions are thus necessary to support the full participation and inclusion of girls and women in the digital economy, while at the same time, addressing stereotypes and social norms that lead to discrimination.

What value do data and an evidence-base offer as tools to policymakers and institutional leaders to address issues of gender diversity and equity?

The European Commission (EC), under the guidance of President Ursula von der Leyen, firmly believes that policy decisions should be based on sound evidence. Data are essential to help quantify and qualify the issues of gender diversity and equity, inform policies and design programs. Data provides an objective measure of reality that informs policy choices and allows us to monitor progress and evaluate the impact of those policies. The challenge that we often face, including at the Joint Research Centre (JRC), is how to translate the data and scientific knowledge that we develop into information that inform policymakers. A good example is the Social Scoreboard, a tool that accompanies the European Pillar of Social Rights, which measures and monitors equal opportunities and access to the labor market.

Things are moving in the right direction, but we need to do more if we want to achieve a good gender balance in the near future.

What combination of interventions do you think are necessary to accelerate greater equity for women and men in research?

It is essential to combine actions at the European, national and institutional levels. With its next Framework Programme, Horizon Europe, the EC has reaffirmed its commitment to gender equality in research and innovation. The first-ever Commissioner for Equality, Helena Dalli, has established an inter-service and intersectional Task Force on Equality. A new EC strategy for gender equality will be devised. In the research sector, particular attention will be paid to gender balance in evaluation panels and in bodies such as expert and advisory groups. At the JRC, we have committed to a fully gender balanced staff and a 50% representation of women in all management categories by 2030 at the latest.

I also think that gender equity in research should not be limited to promoting greater women's participation. The unequal sharing of childcare responsibilities within the family is one of the main reasons for shorter and more fragmented careers in research among women. If we want to achieve true gender equity, we need to support and empower both men and women at the organizational level to achieve balance in their personal and family life and work.

What information/insight from the report do you find particularly interesting and important for policymakers and institutional leaders to consider in relation to your region or a specific subject area(s)?

I found the variation in gender distribution across the disciplines particularly interesting, with fewer women in the more technical and STEM-related fields, from authors to grant receivers to inventors/patent assignees. While initiatives are directed toward addressing this gap, its consistency across the various facets of research makes it clear that we should be doing more.

Trends identified from scientific publications are confirmed for both awarded grants and even more so when analyzing patents. What does this say about a gender innovation gap?

To me, the gender innovation gap is linked to the lower presence of women in the more technical disciplines; it is evident that actions are needed to address this issue. Currently, women account for approximately 30% of start-up entrepreneurs in Europe; thus, female creativity and entrepreneurial potential are a largely untapped resource. The EC's Entrepreneurship 2020 Action Plan supports networking among female entrepreneurs, potential female entrepreneurs and support organizations. The JRC also supports the "EU Prize for Women Innovators," awarded to women who have received EU research and innovation funding during their careers, and then went on to establish a successful company based on their innovative ideas.

What impact, if any, has the #MeToo movement had in the world of research?

The #MeToo movement has raised awareness of workplace sexual harassment, amplified previously unheard voices, changed people's perceptions of what it means to be a sexual assault victim and helped remove the stigma around experiencing such misbehavior. The worldwide momentum of this movement has uncovered accusations of sexual harassment and assault in fields of research and science, with more women are willing to report sexual harassment and its damaging effects on their personal wellbeing and their scientific careers. As stated in your report, there is extensive literature on sexual harassment in academia and its negative impacts on the academic climate and the researchers' job satisfaction.

The EC has begun to clarify the role of universities, research organizations and support networks in preventing sexual and gender harassment, protecting victims and prosecuting perpetrators. In my view, measures implemented at the organization level should be evaluated to gain a better understanding of their impact and inform the development and implementation of effective policies and measures in academic environments and research workplaces in Europe.

Thinking about the future of gender diversity and equity in research globally, where do you think we will be in 10 years' time and what organizational and/or cultural issues do you think will influence change most significantly?

I am positive — I think we will see an improvement in the gender balance in research globally. It will be necessary to address the backlash against gender research and gender equality in some European countries. Where academic freedoms are curtailed, critical thinking around gender issues is likely to suffer too. We also need to do more to promote a better work-life balance for all researchers. Nevertheless, the current effort supporting women and girls' empowerment is huge and the importance of gender diversity is being recognized in various areas, from the economy to the environment and climate change.

Gender equality lies at the heart of the 2030 Agenda for Sustainable Development and the pledge to leave no one behind. With strong support from the EC and President von der Leyen, the commitment to gender equality is strong in Europe. Initiatives to advance gender equality in research and innovation need to continue and expand to strengthen the resilience and quality of our democratic institutions and Europe's competitiveness.

Initiatives to advance gender equality in research and innovation need to continue and expand to strengthen the resilience and quality of our democratic institutions and Europe's competitiveness.

Research Footprint

Conclusion

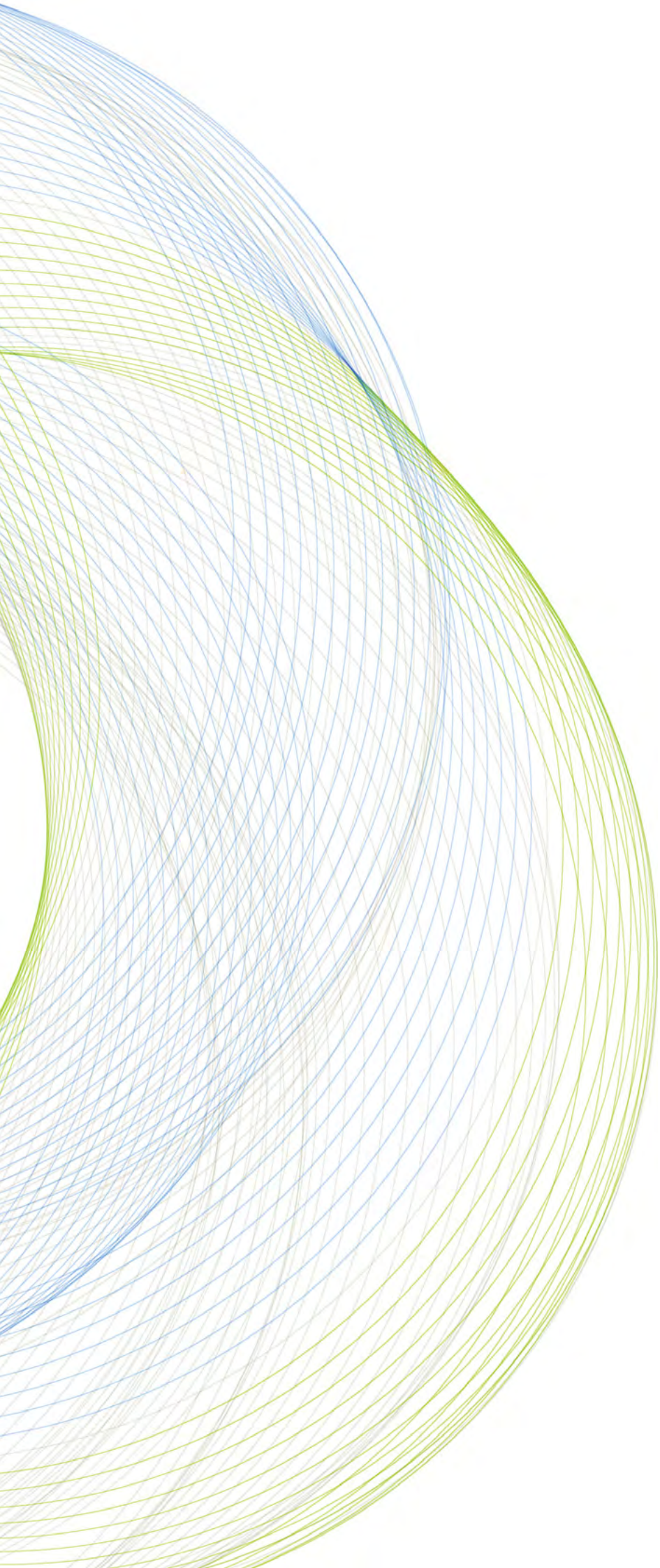
Our analysis shows little difference in the citation impact of women and men researchers, suggesting authors' gender does not have a bearing on the perceived quality of research publications. However, differences observed in the number of grant awards received may have implications for the resources that are available to women to carry out research. It may also have consequences in terms of women's ability to publish: if less funding means fewer projects, it can be assumed that this would also negatively impact the number of publications produced. A similar logic may affect the number of patents filed. Since research funding, publications and patents are often used as measures of success of a researcher's career, it is possible that the observed gender gap across these various types of research output impact how women fare in the research world and inhibit the advancement of women to senior roles. These gender gaps in research output are likely to also affect the content of the research portfolio.[31] Ultimately, understanding the factors that contribute to these gender differences in research output, for example, in researcher career continuity and mobility as analyzed in Chapter 3 and in researcher networks described in Chapter 4, can provide insights into how we might address some of the observed inequalities.

31 Nielsen, M. W., Andersen, J. P., Schiebinger, L., & Schneider, J. W. (2017). One and a half million medical papers reveal a link between author gender and attention t
Behaviour, 1, 791-796. doi: 10.1038/s41562-017-0235-x

Chapter 3

Publishing Careers and Mobility

Assessing author continuity and mobility



Key Findings

- *The ratio of women to men among authors in the cohort declines over time (between the year of authors' first publication in 2009 up to 2018) in all countries and regions except Portugal.*

- *In every country, the percentage of women who continue to publish is lower than the percentage of men who continue to publish.*

- *In every country, the percentage of women who publish internationally is lower than the percentage of men who publish internationally.*

- *Those who publish internationally publish more and have a higher FWCI than their counterparts who do not publish internationally. However, in most countries and the EU28, among those who publish internationally, men tend to publish more and have a slightly higher average FWCI than women.*

Publishing Careers and Mobility

Introduction

Chapter 1 revealed gender gaps related to participation in the research workforce and Chapter 2 highlighted gender differences in various types of outputs related to research, such as publications, grant awards and patents. In this chapter, we turn our attention to the longevity of research careers through an analysis of publishing records and researcher mobility. These two dimensions of a researcher's career trajectory—through time and space—offer important insights into the reasons underlying the observed gender gaps in representation among authors, grant awardees and inventors and the differences in funding success, publications and patent applications. Insights into the factors that contribute to gender gaps in representation and activity can be used to inform policies to redress gender inequities in the world of research.

Several studies have revealed gender disparities in researchers' career trajectories.[32] Men often have higher starting salaries than women researchers and are more likely than women to become independent principal investigators.[33] Women researchers in academia experience a slower pace of career advancement, spending more time at the assistant professor level than men researchers.[34] Persistent implicit bias at the level of institutions—in terms of hiring, provision of start-up funds, mentoring support and promotion—may contribute to the differences in career paths of men and women researchers.[35] Many women researchers have non-linear career paths, for example, taking time off for family reasons, which differentially affects continuity and advancement in research compared to men.[36]

The ability to move to other countries to pursue research opportunities, has a positive effect on career advancement. The 2017 Elsevier Gender in the Global Research Landscape report[37] revealed that men researchers are more mobile than women, publishing more often outside their country of origin. The report further found that publications from mobile researchers are more impactful than those from researchers who never left their country of origin. Differences in mobility may thus contribute to gender disparities in research career advancement.

In this chapter, we utilized bibliometric methods to analyze how and where women and men researchers publish over time,[38] with the goal of understanding whether gender differences can be observed in the longevity of an author's publishing career and how mobility impacts that aspect of career progression.

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33 National Research Council. (2010). Gender differences at critical transitions in the careers of science, engineering, and mathematics faculty. Retrieved from: doi.org/10.17226/12062. Accessed October 23, 2019.; van Dijk, D., Manor, O., Carey, L. B. (2012). Publication metrics and success on the academic job market. Current Biology, 24(11), R516-R517. doi:10.1016/j.cub.2014.04.039

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36 Cech, E., & Blair-Loy, M. (2019). The changing career trajectories of new parents in STEM. Proceedings of the National Academy of Sciences, 116(10), 4182-4187. doi: 10.1073/pnas.1810862116

37 Elsevier. (2017). Gender in the Global Research Landscape. https://www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.

38 Robinson-Garcia, N., Sugimoto, C. R., Murray, D., Yegros-Yegros, A., Larivière, V., & Costas, R. (2019). The many faces of mobility: using bibliometric data to measure the movement of scientists. Journal of Informetrics, 13(1), 50–63. doi: 10.1016/J.JOI.2018.11.002

Assessing the Continuity of Authors Over Time

To examine gender-related differences in how long authors continue to publish, we assessed the publishing records of a cohort of individuals whose first paper appeared in Scopus in 2009. Authors in this cohort were then assigned to countries and subject areas based on their publications during the period 2009-2014 (see additional details in Appendix A). Once we defined the cohort of individuals based on authors' first year of publication, we determined the year of each author's last publication in Scopus (up to 2018). Authors in the cohort were included in the author count for each year until the year of their last publication. For example, an author who first published in 2009 and last published in 2015 was not included in the author count from 2016 to 2018.

Taking this approach, we observed that in every country, there was a decline in the total number of publishing authors over time. The biggest drop was observed after the first year. Among the 15 countries that were assessed and the EU28, only 46-60% of authors who first published in 2009 published again by 2018. These authors, who published only once in 2009 and then did not publish again, may have been researchers who left research or research support staff whose contribution to a research project was acknowledged through authorship. We assumed that this group of individuals was likely heterogeneous across countries depending on local authorship practices, the inclusion of undergraduates in research, the prevalence of support research staff in the research ecosystem and the minimum publication requirements set for graduate students. Thus, we focused our analysis on authors who published at least twice during the period 2009–2018.

If women and men continued to contribute as authors for the same length of time after their first publication, the gender ratio would remain stable over time. In most countries analyzed, we found that the number of women who continued to publish declined more rapidly over time relative to the number of men who continued to publish (Figure 3.1). In the EU28 and in 14 of the 15 countries included in the analysis, the ratio of women to men who continued to publish declined at a rate ranging from -0.004/year (in Japan) to -0.016/year (in Argentina). In real terms, this corresponded to a slightly higher rate of loss in women authors compared to men authors over time (supplemental data, Table B.6). For example, in Brazil, there were 7,181 women authors in the cohort in 2010, which declined by 623 women per year (-8.7% per year); by comparison, there were 9,185 men authors in the cohort in 2010, which declined by 749 men per year (-8.2% per year). Therefore, the decline in the ratio of women to men was due to a 0.5% greater decline in the number of women than men authors over the study period. Portugal stands apart in that the ratio of women to men increased slightly over the study period, at a rate of 0.003/year. Interestingly, in the previous Elsevier report, Portugal was found to have one of the highest levels of gender parity in terms of overall research participation.

The more rapid decline in the number of women among authors compared to men is illustrated in Figure 3.2. By 2018, in all countries with a decline in ratio of women to men, we observed a small gap in the percentage of women who continued to publish compared to men. A chi-square test of independence comparing the difference in proportions confirmed that this difference was significant (i.e., $p < 0.05$) for all countries except the Netherlands, Mexico and Portugal (supplemental data, Table B.6). Similar trends in the decline of women authors were observed for authors who first published in 1999 (supplemental data, Figure B.11). This small but significant difference in the proportion of women compared to men who continued to publish nine years after their first publication could be related to a variety of factors. In Elsevier's 2019 survey of researchers, half of respondents said that they have contemplated changing careers, primarily because of inadequate pay or to pursue an exciting career opportunity. Almost a quarter of women said that they have considered leaving their career in research for reasons other than to pursue a career outside of research. Women, more so than men, cited reasons such as family commitments, that a research career is too demanding or that they experienced discrimination or harassment at work (Appendix C, Figure C.5).

FIGURE 3.1

Gender ratio among authors whose first publication was in 2009 and who published again at least once in any year up to 2018.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

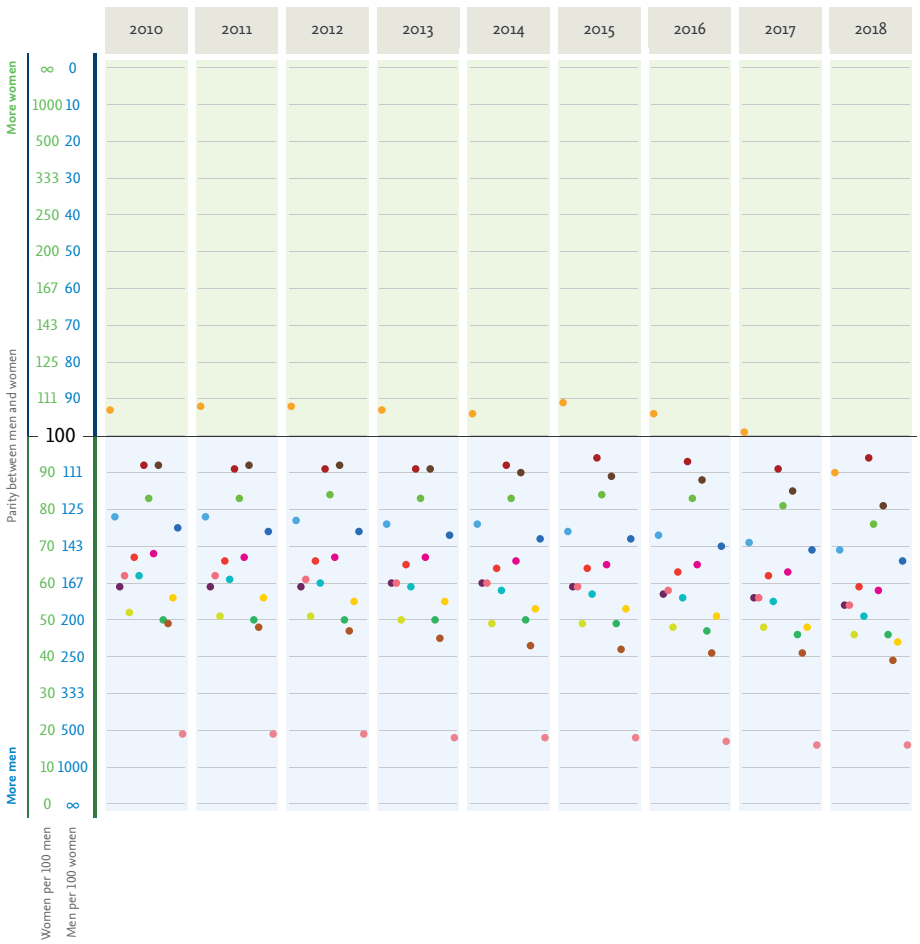


FIGURE 3.1 TAKEAWAY:

The ratio of women to men among authors in the cohort declines over time (between the year of authors' first publication in 2009 up to 2018) in all countries and regions except Portugal.

FIGURE 3.2

Percent of women and men in each country relative to the number of authors in the cohort in 2010. The cohort is comprised of authors whose first publication was in 2009 and subsequently published at least one more publication during the period.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

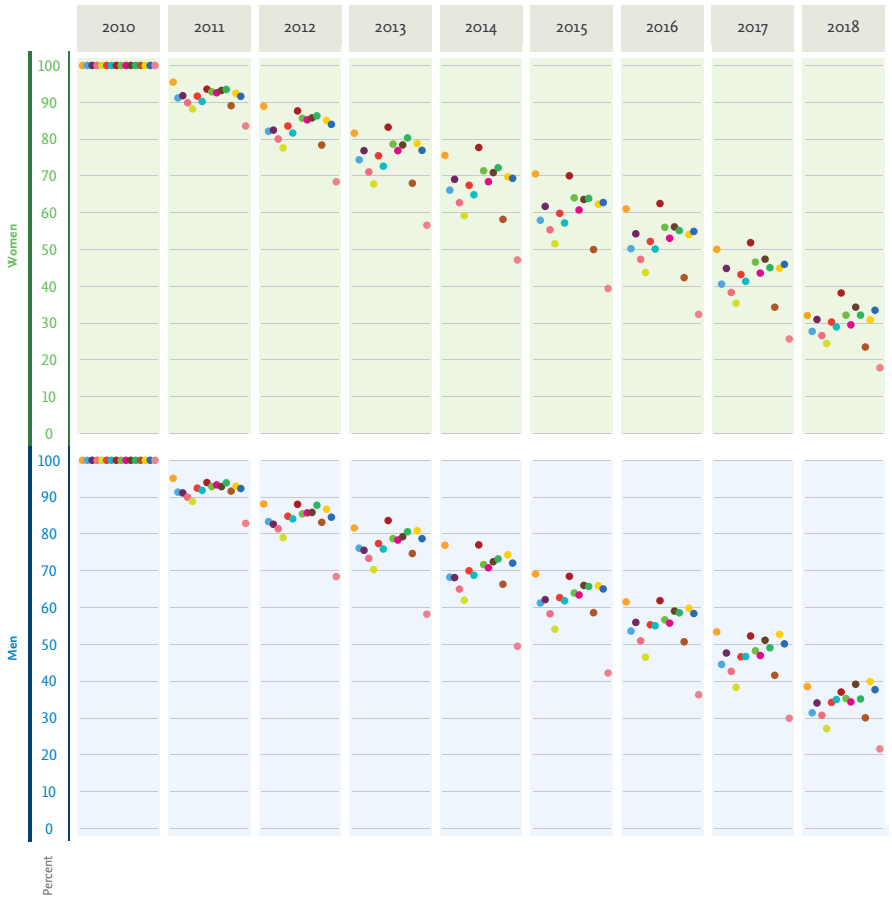


FIGURE 3.2 TAKEAWAY:

In every country, the percentage of women who continue to publish is lower than the percentage of men who continue to publish.

Publishing Careers and Mobility

Gender and Researcher Mobility Trends

Researchers who work in other countries often reap benefits as a result of their time abroad. Conducting research in another country can broaden a researcher's exposure to new techniques, strengthen their network and inspire new ideas. We observed that among authors, those who published outside their country of origin at least once had a lower rate of attrition (supplemental data Figure B.12). Among those still publishing in 2014–2018, authors who published outside their country of origin at least once published more on average and had a higher FWCI than those who never published outside their country of origin. Given the benefits of gaining international research experience, we assessed whether there exist gender-based differences in author mobility, measured on the basis of whether authors have published with an affiliation outside their country of origin (i.e., internationally).

HOW WE ASSESSED MOBILITY

The country of origin of each author was inferred based on the country of affiliation listed in their first publication. The authors were then assigned to one of two groups based on their publication history: authors who have published internationally (i.e., outside their country of origin) and authors who have never published outside their country of origin. To control for authors' level of experience, we limited the cohort to authors who first published during a five-year window (2009–2013 or 1999–2003). Additionally, we excluded authors who published only once in their career because this group of authors was assumed to be heterogeneous (representing undergraduate researchers, research support staff and researchers who left academic research) and vary based on local authorship practices. Detailed methods on the mobility analyses are provided in Appendix A.

Those who publish internationally publish more and have a higher FWCI than their counterparts who do not publish internationally. However, in most countries and the EU28, among those who publish internationally, men tend to publish more and have a slightly higher average FWCI than women.

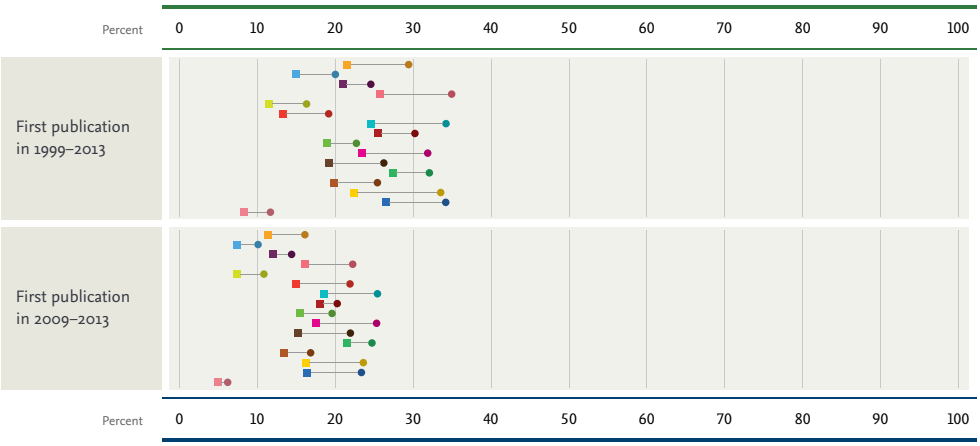
Among authors in both cohorts, we observed that men were more likely to publish internationally than women (Figure 3.3). Among authors who first published in the period 2009-2013 and published internationally at least once, there was a persistent gap in the percentage of men compared to women who published internationally. This gap ranged from 1.3 percentage points in Japan (6.2% of men published outside Japan compared with 4.9% of women) to 7.7 percentage points in France (25.3% of men published outside France compared with 17.6% of women). Assessing trends over a longer period of time among those authors who first published in the period 1999-2003, revealed a wider gap between the genders, ranging from a 3.4 percentage point difference in Japan (11.7% of men published outside Japan compared with 8.3% of women) to an 11.1 percentage point difference in Denmark (33.5% of men published outside Denmark compared with 22.4% of women). Our findings are consistent with an Elsevier survey of researchers conducted that showed that more men than women agreed with the statement "I am considering moving to another country to further my career in research." The difference was greatest in Eastern Europe and Latin America (supplemental Figure C.6). For both men and women, family commitments and lack of invitations from international institutions were inhibitors to relocation.

To assess whether the benefits of publishing internationally were equal among men and women, we analyzed metrics related to each cohort based on author status and publication record during the period 2014-2018. We observed a higher rate of author continuity among both women and men who published internationally compared to those who published solely in their country of origin. However, the rate of attrition was higher among women than men in the long term (Figure 3.4). Among those who published for the first time in 2009–2013 and published internationally at some point, 90–95% of women and men published again in 2014–2018 in the countries studied and little difference was observed between men and women. However, among those who first published in 1999-2003 and published internationally, the percentage of women who published again in 2014-2018 ranged from 60.6% (in Germany) to 81.5% (in Portugal) while among men, the range was higher, from 69.7% (in Germany) to 84.4% (in Argentina). This indicates that although the attrition rate is lower among those who have published internationally, this does not compensate for the higher rate of attrition among women compared to men over an extended period of time.

Comparing the 2014-2018 publications among women and men from each cohort, we observed that women who published internationally published more and had a higher FWCI on average than those who only published in their country of origin (supplemental data Figure B.13). However, the difference between men and women in both average publication count and FWCI was greater among those who published internationally than among those who never published internationally (Figure 3.5). Among the 2009-2013 cohort, men who never published internationally during their careers had between 1.1 times more (in the Netherlands) to 1.3 times more (in Germany) publications than women in the same category. Among those who did publish internationally, the values were higher, ranging from 1.2 times more (in Argentina) to 1.7 times more (in Denmark) publications by men than women. Similarly, men's average FWCI ranged from 0.87 times that of women (in Mexico) to 1.03 times that of women (in Italy) among those who never published internationally. Among those who did publish internationally, the average FWCI of men ranged from 0.95 times that of women (in France) to 1.16 times that of women (in Japan). This suggests that although publishing internationally imparts an advantage (in terms of average publication count and FWCI), the publication metrics gap between men and women is wider among those who publish internationally than those who do not. Further analyses are needed to assess whether subject area differences in representation or authorship position account for the observed gender gaps in authors who publish internationally.

FIGURE 3.3

Percent of authors who first published in 1999–2003 (top) or 2009–2013 (bottom panel) who published internationally (i.e., outside their country of origin) at least once.



KEY

- Women
- Men

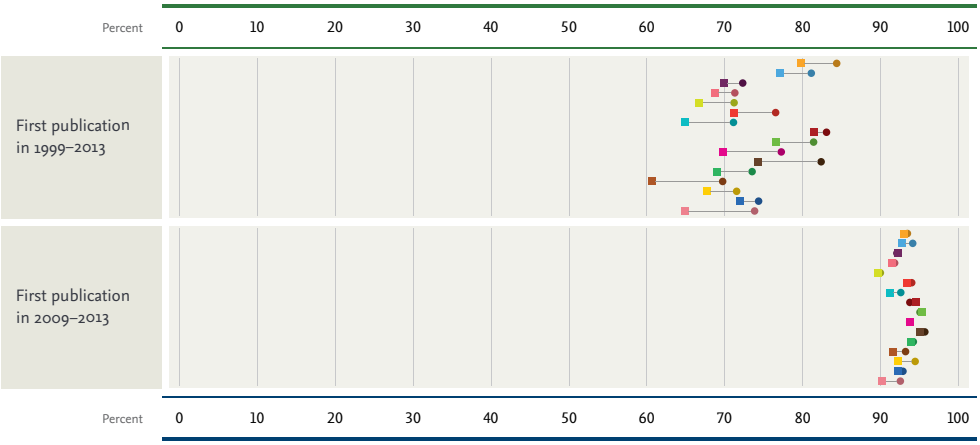
- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE 3.3 TAKEAWAY:

In every country, the percentage of women who publish internationally is lower than the percentage of men who publish internationally.

FIGURE 3.4

Percent of authors who published internationally (i.e., outside their country of origin) and who published at least once in 2014–2018. Data shown for those who first published in 1999–2003 (top) and 2009–2013 (bottom).



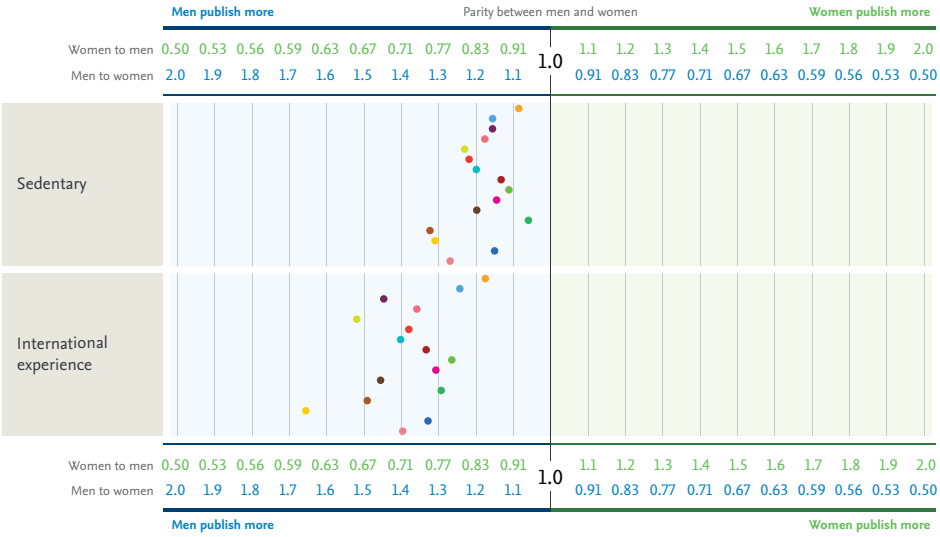
KEY

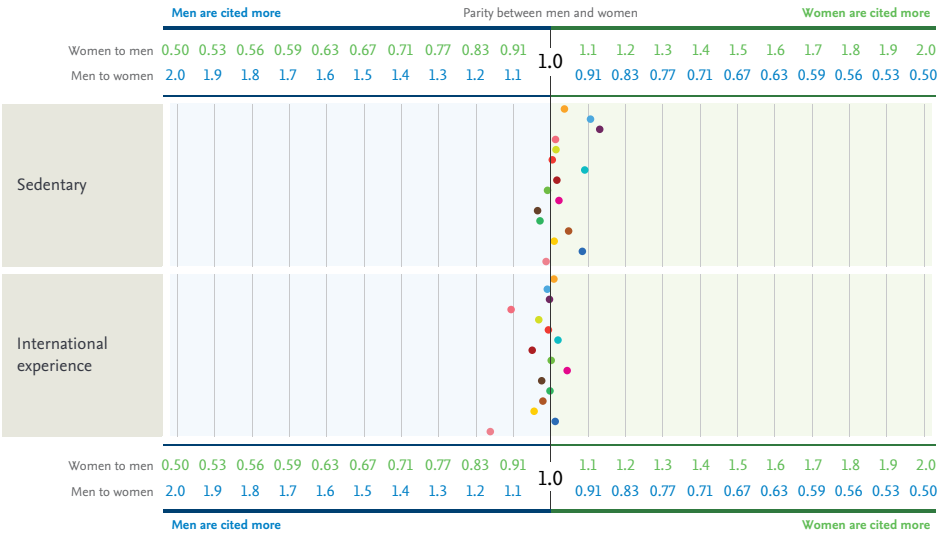
- Women
- Men

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE 3.5

Ratio of average publication count (top) and average FWCI (bottom) of men compared to women authors, among those who first published in 2009-2013, disaggregated according to author country of origin and whether the author has ever published internationally.





- Argentina
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- EU28
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- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

Expert Interview

Miyoko O. Watanabe, PhD

Deputy Executive Director and Director, Office for Diversity and Inclusion
Japan Science and Technology Agency (JST)

How would you describe the current state of gender diversity in research, compared with 5 years ago, and its impact on research and/or researchers globally and/or in your region in particular?

In Japan, the ratio of women to men researchers is continuously increasing, but it is happening very slowly. The government set a target to increase the share of women researchers to 30% by 2020, but by 2019 we had only achieved 16.6%. I believe the pace of change has been so slow because decisions are made by consensus after extensive discussion between multiple stakeholders, rather than by a few decision-makers. While there are advantages to consensus-based decision making, it has slowed the progress towards achieving gender equality in Japan. I should also say that Japanese people are also perfectionists: they may avoid addressing something that they cannot perfect. Perhaps it is time for us to focus on issues that really require attention, even if we cannot achieve perfection.

Are there initiatives, policies, or interventions that have emerged within your region and/or field in the last 3-5 years that you feel have impacted progress and should be monitored to assess impact?

We hosted the Gender Summit in Tokyo in 2017, and it turned out to be a good opportunity for Japan to think about gender equality and initiate change. At the Summit, we presented encouraging data from the Development Bank of Japan showing that the economic value of patents from gender-mixed teams was higher than that of patents from male-only teams. These data were re-analyzed last year, and confirmed that the economic value of patents from gender-mixed teams was 54% higher. Data like this—that describes the economic impact of women's contributions to research—is particularly impressive and effective at changing minds and policy in Japan.

By comparison, data on the ratio of women to men researchers or how slowly it is changing is almost too simple because it does not give us answers about why or how to change it. Japanese researchers want to know about how we got here, not just the result. Our objective in gender equality is not really to achieve a 50:50 ratio, but for everyone to receive equal opportunity and create a society that is inclusive of all kinds of people.

What value do data and an evidence-base offer as tools to policymakers and institutional leaders to address issues of gender diversity and equality?

In the past, we did not have a lot of data. Decisions were made based on people's experiences. Today, data gives us the opportunity to change our decision-making process from something driven by experience and opinion to something that is truly evidence-based. There is a generational component to making this shift—younger people are much more data-literate and are able to use and analyze data more effectively than older people who tend to make decisions based on their experience.

What information or insight from the report do you find particularly interesting and important for policymakers and institutional leaders to consider in relation to your region or specific subject areas?

The qualitative analysis is quite interesting. For example, most researchers said that there are more women in research now compared to 10 years ago, which is consistent with my thoughts. I am slightly anxious, however, about the consequences for young men and boys entering careers in research. Among young researchers right now, it appears easier for young women to get permanent jobs, because many people, managers, and societies want to see an increase in women's participation in research. The emphasis really needs to be on inclusion and opportunity for everyone, regardless of gender.

Gender equality is not an isolated problem—it is related to age, race, ability, culture, sexuality, and geography, among other factors.

My opinion is framed by the fact that Japan will soon experience a drastic depopulation, and many other countries will follow. Considering China's massive population, depopulation in China will have a global effect. In a growing society, efficiency is very important, and the individual is less valued. However, in a shrinking society, there is opportunity for everyone to have a place and contribute.

In the report there are trends identified from scientific publications, which are confirmed for both awarded grants and even more so when analyzing patents. What does this say about the gender innovation gap?

I think there is a huge innovation gap in Japan. Traditionally, men were considered to be the innovators, the inventors. But there are many new ventures in Japan now, and you can really see the difference between those founded by men and women. I get the impression that men founders are interested in industries separated from our daily life, whereas women founders are more interested in new industries connected to our daily lives. Businesses founded by men often achieve a net positive value on a shorter timescale and raise more capital, but the companies have a higher failure rate. On the other hand, businesses founded women might take longer to achieve a net positive value, but once they do, they are successful for a longer time. Both types of businesses are important, so we should continue to promote both men and women.

With regard to funding, I recently analyzed data on venture capital in the US for the World Science Forum. Over 90% of decision-makers at top venture capital firms are men. If you look at how venture capital firms make investments, 85% of their investments go to start-ups founded by men, while 13% go to mixed-gender teams, and only 2% go to women founders. This is consistent with the report's findings that men select and support other men.

I am also on the World Science Forum organizing committee, which decides on candidates for plenary speakers. The committee is 64% female. The steering committee, which decides on the actual speakers, is 35% female. The final ratio of plenary speakers at this year's World Science Forum was 53% female. So, from this example, it is clear that when women and men work together, they select both women and men and together achieve gender balance in the group.

Thinking about the future of gender diversity and equity in research globally, where do you think we'll be in 10 years' time and what organizational and or cultural issues do you think will influence change most significantly?

I always say that gender equality is not an isolated problem—it is related to age, race, ability, culture, sexuality, and geography, among other factors. If we only talk about gender equality, we lose sight of these connections. We should be promoting gender equality in the context of these other factors, with a focus on diversity, not just gender.

In addition, I feel that many senior men are simply unaware of women's talent in Japan. This year we launched the 1st Brilliant Female Researchers Award (Jun Ashida Award) for excellent women researchers and institutions promoting women in science. We always wondered why we didn't have many women researchers applying for funding, but for this award, we had over 100 applicants. Many of us were unaware of these talented women prior to launching this award. We need to continue creating platforms to support and promote women.

Publishing Careers and Mobility

Conclusion

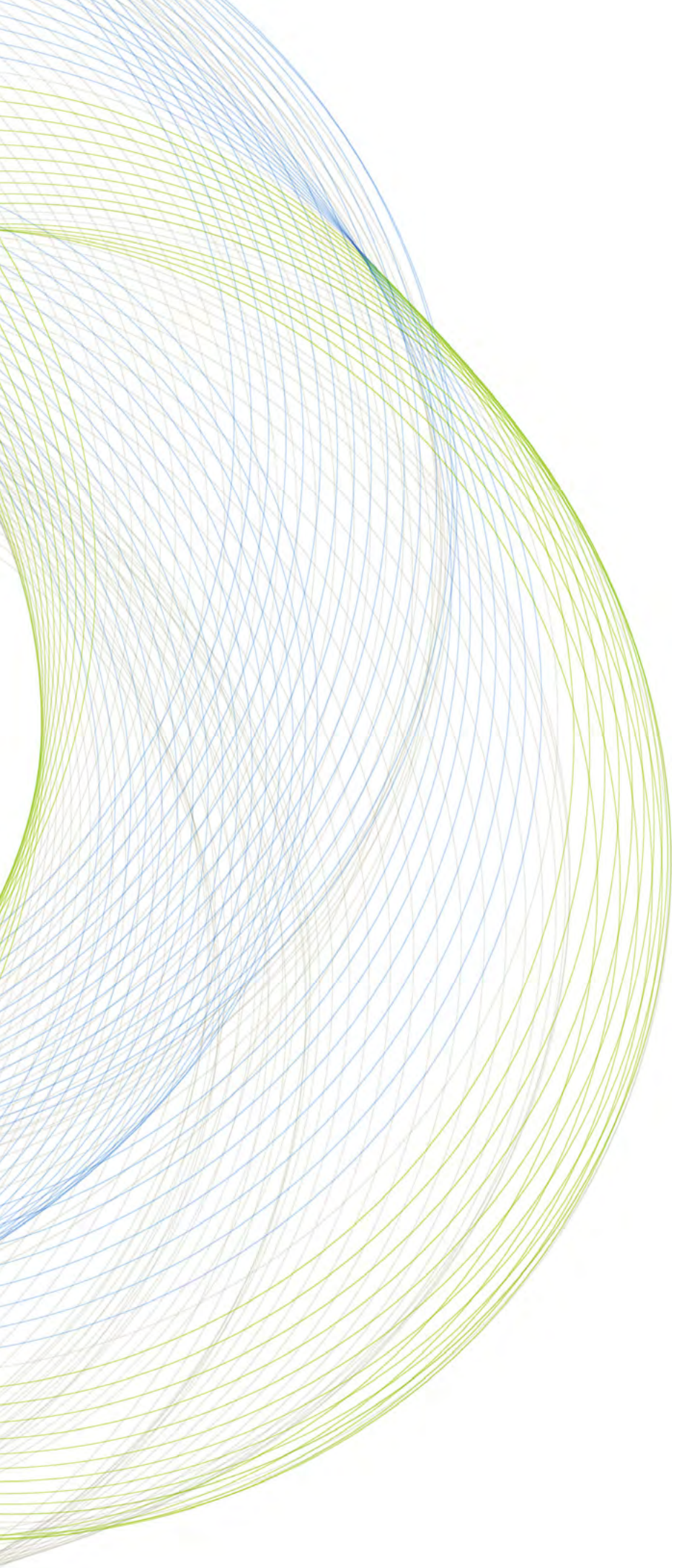
In this chapter, we observed that men were slightly more likely to continue to contribute to research as authors than women, based on a cohort analysis of researchers' publication records over time. Indeed, our survey revealed that women leaving research careers tend to mention family commitments and harassment or discrimination more frequently than men. Of these two reasons for leaving research, the first may be rooted in personal choice as well as the cultural and societal expectations placed on women. The second reason may be addressed through the development and implementation of policies and procedures that ensure safe and respectful workplaces at research institutions.

Our analyses also revealed that men publish more internationally than women. However, while those who publish internationally tend to have a higher number of publications and higher citation impact, a gender gap in these two indicators persists with women trailing men on both counts. It seems that women researchers are not able to benefit equally from international mobility, in terms of participation as well as outcomes. This reinforces the hypothesis from the 2017 Elsevier report that there exists a "glass fence" that limits international mobility of women researchers, and thus their future research career success. There are several factors that may impact the international mobility of researchers, such as one's collaboration network, which is the focus of the next chapter.

Chapter 4

Collaboration Networks

Evaluating gender differences in collaboration activity



Key Findings

- *Across many subject areas and countries, men tend to have more co-authors than women and this difference is wider for authors with a longer publication history.*
- *Women and men are more similar in the way they are connected to their potential collaborative space (second-order collaborators) through their direct collaborators.*
- *Women and men researchers are similar with respect to their share of international collaborators, except for the EU28, where men have a slightly higher tendency to establish international collaborations than women.*
- *On average, authors tend to preferentially collaborate with authors of the same gender across the subject areas and regions studied.*

Collaboration Networks

Introduction

In this report, we used a network analysis approach to study whether gender impacts authors' collaboration relationships. Network analysis provides a unique perspective that reveals the complex nature of relationship structure among researchers and the characteristics of authors' collaborative networks. It is through complex interactions between individuals and institutions that processes of knowledge diffusion, innovation[40] and individual career progression take place.

Assessing collaboration through network analysis allows us to consider complex interactions between an author's characteristics and the characteristics of their co-authors. For example, an author may have a relatively high number of collaborators who have co-authors who are not well-connected or experienced. Conversely, an author may collaborate with a relatively low number of exceptionally well-connected and/or experienced co-authors. In this context, network analysis can evaluate whether opportunities to connect to other authors in the research community are greater in the latter case than the former, despite the former having a higher number of co-authors.[41] A network analysis approach also allows us to examine direct and indirect co-authorship ties of an author (i.e., the focal author) to assess how the network positioning and productivity of co-authors (i.e., direct collaborators of the focal author), and co-authors' co-authors (i.e., second-order collaborators of the focal author), relate to individual research output and scientific trajectory.[42]

Scientific collaboration is impacted by gender, as well as other social identities. Because gender is a factor that has been shown to influence social interactions, gender may also determine exclusion or subordination within scientific institutions.[43] Therefore, it is relevant to examine how men and women are positioned in collaboration networks, as their network characteristics may be shaped by gender differences and form the basis for future and downstream scientific activity.

In this chapter, we add to a growing literature on men's and women's positioning in the structure of scientific collaboration with a study of co-authorship network using a sample of authors in 16 networks defined by the focal authors' geographic region and subject area (referred to as region-subject pairs) where the region was

40 Whittington, K. B., Owen-Smith, J., & Powell, W. W. (2009). Networks, propinquity, and innovation in knowledge-intensive industries. Administrative Science Quarterly, 54(1), 90-122. doi: 10.2189/asqu.2009.54.1.90; Barabási, A., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., & Vicsek, T. (2002). Evolution of the social network of scientific collaborations. Physica A: Statistical Mechanics and its Applications, 311(3-4), 590-614. doi: 10.1016/S0378-4371(02)00736-7

41 Madlock-Brown, C., & Eichmann, D. (2016). The scientometrics of successful women in science. In Advances in Social Networks Analysis and Mining (ASONAM), 2016 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (pp. 654–660). IEEE. Retrieved from: https://doi.org/10.1109/ASONAM.2016.7752307. Accessed December 5, 2019.

42 Bordons, M., Aparicio, J., González-Albo, B., & Díaz-Faes, A. (2015). The relationship between the research performance of scientists and their position in co-authorship networks in three fields. Journal of Informetrics, 9(1), 135-144. doi: 10.1016/j.joi.2014.12.001; Dehdarirad, T., & Nasini, S. (2017). Research impact in co-authorship networks: a two-mode analysis. Journal of Informetrics, 11(2), 371-388. doi: 10.1016/j.joi.2017.02.002; Ebadi, A., & Schiffauerova, A. (2015). How to become an important player in scientific collaboration networks? Journal of Informetrics, 9(4), 809-825. doi: 10.1016/j.joi.2015.08.002; Warner, E. T., Carapinha, R., Weber, G. M., Hill, E. V., & Reede, J. Y. (2016). Faculty promotion and attrition: The importance of coauthor network reach at an academic medical center. Journal of General Internal Medicine, 31(1), 60-67. doi:10.1007/s11606-015-3463-7.

43 Whittington, K. B. (2018). A tie is a tie? Gender and network positioning in life science inventor collaboration. Research Policy, 47(2), 511-526. doi:10.1016/j.respol.2017.12.006; Abramo, G., D'Angelo, C. A. & Murgia, G. (2013). Gender differences in research collaboration. Journal of Informetrics, 7(4), 811-822. doi: 10.1016/j.joi.2013.07.002; Beaudry, C. & Larivière, V. (2016). Which gender gap? Factors affecting researchers' scientific impact in science and medicine. Research Policy, 45(9), 1790-1817. doi: 10.1016/j.respol.2016.05.009; van Emmerik, I. H. (2006). Gender differences in the creation of different types of social capital: A multilevel study. Social Networks, 28(1), 24-37. doi: 10.1016/j.socnet.2005.04.002; Bozeman, B., & Gaughan, M. (2011). How do men and women differ in research collaborations? an analysis of the collaborative motives and strategies of academic researchers. Research Policy, 40(10), 1393-1402. doi: 10.1016/j.respol.2011.07.002; Warner, E. T., Carapinha, R., Weber, G. M., Hill, E. V., & Reede, J. Y. (2015). Faculty promotion and attrition: the importance of coauthor network reach at an academic medical center. Journal of General Internal Medicine, 31(1), 15–17. doi: 10.1007/s11606-015-3463-7; Ghiasi, G., Larivière, V., Sugimoto, C. R., Larivi, V., & Sugimoto, C. R. (2015). On the compliance of women engineers with a gendered scientific system. PLoS ONE, December(12), 1–19. doi: 10.1371/journal.pone.0145931

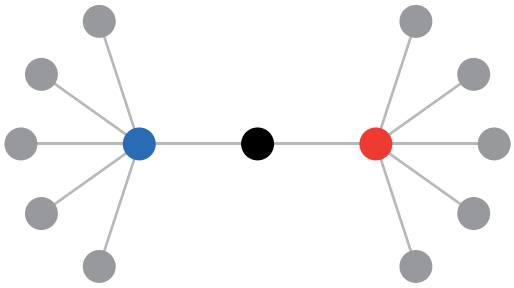
Brazil, Japan, USA or the EU28 and the subject area was biochemistry, business & economics, engineering or medicine (see Appendix A, sections "Author country and subject area assignation" and "Author mobility"). Brazil, Japan, USA and the EU28 were selected for our analyses because they were expected to reflect different research cultures and have different ratios of women to men among authors.[44] Biochemistry, business & economics, engineering and medicine were chosen as representative subject areas from each of the four broad subject clusters: life sciences, social sciences, physical sciences and health sciences, respectively, with different ratios of women to men among authors.[45]

We measured authors' network centrality (i.e., the count of co-authors) and the average network centrality of their direct collaborators, as depicted in Figure 4.1. We paid particular attention to the attributes of authors' immediate ties, to the characteristics of these ties, to tendencies towards gender homophily (proportion of same-gender ties) and the nature of men's and women's international reach (proportion of collaborators affiliated with different countries). These analyses are a starting point from which we can consider how gender shapes collaborative activity in research.

Our analyses focused on a set of focal authors who published during the year 2013 and were "active authors." A full description of how focal authors were defined can be found in Appendix A, section "Author collaboration network analysis." We built collaborative network profiles for these authors based on their co-authorships from the period 2009-2013 and built an author-level collaboration network in which the "nodes" in the network represent authors and the connections between them (the "links") represent co-authorship relationships (i.e., authorship of one or more publications by two authors during the period).

FIGURE 4.1

A simple ideal collaboration network. The focal author (black circle) is tied to two direct co-authors (blue and red circles), which are in turn connected to five co-authors (gray circles).



This results in a direct network centrality of the focal author equal to 2 and an average network centrality of their direct collaborators equal to 5. Each individual direct collaborator can be assigned a binary attribute according to gender and region (same or different from the focal author's), represented here as different node colors (blue and red), to compute gender composition and internationality of the focal author's direct co-authors.

44 Elsevier. (2017). Gender in the Global Research Landscape. Retrieved from: www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.
45 Ibid.

Collaboration Networks

Network Centrality of Focal Authors

An author collaboration network can be first described by the count of direct collaborations established over a certain period of time, referred to in our analyses as "network centrality." To understand if gender contributes to the formation of research collaborations, we assessed the average network centrality[46] for men and women authors in networks defined by 16 region-subject pairs.

Figure 4.2 depicts the average network centrality of men and women focal authors as a function of their first year of publication in 16 region-subject pairs. The absolute value of average network centrality within each gender group was normalized to the average network centrality of observations within each group of authors of the same region, subject area and year of first publication to isolate the difference between the two gender groups. In other words, any differences observed across men and women within a given region, subject area and year of first publication would be due to gender.

Figure 4.2 shows that there were similar trends across regions, with the least difference between men and women among the younger cohorts (based on year of first publication) and the difference increased with longer author publication histories. The difference in network centrality by gender was greatest in medicine. We observed more variable trends in engineering and business & economics in Japan and Brazil, which may be due to the small number of observations for these cohorts.[47]

Network centrality
We measure network centrality as the number of direct collaborators, i.e., the number of unique authors with whom an author has co-authored papers during a period of time. In network science, this measure is called "degree centrality." See also Appendix A for details on modeling and computation of network centrality.

46 For this analysis, we counted the number of each author's direct co-authors during the period 2009–2013, excluding possible collaborations prior to 2009 or collaborations that were not captured as co-authorship on a published paper.

47 For completeness, we included focal author cohorts from Japan and Brazil in analyses of engineering and business & economics and more senior cohorts from EU28 in business & economics, as these cohorts included a small number of observations. The aggregate statistics for these groups cannot be considered reliable as they can generate fluctuating trends. Therefore, we intentionally avoided interpreting the results for these cohorts.

FIGURE 4.2

Normalized number of direct collaborators (x-axis) of focal authors, grouped based on year of their first publication (y-axis), by region and subject area.

Values were normalized by average values of observations by region, subject area and binned focal authors' year of first publication. Average values corresponding to less than 10 observations were excluded from the analysis.

GROUP	YEAR OF FIRST PUBLICATION
A	1989–1993
B	1994–1998
C	1999–2003
D	2004–2008
E	2009–2013

- **Women**
- **Men**

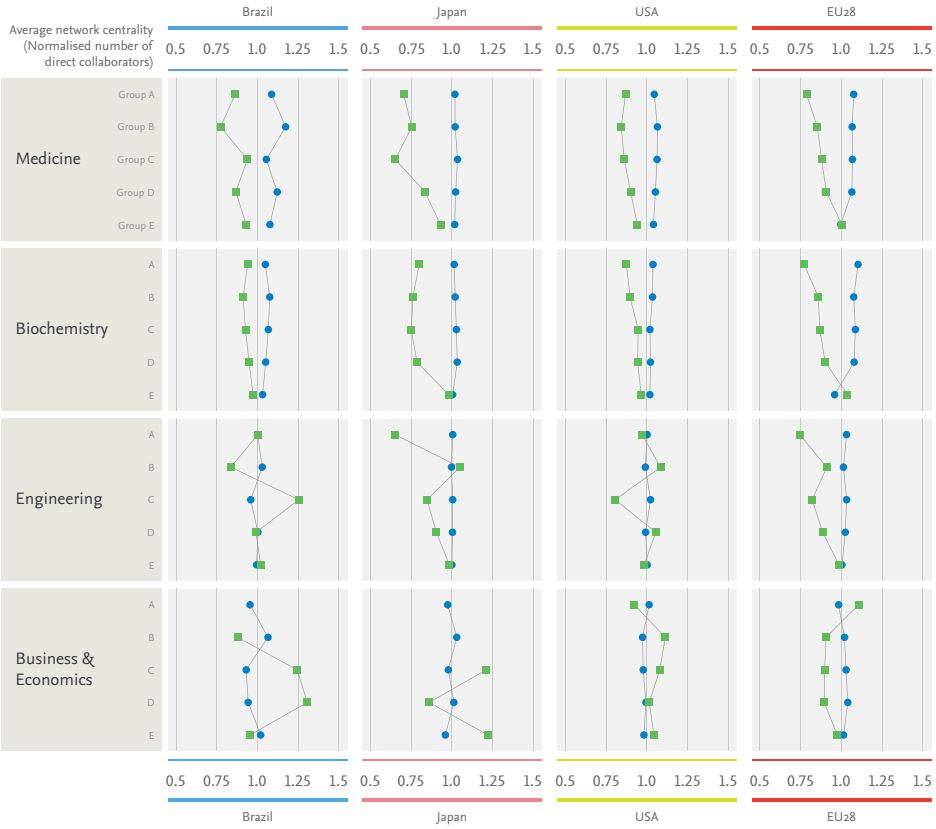


FIGURE 4.2 TAKEAWAY:

Across several regions and subject areas, men tend to have more co-authors than women and this difference widens for authors with a longer publication history.

Collaboration Networks

Characteristics of Collaboration Ties

To provide insight on the gender differences in collaboration beyond the average number of co-authors, we considered several characteristics of men and women authors' collaborators. We studied:

- how well-connected the direct collaborators of men and women authors are (on average),
- the proportion of men and women authors' collaborators who are the same gender (gender homophily) and
- the proportion of men and women authors' collaborators who were "international" collaborators (i.e., affiliated with a different country).

Responses to Elsevier's 2019 survey of active researchers provided insights into the quality of their social networks. Active researchers (self-identified as spending at least 20% of their academic/work activity conducting research on an ongoing basis) were asked if they know (i.e., if they are able to remember the name of the person/job holder and easily start a conversation when encountering them) people who hold certain job positions of varying levels of prestige within their fields. Women reported having more close ties with people in positions of moderate prestige, whereas men reported knowing people considered to be in positions of high prestige. These influential connections, as a measure of research network quality, could allow for greater career mobility and a distinct advantage in career progression opportunities (Appendix C, Figure C.7).

The survey also found that, when defining seniority by years in research, similar percentages of men (59%) and women (57%) in later stages of their research careers (i.e., actively involved in research for 10 or more years) reported having at least one high-prestige connection. Among early-career researchers (i.e., actively involved in research for less than 10 years), significantly fewer women (38%) reported having at least one high-prestige connection compared to men (49%). These differences in social network quality may contribute to the observation that fewer women gain senior leadership roles (Appendix C, Figure C.8).

In the 2019 Elsevier survey, significantly more women (70%) than men (64%) agreed that it is easy to collaborate with colleagues in their field of research. This suggests that women may be better at creating close-tie connections, or that men may be actively reaching out to collaborate more often, but these attempts do not always result in a collaboration (Appendix C, Figure C.9).

The network centrality of direct collaborators

Beyond the number of direct collaborators, an author's collaboration network properties can be assessed by looking at potential collaborations, qualifying the strength of each direct connection based on how many potential other connections a direct collaborator would unlock for the focal author. We assessed how well-connected a focal author's direct collaborators are by calculating the number of collaborators of the direct collaborator. These collaborators of the direct collaborator are referred to as second-order collaborators (in Figure 4.1, second-order collaborators are depicted as gray dots, see also the definitions in Appendix A, section "Author collaboration network analysis"). We then calculated the average number of second-order collaborators of each focal author. If a focal author's average number of second-order collaborators is high, this indicates that the focal author has high-value direct collaborators. Therefore, the average number of second-order collaborators may be considered as a measure of the network "reach," to the available social capital held by the direct collaborators of a focal author. The implication is that the more co-authors an author's direct collaborators have, the wider the current and/or future collaborative space is for that author.

Figure 4.3 depicts the average number of second-order collaborators of men and women focal authors as a function of their first year of publication, in 16 region-subject pairs. We normalized the average number of second-order collaborators within each gender group to the average number of second-order collaborators within each group of authors of the same region, subject area and year of first publication to examine the difference between the two gender groups. Thus, any differences observed across men and women within a given region, subject area and year of first publication would be due to gender.

As Figure 4.3 shows, we found that collaborators of men and women focal authors across publication history lengths tended to have a similar average number of second-order collaborators. In the subject area of medicine in Brazil, co-authors of women focal authors tended to show lower connectivity levels compared to collaborators of men focal authors, and this difference widened among those with a longer publication history. Fluctuating trends in the average number of second-order collaborators were seen in business & economics and engineering[48] across all regions, and in some cases, collaborators of women focal authors had a higher average number of second-order collaborators than men, particularly in Japan and Brazil. This may be due to the smaller number of observations in these groups, particularly among women (sample size of networks can be found in Appendix A, Table A.1).

Given that men have higher network centrality than women (see Figure 4.2), the results pertaining to second-order collaborators are interesting. Together, these results indicate that although women authors tend to connect with fewer collaborators than men on average, the average number of second-order collaborators of women is similar to that of men. In other words, the direct collaborators of women are as well-connected as the direct collaborators of men.

48 The number of focal authors was lowest among authors who first published between 1989-1993, particularly in Brazil and Japan, and in the subjects of business & economics and engineering.

FIGURE 4.3

Average number of second-order collaborators (x-axis) of focal authors, grouped based on year of their first publication (y-axis), by region and subject area.

Values were normalized by average values of observations by region, subject area and binned focal authors' year of first publication. Average values corresponding to less than 10 observations were excluded from the analysis.

GROUP	YEAR OF FIRST PUBLICATION
A	1989–1993
B	1994–1998
C	1999–2003
D	2004–2008
E	2009–2013

■ **Women**

● **Men**

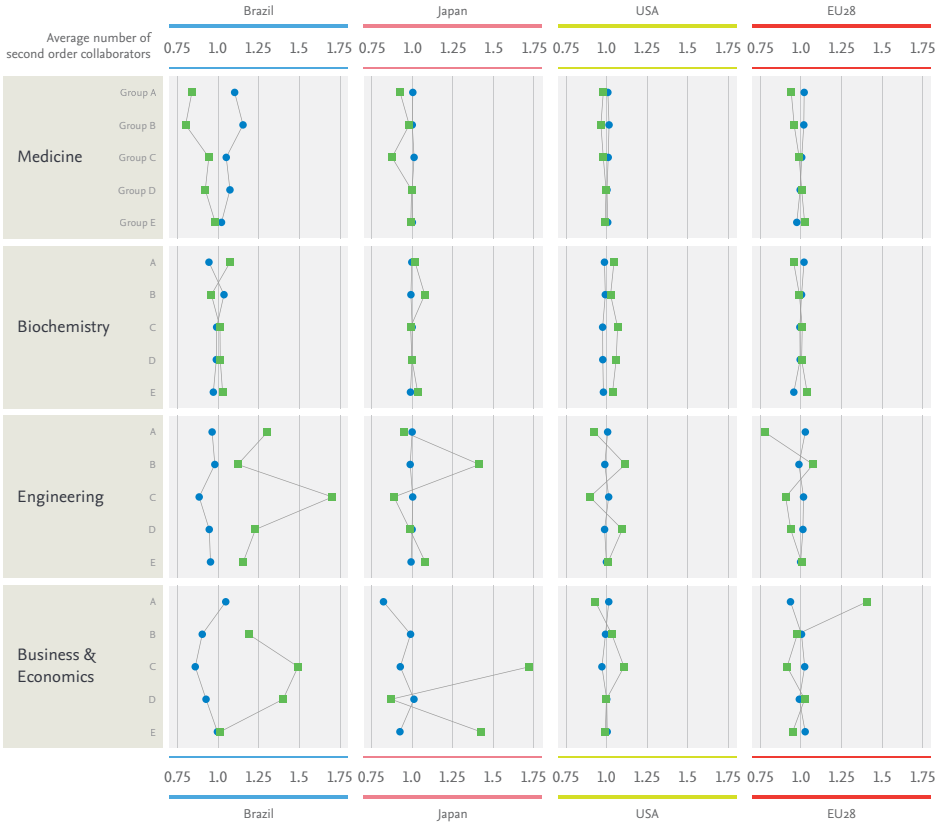


FIGURE 4.3 TAKEAWAY:

Women and men are similar in the way they are connected to others in their networks through their direct collaborations (i.e., the average number of collaborators of their collaborators).

Gender composition of direct collaborators

Studies have demonstrated that gender composition in a collaborative context has an effect both on collaboration practices and team performance.[49] Network homophily based on gender status is a relevant aspect of a collaboration system because co-authorship connections are often driven by gender status inclusion and exclusion processes (i.e., conscious or unconscious decisions to seek out gender-similar collaborators).[50] When present, such preferences have implications for women's downstream research productivity. The presence of gender homophily also has implications for the importance of women's representation in a field.

We measured the gender composition of focal authors' collaborators, calculated as the proportion of focal authors' collaborators who were women (referred to as the average share of women collaborators), to provide insight on gender-based network homophily among researchers.

Figure 4.4 depicts the average share of focal authors' direct collaborators who were women, disaggregated by gender group as a function of first year of publication, in each of the 16 networks defined by focal author region and subject.

The results shown in Figure 4.4 strongly suggest that women authors show a greater tendency to collaborate with other women than men authors do, and vice versa (see supplemental data, Figure B.14); this was seen across regions, subject areas and publication history lengths. A homophily pattern was clearly detected, where authors from the same gender group tended to connect to others of the same gender with higher probability. These findings corroborate those found in other collaboration network analyses, including studies of men's and women's co-inventing ties.[51] Our analysis also revealed that men's and women's levels of homophily tend to be greatest among those with the least publishing experience (i.e., earlier career researcher cohorts).

49 Bear, J.B. & Woolley, A.W. (2011). The role of gender in team collaboration and performance. Interdisciplinary Science Reviews, 36(2), 146-153. doi: 10.1179/030801811X13013181961473

50 Whittington, K.B. (2018). A tie is a tie? Gender and network positioning in life science inventor collaboration. Research Policy, 47(2), 511-526. doi: 10.1016/j.respol.2017.12.006

FIGURE 4.4

Average share of women collaborators (x-axis) of focal authors grouped based on year of their first publication (y-axis), by region and subject area.

Average values corresponding to less than 10 observations were excluded from the analysis.

GROUP	YEAR OF FIRST PUBLICATION
A	1989–1993
B	1994–1998
C	1999–2003
D	2004–2008
E	2009–2013

Women

Men

FIGURE 4.4 TAKEAWAY:

On average across regions and subject areas, authors tend to collaborate more with authors of the same gender (see also figure B.14).

International reach of direct collaborators

Scientific collaboration is an increasingly global endeavor. Research collaborations that span geographic boundaries facilitate the transfer of knowledge across national borders. International ties broaden the reach of a research program and can introduce new and diverse ideas into an author's work. Studies have shown that research published in collaboration with a greater international author presence receives higher rates of citation and has positive downstream effects on the authors' research career opportunities and research programs.[52]

We therefore wanted to examine if any difference between men and women exists in terms of the share of focal authors' collaborators who are affiliated with international institutions (i.e., institutions not in the same country as the focal author's institution). We called this measure "international reach."

Figure 4.5 shows the share of a focal author's direct collaborators who were international, separated according to gender group as a function of year of first publication, in the 16 networks defined by focal author region and subject. The analysis revealed that men and women authors have a similar share of international collaborators across cohorts, regions and subject areas. A possible exception was the EU28, where women had a slightly lower share of international collaborators on average than men across all subject areas. Our analysis treated the EU28 as a single region, with "international collaborators" defined as those outside any EU28 country; however, we found similar results when defining "international collaborators" as those outside the focal author's country. We also found evidence of slightly lower levels of international collaboration for women in engineering and business & economics in the USA. The data depicted in Figure 4.5 also shows that authors with longer publication histories have higher international reach. Researchers with a longer publication history tended to collaborate with co-authors from other regions more often than more early career researchers did. These findings contrast with the results from Elsevier's 2017 report,[53] which found that women were less likely than men to collaborate internationally on research papers because our methodology in 2017 used publications rather than authors as the unit of analysis.

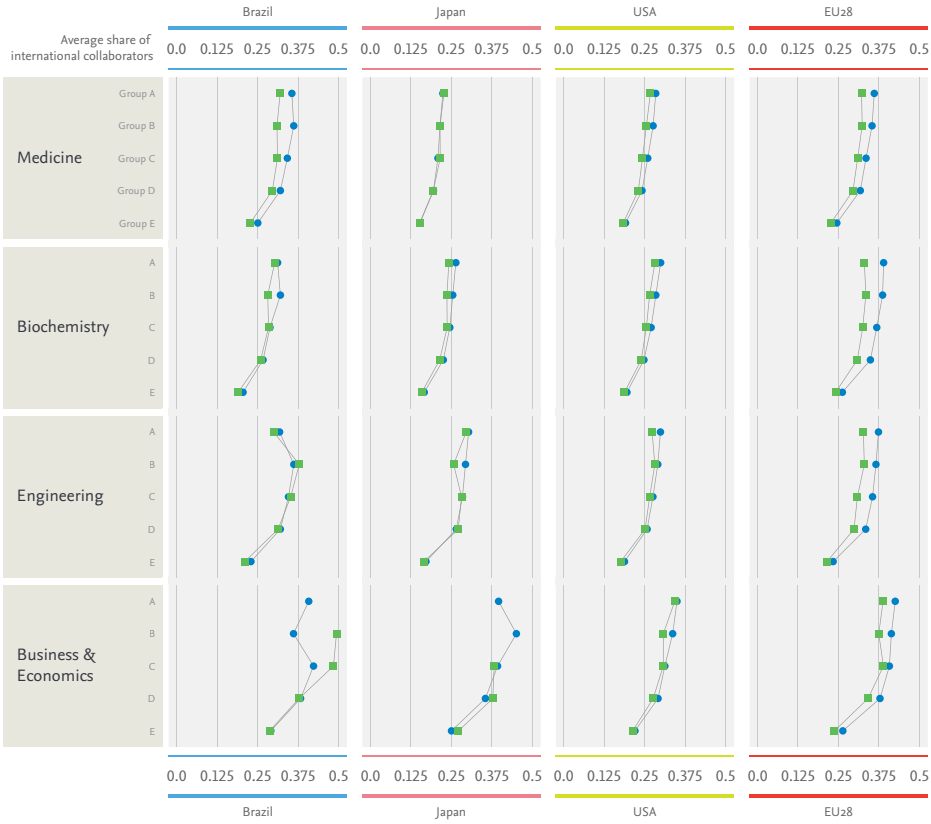
52 Aksnes, D. W. (2003). Characteristics of highly cited papers. Research Evaluation, 12(3), 159-70. doi: 10.3152/147154403781776645

53 Elsevier. (2017). Gender in the Global Research Landscape. Retrieved from: www.elsevier.com/research-intelligence/campaigns/gender-17. Accessed October 23, 2019.

FIGURE 4.5

Average share of international collaborators (x-axis) of focal authors where the latter are grouped based on year of their first publication (y-axis), by region and subject area.

The share of international collaborators is computed as the ratio of the count of direct collaborators not affiliated in the same country and/or region as the focal author to the overall count of their direct collaborators. The EU28 was treated as a single region, with "international reach" defined as collaborations beyond the EU28. Average values corresponding to less than 10 observations were excluded from the analysis.



GROUP	YEAR OF FIRST PUBLICATION
A	1989–1993
B	1994–1998
C	1999–2003
D	2004–2008
E	2009–2013

Women

Men

FIGURE 4.5 TAKEAWAY:

Women and men authors in most regions and subject areas are similar in terms of international reach, with the exception of EU28, where men have slightly more international collaborations than women.

Expert Interview

Sarah Sharples, CErgHF, FIET, FIEHF, PhD, MSc,BSc (hons), PGCAP

Pro-Vice-Chancellor for Equality, Diversity and Inclusion
University of Nottingham

How would you describe the current state of gender diversity in research, compared with 5 years ago, and its impact on research and/or researchers globally and/or in your region in particular?

One of the biggest changes I've seen in the last five years is an increased awareness of gender diversity with regard to leadership and in research teams. From an engineering context, we know that women are significantly underrepresented in general, and in particular among leaders of research teams. There is a lot being done to address gender diversity at the PhD and postdoctoral stages, but these efforts haven't moved up the career ladder to have an impact at the research leadership stage. I think we are still seeing significant bias toward men in STEM research, and though gender issues come through less strongly in the arts and social sciences, they are still present. So I would say there has been progress made in terms of the awareness of gender issues in research and their importance, but I haven't seen a significant change in terms of the actual makeup of research teams to the extent I hope we will see in five years' time.

Are there initiatives, policies, or interventions that have emerged within your region and/or field in the last 3-5 years that you feel have impacted progress and should be monitored to assess impact?

There are two examples. The first are changes in research fellowship recruitment programs, such as the UKRI Future Leadership fellowship program, which considers all aspects of diversity, not just gender. My colleague, Jessica Corner, who leads the research fellowship recruitment here at Nottingham, has made significant inroads in examining and exploring both gender and ethnic diversity and potential bias at all stages within the recruitment process, from the criteria to communication and advertising to mentorship. Her work was featured in the recent UKRI report as an example of good practice in this area. These fellowships are competitive and prestigious, so incorporating diversity in our recruitment process is in no way about positive discrimination, it is about positive action to encourage applicants from as many diverse groups as possible. In doing so, we create an incredibly diverse pool from which to select fellows. We are also very careful in making sure the interview process itself is not biased; for example, we look at quality of publications rather than quantity to account for applicants who may have taken time off for maternity leave. We also deliberately attract people with care responsibilities by providing opportunities and funding for childcare during the fellowship period.

The second example is at the other end of the career ladder—promotions criteria. Within universities, promotion criteria are fraught with myths; for example, that you must have X number of publications or a certain level of funding to become a professor. Many universities are trying to address bias in promotion by emphasizing teaching, public engagement, and entrepreneurship as well as research activities and focusing on the quality of publications rather than quantity. The goal is recognizing that there are a variety of paths that people take to do excellent research and we need to make sure that everyone is assessed fairly.

What value do data and an evidence-base offer as tools to policymakers and institutional leaders to address issues of gender diversity and equality?

Data—both quantitative and qualitative—are hugely valuable in identifying where disadvantage is happening and prioritizing where we should be intervening as leaders, policymakers, and funders. The top-level quantitative data tells us what is going on, and the qualitative data can help us understand why, by providing real-life examples illustrating the multiple factors that interact to produce the systemic disadvantage that women experience in research. In the report, the summary of the qualitative data along the four quadrants of opinions that people might have—whether the system is fair or biased and whether gender balance is or is not a high priority—was a really elegant articulation of some of the challenges to gender diversity. I was particularly interested in the "fair-minded women" and "indifferent women"

I had a really supportive PhD supervisor who absolutely supported me and recognized when I needed a little more confidence to demonstrate my role as a leader within the research team.

groups. Some women, perhaps understandably, feel that they have successfully worked through a very difficult and biased system on their own merits and they never want to feel that they would be seen as having been given an unfair advantage because of their gender. While the report's data can be quite dispiriting, it nevertheless gives us a starting point for conversations within our research communities about what needs to change.

Given the diversity of perceptions on gender issues, what do you consider the most important factors that influence progress toward equality for men and women in research?

Looking at my colleagues, particularly women, who have successful careers in research, the most common factor is that they have had support, often from a research leader. I had a really supportive PhD supervisor who absolutely supported me and recognized when I needed a little more confidence to demonstrate my role as a leader within the research team. When I talk to colleagues who have had more difficulty in their careers, it is often because they lacked that mentoring, that external support from colleagues. Now that I am in a senior position, I try to consciously support people as they pursue their research careers. It's not altogether a selfless act, because when your colleagues are at their best, the entire research team benefits. But being a really good leader is about helping others rise.

What information or insight from the report do you find particularly interesting and important for policymakers and institutional leaders to consider in relation to your region or specific subject areas?

The sexual harassment and misconduct issues—that unacceptable behaviors are still being tolerated or accepted and that they are having a significant and lasting impact on some women's research careers—was really upsetting, but important to recognize.

I was also struck by the networks data because we do know that building networks often requires national and international travel. I made the explicit decision when my children were young not to travel internationally. The decision led me to become more involved in EPSRC and doctoral training as I worked more on building my national profile and research network. I thought—probably wrongly—that this strategy would have less of an impact on my homelife, but it worked out pretty well. But that decision also likely shaped my research network so that it looks different from that of a colleague who did not have similar care responsibilities.

In the report there are trends identified from scientific publications, which are confirmed for both awarded grants and even more so when analyzing patents. What does this say about the gender innovation gap?

I absolutely recognized the gender gap in terms of grants, patents, and entrepreneurship. At Nottingham, we are working to encourage women to apply for more grants, particularly large grants. Once women apply, they have a reasonably equal chance for success as men, but the absolute number of applications remains lower for women. Because there are fewer of the larger, more prestigious grants, the underrepresentation of women is even more apparent there. This also means that there are fewer women in strategic policymaking discussions, presenting to parliamentary scientific committees, or engaging with government departments.

Colleagues at Nottingham recently led an event as part of a consortium of universities to establish a network for women researchers who are interested in entrepreneurship and innovation. We discussed why fewer women might be engaged in entrepreneurship, including a lower willingness to take risks, the greater time demands, especially when added to an already demanding academic research career, and the lack of women role models. We hope that the new network will address some of these challenges.

What impact do you think, if any, the #MeToo movement has had on the world of research?

The sexual harassment and misconduct experiences that are being described by the #MeToo movement are important to address in the research environment, but I'm not sure how much of an impact it has made. Just one incident of sexual misconduct or harassment is one too many. If the #MeToo movement has made people feel more confident or more trusting in sharing their experiences and raising awareness, then that is valuable. Working in the fields of engineering and technology, I have observed these issues more often through online communications and online collaborations. I feel that such issues would not have received as much attention if it wasn't for the #MeToo movement.

Thinking about the future of gender diversity and equity in research globally, where do you think we'll be in 10 years' time and what organizational and or cultural issues do you think will influence change most significantly?

I think we are heading in the right direction, but it's going to take more than 10 years to achieve something that looks like gender equity. First, we need to address issues around gender disparity starting at primary and secondary school. For example, children who are exposed to maths early and throughout their school years are more likely to feel comfortable engaging a career in engineering.

We also need to make sure that women are treated fairly, academically and professionally. We need to work with the research community to find practical ways to make changes that move us toward gender equity. Routine reporting of pay data and routine reflection on that data is incredibly important. It's not just about paying women more, it's about how to create a fair pay structure that reduces the gender pay gap.

We are also making significant progress on the ability to discuss topics like gender, care responsibilities, and protected characteristics in research, but there needs to be a conversation about the intersectionality of gender, disability, and ethnicity, and how these together have more of an impact on successful progression through a research career. Being able to ask for reasonable adjustments—for example, allowing meetings to be joined remotely rather than requiring international travel, or accommodating the changing health care needs of team members—will allow everyone to do their best.

Finally, while we are making progress in these conversations, we also need to recognize that there is still resistance to gender diversity and equity, primarily because of a lack of knowledge. This report is incredibly useful for increasing knowledge in a non-threatening, data-driven way. Overall I am hopeful, but there is still an awful lot of work to do. We recognize the enormity of the task and the role we can all play in enabling everyone to participate and bring diverse ideas together to strengthen research.

Finally, while we are making progress in these conversations, we also need to recognize that there is still resistance to gender diversity and equity, primarily because of a lack of knowledge.

Collaboration Networks

Conclusion

We conducted a network analysis based on a large set of Scopus publications to examine men's and women's collaborative research activities. This study included a cohort of focal authors from 16 selected region-subject pairs. We further focused our attention on an author set from a single year (2013) and examined their collaborative activities across a five-year window (2009-2013). Our exploratory network analysis describes the characteristics of men and women researchers' collaboration activities in these regions and subject areas.

We found that, across several regions and subject areas, men tended to have more co-authors than women and this difference widened among authors with a longer publication history. This data suggests that the higher network centrality among men authors may be an underlying factor driving the higher average publication output observed among men compared to women authors (in any authorship position; see Figure 2.1).

However, we also found that women and men were more similar in the way they were connected to their potential collaborative space (to second-order collaborators) through their direct collaborations and with respect to their share of international collaborators (with the exception of the EU28, where men authors had a slightly higher tendency to establish international collaborations than women authors). We also found that women authors tended to collaborate more with women than men on average while men collaborated more with men than women across regions and subject areas.

Future work could broaden the scope of the measures and time periods used and include more regions and subject areas. For example, the collaboration network characteristics studied here were limited to a five-year time window, which could be expanded in future analyses. In addition to the metrics considered here, future studies could make use of more sophisticated metrics that a network analytic perspective can provide. It would also be relevant to investigate how network-based indicators revealed in this dataset relate to an author's future productivity and other career outcomes.

Chapter 5

Researcher Perspectives

Perceptions about gender-related issues in academia

Key Findings

- *Researcher attitudes towards gender diversity and equity vary widely among men and women. Most of the differences in viewpoints are related to the importance an individual places on gender balance and to the perception of fairness in the academic system.*

- *There are two opposing opinions on the causes of gender imbalance and inequality in academia. Some groups (men and women) attribute gender inequality to the attitudes and ambition levels of women. Other groups attribute gender inequality to a systemic and cultural (unconscious) bias against women.*

- *Researchers perceive that family duties can have a negative impact on research careers (for both women and involved men).*

- *Researchers suggested interventions to increase gender balance and equity that reflect their perception of causes of the gender inequality. Those suggested are either aimed at increasing the assertiveness and self-confidence of women or at changing the male-dominated culture and reducing the possibility of (unconscious) bias.*

- *The lack of consensus over a single best intervention may be interpreted as a lack of a "one size fits all" intervention.*

- *Additional research is needed to understand the viewpoints from women and men researchers who are indifferent to the gender equity discussion and from men who are negative about current interventions that they perceive discriminate against men.*

Researcher Perspectives

Introduction

The analysis of quantitative data in the previous chapters revealed various gender-based differences in research participation, researcher footprint, publishing continuity, author mobility, and collaboration patterns. In this chapter, we present the results of additional research to provide a deeper understanding of researchers' unique experiences and perceptions of issues related to gender in research. This qualitative research serves to illustrate the diverse viewpoints of researchers related to gender diversity and equity. It aims to provide insight into the differences in perceptions and attitudes on gender-related issues in academia such as the importance of gender diversity or equity, the factors believed to contribute to a lack of gender diversity or equity and potential interventions to support greater gender diversity in the future. Some of the collected stories may serve as starting points for new hypotheses and inspire future investigations. A detailed description of the methodology can be found in Appendix A section "Qualitative Analysis."

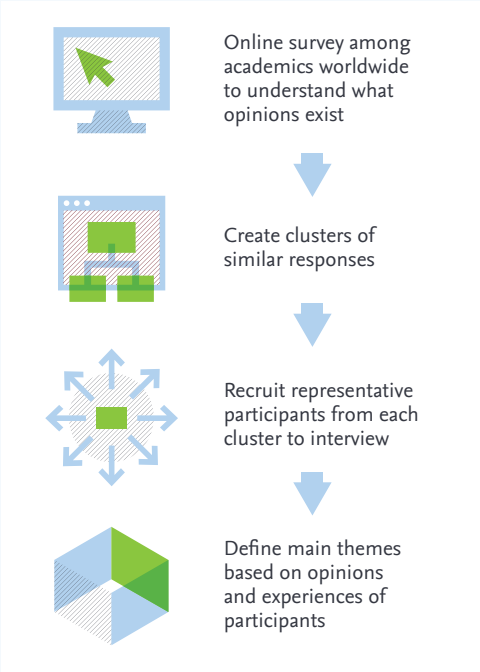


FIGURE 5.1

Overview of the qualitative research methodology: using survey results to define categories, then recruiting participants from each category for interviews.

Researcher Perspectives

Analyzing the Diversity of Opinions on the Role of Gender in Academia

To understand perceptions and attitudes of researchers about the role of gender in academia, we first conducted an online survey that was sent to researchers working in various subject areas and geographic regions (see Appendix A, section "Qualitative Analysis - Preliminary survey"). The respondents included researchers from the Elsevier Advisory Panel,[54] as well as researchers contacted through social media channels. The survey included various statements about gender diversity and equity in academia related to career progression, the workplace and personal experience. The participants were asked to indicate their level of agreement or disagreement with each statement in a set of closed-ended questions as well as respond to a series of open-ended questions. We collected 423 valid responses from the online survey, of which 257 had complete responses to the open-ended questions.

Based on the survey results, we defined eight clusters of survey answers with related points of view on gender (see Appendix A, section "Qualitative Analysis - Defining respondent clusters"). To get a better understanding of the varying viewpoints and the personal experiences with gender issues, we interviewed 25 researchers who had provided open-ended responses in the online survey that most closely represented each of the eight clusters. Our goal was to recruit equally from the different clusters of perceptions; however, we were unable to reach any researchers who gave survey responses representative of three clusters: "indifferent men," "indifferent women" and "indignant men," and we interviewed only one researcher within the category of "aware women."[55]

The interviews focused on the differences in perceptions on gender issues, reflecting the opinions from the eight categories that were defined based on the online survey. See figure 5.1 for an outline of the methodology described in this chapter.

54 The Elsevier Advisory Panel is managed by Elsevier (Customer Discovery & Innovation) for user research purposes. The Panel comprises more than 3000 researchers from around the world, across disciplines and career levels.

55 Although we did not interview any researchers with survey responses from these clusters, some of our interviewees did share their impressions from peers who represented opinions representative of the clusters "indifferent men/women" and "indignant men."

Grouping researchers' perceptions based on attitudes and experience

We observed a wide variety of perceptions in the survey among men and women, both in agreement and in disagreement with statements pertaining to equal career opportunities for women and men. Based on the answers to both closed- and open-ended questions, there were two main **parameters along which people's attitudes differed.** These were:

- The degree to which there was agreement that gender balance in academia is important (gender balance was not considered to be the same as gender diversity)[56]
- The degree to which there was agreement that the current academic system is fair to both women and men

Additionally, we also identified specific **contextual parameters based on varying personal experience** among the respondents that related to:

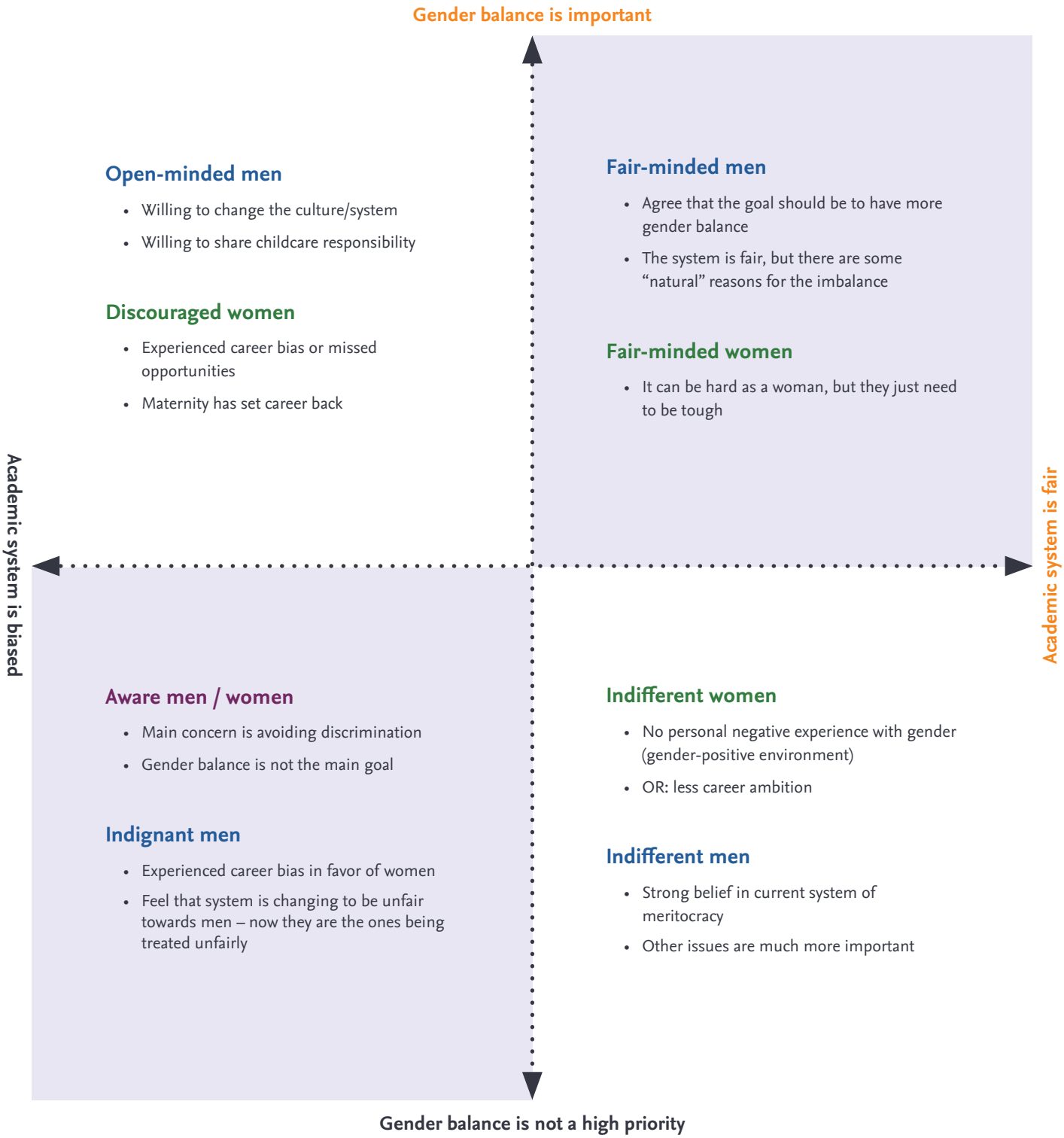
- The personal experiences of men and women in combining an academic career with parenthood
- The personal experiences of men and women in gender-biased career situations, either their personal experience or observations of their peers' experiences
- The current environment and gender policies at their institutions
- Some social, cultural and economic differences that affected people's experiences and perceptions (e.g., generational gaps, cultural/religious expectations on the role of women as caregivers, education of girls/women and boys/men to behave in certain ways, the legacy of political ideologies and economic influences)

In trying to capture this wide variety of attitudes and personal experiences, we defined eight clusters of survey answers with related points of view on gender in academia (Figure 5.2). These eight clusters were based on similarity of opinions on gender-related issues as expressed in the open-ended survey questions and do not represent homogeneous groups of people. The clusters were classified along the two main attitude parameters (axes)—importance of i) gender balance and ii) fairness—and by certain personal experiences. This section explains the two attitude parameters and the experience factors.

56 Respondents distinguished between gender balance and gender diversity, with gender balance referring to equal numbers of both men and women and gender diversity referring to representation of both genders.

FIGURE 5.2

Overview of the eight clusters of different points of view on based on the survey results, aligned along the two main parameters evaluated.



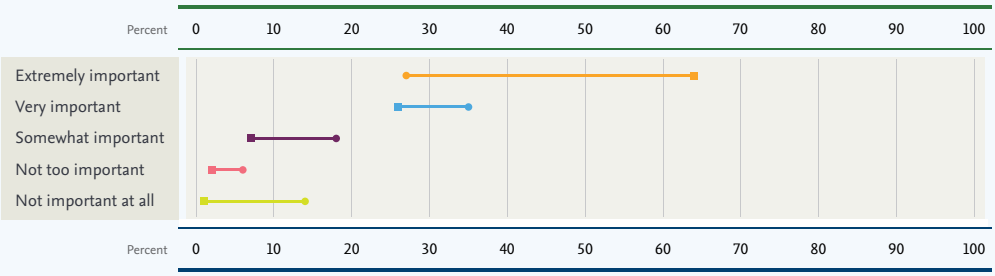
The importance of gender balance

The survey revealed differences in the perception of gender issues reported by men and women, as well as differences in perceptions among men and among women. When asked about the importance of gender diversity in the research workplace, most women (90%) and most men (62%) answered that it was extremely or very important (Figure 5.3)

The viewpoints on the importance of gender balance varied. In our interviews, several men and women recognized the benefits of gender diversity and balance. These individuals cited the positive impact of diversity on science, the diversity of topics that result from increased diversity and gender balance and the more pleasant work environment and positive cultural shift that result from increased diversity and gender balance (Figure 5.4, upper quotes). There were also men and women who were not concerned with gender balance, arguing that there would be no effect on the quality of research at all and that it should be a matter of personal choice to pursue a career in academia. There were some men who thought there was too much attention given to the matter of gender diversity; these were often men who had experienced discrimination in their careers (Figure 5.4, lower quotes).

FIGURE 5.3

Responses to the survey question, "How important is it to have gender diversity in the research workplace?"



■ **Women**

● **Men**

FIGURE 5.4

Representative quotes from the online survey from each of the eight viewpoint clusters in relation to the parameter "the importance of gender balance in academia."

Gender balance is important

Open-minded men

"I find women easier to work with, as with some men there often are problems with too many (self-assumed) 'alpha-males,' women are a lot more stable and dependable to work, and in my opinion care more about the work and less about themselves compared to some men who care mostly about their own stature."

Man, UK, postdoctoral fellow : medicine & life sciences

Discouraged women

"We need to change the culture of leadership – you can only do that if there are more women in leadership positions."

Woman, UK, midlevel career : medicine & life sciences

Fair-minded men

"Gender diversity provides the opportunity for different and important viewpoints that often differ from that of men, which is sorely lacking in male-biased environments."

Man, UK, postdoctoral fellow : medicine & life sciences

Fair-minded women

"There should "naturally" be diversity, not a forced one. This leads to views such as, "Oh, she got the position because of gender diversity."

Woman, Italy, postdoctoral fellow : physical sciences

Aware men / women

"Gender equity is really important and fair, but I personally don't think that gender diversity is SO important: if a lab is made of only female, only male or mixed, don't change its quality. I think that what is important is that good workers are selected and fairly treated for their skill and passions, and not selected for gender or race..."

Man, US, postdoctoral fellow : medicine & life sciences

Frustrated men

"Gender diversity is just another artificial problem in science."

Man, Poland, mid career : social sciences

Indifferent women

"Woman's choices: not all woman want to be researchers! I think the matter is overrated. Woman do what they want, choose what they want, have their own tastes and priorities."

Woman, UK, early career: medicine and life sciences

"Too few of us are concerned since other priorities are generally put forward, e.g., financial."

Woman, France, senior career : medicine & life sciences

Indifferent men

"I've never paid attention to how much attention is brought to the subject."

Man, US, postdoctoral fellow : physical sciences

Gender balance is not a high priority

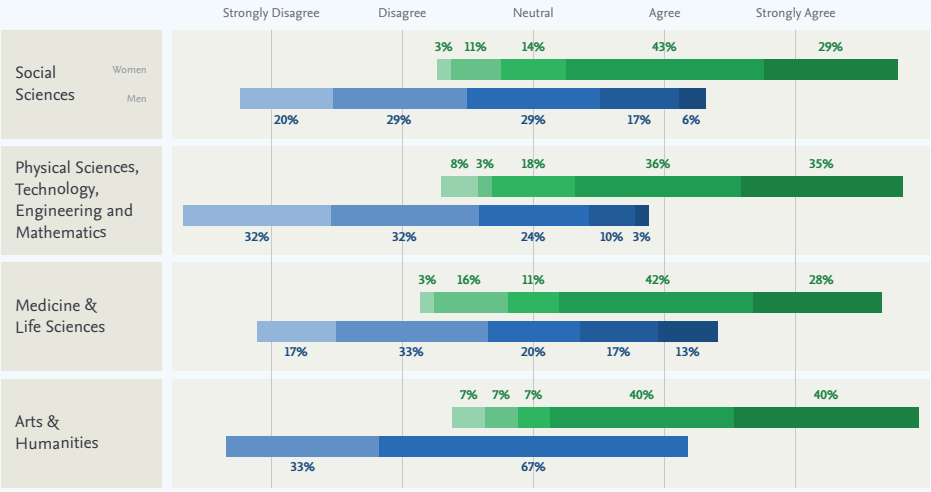
Perceptions of fairness of the academic system

The online survey included several questions on the perception of equal career opportunities for men and women in research. For instance, we asked about the level of agreement with statements about the opportunities women have compared to men to obtain entry-level research positions and tenured positions, to lead research teams or to work in administrative leadership positions. The answers revealed that, in general, women have more negative viewpoints on the career opportunities for women, whereas men have more positive viewpoints on career opportunities for women. This is consistent with previously published findings.[57] In our survey analysis, we used a proxy to measure the perception of bias against women in their research careers, asking whether women[58] need to work harder than men to be considered good at their job (Figure 5.5). The responses to this question made it clear that women and men differ in their perceptions of gender bias in research, and that there is disagreement among men and women with regards to the impact of bias against women in their research careers.

In the open answers the viewpoints on the fairness of the system were very diverse too. Figure 5.6 shows quotes from both men and women who feel that the rules of the academic system are fair and that there are equal opportunities for men and women. The opinions about the system not being fair were very diverse. They were either based on observations or on personal experience of bias against women or against men.

FIGURE 5.5

Survey responses to the statement, "In my organization, women have to perform better than men to be considered good at their job," by gender and subject area.



- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

57 Garcia-Gonzalez, J., Forcen, P., & Jimenez-Sanchez, M. (2019). Men and women differ in their perception of gender bias in research institutions. SocArXiv. Retrieved from: https://osf.io/preprints/socarxiv/pr5ec/. Accessed December 6, 2019.

58 We did not ask if men need to work harder than women to be considered good at their job.

FIGURE 5.6

Representative quotes from the online survey from each of the eight viewpoint clusters in relation to the parameter "the fairness of the academic system."

Academic system is biased

Academic system is fair

Open-minded men

"Cohorts of older male researchers still have bias, which influences decision making (directly and indirectly)."

Man, UK, postdoctoral fellow : medicine & life sciences

Discouraged women

"I have inhibited myself from applying for a full professorship position on the belief that I will be rejected even while having more merit than others and thus will have to wait five more years to apply again. I think the commission will act subjectively and not on merit-based criteria."

Woman, Chile, early career : medicine & life sciences

Fair-minded men

"The laws and bylaws do not differentiate between men and women. Gender insensitive performance indicators are applied at any phase of appointment, promotion or funding."

Man, Egypt, senior career : medicine & life sciences

Fair-minded women

"I have been professor, researcher, coordinator of postgraduate program, research advisor, mother, wife....I suppose my gender, in my career, did not impact my professional activity."

Woman, Brazil, midlevel career : physical sciences

"Personally, I do not let discrimination, either negative or positive, step in my career. I just do my work to do my best. I am over 50, female and indigenous. So there is age, gender and racial bias in my way."

Woman, Ecuador, senior career : physical sciences

Aware men / women

"It is hard to know if and to what extent being privileged has helped my career. I would like to think it hasn't, but there is always a chance a woman in my position wouldn't have gotten my job."

Man, UK, postdoctoral fellow : physical sciences

Indignant men

"At times women are even considered more than men. If a man and a woman are competing for something, priority is given to the woman than the man."

Man, Ghana, predoctoral candidate : social sciences

Indifferent women

"I've never had any problems by gender. I have always been evaluated based on my competence."

Woman, Brazil, doctoral candidate : social sciences

"I think in research what should matter is meritocracy, independent of gender."

Woman, Australia, postdoctoral fellow : physical sciences

Indifferent men

"Usually every laboratory has around the same number of men and women. I don't see any particular attention in doing so, it is simply that men and women are equally good, and during the time the laboratories tend to have the same number of people of both genders."

Man, US, postdoctoral fellow : medicine & life sciences

Perceptions on how gender influences researchers' academic careers

In our interviews with 25 survey respondents, we further examined the personal experiences and the influence of these experiences on researchers' opinions about the role of gender in academia. We explored differences in perceptions and personal experiences in a range of aspects of the academic career, including recruitment, promotion, salary, publishing, citation practice and funding. We mapped the interview findings to the eight clusters defined in the survey; here, we illustrate these differences in opinions and experiences using quotes from the interviews.

The interviewees also reported observing greater gender diversity at the early-career level and less gender diversity among more senior leadership positions, such as group leaders, tenured professor positions or senior administrators.

The perceptions on the topic of career progression of women in academia were very diverse (Figure 5.7 and Table 5.1 overleaf). Some interviewees attributed the lower proportion of women at senior levels to the tendency of women to be less self-confident and lacking in ambition. Others saw unconscious bias as an important cause for lack of career progression. Finally, there was also an impression that the competitive and more demanding culture at more senior levels were less attractive to women, resulting in more women not aspiring to pursue these roles.

PERCEPTIONS OF THE CAUSES OF LOW REPRESENTATION OF WOMEN IN STEM

Our survey results confirmed the perception that there are relatively fewer women working in STEM (science, technology, engineering and mathematics) than in other fields. When researchers were asked about the factors that contribute to the lower participation of women in STEM, the responses varied. Numerous respondents indicated that women are not encouraged enough during primary or secondary education to engage in more technical fields.

One respondent also suggested that **not many women would be interested in the more physically demanding work in STEM fields,** for example, working on overnight experiments and going on field expeditions. Both men and women reported that it can be daunting to be the only woman in a working environment, and that women might prefer to work among other women.

One explanation given for the lack of gender diversity was that the **low number of women role models in STEM** gives the impression that there are fewer opportunities for women. Based on current experience, some researchers suggested that if an institution actively creates opportunities for women to progress in their STEM careers, there will be more women role models and the field might become more attractive to other women.

FIGURE 5.7

Representative quotes from interviewees on their attitudes about the career progression of women in academia, categorized according to the different viewpoint clusters and in relation to the two main parameters analyzed.

Gender balance is important

Academic system is biased

Academic system is fair

Gender balance is not a high priority

Open-minded men

"I have a position in my group and it's only for females, so I have no problem on this and actually there are two very good candidates that are male, that I know personally but okay. They will find another position."

Man, Netherlands, professor : physical sciences

Discouraged women

"Sometimes the way that you have to behave in order to be successful isn't in line with our values, and how we want to behave professionally. And so we actively would make the choice to take ourselves out of that. And not to be involved in it."

Woman, UK, midlevel administrator : medicine & life sciences

Fair-minded men

"Because of the way women are raised, and also the fact that the leadership is mainly male leadership, they have values that are not necessarily...where professional women do not fit."

Man, China (from EU), lecturer : arts & humanities

Fair-minded women

"I know I've been disadvantaged because my head of department refused to support my promotion, and initially I listened, and then I got stubborn and went about it independently, which was much harder. But I eventually, I did get promoted in that round of promotion."

Woman, Australia, professor: physical sciences

Aware men / women

"There probably is overall [gender balance], but I think you probably see more positions of power held by men. There's more female Vice Chancellors across the faculty – In the more let's say the professional service or the administrative type roles I think women sort of dominate that side of things..."

Woman, UK, professor, administrator : physical sciences

Indifferent women

"But from the work point of view, in terms of career progression, no, not every woman does want to progress into senior roles. And I'm not necessarily sure that I do..."

Woman, UK, midlevel administrator : medicine & life sciences

Indifferent men

"Men do not make it to the top by mere wishing and taking advantage for being men. They worked hard and hard everyday to get there. So women should try hard and have hope that they will be there one day."

Man, Ghana, PhD candidate : social sciences*

* Indicates quote is from open-ended survey response

TABLE 5.1

Reasons given by survey respondents and interviewees for the lack of career progression among women researchers

Attitude:
Women lack ambition/skills

Examples:

- It is too difficult to combine a time-consuming career with children
- Some women are content to just do research and not seek a leadership position
- Women are not competitive or assertive enough for senior leadership positions
- Women feel more insecure and strive for perfection before applying for position
- Women do not deal well with the frequent rejections in academia (funding, publications, promotions)
- Women need to develop new skills to be research leaders and need to be strong to deal with the responsibility

Attitude:
Women lack opportunity, possibly due to bias

Examples:

- Some men think women are less intelligent (unconsciously), therefore
  - Women need to work harder to prove themselves
  - Women are being patronized and not getting the same attention from supervisors
  - Women are not considered for promotion or awarded grants so they can lead a group
- Historically, the characteristics that are valued for leadership positions have been defined by men. Women might have other characteristics, but these are not considered valuable in leadership positions.

Perceptions on differences in salary

Most interviewees said they were not aware of their colleagues' salaries. We observed that researchers who perceive that the system is fair also expected salaries to be equal for men and women in the same positions, especially if the salary structures were shared openly. Conversely, lack of transparency in pay was mentioned as a contributor to pay disparity.

> "I mean anything I'd say on salaries, that we have found the key issue is generally in loadings [extra payment employees may be entitled to on top of their usual pay], and negotiation of loadings, which again, tends to happen in an opaque manner, they're not transparent. So there is a level of aspect where men tend to enter maybe on the second step of the salary because they negotiate that, whereas women tend to enter on the first step of their salary. So you get a big disparity there, but then when it comes to loadings, there's huge disparity. And so the easiest way to deal with that is just to make that entire process transparent."
>
> **Man, Australia**, senior administrator : social sciences

Some interviewees who perceived the system to be biased mentioned negative situations regarding the salaries for women researchers. However, these tended to point to difficulties for women in reaching the same position (level), rather than to differences in pay between colleagues at the same level.

> "In general, it's still harder for women to get the same position as the men and they have the gender pay gap. So men get paid better for the same position than women."
>
> **Man, Germany**, postdoctoral fellow : medicine & life sciences

Perceptions of gender bias in recruitment and promotion

Unconscious bias in recruitment and promotion was mentioned as a potential cause of gender imbalance in the working environment. In the active researchers survey, 38% of women (and 13% of men) said there is a lack of gender balance in their field because there is bias or discrimination in recruitment, hiring and promotion processes. (Figure C1)

Based on the responses to open-ended questions in the online survey and the interviews, we summarized the factors that were suggested as contributors to bias against women in recruitment and promotion in institutions:

- Job postings that included **gendered words** might dissuade women from applying for the position
- Networks of mainly men professional contacts (or recruiting agencies) that are asked to suggest talent, resulting in a lack of women representation on recruiting shortlists
- Promotion committees in the university that consist of predominantly men and prefer masculine leadership characteristics
- After-work socializing to build personal network, which is more common among men than women
- Women more likely to hold off applying until they are past the point where they could have received the promotion
- To be able to lead a research team, it is necessary to win **funding**. If grant applications are not anonymous they are open to gender bias.
- Less frequent conference attendance by women that restricts opportunities to establish collaborations
- Fewer invitations to be keynote speakers or serve as panel members at conferences
- Women tending to be asked to do supporting tasks, such as sitting on committees or organizing events that take away from research work and are not part of the evaluation for promotion

Impact of family on research careers

When asked about the impact of family on research careers, interviewees responded that they felt that having children and the availability of maternity leave and childcare support have a significant impact on both men and women as well as gender diversity in research. Both men and women reported that having children could cause a delay or change in career opportunities.

Overall, most of the researchers we interviewed agreed that maternity leave and childcare duties can have a negative impact on women researchers' career progression (Figure 5.8). Women were more likely than men to report taking on the main share of childcare compared to their partners. There were also women who had successfully navigated hurdles in balancing their family life with their research careers. They described the need to be very efficient and having to be comfortable entrusting their children to others (e.g., grandparents, childcare workers, nurses).

In Elsevier's active researcher survey (see Appendix A, section "Researcher Survey"), 45% of women researchers felt that balancing their personal life with their career is one of the biggest barriers to their career progression (Figure C.11), and women were more likely to leave their career in research due to family commitments (Figure C.5).

Our interviewees pointed to different aspects of academic jobs that can worsen the impact of childcare duties on career progression:

- The need for greater job security and more flexible hours after having children
- The prevalence of short-term contracts, especially when the maternity period coincides with the end of the contract
- The practice of long work hours and the expectation that working part time will have negative career consequences
- Lab-based research is not as accommodating to flexible working hours and locations
- The high cost of childcare coupled with little support from universities

FIGURE 5.8

Representative quotes from interviewees on the impact of family life on research careers, categorized according to the different viewpoint clusters and in relation to the two main parameters analyzed.

Gender balance is important

Academic system is biased

Academic system is fair

Gender balance is not a high priority

Open-minded men

"There's enough childcare help and enough opportunities for fathers to step up and do more work. I'm a good example of that...it's challenging in order to balance your life and work as much as it is for women, but I didn't feel that I was harmed in my career because of having to do more with my family."

Man, UK, research associate : physical sciences

Discouraged women

"I think I'm frustrated because I feel that having had my two children and two periods of maternity leave and being part-time has been disadvantageous in terms of progression because it makes it really, really difficult to tick all the boxes that I would need to tick in order to progress."

Woman, UK, midlevel administrator : medicine & life sciences

Fair-minded men

"...the condition is the woman has to find a job that's part time, to have enough time for her children."

Man, Greece, postdoctoral fellow : physical sciences

Fair-minded women

"I love being a mum. But my professional identity, my career is important to me too. And I think that my husband and I should be a team on it. And therefore, if he's the one who takes the lion's share of the work, that's absolutely fine by me, as long as one of us is doing it, and one of us sees that as work, and values that, and does it properly."

Woman, UK, midlevel administrator : medicine & life sciences

Aware men / women

"You're working at the lab and get papers and stuff like that. And if you took time out to have a child, I imagine it would be really very difficult and a lot of pressure, as a woman, I mean, yeah. And, as a man, I know I don't have to face that choice... I can make a choice to not go to work as much, but I don't have to do that. I mean, I would be willing to make that choice, but I don't have to. It's not forced upon me by the situation [as is the case with women]."

Man, UK, postdoctoral fellow : medicine & life sciences

Indifferent women

"[Some women] want to put child-rearing first...and that affects their career progression. And they're absolutely happy with that because that's what they want."

Woman, UK, midlevel administrator : medicine & life sciences

Indifferent men

"...if you hire a woman of a certain age, they're going to leave to have children, and this is detrimental to your business. As a PI, this would be something that they would think about, and would cross your mind, whether you act upon it or not. It would definitely be in the back of your mind."

Man, UK, postdoctoral fellow : medicine & life sciences

Impact of gender on research outputs: funding, publishing, citation

In our interviews, we discussed perceptions of gender bias in current funding, publication and citation processes (Figure 5.9). In general, the current publishing and citation system was perceived to be fairer than the academic career system; in other words, the negative attitudes towards the fairness of the academic system was not reflected in the attitudes towards the publishing system. Many of our interviewees were editors or peer-reviewers themselves. They said they would not let the gender of the author affect their decision to publish. Furthermore, they said most publications have multiple authors of both genders. However, a small minority of interviewees considered the possibility of unconscious gender bias in the publishing system if the peer-review process is not anonymous.

Another suggestion was that the review process could be influenced because men and women can have different writing styles—if men present their results in a more assertive way, it might give them more credibility.

> "I don't believe that the vast majority of men would be actively seeking to discriminate against women. I do think it is an unconscious bias level the majority of the time. And that is to do with the language that we use, and how emphatically men sell what they're doing compared to women, and the kinds of words that we use to describe what we're doing, and why it's important and the value that it has."
>
> **Woman, UK**, midlevel administrator : medicine & life sciences

FIGURE 5.9

Representative quotes from interviewees on their perceptions of the publishing system, categorized according to the different viewpoint clusters and in relation to the two main parameters analyzed.

Gender balance is important

Academic system is biased

Academic system is fair

Gender balance is not a high priority

Open-minded men

"Well, it's not blind from the editor's point of view. It's blind from the peer reviewers. But if you talk about articles that the editor would knock off out of hand without even sending it to peer review, it would be important to understand the numbers there."

Man, Australia, senior administrator : social sciences

Discouraged women

"I have a friend, a colleague, that is very, very good in her research [social sciences - terrorism]. And she is a woman and she has had problems with these issues. She told me that in her area, women are also rejected. It's more difficult for them to publish and to get the citations."

Woman, Spain, midlevel researcher : social sciences

Fair-minded men

"I think there is no discrimination in these days. If results are good, and publishable, they will be published."

Man, Greece, postdoctoral fellow : physical sciences

Fair-minded women

"I want to say is that for the procedure to choose your papers or the peer review will not be a biased choice, which paper to get [published]. For I was once an editor and I will not know whether the author is a woman or whether he is a man. So that's what I mean."

Woman, China, assistant professor : medicine & life sciences

Aware men / women

"The feeling that I got from speaking to women colleagues is that they tended to be treated harsher in their criticism."

Man, UK, research associate - physical sciences

"And because it's not anonymized, and I think it's almost impossible to anonymize it. So I'm not recommending that. People start off with their prejudices, probably about the people they know or what they know about their work."

Woman, Australia, professor : physical sciences

Indifferent women

"I haven't had any bad experience in publishing, so I don't have any personal example to talk about this, because I published several articles and I didn't have any problem."

Woman, Spain, midlevel researcher : social sciences

Indifferent men

"[If women on average publish less, it is] because they are the minority in the research community. So it's normal."

Man, Greece, postdoctoral fellow : physical sciences

There were also some possible explanations given for the difference in publishing between men and women that were not related to the publishing system but rather to the academic context prior to publishing, as mentioned in the previous section: women hesitating to believe they are ready for publishing, not finding good collaborators, and less frequent conference attendance.

> "It might be because you kind of miss out on, scoring a really good collaborator, it might be because you are not paid attention to as much in your lab and so your PI isn't really pushing your research along. It may take you longer to publish, it may seem like you have to jump through more hoops before you're ready to publish."
>
> **Woman, US**, funding agency : medicine & life sciences

> "There's a hesitancy, sort of a almost psychological hesitancy of a lot of females to think that they're ready, to think that things are in good enough shape to be submitted for someone else's review."
>
> **Woman, US**, funding agency : medicine & life sciences

> "So the fact that women are not as good at going to conferences as men, and that is also quite well established. I think it's they feel less inclined to leave home and family. So they don't go to conferences, so they don't meet people, so they don't network as much. Then the referees don't know them. And even if it's only a little difference every time, over a career it adds up."
>
> **Woman, Australia**, professor : chemistry

The majority of interviewees felt that there is no clear evidence or personal experience related to gender bias in citation. Some mentioned there are studies on this topic, but they were not directly confronted with this issue themselves.

The funding system was not discussed to the same extent with all participants. There were interviewees who believed the system to be fair and based on experience and on merit, while others perceived that the funding system could be more susceptible to bias.

> Funding does not depend on the gender, only or depends of your academic position. And so on. And no dependence with gender."
>
> **Woman, Russia**, associate professor : marine biology

> When I was in the system, when I was a post-doc, when I was a grad student, I thought the system was quite fair. Now that I'm working at what I would call an administrative systems level, looking across and seeing all the data that we have as a funding agency—on the disproportionate rates of funding and on the disproportionate rates of publishing, gaining tenure, getting to mid-career faculty—there's no way I can still look at the system and think that it's fair. I think it's hidden."
>
> **Woman, US**, funding agency : medicine & life sciences

As for reasons given, the same factors affecting funding were mentioned by interviewees as were explored earlier in this chapter:

- More men researchers apply for grants than women researchers. Women may feel they are less ready to apply for a grant than men. Because funding proposals are usually not anonymous, there is the possibility of unconscious bias from reviewers.
- Furthermore, with block funding, the university is responsible for distributing the grants, with an internal board of senior administrators and researchers choosing who will be awarded funding. Thus, the same gender bias issues that arise in the promotion process would apply to grant distribution.

Less funding can have a profoundly negative effect on academic careers, such that women researchers cannot progress in their academic careers if they receive less funding. Without funding, they are unable to lead a group of researchers and productivity is lower, leading to fewer publications and a lower chance of promotion.

> I think if a man gets more funding then they will finish more research and maybe they...are more likely to get promoted. And then maybe [they would] have more students to do all their research for them. Then the gap between a man and a woman gets bigger as time goes by."
>
> **Woman, China**, assistant professor : medicine & life sciences

Sexual harassment

There is an extensive body of literature on sexual harassment in academia and its negative effects on the academic climate,[59] researchers' job satisfaction[60] and health.[61] In the open-ended section of the preliminary survey, many women reported that sexual harassment has impacted their scientific career in a negative way. These responses were consistent with Elsevier's 2019 active researcher survey, which found that sexual harassment can be influential for women researchers in terms of progressing in their academic careers. Specifically, significantly more women than men felt that discrimination or harassment is a barrier to their career progression (Appendix C, Figure C.11), and significantly more women than men contemplated leaving their career in research because they experienced discrimination or harassment at work (Appendix C, Figure C.5). Hence, the question of representation of women, especially at higher career levels, and harassment appear to be linked.

To explore the perceptions of sexual harassment and its impact on the research workforce, we discussed the topic in our interviews.

All interviewees agreed that sexual harassment is a serious offense that should not be tolerated; however, few of the interviewees had experienced it directly. We were unsure if they were not aware of sexual harassment at their institution because it did not exist or because it might not have been reported (or kept from the public if reported). In cases where sexual harassment was acknowledged, universities were more likely to be actively addressing it as a problem.

> "There's been different surveys here, but if you're talking about even 20%, 30% or 40% of females being harassed in the workplace, it's not acceptable."
>
> **Woman, US**, funding agency : medicine & life sciences

59 Cortina, L. M., Swan, S., Fitzgerald, L. F., & Waldo, C. (1998). Sexual harassment and assault: chilling the climate for women in academia. Psychology of Women Quarterly, 22(3), 419-441. doi: 10.1111/j.1471-6402.1998.tb00166.x

60 Chan, D. K. S., Tang, C. S. K., & Chan, W. (1999). Sexual harassment: a preliminary analysis of its effects on Hong Kong Chinese women in the workplace and academia. Psychology of Women Quarterly, 23(4), 661-672. doi: 10.1111/j.1471-6402.1999.tb00390.x

61 Roosmalen, E. V. & McDaniel, S.A. (1999). Sexual harassment in academia: a hazard to women's health. Women & Health, 28(2), 33-54. doi: 10.1300/j013v28n02_03

Some interviewees knew women who had experienced sexual harassment. According to them, women researchers do not always report these experiences for various reasons:

- Women sometimes consider this behavior "normal" in their culture;
- In some cultures, women would feel too shy or embarrassed to report harassment;
- Some women researchers said that if they expect no action to be taken in response to reporting harassment, they will not report it
- Some women researchers are afraid of personal consequences for reporting harassment
- In certain societies, men may consider it a compliment for a woman to be harassed

> "And so then you have to work in an environment where people kind of know that you have reported and they don't like that you have disturbed the peace and there can be, again, very low level, almost implicit retaliation. Just a lack of opportunities given, lack of attention given, talking behind people's back. There's little kinds of things that are really important and really can affect one's career. I think that's actually the bigger effect and I think that's what keeping these women, some of whom are my colleagues and I've heard this sort of thing directly, I think that's what's keeping them from reporting. It's not that it's being handled badly up the top, but you then have to like live with the consequences of the local level."
>
> **Man, US**, assistant professor : clinical psychology

Some researchers recounted cases where harassment had been reported, but the university may choose to "sweep the issue under the rug." Sometimes the offender was reprimanded, but there were no further consequences (i.e., "they just got a slap on the wrist"). This was often the case if the harasser was a professor of high reputation who brings a large amount of research funding to the university or who the university prioritizes to maintain its own reputation.

> "In terms of the US academic system, I think one of the reasons it seems to be tolerated is, our schools...are heavily dependent on funding to stay afloat, far more so than tuition or any kind of supplementation by the local government...What tends to happen is the ones who really get a free pass are university professors who are well established, they're tenured and they bring in millions of dollars a year to the university in research funding. It's not in the university's best interest to have that research funding go away."
>
> **Woman, US**, funding agency : medicine & life sciences

Researcher Perspectives

Interventions Towards Achieving Gender Diversity and Equity: Comments and Suggestions

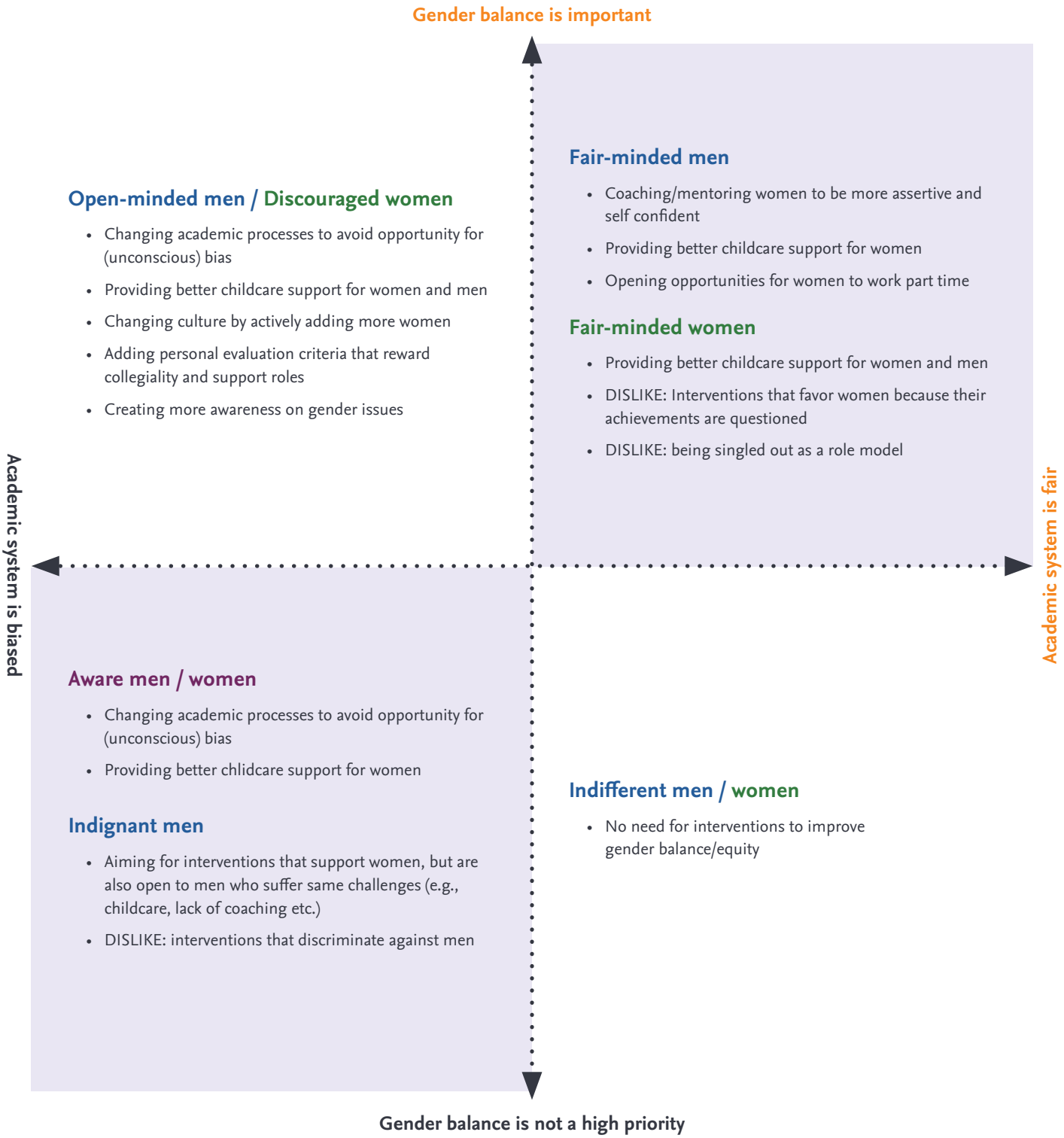
Following our discussion with interviewees on their perceptions and personal experiences of gender diversity and equity, we next asked about opinions on existing interventions and suggestions for future interventions towards achieving gender diversity and equity in academia.

Exploring the range of opinions on interventions

Through the open-ended survey questions, we collected responses on interventions that aim to achieve gender diversity and equity in academia. During the interviews, we asked the researchers to comment on these interventions. The two main parameters we defined to categorize the perceptions towards gender issues (importance of gender balance and perception of fairness of the system) aligned well with the respondents' attitudes towards the interventions. These parameters also showed how different interventions were favored by the different viewpoint clusters of the respondents, based on their attitudes and personal experiences (Figure 5.10).

FIGURE 5.10

Different attitudes toward interventions to achieve gender diversity or equity, categorized according to the different viewpoint clusters of interviewees, aligned along the two main parameters evaluated.



The lack of consensus over a single best intervention may be interpreted as a lack of a "one size fits all" intervention, as articulated by some of the interviewees:

> "It's understanding how best to target any intervention...because you're dealing with men and women from many different backgrounds. What will work for women from one set of situations doesn't work for women in another set, so it's hard to do something that will attract them all, and work with them all."
>
> **Woman, UK**, professor, administrator : engineering, administrator role

The divergence in opinions regarding interventions could be summarized across three dimensions.

First, there were conflicting attitudes regarding whether interventions should "fix the women" or "fix the culture." Both men and women felt that leadership training as an intervention could encourage women to progress to more senior levels in their careers. The idea was that if women are taught to be more assertive and less insecure, they will be better able to cope in the competitive environment to achieve more senior leadership positions. However, some researchers questioned whether this kind of assertive culture should be the norm, on the ground that this kind of culture is not necessarily good for either women or men in academia.

> "Why does that dynamic at that level have to operate at the level of being incredibly competitive? You know, women might want to do those roles if the culture at that level was different, and that doesn't mean that they will do those roles any less successfully. They might even do it more successfully and that we should see the roles about what is being achieved, and not about being able to be cutthroat enough to achieve it in a particular way."
>
> **Woman, UK**, midlevel administrator : medicine & life sciences

The second dimension of the opinions was whether interventions should take the form of quotas, or that gender diversity will follow from interventions directed at the underlying causes and by raising awareness.

One group of researchers (frustrated women and open-minded men) advocated for positive discrimination (quotas) as the only effective way to change the current culture in academia in the short term:

> "To be blunt, I suppose the way you change that is by injecting a whole lot of women into the room. If you've got a situation where you've got 1 woman and 20 men in a department, the way you change that is by accrediting 10 women. And that will fundamentally change the culture of that department over time. Are many of the men in that room going to enjoy that process? Probably not. But that's how you change it."
>
> **Man, Australia**, senior administrator : social sciences

On the other side was a large group of interviewees who were strongly opposed to any sort of affirmative action interventions that promote women in academia. Among women, the rationale was that women want to be valued based on their achievements and not because of their gender. Men indicated that it can be uncomfortable to experience being discriminated against through "unfair" promotion and encouragement of women. Additionally, it was suggested that these kind of interventions might be illegal in some countries.

> "This is not something that I want. I don't want to be seen as having to have a medal or a prize just because I'm a woman. It's not a crutch that I need."
>
> **Woman, UK**, principal investigator : biology

> "No, [quotas would not be easily accepted in my organization]. I think men will have to change their way of thinking. I guess men still feel uncomfortable with women or think women are not equal to men. Even if you have the quota, women can still have disadvantages in doing the daily work. So they can be excluded from meetings or not given the money for resources. For most other things, which can not be put into any law. And harassment or mocking…such things can still happen even if you force the quota."
>
> **Man, Germany**, postdoctoral fellow : medicine & life sciences

The third and last dimension that was suggested was whether interventions should be designed to support women only or whether they should also be open to men who suffer the same problems:

> "I try to structure [interventions] for men and women that deal with the problems that women suffer from more than men suffer from. We have a fellowship that in practice has gone to women who've been on maternity leave, but it is also open to men who've taken paternity leave as long as they've had at least six months leave. So, as I say, in practice it has gone to women since it was instituted, but men are eligible for it too, if they satisfy the eligibility criteria."
>
> **Woman, Australia**, professor : chemistry

Suggestions for future interventions by different stakeholders in academia

During our interviews, we asked the interviewees to provide suggestions for interventions for achieving gender diversity and equity in academia that they felt would be effective. We categorized their suggested interventions based on the different levels of responsibility within academia: governments, universities, funders and publishers. Below is a list of brief intervention suggestions given by the interviewees.

Suggestions for interventions at the government level:

- Avoid gender bias and stereotypes in the early education system;
- Promote women role models in science, specially STEM (science, technology, engineering and mathematics) fields;
- Provide maternity support for women researchers

Suggestions for interventions at the university level:

The interviewees tended to think that as employers, universities are critically positioned to create gender-balanced environments. They noted different types of interventions targeting various systems at the university level, but that all university interventions need to be a priority at higher levels of management. Current interventions depend on initiatives by individual leaders, but broader strategies need to be implemented at higher organizational levels in order to be successful and sustainable in the long term.

> "I think really it's sort of a perfect moment. People, like executives at the top, really care about it. At the same time that they're doing a lot of networking events and sort of grassroots organization within the university, some of which had been informal, some of them not, which has linked up and over the last two years, I'd say sort of created a longer-term cultural shift. And it's been driven formally, but there's an agenda equity strategy process. There's also, I would say, a gender equity self-assessment process, which is going on, which is to get formal bond accreditation in Australia."
>
> **Man, Australia**, senior administrator : social sciences

Examples of recruitment interventions that were suggested:

- Use more inclusive language in job posts;
- Use transparent recruitment criteria;
- Outsource recruitment to an external company to avoid nepotism;
- When outsourcing recruitment to external agency, give instructions to provide a candidate list with a substantial number of women;
- Actively reach out to attract women candidates who may not be part of the current network;
- Form mixed gender recruitment committees and take the time to understand the scientific role of each candidate;
- In cases of equal-quality candidates, recruit women;
- Recruit based on quotas for ratios of men and women

Examples of promotion interventions that were suggested:

- Use mixed recruitment panels and transparent evaluation criteria;
- Evaluate candidates on more than just research output, for example, by giving credit for supporting activities and collegiality (this approach is currently in place in Australia);
- Take enough time for candidates to present themselves and discuss their role and contributions

Examples of mentoring and coaching interventions that were suggested:

Mentoring and coaching as an intervention to achieve gender diversity and equity was generally supported by both men and women respondents. Some described that this type of mentoring is now mostly done on an ad hoc basis, while it should be part of the institutional structure. Some of the respondents felt that senior-level women or men who act as mentors or coaches can encourage women to:

- Be noticed. Senior-level women can actively look for successful women who are standing in the shadow of their PI or who are not actively promoting themselves;
- Overcome their insecurities to publish, acquire grants or go for promotion sooner;
- Hang in there when they need to overcome challenges, like rejections of grants or publications;
- Learn from their shared stories on how they handled personal and professional issues, like childcare or reacting to harassment or bullying

> "I thought it was just me who had these experiences."
>
> **Woman, China** (from EU), lecturer : arts & humanities

Examples of work-life balance interventions that were suggested:

Some researchers reported having a positive working environment that supported them in balancing a career in science with taking care of their children. Often this was dependent on the attitude of their supervisor rather than being an institutional norm. Recommended interventions were:

- Allow flexible working hours to enable men and women to pick up children from day care or school;
- Avoid scheduling early or late meetings during times when parents need to pick up or drop off children;
- Provide childcare on campus to make it easier to pick up and drop off children and enable women to breastfeed during working hours (e.g., this is common in Germany);
- Offer the option to work part-time; though the researchers felt it would be good to have this as a personal choice, it was generally perceived that working part-time would delay a researcher's career progress.

Suggestions for interventions at the funder level:

- Increase diversity in the senior leadership of funding agencies;
- Anonymize peer-review of funding applications;
- Require gender balance for large collaborative projects—make it necessary for project leaders to actively involve women researchers. One example of this are EU COST projects where bias is avoided by making the funding applications are completely anonymized – the required information for all group members is only their field, their gender and their seniority level.
- Develop special awards for women and engage in outreach to make women aware of these funds and encourage them to apply;
- Add a requirement that a university should have a gender-positive culture to receive funding; this will create incentives for the entire institution to revise its culture. Obtaining, for example, Athena SWAN status (bronze or silver) was often mentioned as a way to show that gender-related issues are being addressed by an institution;
- Add the possibility of explaining delays in career progression on a funding application, take into consideration whether women (or men) researchers took time off to care for their children;
- Offer additional funds to extend a project if a researcher gets pregnant and needs to extend project deadlines;
- Offer funds for women to go to conferences and help pay for additional childcare needed for them to attend

Suggestions for interventions at the publisher level:

- Anonymize manuscript submission and use double blind peer-review to avoid bias;
- Achieve gender balance among reviewers and editors;
- Provide gender-related issues awareness training for peer-reviewers based on writing style (e.g. the perception that men are more assertive at presenting their results than women are) and language for non-native authors

> "The people who are leading those conversations, engaging in those conversations, developing programming and interventions, they are the people who are kind of the least likely to need and to benefit from those interventions and those conversations because they're already committed to the cause…I think we really need to be thinking about how to engage everyone in discussions on this sort of thing. I think that there's a lack of…I think people don't know what they don't know. And I think that there's a lack of awareness to these sorts of issues…It takes figuring out how to engage equal, particularly the ones who don't have some vested interest or just interest because they're interested. I think that that's going to be the major contributor to moving the needle on this, and that's much harder to do than a major intervention."
>
> **Man, US**, assistant professor : clinical psychology

Expert Interview

Sandra W. Robert, CAE

Chief Executive Officer
Association for Women in Science (AWIS)

How would you describe the current state of gender diversity in research? Are there initiatives, policies, or interventions that have emerged in the last 3-5 years that you feel have impacted progress in gender diversity in research and should be monitored?

I see that more people are talking about—and in a very open way—the gender bias that is often brought to decisions regarding who is hired and who is included in research. I was particularly struck by the stance that the NIH director, Francis Collins, took this summer against all-male speaker panels, or "manels." That was very significant. The report from the National Academy of Sciences, Engineering and Medicine, "Sexual Harassment of Women: Climate, Culture, and Consequence in Academic Science, Engineering, and Medicine," is referenced in almost every conversation I have in Washington, D.C. That report actually spurred the formation of a scientific societies consortium on sexual harassment, where more than 100 associations are now working together to develop standards for addressing concerns around gender equity and inclusion, as well as anti-harassment policies. I think there is a lot more interconnection taking place. People are not only paying attention to gender disparity in research, they are now acting on it in a systemic way.

What value do data and an evidence-base offer as tools to organizations such as AWIS and the academies, as well as policymakers, funders, and institutional leaders to address issues of gender diversity and equity?

The wonderful thing about data is that it helps to neutralize conversations that could otherwise be very pulled to one pole or another. Data helps create a common platform for us to talk about what is actually going on, and not make decisions based on personal opinion. Data also gives us a place to start the narrative—to understand what is currently going on and what the gaps are. Then we have the opportunity to identify the best approaches and partners that will help us cross that gap and move toward our desired future. Data is absolutely essential for moving policy forward.

What information or insight from the report did you find particularly interesting, either from the perspective of AWIS or that of policymakers and institutional leaders?

I appreciate that this report combines both qualitative and quantitative research; that is the approach that AWIS takes toward research, and we feel strongly that both types of data are extremely important to a good analysis. Qualitative research allows you to go deeper into the individual stories and perceptions behind the quantitative data. When we look at just the data, we're left with many questions. We might be able to see the full scope and scale of a particular issue, but we need qualitative data to make meaning of the numbers.

The visuals also clearly illustrate where we have been and where we are now in terms of gender equity in research. I was particularly struck by the gender differences in publication counts and the publication histories of men and women researchers, and the idea that the gender differences among authors may be related to differences in invitations to collaborate. The worldwide nature of the report is also remarkable—not everyone has the means to do this kind of broad study and it is important that Elsevier is taking the initiative.

The trends identified in terms of scientific publications are confirmed for both awarded grants and even more so when analyzing patents. From your perspective, what do you think this says about a gender innovation gap and the ability to translate research?

I am personally very concerned about the patent side of the equation. The US Patent and Trademark Office report on trends and characteristics of US women in ventures, which

> It takes many different connection points to create this kind of change and we at AWIS appreciate the work that Elsevier is doing.

came out in February 2019, is something that needs more attention. AWIS and the National Women's Business Council have also been supporting new legislation around more accurate tracking of patent data, particularly disaggregating data on underrepresented groups so that we can better understand the gaps and develop strategies to improve participation in the patent process. We feel that it is incredibly important to get a good read on who is showing up and to track data in a way that allows us to see the gaps and monitor change. My colleagues in the US Patent and Trademark Office are really keen on moving the needle on the issue of gender representation in innovation.

Thinking about the future of gender diversity and equity in research globally, within AWIS membership, within the United States, or on a global scale, where do you think we will be in 10 years' time and what do you think have the most significant influence on creating change?

I believe this is the first era in history that five generations are working together. As the baby boomer generation continues to retire, it will make more space for new people, new voices, and new perspectives to enter the research community. I see that happening within our AWIS membership and we celebrate it. As you know, we have a very strong focus on furthering diversity and inclusion as key considerations in innovation. This generational shift in the research workforce will also be affected by the expansion of new media channels that have not been available previously. Platforms like Twitter are allowing people to communicate about their research and their perspectives in a personal and direct way. These platforms are giving a voice to people who have been underrepresented in research, bringing down barriers and allowing them to participate in the conversation and shape the future direction of the research community. These changes in the research workforce are happening in a positive, healthy way and will accelerate diversity and innovation.

What impact, if any, has the #MeToo movement had in the world of research?

The #MeToo movement has greatly impacted our society at large. I think it has had a positive impact and one that has been unanticipated in some ways. There is a greater recognition of the need for caution in terms of interactions in professional and social settings, but I'm not sure that has translated into creating more balance and inclusion. But we have to start somewhere. By bringing greater realization about what has been going on and making it more public, the #MeToo movement has had an overall positive impact. It has created a "call the heart" in which we can access the human perspective and agree that this kind of inequality and treatment of women cannot continue.

Are there any other thoughts you'd like to share about the report or issues related to gender diversity or equity in research?

As the CEO of AWIS, I respect Elsevier's deep commitment to continuing to study gender diversity an equity and to be partners, not only with AWIS, but with the scientific community and STEM professionals to address this issue in the long-term. It takes many different connection points to create this kind of change and we at AWIS appreciate the work that Elsevier is doing. Women have important things to share and they need to be able to show up and innovate.

Researcher Perspectives

Conclusion

The preliminary qualitative research survey and the interviews demonstrate great diversity in perceptions and attitudes of gender in research. We believe there is great value in recognizing these different perspectives, as this improves the chances of finding effective solutions.

Classifying researchers by their attitude to gender-related issues into eight viewpoint clusters provides a deeper understanding of the diversity of opinions. Most of the differences in viewpoints can be related to the importance that the individual placed on gender balance and to the perception that the academic system is fair.

When looking at most of the topics we discussed with the interviewees, we see that on one hand, some clusters (men and women) tended to attribute gender inequality to the attitudes and ambition levels of women. Other clusters attributed gender inequality to a systemic and cultural (unconscious) bias against women. Even in fields where the ratio of men and women is balanced the proportion of women in more senior levels is reported to be lower than men.

We note consensus among interviewees that family responsibilities can have a negative impact on research careers (for both women and involved men). In turn, the ambition level of women is strongly influenced by challenges women experience in combining family life and a career. Many researchers reported that women are expected to be the primary caregivers. Women report a positive effect on their ability to successfully advance in their career if they receive childcare support (e.g., from their spouses, family, external childcare provider).

The suggested interventions are in line with the respondents' different perceptions on the causes of gender-related issues. These interventions were either aimed at increasing the assertiveness and self-confidence of women or at changing the male-dominated culture and reducing implicit bias. Since the differences in perceptions regarding effective interventions were so large, we conclude that a combination of multiple interventions is needed rather than any single intervention or a one-size-fits-all solution.

Respondents to the survey who did provide open answers that show they are indifferent men and women or indignant men did not agree to be interviewed for this study. Consequently, we did not discover viewpoints from men and women who are indifferent to the gender discussion. Nor did we speak to men who are negative about current interventions that sometimes discriminate against men. We feel that it will be important to uncover their perceptions to understand how they can be included in the discussions to create a diverse research environment with equal opportunities for both men and women.

Appendices

Appendix A

Methods and Experimental Approach

Analysis of Bibliometric Data

DATA SOURCE:

The bibliometric data used for the analyses in this report were based on the June 6, 2019 snapshot of the Scopus database.

PUBLICATIONS INCLUDED IN THE ANALYSIS:

Bibliometric analyses were based on three publication types combined: articles, reviews and conference papers. Bibliometric indicators presented in this report, such as average number of publications and average field-weighted citation impact (FWCI), were based on these publication types.

AUTHOR DEFINITION AND DISAMBIGUATION (SCOPUS AUTHOR PROFILES):

Data analyses were based on authors as listed on the author byline of publications. Scopus uses a sophisticated author-matching algorithm to precisely identify publications by the same author. The Scopus Author Identifier assigns each author a unique ID (called the author ID) and groups together all documents published by that author into a Scopus Author Profile, matching alternate spellings and variations of the author's last name and distinguishing between authors with the same last name by differentiating on data elements associated with the publication (such as affiliation, subject area and co-authors). The profile is enriched with manual, author-supplied feedback, both directly through Scopus and via Scopus' direct links with ORCID (Open Researcher & Contributor ID; https://orcid.org/). Gender is not captured in Scopus Author Profiles.

AUTHORS INCLUDED IN THE ANALYSIS:

Authors included in the analysis were limited to those authors for whom a first name could be determined (based on name data from the June 6, 2019 snapshot of Scopus, as described in the section "First name determination") and a gender could be predicted based on the latest version of the NamSor API (i.e., surpassing a Gender Probability Score of 1.735; described in the section "Gender Probability Score").

ACTIVE AUTHORS:

Analyses of authors during the periods 1999–2003 and 2014–2018 were based on "active authors." We defined "active authors" as those having published at least two publications (i.e., articles, reviews or conference papers) during the period of interest. To ensure inclusion of earliest career authors among those analyzed, we also included authors in the period 1999–2003 if their first Scopus-indexed publication occurred in that period and they published at least one more publication within five years of the first publication. For example, if an author's first publication was published in 2000, we included that author if their second publication was published in or before 2005. We included authors in the period 2014–2018 if their first Scopus-indexed publication occurred in that period. We applied a two-publication minimum filter to ensure that we were analyzing the active author population and not those who publish only occasionally.

CORRESPONDING AUTHORS, FIRST AUTHORS AND LAST AUTHORS:

Authors in the positions of corresponding author, first author or last author (as provided by the authors at the time of publication, as captured in Scopus) were the subset of active authors who had ever authored a publication during the period of interest as corresponding author, first author or last author, respectively.

AUTHOR COUNTRY AND SUBJECT AREA ASSIGNATION:

We assigned authors to countries and subject areas based on their publication output during the period of interest. Whole counting methods were used for this process. Authors were assigned to a country if more than 30% of their publications during the five-year period of interest were from that country. Authors assigned to any of the EU28 countries were also assigned to the category EU28. The United Kingdom is included in the EU28, as was correct at time of analysis for the report. Similarly, an author was assigned to a subject area if more than 30% of their publications during the five-year period of interest were in that subject area. If an author did not meet these thresholds for any country or any subject area, they were not assigned to one.

SELECTION OF COUNTRIES TO INCLUDE IN THE ANALYSIS:

To ensure that country-level analyses were based on robust data, countries in the report were limited to those with at least 30,000 authors (enumerated based on the description in the section "Authors included in the analysis") with at least two publications during the period 2014–2018.

The prediction of gender based on name was dependent on two factors: the author ID having a first name (as described in the section "First name determination") and the Gender Probability Score assigned to the author name by NamSor. We therefore included additional thresholds to ensure that the prediction of gender based on name was similar across countries included in the report: countries included in the report were limited to those for which at least 80% of author profiles had a first name and at least 75% of author profiles with a first name had a Gender Probability Score equal to or above 1.735 (described in the section "Gender Probability Score").

SCOPUS ASJC MAJOR SUBJECT AREAS	BROAD CLUSTER	SUBJECT AREA NAME USED IN THIS REPORT
Multidisciplinary (journals like *Nature* and *Science*)	All	Publications in these journals are reclassified to the 26 subject areas listed below for this report
Agricultural and Biological Sciences	Life Sciences	Agricultural Sciences
Arts and Humanities	Social Sciences	Arts & Humanities
Biochemistry, Genetics and Molecular Biology	Life Sciences	Biochemistry
Business, Management and Accounting	Social Sciences	Business
Chemical Engineering	Physical Sciences	Chemical Engineering
Chemistry	Physical Sciences	Chemistry
Computer Science	Physical Sciences	Computer Science
Decision Sciences	Social Sciences	Decision Sciences
Dentistry	Health Sciences	Dentistry
Earth and Planetary Sciences	Physical Sciences	Earth & Planetary Sciences
Economics, Econometrics and Finance	Social Sciences	Economics
Energy	Physical Sciences	Energy
Engineering	Physical Sciences	Engineering
Environmental Science	Physical Sciences	Environmental Science
Health Professions	Health Sciences	Health Professions
Immunology and Microbiology	Life Sciences	Immunology
Materials Science	Physical Sciences	Materials Science
Mathematics	Physical Sciences	Mathematics
Medicine	Health Sciences	Medicine
Neuroscience	Life Sciences	Neuroscience
Nursing	Health Sciences	Nursing
Pharmacology, Toxicology and Pharmaceutics	Life Sciences	Pharmacology
Physics and Astronomy	Physical Sciences	Physics & Astronomy
Psychology	Social Sciences	Psychology
Social Sciences	Social Sciences	Social Sciences
Veterinary	Health Sciences	Veterinary

SUBJECT AREAS AND SUBFIELDS INCLUDED IN THE ANALYSIS:

Titles in Scopus are classified under four broad subject clusters (life sciences, physical sciences, health sciences and social sciences & humanities), which are further divided into 27 major subject areas (known as All Science Journal Classification or ASJC). Titles may belong to more than one subject area. Subject areas in this report are based on 26 subject areas, with titles classified as "Multidisciplinary" by ASJC reclassified for this report.

To define subfields of research within medicine, we leveraged a system in which the major subfields of medicine are further classified into subcategories. Because there is considerable overlap in some subcategories, we defined medicine subfields by grouping the appropriate subcategories based on the frequency that publications were categorized in overlapping subcategories. For example, we created the subfield "Fertility & Birth" because a high percentage of publications in the subcategory "Obstetrics and Gynecology" were also classified in the subcategory "Reproductive Medicine". Further, for inclusion in this analysis, we focused on subcategories with less than 40% overlap in the author population compared with the major subject area of medicine. That is, if more than 40% of authors from a subcategory or subfield were also represented in the major subject area of medicine, we considered the two populations of authors to be sufficiently similar that analysis of the subfield would not yield major insights. The final selection of research subfields in medicine is shown here.

MEDICINE SUBFIELD NAME	SUBCATEGORIES INCLUDED
Cancer	Cancer Research Oncology
Cardiology & Pulmonology	Cardiology and Cardiovascular Medicine Pulmonary and Respiratory Medicine
Diabetes & Endocrinology	Endocrinology Endocrinology, Diabetes and Metabolism
Emergency Medicine	Critical Care and Intensive Care Medicine Emergency Medicine
Fertility & Birth	Obstetrics and Gynecology Reproductive Medicine
General Clinical Medicine	General Medicine Family Practice Internal Medicine
Infectious Diseases & Allergy	Immunology and Allergy Infectious Diseases Microbiology (medical)
Pediatrics	Pediatrics, Perinatology and Child Health
Public Health	Epidemiology Health Policy Public Health, Environmental and Occupational Health
Radiology & Imaging	Radiology, Nuclear Medicine and Imaging
Surgery	Surgery

We also explored whether the following subfields would provide additional insight. However, we found that more than 40% of authors from these subfields (defined according to the subcategories listed) were also represented in the major subject area and therefore would not provide more insight than what was provided at the subject area level.

MEDICINE SUBFIELD NAME	SUBCATEGORIES INCLUDED	MAJOR SUBJECT AREA
Infectious Diseases & Allergy	Immunology and Allergy Infectious Diseases Microbiology (medical)	Immunology & Microbiology
Neurology	Neurology (clinical) Neurology	Neuroscience

The following subfields were assessed but were not presented because results were similar to the subject area of biochemistry.

MEDICINE SUBFIELD NAME	SUBCATEGORIES INCLUDED
Biochemistry & Biophysics	Biochemistry Biophysics Structural Biology
Biotechnology	Biotechnology Applied Microbiology and Biotechnology

AUTHOR GENDER INFERENCE:

We used NamSor to infer the gender of authors. NamSor treats gender as a binary variable and is only able to infer the gender as "woman" or "man." We acknowledge that this poses a limitation to fully assessing gender inclusiveness.

A binary gender was inferred for author IDs using the NamSor API (January 2019 release). The API provides a Gender Probability Score and gender classification based on three data points: country of origin, first name and last name. We generated these three data points for authors based on information related to each author ID.

Determination of author country of origin:

We determined each author's country of origin based on the country of affiliation listed on the publications from their first year of publication in Scopus (i.e., articles, reviews and conference papers). In some cases, authors had published in more than one country in their first year of publication. In these cases, we designated the country with the largest number of publications as the author's country of origin. Authors with equal numbers of publications in two or more countries were excluded from the gender disambiguation analysis. The process used to determine the author country of origin is summarized here.

For each author ID:

1. Identify year of first publication in Scopus.
2. Identify all publications from the first year that the author published.
3. Identify the country affiliation indicated by the author in their first-year publications.
4. Tabulate the countries of affiliation.
5. Tabulate the number of times each country was listed as the country of affiliation in the first year of publication.
6. Assign the author ID to the country most often indicated as the country of affiliation in the first year of publication as the country of origin.
7. If two countries appeared as the country of affiliation for an author an equal number of times in the first year of publication, then that author was excluded from the analysis.

First name determination:

First and last name are required as input data for NamSor. Therefore, only author IDs with a first and last name were passed through the NamSor API to retrieve a Gender Probability Score. All author IDs for whom no first name data was available were not included in the analysis.

Different variants of an author's name are commonly observed across their publications. To identify the best first name to pass through NamSor for each author, we assessed all the name variants associated with each author ID. For each author ID in the Scopus snapshot, we examined all publications on which the author ID appears in the author field and generated a list of all distinct first names associated with the author ID. Based on this list, we generated a table with a revised first name for each author ID. The process used to determine the best first name to pass through NamSor is described here.

In cases where only a single first name was associated with an author ID:

1. When the name was of zero length, the best first name was assigned as null
   e.g., author first names: [ ]
   best first name: null

These author IDs were excluded from the analysis.

2. When the name was not of zero length, we removed the following nonsensical characters if they were leading or trailing: "-!#&"
   e.g., author first names: ["Tom&"]
   best first name: Tom

In cases where multiple first names were associated with an author ID, we selected the longest available name following removal of nonsensical characters, provided this name was not composed of a string of initials, according to the following steps for each author ID:

1. Author first names were collected into a list.
2. Author first names were initialized as the empty string ' '.
3. The list of names was looped through. Each name in the list was stripped of nonsensical leading and trailing characters (-!#&).
4. The next name in the list was considered and subjected to the same treatment. If the length of the string was longer and not composed of a string of initials, this next name was then assigned as the revised first name. We identified a string of initials among author first names by comparing the number of periods that appear in the string to the number of characters (excluding whitespace, periods and nonsensical characters). When the number of periods was equal to the number of characters, this string was identified as a string of initials. This was done using Regex expressions.
5. This process was repeated until the end of the list of author first names is reached.
   e.g., author first names: ["Samantha", "#Sam", "Sam", "S. E."]
   best first name: Samantha
   e.g., author first names: ["Samuel", "#Sam", "Sam", "S. E."]
   best first name: Samuel

Gender Probability Score:

The NamSor Gender Probability Score was used to predict the gender of each author. The Gender Probability Score is the natural log of the ratio of probabilities, as determined by a Naïve-Bayes model, of the name receiving the classification of either MALE or FEMALE. The Gender Probability Score is based on the best first name, last name and country of origin.

To predict the gender of each author, we first created a table containing unique name-country combinations (represented in the Scopus snapshot) from the following three fields:

- best first name (based on the process described in the section "First name determination")
- last name (based on author ID)
- country of origin (based on the process described in the section "Determination of author country of origin")

We next took the resulting name-country combinations and passed them through the NamSor API, which generated a classification (either MALE or FEMALE) with the associated Gender Probability Score for each combination.

The detailed equation for the following classification and Gender Probability Score are:

$$\text{Gender Probability Score (MALE)} = \ln\left[\frac{\text{Prob(MALE)}}{\text{Prob(FEMALE)}}\right]$$

$$\text{Gender Probability Score (FEMALE)} = \ln\left[\frac{\text{Prob(FEMALE)}}{\text{Prob(MALE)}}\right]$$

We set a threshold value for Prob(CLASSIFICATION) by testing against a dataset of 2,260 athletes competing in the 2012 Olympics in London. The dataset included each individual's first name, last name, self-identified gender and country. The Prob(CLASSIFICATION) threshold of ≥0.85 on the Olympics dataset corresponded to recall and precision rates of 98.0% / 93.0% for men and 87.8% / 98.3% for women, resulting in an F1 score of 0.95 for men and 0.93 for women. Due to the high F1 score, we used the threshold of ≥0.85 (equivalent to Gender Probability Score ≥1.735) to infer gender.

Once the Classification and Gender Probability Score were obtained for each name-country combination, we solved for Prob(CLASSIFICATION). Gender was assigned for name-country combinations that had Prob(CLASSIFICATION) ≥0.85. Name-country combinations that fell short of this threshold were classified as UNKNOWN. The gender inferred for each name-country combination was then matched to author IDs based on the best first name, last name and country of origin.

AUTHOR PUBLICATION HISTORY:

Author publication history was determined based on the year in which the author's first publication appears in Scopus. We binned authors into groups based on the year of their first publication as follows:

- Group A – first publication in Scopus in 2003 or earlier (but not before 1930)
- Group B – first publication in Scopus between 2004 and 2008
- Group C – first publication in Scopus between 2009 and 2013
- Group D – first publication in Scopus between 2014 and 2018.

HYPER-AUTHORED PUBLICATIONS:

Author count varies across subject areas, with some subject areas accounting for a greater proportion of hyper-authored publications. We assessed whether it was reasonable to define hyper-authored publications for each subject area as those publications with an author count greater than the author count for the majority of publications in the same ASJC (All Science Journal Classification) subject area. We considered using an author count of 1.5 times the interquartile range for authors in that subject area as a reasonable threshold for defining and excluding hyper-authored publications; however, we found that using this threshold would result in exclusion of a large number of publications. For example, in the subject area of medicine, excluding publications with an author count higher than 1.5 times the interquartile range would result in the exclusion of any publications with more than six authors. In the absence of a standardized method to set the threshold of author count to define hyper-authored publications, we decided to include hyper-authored publications in all analyses of bibliometric measures in the report.

AVERAGE NUMBER OF PUBLICATIONS:

The average number of publications by men and women was calculated as the arithmetic mean of the number of publications by each active author during the period of interest and within a given group (based on gender, country and subject area). For example, the average number of publications authored by women who were active authors in Argentina in the field of medicine during the period 2014–2018 was 3.2 publications. This value is the arithmetic mean of the publication count of the 9,938 women who were active authors in medicine in Argentina during the period 2014–2018. Author assignation to a country, subject area and period were determined as described in the section "Author country and subject area assignation." All publications by an author, once assigned to a country, subject area and period, contributed to that author's publication count. Publications were counted using whole counting rather than fractional counting. For example, a publication listing five authors in the author byline counted as a single publication towards the publication count of each author, rather than contributing 0.2 publications towards each author's publication count.

We determined the average number of publications by men and women among authors in the position of corresponding author, first author and last author using the same approach, except that the calculation was based only on those authors who had ever published as corresponding author, first author or last author, respectively. We limited the calculation of publications in which the author was first or last author to those publications that did not have authors listed in alphabetical order and that had at least three authors.

The example illustrates how average publication count was calculated for a hypothetical group of active authors of the same gender in a given country and subject area. The number of publications for each author A, B, C and D is given in the table, with the average number of publications for the authors in each author position provided in the bottom row.

AUTHOR POSITION

AUTHOR	ALL	CORRESPONDING	FIRST AUTHOR	LAST AUTHOR
A	9	4	1	1
B	10	7	3	1
C	11	n/a	n/a	n/a
D	6	4	n/a	1
Average	9	5	2	1

n/a indicates the author had no publications in this position.

AVERAGE FIELD-WEIGHTED CITATION IMPACT (FWCI):

Field-weighted citation impact (FWCI) is an indicator of the academic impact or reach of a publication. It is calculated by comparing the number of citations actually received by a publication with the number of citations expected for a publication of the same type, publication year and subject area. An FWCI of more than 1.0 indicates that the publication has been cited more than would be expected based on the global average for similar publications. For example, an FWCI of 2.1 means that the publication has been cited 110% more than the world average for similar publications. An FWCI of less than 1.0 indicates that the publication has been cited less than would be expected based on the global average for similar publications. For example, an FWCI of 0.9 means that the publication has been cited 10% less than the world average for similar publications.

In general, the FWCI is defined as:

$$FWCI = \frac{C_i}{E_i}$$

with

C_i = citations received by publication i

E_i = expected number of citations received by all similar publications in the publication year plus the following three years

When a publication was allocated to more than one subject area, the harmonic mean was used to calculate FWCI.

To calculate the average FWCI among men and women, we first calculated the arithmetic mean FWCI for each author based on their publications during the period of interest. This was done using fractional counting and a weighted average. For a publication with N authors, each author on that publication was assigned a fractional count of 1/N. In order to calculate an author's FWCI over their body of work, the author's fractional count for each publication was multiplied by the publication's FWCI. These products were then summed and divided by the sum of the of all fractional counts assigned to the author.

We also calculated the arithmetic mean FWCI for each author based on their publications as corresponding author, first author and last author. These calculations were done using the same method of fractional counting and a weighted average, with the exception that the corpus of publications was restricted to those publications for which the author was the corresponding author, first author or last author, respectively. Publications in which authors were listed in alphabetical order and those with two or fewer authors were excluded from the calculations related to first and last author.

The average FWCI among men and women in a country and subject area was calculated by taking the arithmetic mean of the FWCI for authors in the group.

AUTHORSHIP CONTINUITY OVER TIME:

Author continuity studies were based on two cohorts of authors: one cohort that first published in 2009 and a second cohort that first published in 1999. Authors in these cohorts were assigned to a country and subject area based on their publications in the five-year periods of 2009–2013 or 1999–2003, respectively. An author was assigned to a country if more than 30% of their publications in the five-year period of interest listed an affiliation based in that country. Similarly, an author was assigned to a subject area if more than 30% of their publications in the five-year period of interest were in that subject area. These assignations were based on whole counting methods.

As part of the analysis, for each author in the two cohorts, we determined the year of the last publication indexed in Scopus and defined the time span between the first and last publication as the period during which they authored papers.

AUTHOR MOBILITY:

Author mobility studies were based on two cohorts of authors: one cohort that first published during the period 1999–2003 and a second cohort that first published during the period 2003–2013. We defined an author's country of origin as described in the section "Determination of author country of origin." Authors with a null country in their first publication (i.e., no country associated with the author affiliation listed or no affiliation listed) were excluded from the analysis.

To assess author mobility, we categorized authors as those who never published with an affiliation outside their country of origin and those who published with an affiliation outside their country of origin at least once between the time of their first publication and 2018. Authors with only one publication were not included.

Bibliometric analysis of author mobility within each cohort was based on publications by authors from each cohort during the period 2014–2018. The average number of publications and average FWCI were calculated as described in the sections "Average number of publications" and "Average Field-weighted Citation Impact (FWCI)."

AUTHOR COLLABORATION NETWORK ANALYSIS:

Network specifications:

Author collaboration network analyses were based on a defined set of focal authors and their collaborators. Focal authors were defined as those authors who:

- Were deemed "active authors"
- Published in the year 2013
- First published in or after 1989
- Had a first name associated with their Author ID
- Had a gender predicted using NamSor

Active authors were defined using the approach described in the section "Active authors." Authors were deemed active if they published at least two publications (i.e., articles, reviews and/or conference papers) during the period 2009–2013. Additionally, authors whose first Scopus-indexed publication occurred in 2009–2013 who then published at least one publication within five years of the first publication were also included so that earliest career authors would be represented among the focal author set. We excluded authors who published before 1989 from the focal set to ensure that we could disaggregate authors by year of first publication and still work with a robust number of women and men among authors. 87% of authors who published in 2013 first published in or after 1989. Author's first name and gender were determined as described in the section "Authors included in the analysis." Author first name determination and gender inference was done as described in the section "Author gender inference."

Collaborative network profiles were built for focal authors based on their co-authorships (i.e., publications with other authors) during the five-year period, 2009–2013. We selected this period for analysis to permit assessment of future outcomes (i.e., in the period 2014–2018) of the cohort. We built an author-level collaboration network where the "nodes" in the network represent authors and the connections between them (i.e., the "links") represent co-authorship relationships, defined as instances where the authors connected by the links appeared together in one or more papers during the five-year period. We used a five-year network window to capture ongoing and repeated co-authorship ties, with the understanding that this approach would capture network and productivity statistics bounded in time and not necessarily characteristic of an author's full set of co-authors and collaborative activities across their career.

To retain network integrity, all focal authors and their co-authors on publications during the period 2009–2013, regardless of their productivity during the period, inferred gender or assigned country/region and subject area, were included to generate collaboration network characteristics.

We assessed whether hyper-authored publications should be included in the analysis. Participation in hyper-authored papers can have a dramatic impact on connectivity of authors within collaboration networks. Therefore, we also assessed whether men and women are differentially represented in hyper-collaborative research. As only small differences between men and women were observed in aggregate (with men slightly more likely to be represented on hyper-authored papers in some subject areas and countries/regions), we included these publications in this analysis as they appeared to have little influence on the trends.

For each focal author analyzed, we computed the following measures (see also):

- Network centrality: the number of direct collaborators, i.e., the number of unique authors with whom the focal author co-authored papers with during the five-year time period
- Second-order collaborators: the average number of collaborators of an author's direct collaborators, i.e., the average number of collaboration ties of the direct collaborators of a focal author
- Direct collaborators' gender composition: share of direct collaborators by gender
- International reach: share of direct collaborators who were not assigned to the same country and/or region as the focal author. Note that the EU28 region was treated as a single geographic area, meaning that international collaborators of authors assigned to the EU28 were defined as those authors assigned to countries outside the EU28
- Direct collaborators' publication history: average number of years from the year of first publication until 2013 of focal authors' direct collaborators

To measure the network gender composition and international reach of focal authors, we classified the focal authors' direct collaborators by:

- Gender
- Country/region similarity compared to focal author

Gender was determined and country/region and subject area were assigned to direct collaborators as described in the sections "Author gender inference" and "Author country and subject area assignation," respectively.

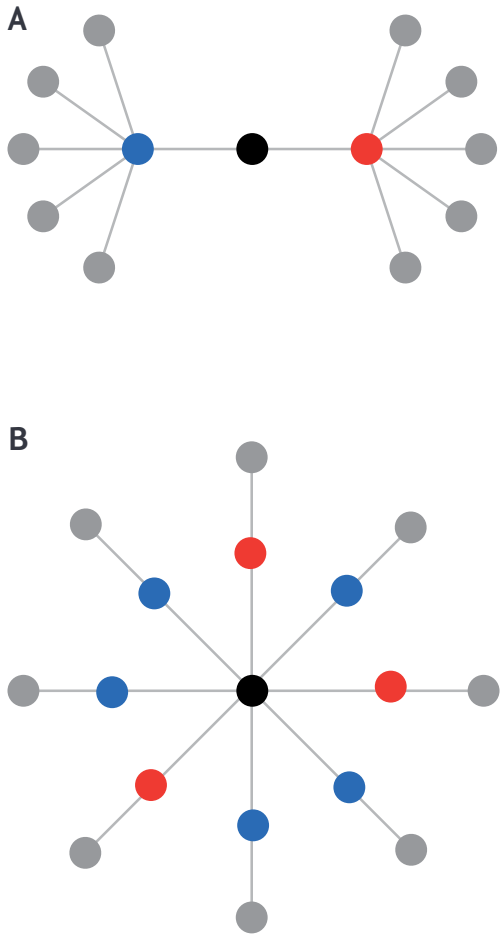
The collaboration network among all authors who published between 2009 and 2013 comprised 144,347,507 links (co-authored publications) and 10,470,713 nodes (authors). Although we utilized the full network (all years [2009–2013], subject areas and countries) to generate network statistics, we focused on 16 region-subject pairs. These region-subject pairs are defined based on focal author assignation to 16 combinations of regions and subject areas selected of analysis. The regions selected for analysis were Brazil, Japan, USA and EU28 and the subject areas selected for analysis were biochemistry, business & economics, engineering and medicine.

The subject area of business & economics was created by combining two major subject areas: "Business, Management and Accounting" and "Economics, Econometrics and Finance". We combined these categories because we observed high (i.e., greater than 40% in some cases) representation of authors in both subject areas. For example, 76% of the authors in the subcategory of accounting (within Business, Management and Accounting) were also represented in finance (within Economics, Econometrics and Finance). Furthermore, our 2017 analysis revealed that both subject areas had similar ratios of women to men.

The final sample size of the focal author set (i.e., authors who were assigned to the 16 region-subject pairs studied in this report) was 1,271,488. Of these, 875,492 were men and 395,996 were women. The EU28 contained the greatest number of focal authors (661,911), followed by USA (445,046 authors), Japan (128,277) and Brazil (54,064). Medicine had the greatest number of authors in the focal set (728,143), followed by biochemistry (459,195), engineering (324,025) and business & economics (53,801).

FIGURE A.1

Toy networks depicting two hypothetical focal authors within networks that have different structural characteristics. A) I focal author (black circle) is tied to two direct co-authors (red and blue circles), which are in turn connected to five co-authors (gray circles, second-order collaborators of the focal author). This results in a direct network centrality equal to 2 and an average number of second-order collaborators equal to 5. B) The focal author (black circle) is tied to eight direct co-authors (red and blue circles), which are in turn each connected to a single co-author (gray circles, second-order collaborators of the focal author). This results in a direct network centrality equal to 8 and an average number of second-order collaborators equal to 1. For the analyses in this report, each direct co-author was assessed based on inferred gender and assigned country/region, represented here as different node colors, to compute the gender composition and international reach of direct co-authors.



Stratification of authors by their first year of publication:

We stratified authors into groups based on the year that their first publication appears in Scopus to ensure that we were comparing authors with similar publication histories as follows: 2009–2013, 2004–2008, 1999–2003, 1994–1998 and 1989–1993. For more details on distribution of observations by author groups, see Table A.1.

TABLE A.1

Number of observations within each subject area, country/region, gender and year of first publication within each network analyzed.

			SUBJECT AREA			
GEOGRAPHY	GENDER	YEAR OF FIRST PUBLICATION	MEDICINE	BIOCHEMISTRY	ENGINEERING	BUSINESS & ECONOMICS
EU28	Women	2009–2013	100,426	65,079	22,262	6,866
		2004–2008	21,572	14,566	4,197	1,318
		1999–2003	14,172	9,398	2,477	684
		1994–1998	9,353	6,559	1,347	290
		1989–1993	6,161	4,206	737	132
	Men	2009–2013	95,180	58,885	84,509	12,821
		2004–2008	30,563	18,347	19,849	3,471
		1999–2003	25,306	14,406	13,759	2,420
		1994–1998	20,683	12,167	8,954	1,387
		1989–1993	17,345	9,327	5,907	847
USA	Women	2009–2013	57,328	32,532	8,889	2,814
		2004–2008	12,278	7,327	1,469	649
		1999–2003	7,987	4,390	892	483
		1994–1998	5,614	3,099	561	302
		1989–1993	3,934	2,095	359	192
	Men	2009–2013	80,357	58,781	52,253	7,127
		2004–2008	23,124	18,012	11,027	2,015
		1999–2003	17,496	11,914	7,501	1,759
		1994–1998	13,540	9,010	5,632	1,338
		1989–1993	11,214	6,918	4,532	1,029

GEOGRAPHY	GENDER	YEAR OF FIRST PUBLICATION	SUBJECT AREA			
			MEDICINE	BIOCHEMISTRY	ENGINEERING	BUSINESS & ECONOMICS
Japan	Women	2009–2013	7,431	5,185	1,608	108
		2004–2008	1,223	907	219	16
		1999–2003	701	532	152	10
		1994–1998	465	311	80	6
		1989–1993	294	200	40	4
	Men	2009–2013	28,262	18,689	22,237	613
		2004–2008	8,508	5,774	4,801	172
		1999–2003	6,796	4,655	3,988	100
		1994–1998	5,493	3,563	2,934	56
		1989–1993	4,460	2,665	2,298	52
Brazil	Women	2009–2013	11,911	6,456	1,835	447
		2004–2008	1,986	1,097	283	28
		1999–2003	1,177	623	147	19
		1994–1998	693	380	80	11
		1989–1993	379	219	29	1
	Men	2009–2013	10,956	5,774	5,945	1,097
		2004–2008	2,193	1,159	1,173	149
		1999–2003	1,379	699	881	66
		1994–1998	912	450	461	21
		1989–1993	608	281	234	12

Network and metrics definition:

We defined A=[a_ij] as the adjacency matrix describing the connections among all the authors (nodes) in the network, such that the entry a_ij is equal to 1 if there is a link (collaboration) from i to j, and zero otherwise.

Thus, the count of direct collaborators of an author i, or equivalently its degree d_i , in the network of collaboration was defined as follows:

$$d_i = \sum_j a_{ij}$$

The average number of second-order collaborators was computed as the average degree of an author i's direct collaborators j and was defined as follows:

$$\langle d_j^i \rangle = \frac{d_i = \sum_j d_j^i}{d_i}$$

with d_j^i being the degree of i's direct collaborators and d_i the number of direct collaborations.

Analysis of funding data

DATA SOURCE:

The funding data used for the analyses in this report were based on a snapshot of the Elsevier's funding database, taken June 9, 2019. This snapshot was chosen as it is the closest in time to the Scopus snapshot used for the bibliometrics analyses (June 6, 2019).

AWARDS INCLUDED IN THE ANALYSIS:

Analyses of grants were limited to research awards with start dates between 2014 and 2018, inclusive. Awards coded as "research awards" in the database were defined as those that support discrete, specified, researcher-initiated projects to be performed by named investigators in areas representing their specific interest and competencies. The following phrases in the synopsis or description and abstract sections were used to identify research awards:

- Support or assist (some type of research)
- Foster or encourage research
- Enhance current research
- Offer funds to support or encourage research
- Grant support for investigators

AWARDEES INCLUDED IN THE ANALYSIS:

Awardees included in the report were limited to those for whom a Scopus author ID was available and the associated Scopus author ID data (first name, last name and country of origin) could support gender inference (as described in the section "Analysis of Bibliometric Data"). Awardee names in the Elsevier's funding database were matched to Scopus author IDs based on awardee name and institution details.

FUNDING AGENCIES INCLUDED IN THE ANALYSIS:

All agencies indexed in the Elsevier funding database that granted a research award with a start date during the time period 2014–2018 to an individual with an author ID were included in the analysis and contributed to the country-level statistics.

AWARDEE COUNTRY ASSIGNATION:

We assigned awardees to countries based on the country that the funding agency awarding the grant is located. Awardees who received grants from more than one funding agency based in more than one country thus counted towards more than one country or region.

SELECTION OF COUNTRIES TO INCLUDE IN THE ANALYSIS:

Awardees were aggregated at the country level based on the country of the awarding funding agency. Therefore, awardees were assigned to a country based on the location of the funding agency. To ensure we were working with a robust data set, we limited the analyses to those countries with at least 5,000 awardees (enumerated based on the description in the section "Awardees included in the analysis") during the period 2014–2018.

Consistent with our approach for selecting countries for bibliometric analyses (as described in the section "Analysis of Bibliometric Data), we limited the countries included in the analysis of grants and awardees to those countries for which at least 80% of author profiles had a first name and at least 75% of author profiles with a first name (as described in the section "First name determination") had a Gender Probability Score equal to or above 1.735 (described in the section "Gender Probability Score"). Among those countries that passed these thresholds, the percentage of awardees for whom gender could not be inferred represented less than 1% of awardees.

AWARDEE GENDER INFERENCE:

Awardees were matched to their Scopus author ID and gender was inferred as described in the section "Author gender inference."

AVERAGE NUMBER OF AWARDS:

The average number of awards granted to men and women was calculated as the arithmetic mean of the number of awards received by each awardee during the period of interest and within a given group (based on inferred gender and assigned country). Awards were counted using whole counting rather than fractional counting. For example, an award listing four awardees as recipients counted as a single award towards the award count of each awardee, rather than contributing 0.25 awards towards each awardee's award count.

Analysis of patent data

DATA SOURCE:

The data used for the analyses of patent applicants and inventors in this report were from the 2019 Spring Edition of PATSTAT, a patent database covering close to 100 patent authorities worldwide.

PATENT AUTHORITIES INCLUDED IN THE ANALYSIS:

Inclusion of patent offices in the analysis was based on the quality of data provided by each patent office. We evaluated data quality for the IP5 offices (the 5 offices covering the largest markets) as follows:

- United States Patent and Trademark Office (USPTO) data were included because 98% of patents include the names of the inventors and 98% of patents include the country of the inventors. One caveat is that applicants on USPTO patents may ask that their application not be published until the patent is granted. Therefore, USPTO patent data included in this report were for inventors and applicants with applications that have already been published.
- European Patent Office (EPO) data were included because 95% of patents include the names of inventors and 95% of patents include the country of the inventors.
- China National Intellectual Property Administration (CNIPA) data were excluded because although the names of the inventors are reported for 95% of all applications, the country of the inventor is reported for only 14% of all applications; thus, we were unable to assign inventors to countries.
- Japan Patent Office (JIPO) data were excluded because although the names of the inventors are reported for 85% of all applications, the country of the inventors is reported for less than 1% of all applications; thus, we were unable to assign inventors to countries.
- Korean Patent Office (KIPO) data were excluded because although the names of the inventors are reported for 92% of all applications, the country of the inventors is reported for only 75% of all applications; thus, we were unable to assign inventors to countries. Although these values were relatively high, we elected not to include KIPO data because inventor gender inference as described in the section "Analysis of Bibliometric Data," was expected to return a low level of precision and recall based on the high number of inventors from Korea (approximately 75% of inventors with country information were from Korea).

INVENTOR AND ASSIGNEE DEFINITION AND DISAMBIGUATION:

Data analyses were based on inventors, defined as those named as inventors on the patent (those who contribute to the claims of a patentable invention), and assignees (the subset of inventors who own intellectual property rights to patents), defined as those named as assignees on the patent.

To determine if two inventors or assignees of the same name were the same person, we used the unique identifier, doc_std_name_id key found in table tls206_person in PATSTAT. This key is similar to the author ID in Scopus in that it aims to group all person_name data related to the same individual under a single key.

INVENTORS INCLUDED IN THE ANALYSIS:

Inventors included in this analysis were limited to those who appear as inventors in any patent application filed with USPTO or EPO, regardless of if the patent was granted or not, during two periods based on the filling year at the patent office: 1999–2003 and 2012–2016. We assessed patents in 2012–2016 rather than 2014–2018 as in the bibliometric analyses because patent applications must be published before they appear in PATSTAT, which results in a lag of up to 18 months for patent offices such as the EPO.

ASSIGNEES INCLUDED IN THE ANALYSIS:

Assignees are the subset of inventors who own intellectual property rights to patents and are listed as patent assignee on a given patent. For the majority of patents, patent assignees were corporations, but in some cases, some or all the inventors also owned the IP rights and were thus were named as both inventors and assignees. Assignees included in this analysis were limited to those who appear as assignee in any patent application filed with USPTO or EPO, regardless of if the patent was granted or not, during two periods: 1999–2003 and 2012–2016, based on the filing year at the patent office.

INVENTOR COUNTRY ASSIGNATION:

Inventors were assigned to a country if at least 30% of their patent applications during the period of interest indicated that country as the inventor country. Therefore, inventors could be assigned to more than one country within a period if the share of patent applications was higher than 30% for more than one country.

ASSIGNEE COUNTRY DETERMINATION:

Assignees were designated to a country if at least 30% of their patent applications during the period of interest indicated that country as the assignee country. Therefore, assignees could be assigned to more than one country within a period if the share of patent applications was higher than 30% for more than one country.

SELECTION OF COUNTRIES TO INCLUDE IN THE ANALYSIS:

Countries included in the patent analysis were those with at least 1,400 inventors during the time periods of interest. Furthermore, countries were included only if at least 85% of inventors from the country had a gender inferred (according to the methods described in the section "Author gender inference").

INVENTOR GENDER INFERENCE:

As described in the section "Author gender inference," a binary gender was inferred for inventors using the NamSor API (January 2019 release). The API provides a Gender Probability Score and gender classification based on three data points: country of origin, first name and last name. To determine the gender of inventors, we relied on first and last name only. First and last names were determined as described in the next section. Once inventor names were parsed into first and last name, these data were passed through NamSor and gender was inferred based on the Gender Probability Score as described in the section "Gender Probability Score."

First and last name determination:

Names in PATSTAT are not consistently parsed into first names and last names; in most cases, the format of names in PATSTAT is [lastName, firstName], but in other cases, the format is [firstName lastName], without the comma. Because NamSor requires first and last names to predict gender, we split names from PATSTAT into first and last name components. We used the comma to delineate the first section of the string as the last name and the second part as the first name. We used the absence of a comma as an indication that the first section of the string is the first name and the second section is the last name.

Analysis of authors for case study on China

We conducted tests to assess the accuracy of NamSor in predicting the gender of Chinese names. Our initial assessment of NamSor was done using a data set of 4,249 Olympic medalists that included medalists' first name, last name, country and gender. Because China was under-represented among this data set (38 men and 64 women), we assessed precision and recall for Chinese names using a set of 5,000 members of the Chinese Chemical Society, for whom first name, last name and gender information was available. Names in this data set were available in Mandarin only. Because the majority of names in Scopus are captured using the Roman alphabet, the Mandarin names were converted to Pinyin (the standard system of applying Romanized spelling to transliterate Chinese characters) using the python Pinyin software package. These Pinyin names were tested in NamSor for precision and recall using a threshold of 0.85, resulting in a precision of 95% for men and 0.0% for women and a recall of 20.1% for men and 0.0% for women. However, when we ran the Mandarin names through NamSor, the accuracy was much higher for women without greatly impacting the accuracy for men (precision of 97.6% for men and 35.8% for women and recall of 21.9% for men and 8.8% for women). We therefore decided to use Mandarin names as a means of assessing the gender of researchers in China.

DATA SOURCE:

The data used for the analysis of Chinese authors were based on the September 13, 2019 snapshot of the Scopus database.

PUBLICATIONS INCLUDED IN THE ANALYSIS:

Publications included in the analysis were selected as described in the section Analysis of Bibliometric Data.

AUTHOR DEFINITION AND DISAMBIGUATION (SCOPUS AUTHOR PROFILES):

Authors were defined and disambiguated as described in the section Analysis of Bibliometric Data.

AUTHORS INCLUDED IN THE ANALYSIS:

This case study is based on authors who provided a Mandarin name as an alternative author name in a Scopus-indexed publication published between 2014 and 2016.

ACTIVE AUTHORS:

Analyses of authors was limited to those authors who were active during the period 2014–2018 (i.e., "active authors"). We defined "active authors" as those having published at least two publications (i.e., articles, reviews and/or conference papers) during the period of interest. To ensure inclusion of earliest career authors among those analyzed, we also included authors in the period 2014–2018 if their first Scopus-indexed publication occurred in that period. We applied a two-publication minimum filter to ensure that we were analyzing the active author population and not those who publish only occasionally.

AUTHOR GENDER INFERENCE:

We determined the gender of authors included in this case study by passing the Mandarin names of authors through the NamSor API (January 2019 release).

Name determination:

We retrieved Mandarin names from 1,795,177 publications published in 29,039 journals. Mandarin names were identified using a nicode filter in python (called regex) that was used to test whether an "alternative name" was comprised of Mandarin characters.

Because Mandarin uses characters and not letters, the presence of a character is sufficient for name identification. Therefore, there was no need to exclude authors for whom only a single initial was available as the author name, as described in the section "First name determination" under Analysis of Bibliometric Data.

Gender Profitability Score:

We set a threshold for Prob(CLASSIFICATION) by testing against a dataset of 5,000 members of the Chinese Chemical Society. The dataset included each individual's first and last name (in Mandarin only) and self-identified gender. Based on NamSor precision and recall with this dataset, we determined that the threshold for credibly identifying the gender associated with a Mandarin name was reached when the Calibrated Probability parameter returned by the API was ≥70% (i.e., Prob(CLASSIFICATION) ≥0.70). This impacts the precision and recall of author gender matching and corresponds to a recall of 42.0% for men and 41.7% women and a precision of 96.3% for men and 93.0% for women, resulting in an F1 of 0.59 for men and 0.58 for women. Authors meeting this threshold remained in the analysis and authors not meeting this threshold were tagged as gender "unknown."

AUTHOR SUBJECT AREA ASSIGNATION:

Authors were assigned to a subject area as described in the section Analysis of Bibliometric Data.

AUTHOR PUBLICATION HISTORY:

We assessed author publication history as described in the section Analysis of Bibliometric Data.

Elsevier's 2019 researcher survey

SURVEY TOOL:

A branded Elsevier online survey available in English only was used to examine researchers' experiences and opinions related to career progression and diversity, specifically gender balance, within scholarly research. The survey questions were designed to provide insight on gender differences in job satisfaction, perception of work culture, perception of gender balance, researchers network size and collaborative activities, barriers and reasons why individuals leave careers in research, and gender diversity policy. The survey took 15 minutes to complete (median average). Fieldwork took place in August 2019.

SURVEYED POPULATION:

Of 40,130 individuals who were randomly selected from a database of 3.6 million researchers to participate in the survey, 1,213 researchers responded (3% response rate).

ANALYSIS OF RESULTS:

Responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Base sizes shown were unweighted unless otherwise stated.

STATISTICAL TESTING:

The maximum error margin for 1,213 responses was ± 2.4% at a 90% confidence level. When comparing men and women, we used a Z-test of proportion to identify differences between two independent groups (90% confidence level). Statistically significant differences indicate that we can be 90% confident the difference is explained by gender ($p < 0.10$).

Qualitative analyses

ONLINE SURVEY TO PREPARE FOR THE QUALITATIVE RESEARCH:

An online survey was designed to gain initial insights into the divergency in "perceptions of gender diversity and equity." The survey had 24 questions: 17 closed-ended questions about demographic information, career progression, organizational and workplace environment and personal experience; 6 open-ended questions about the perceptions of the development of gender diversity and equity; and 1 question about the willingness to be contacted and contact information for a follow-up interview. The survey was first sent to 850 researchers from 84 countries in the Elsevier Advisory Panel, and then was forwarded to a broader group of potential respondents via members of Elsevier's Global Strategic Network team.

DEFINING RESPONDENT CLUSTERS:

We received 453 responses in total, of which 423 had complete responses to closed-ended questions. Thus, there were 423 valid responses to the closed-ended questions and 257 valid responses to the open-ended questions. The 423 responses to the closed-ended questions revealed substantial differences between women and men respondents on their understanding of the impact of gender on career progression and the organizational environment. However, the results from a portion of the online survey were not statistically significant, and we therefore decided not to publish them. Upon coding and grouping the 257 open-ended answers from the survey, we distinguished eight clusters of responses representing distinct perceptions of the development of gender diversity and equity in academia: four clusters among men respondents and four clusters among women respondents. For brevity and visualization purposes, we used the term "cluster" in the report to refer to similar opinions on gender-related issues in academia as expressed by respondents in the open-ended survey questions. Hence, "clusters" do not necessarily represent homogeneous groups of people, but homogeneous opinions.

We point out that the open-ended questions likely overrepresent the opinions of respondents with strong views on gender-related issues. As Ovseiko et al. have pointed out in their study on women's and men's perceptions of the Athena SWAN Charter, "the voluntary open-ended nature of questions in the survey might represent those with strong views. Those who provide anonymous survey responses might have been more inclined to express negative attitudes."[62]

INTERVIEW OUTLINE DESIGN:

Based on the survey results, we designed the interview outline to achieve two goals: (1) to confirm the interviewees' perceptions of gender-related issues in academia as they reported in the survey and (2) to identify the underlying reasons for the differences in perceptions of gender-related issues.

The interview outline was composed of three parts: i) socio-economic, cultural, organizational and family background information; ii) attitudes to gender-related issues in academia and their personal experience with these issues and iii) existing intervention policies and suggestions of future interventions to achieve gender diversity and equity.

INTERVIEWEE SELECTION:

We followed this rule of criterion sampling to select interviewees: "Criterion sampling involves reviewing and studying 'all cases that meet some predetermined criterion of importance'."[63] We contacted 2-4 researchers from each of the eight viewpoint clusters who provided their contact information in the survey. A total of 30 women and 20 men survey respondents were invited to participate in individual interviews, which were conducted remotely. Interviews were conducted with 25 researchers total, 14 men and 11 women. The interviewees were geographically diverse, with 6 from EU, 6 from Asia, 1 from Russia, 3 from Australia, 2 from the USA and 3 from Latin America. No survey respondents from Africa were interviewed.

ANALYSIS OF QUALITATIVE DATA:

Despite the use of an interview outline with a predetermined set of questions, the discussions with the interviewees covered many subtopics within the topic of gender-related issues in academia. Thus, the interview data was coded by the subtopics that emerged during the interviews. The 25 interview recordings were transcribed and coded using MaxQDA. Codes were grouped under each subtopic.

62 Ovseiko, P. V., Chapple, A., Edmunds, L. D., & Ziebland, S. (2017). Advancing gender equality through the Athena SWAN Charter for Women in Science: an exploratory study of women's and men's perceptions. Health Research Policy and Systems, 15(1), 12. doi: 10.1186/s12961-017-0177-9

63 Suri, H. (2011). Purposeful sampling in qualitative research synthesis. Qualitative Research Journal, 11(2), 63-75. doi: 10.3316/QRJ1102063

Appendix B

Supplemental Data

FIGURE B.1

Percent of active authors during the period 2014–2018 categorized based on author publication history.

KEY	GROUP	YEAR OF FIRST PUBLICATION
●	A	2003 or prior
●	B	2004–2008
●	C	2009–2013
●	D	2014–2018

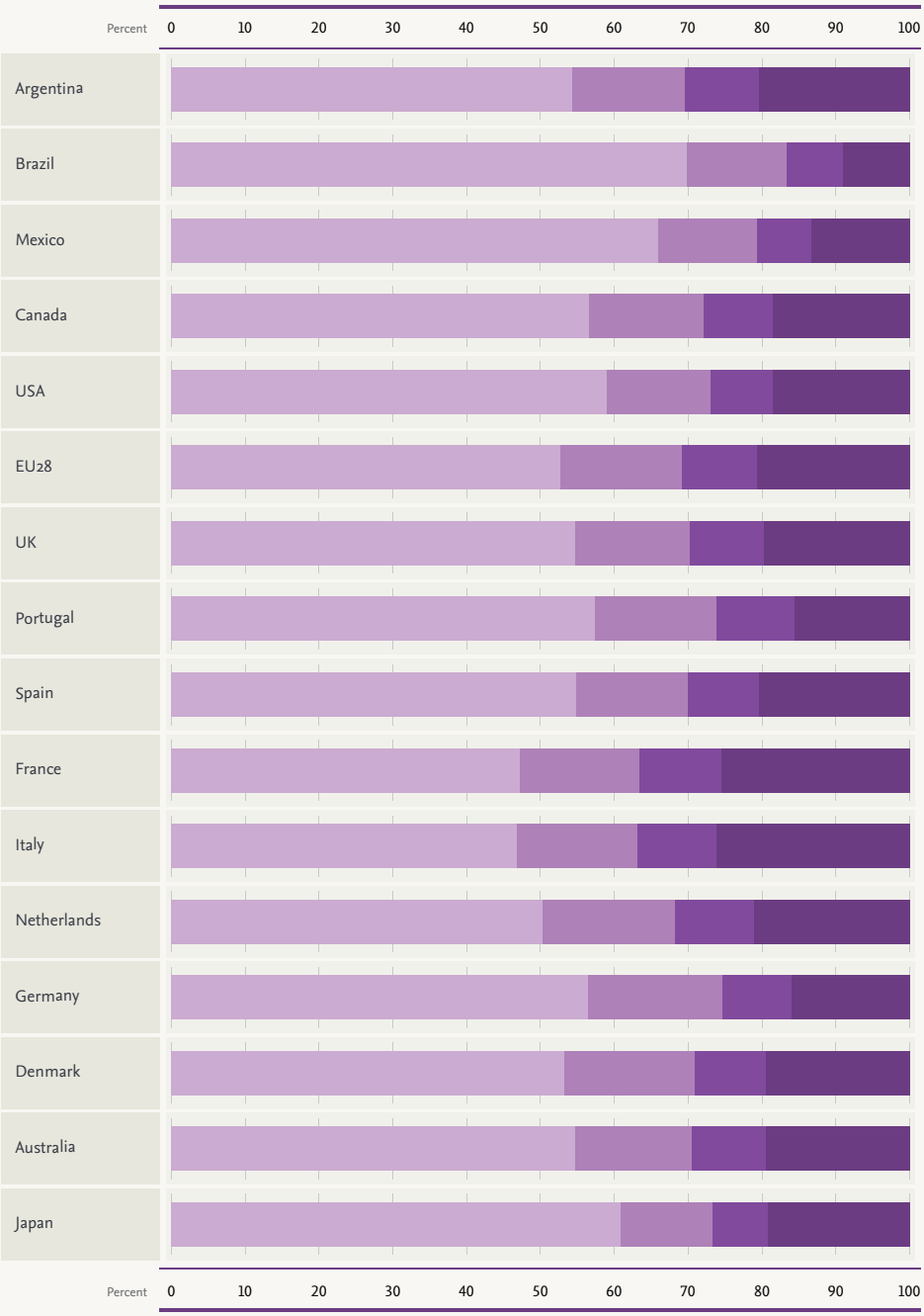


FIGURE B.2

Percent of active authors during the period 2014–2018 categorized based on author subject area.

- Dentistry
- Decision Sciences
- Veterinary
- Economics
- Health Professions
- Business
- Nursing
- Psychology
- Energy
- Arts & Humanities
- Pharmacology
- Chemical Engineering
- Neuroscience
- Earth & Planetary Sciences
- Immunology & Microbiology
- Mathematics
- Environmental Science
- Chemistry
- Materials Science
- Social Sciences
- Physics & Astronomy
- Agricultural Sciences
- Computer Science
- Engineering
- Biochemistry
- Medicine

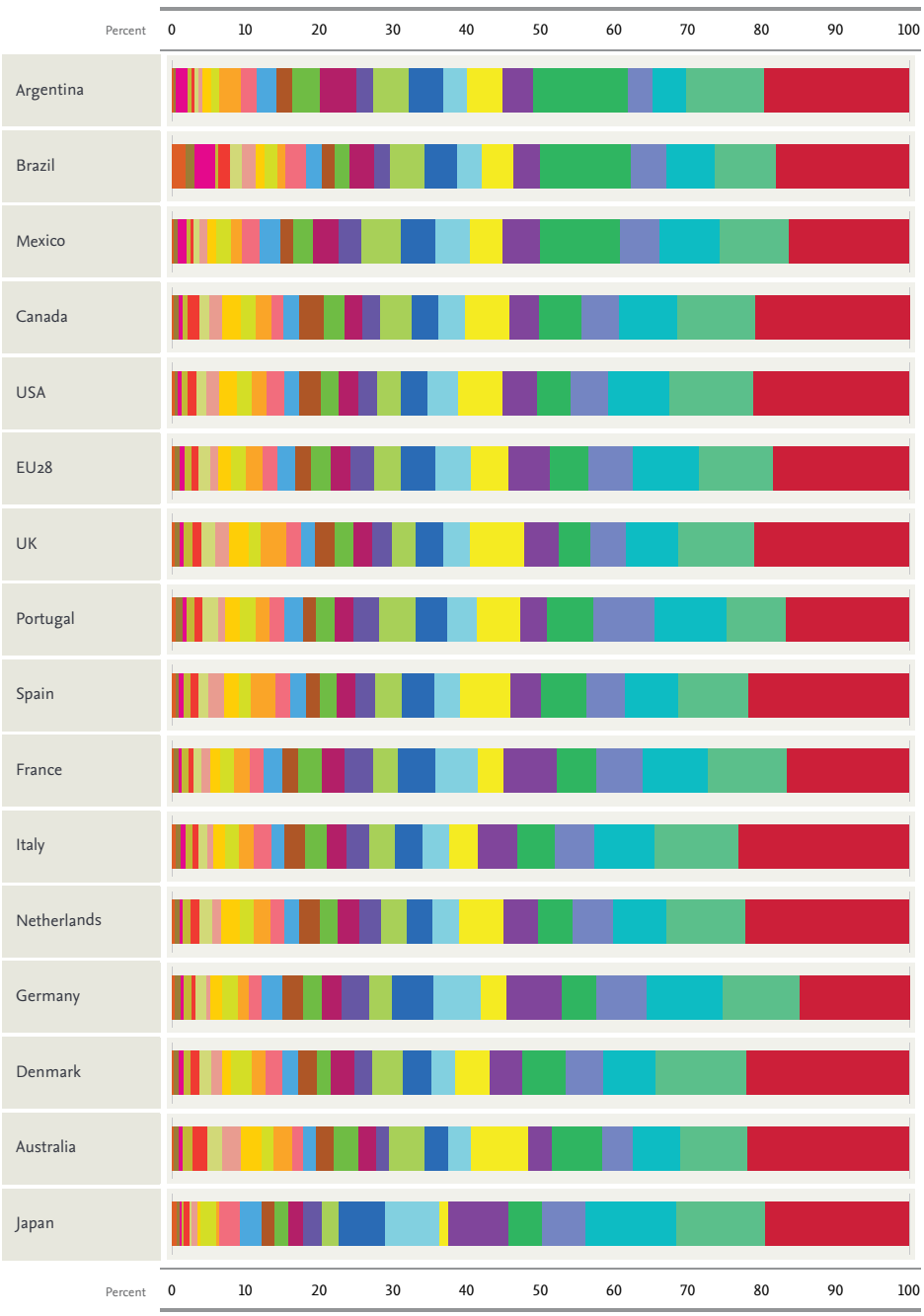


FIGURE B.3

Ratio of women to men among active authors during the period 1999–2003 and 2014–2018, disaggregated according to author subject area.

KEY

- 1999–2003
- 2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

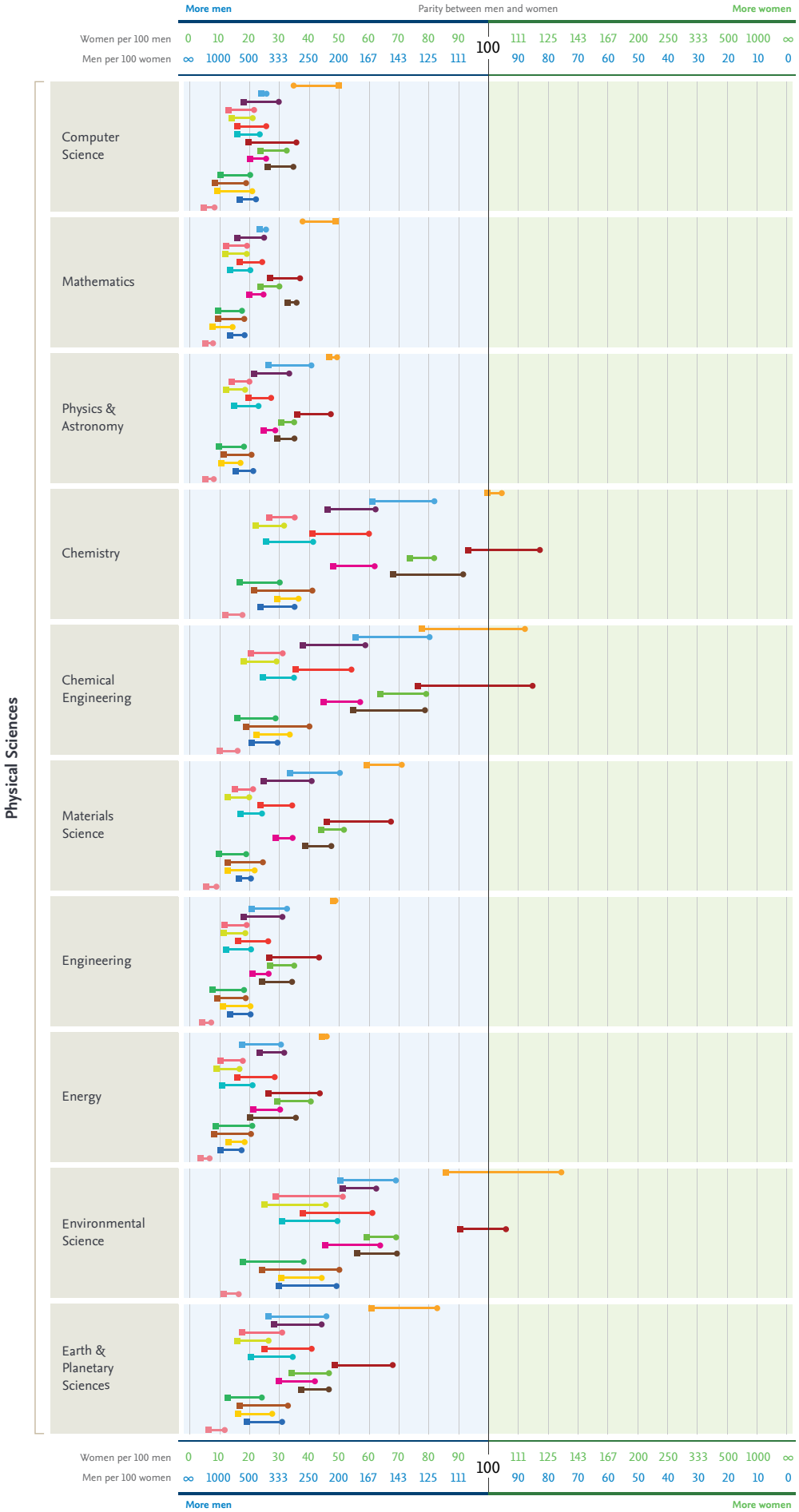


FIGURE B.3 (CON'T)

Ratio of women to men among active authors during the period 1999–2003 and 2014–2018, disaggregated according to author subject area.

KEY

- 1999–2003
- 2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

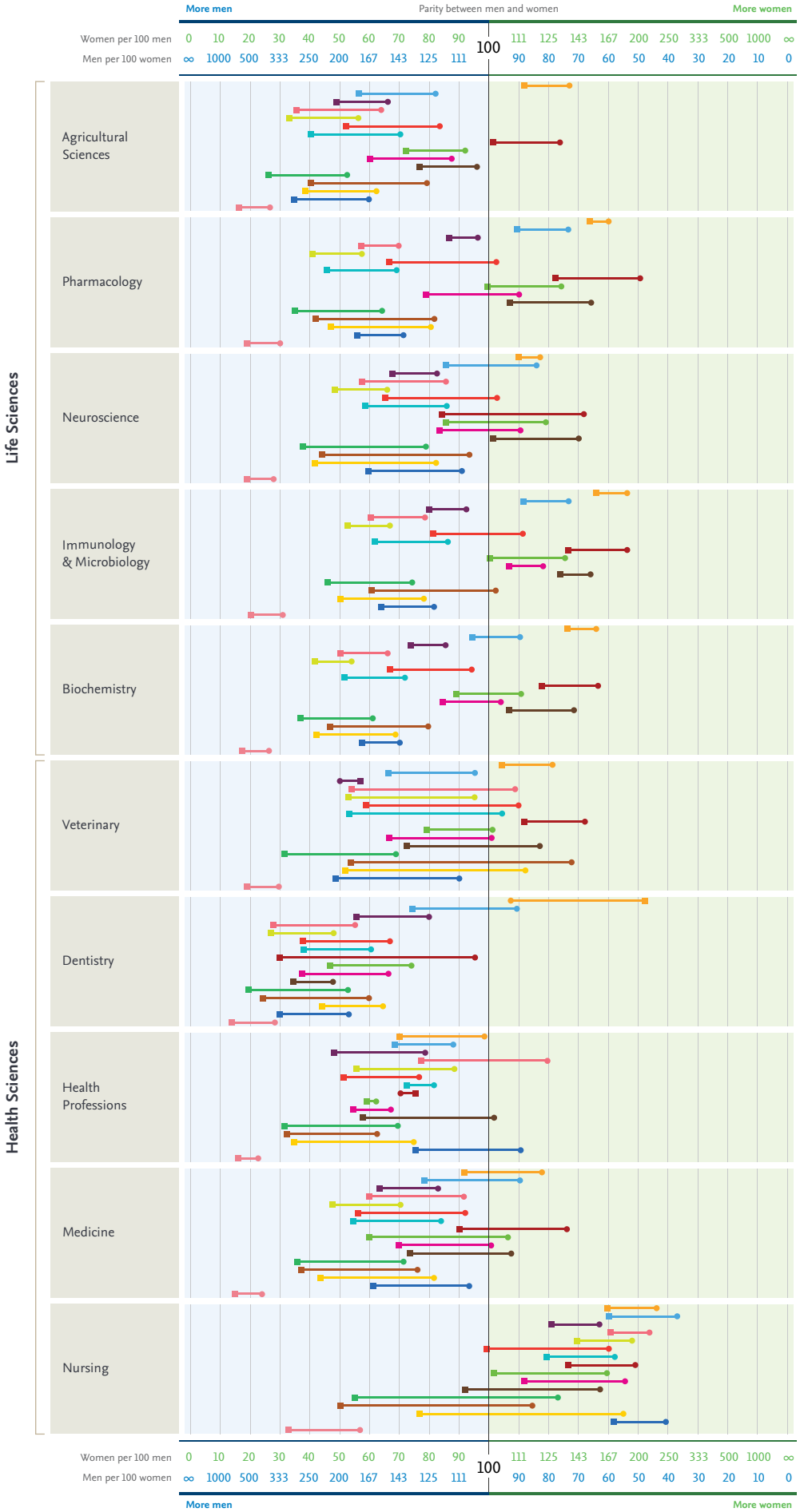


FIGURE B.3 (CON'T)

Ratio of women to men among active authors during the period 1999–2003 and 2014–2018, disaggregated according to author subject area.

KEY

- 1999–2003
- 2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

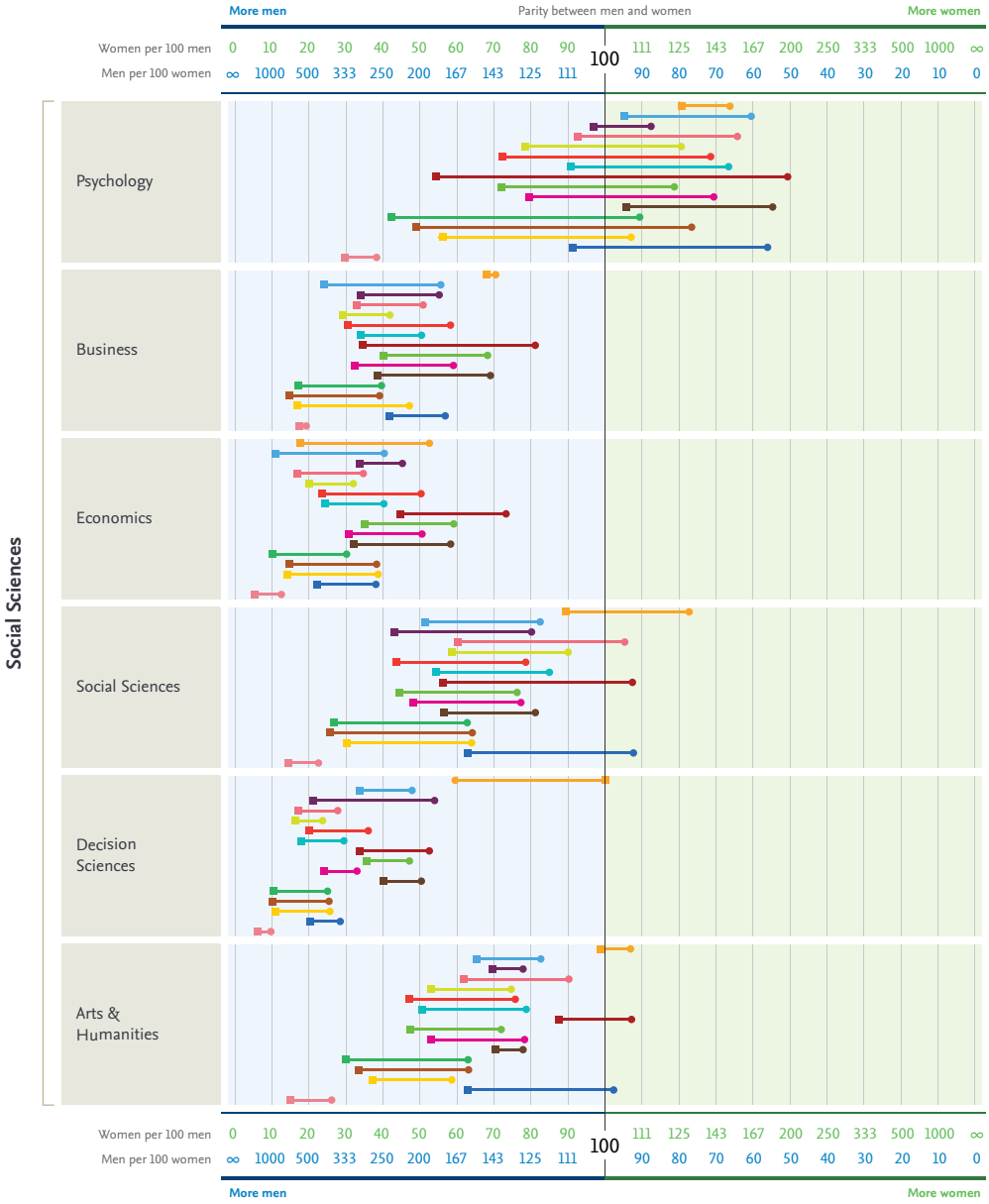


FIGURE B.4

Ratio of women to men among active authors during the period 2014–2018 in each country disaggregated by author subject area and publication history.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.4 (CON'T)

Ratio of women to men among active authors during the period 2014–2018 in each country disaggregated by author subject area and publication history.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.4 (CON'T)

Ratio of women to men among active authors during the period 2014–2018 in each country disaggregated by author subject area and publication history.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

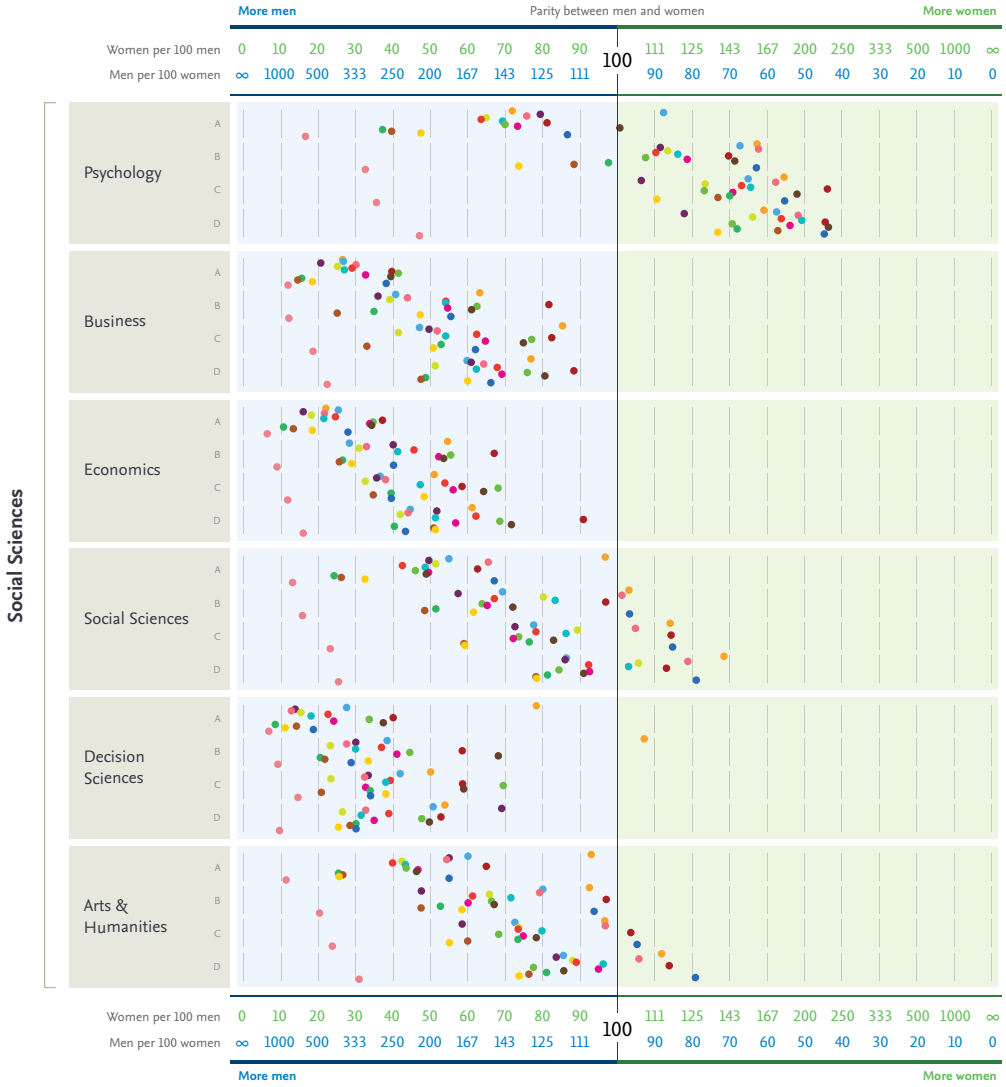


FIGURE B.5

All authors

Percent of active authors during the period 2014–2018 in each publication history category within each country, subject area and authorship position.

KEY	POSITION
■	2003 or prior
■	2004–2008
■	2009–2013
■	2014–2018

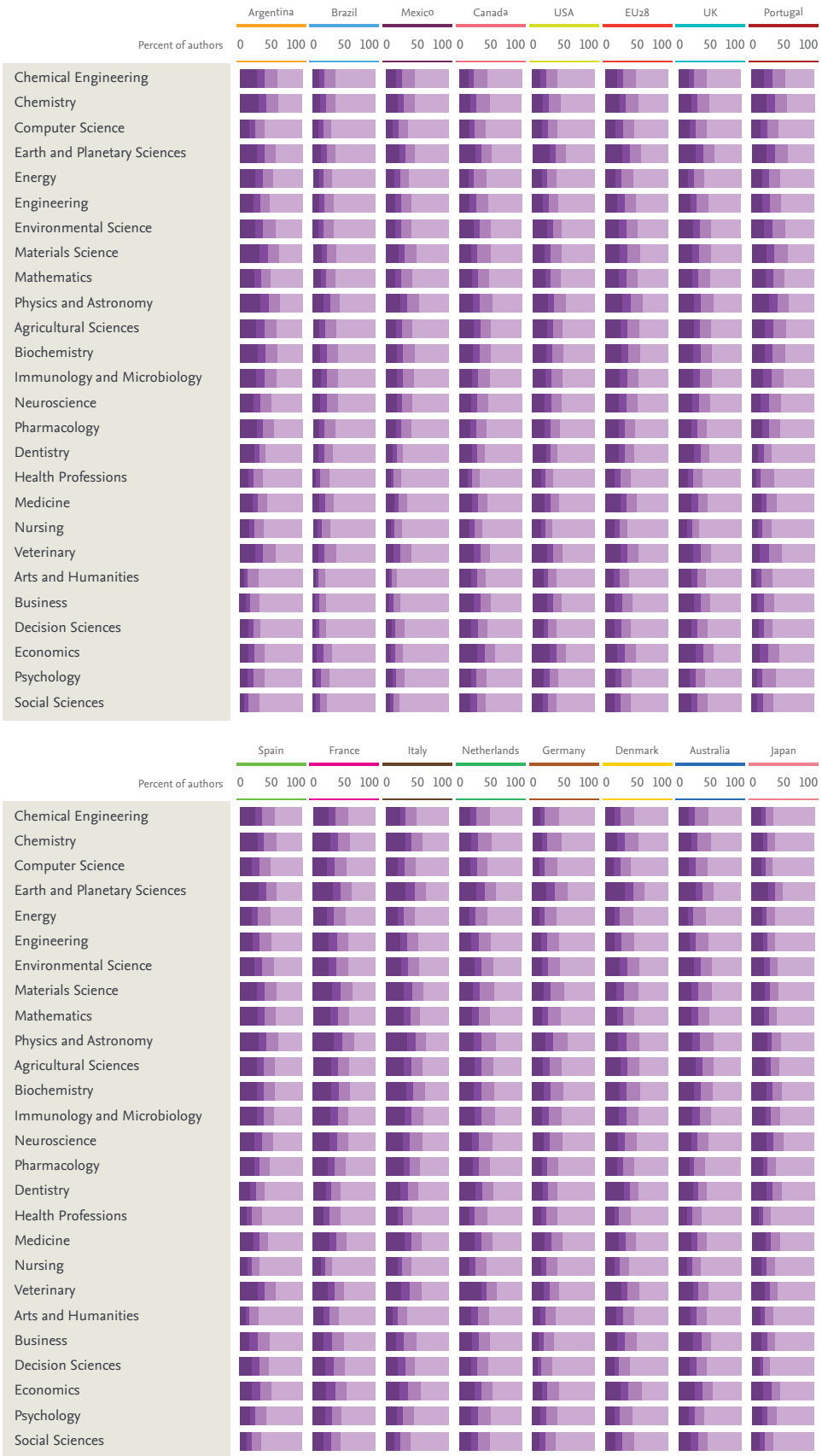


FIGURE B.5 (CON'T)

Corresponding authors

Percent of active authors during the period 2014–2018 in each publication history category within each country, subject area and authorship position.

KEY	POSITION
■	2003 or prior
■	2004–2008
■	2009–2013
■	2014–2018

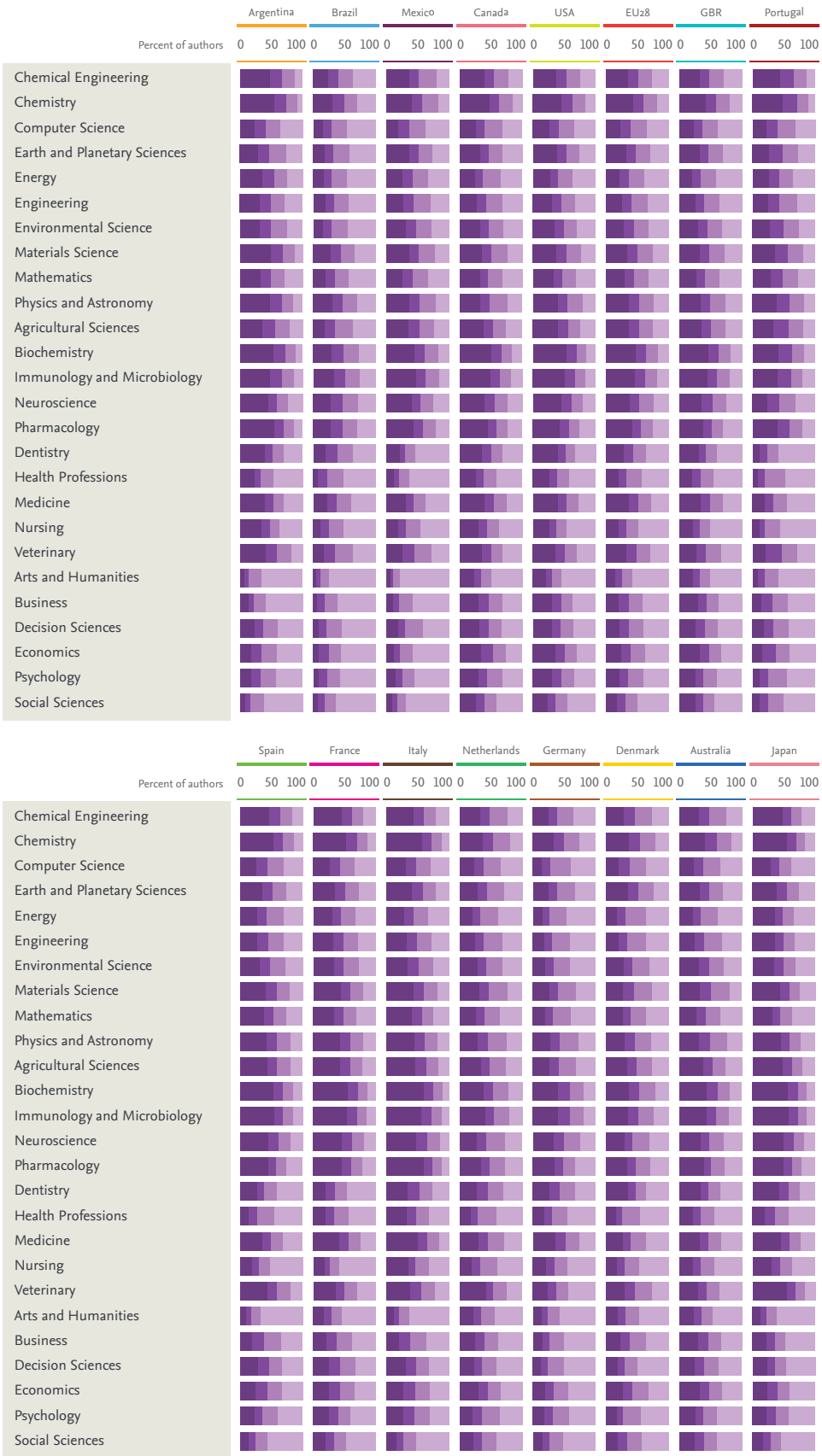


FIGURE B.5 (CON'T)

First authors

Percent of active authors during the period 2014–2018 in each publication history category within each country, subject area and authorship position.

KEY	POSITION
■	2003 or prior
■	2004–2008
■	2009–2013
■	2014–2018

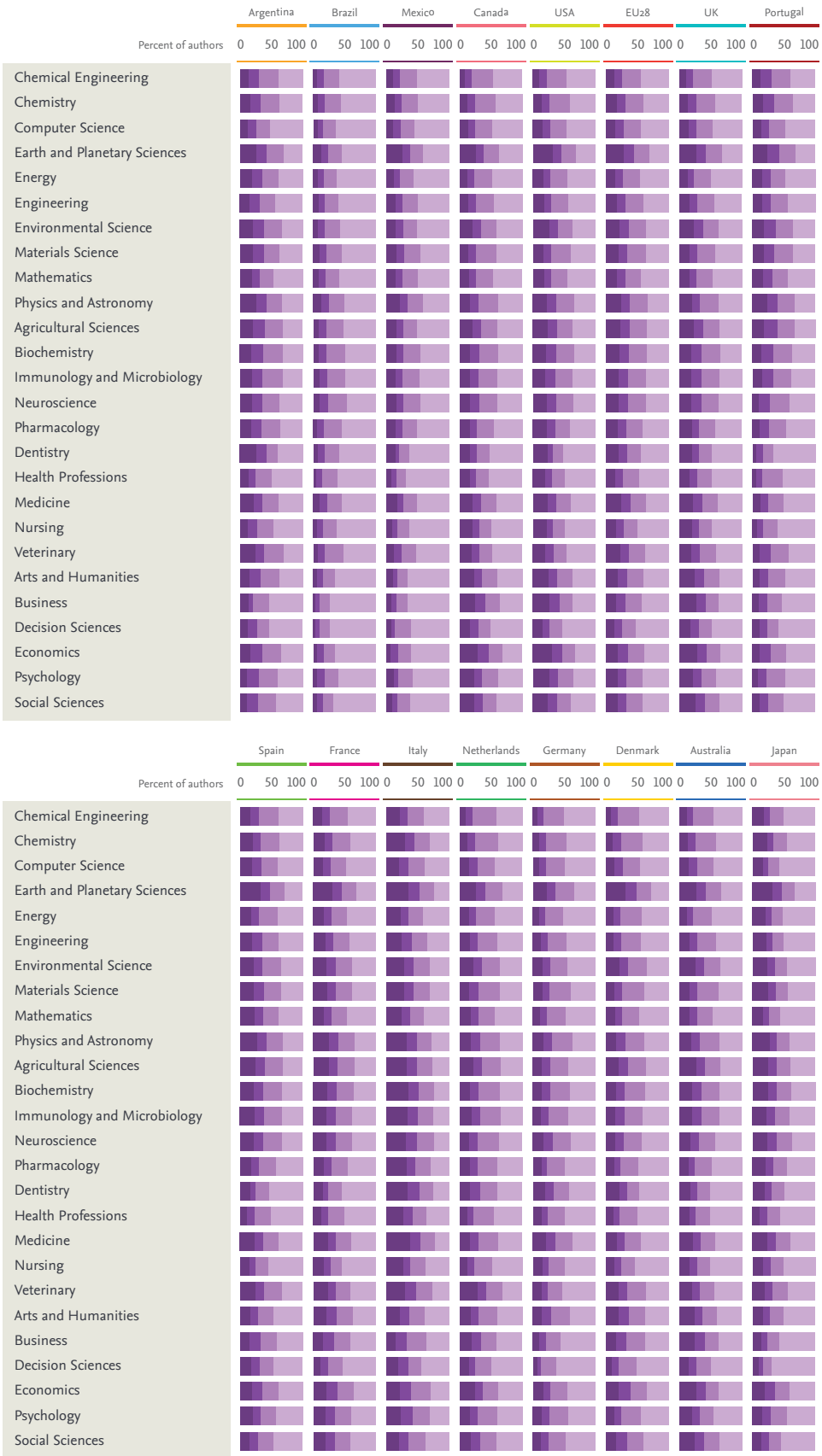


FIGURE B.5 (CON'T)

Last authors

Percent of active authors during the period 2014–2018 in each publication history category within each country, subject area and authorship position.

KEY	POSITION
■	2003 or prior
■	2004–2008
■	2009–2013
■	2014–2018

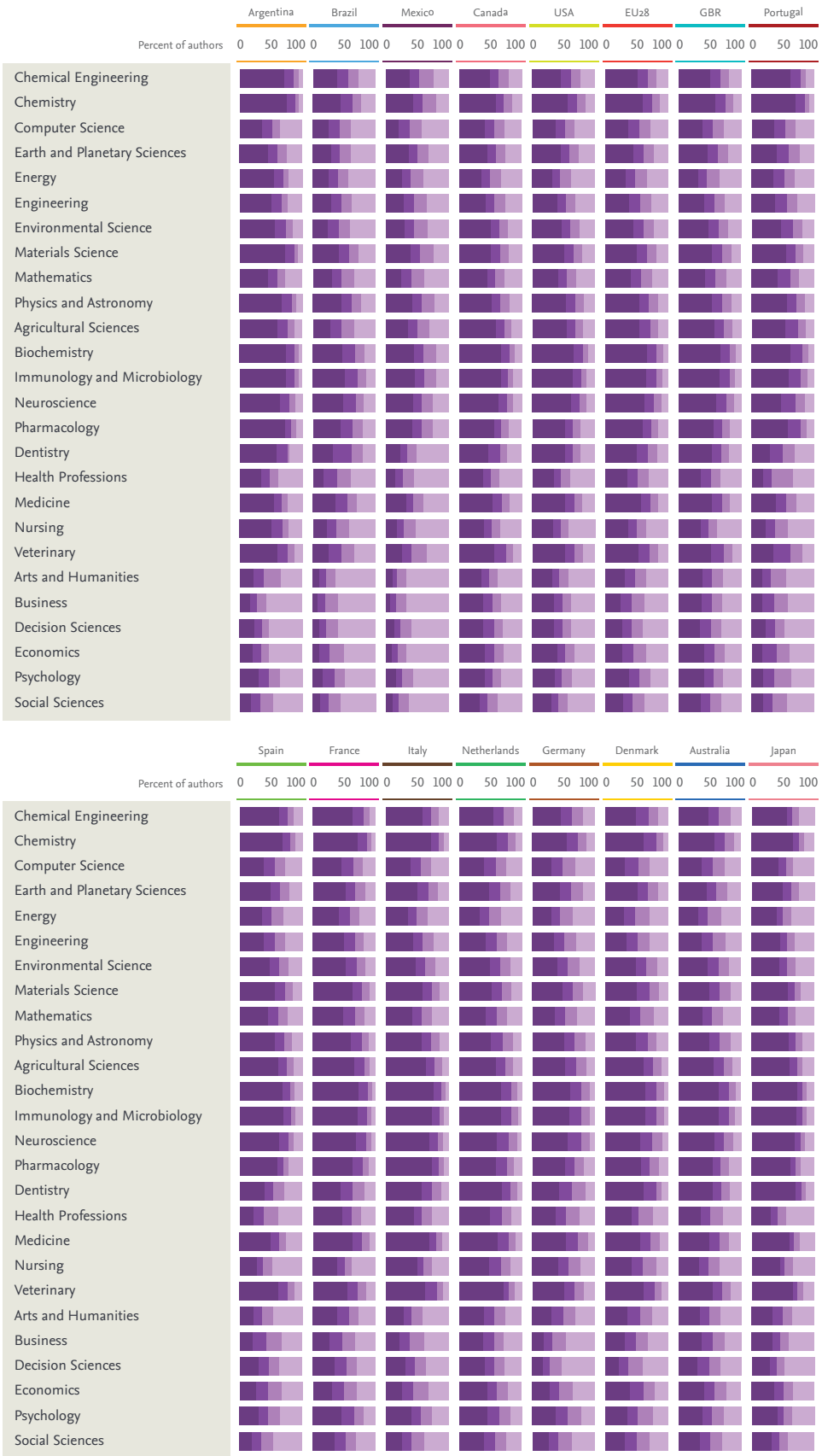


FIGURE B.6

Ratio of women to men among active authors during the period 1999–2003 in each country disaggregated based on authorship position.

KEY	GROUP	POSITION
●	A	All Authors
●	B	Corresponding Authors
●	C	First Authors
●	D	Last Authors

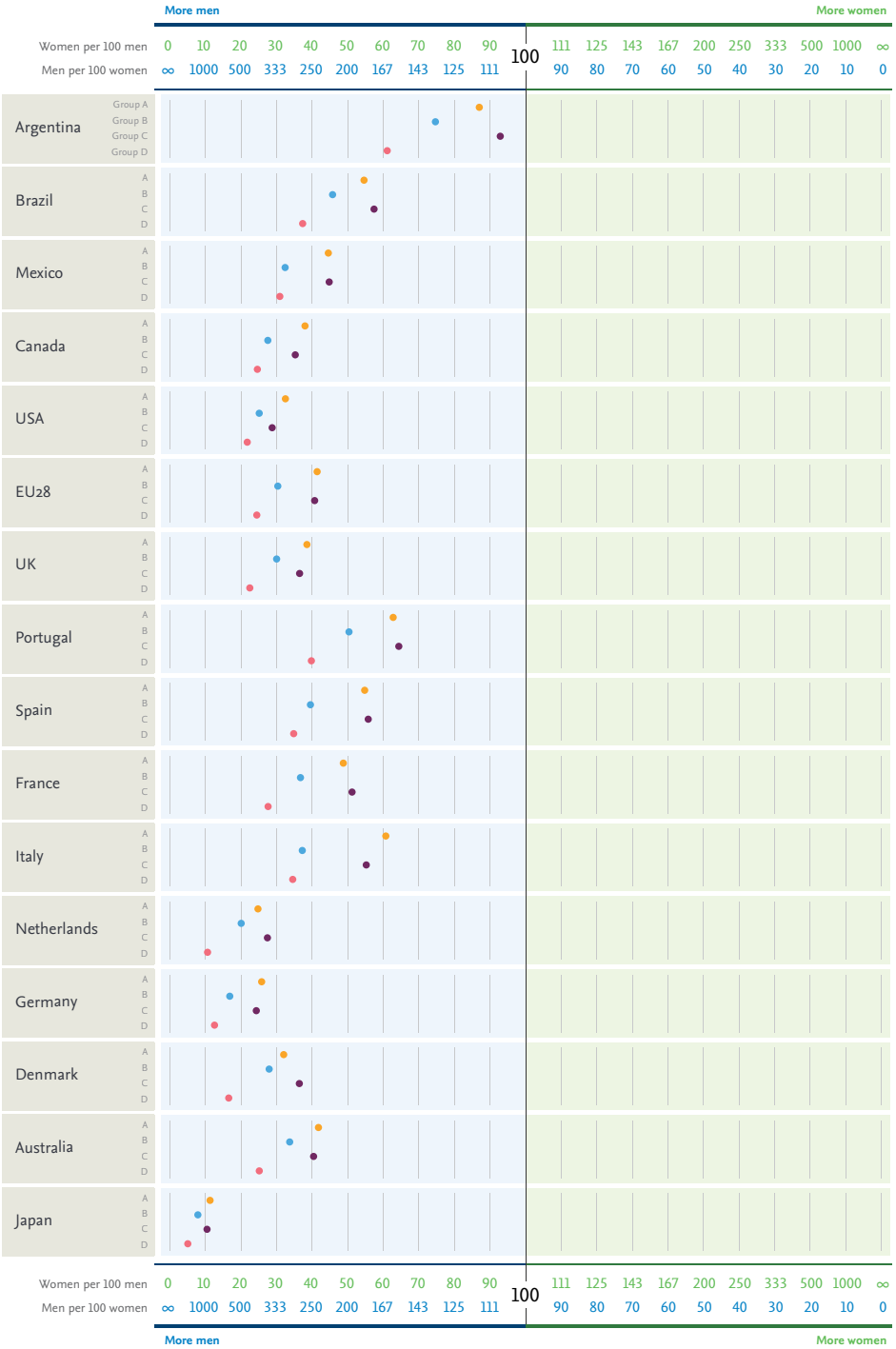


FIGURE B.7

Ratio of women to men among active authors during the period 2014–2018 in each country and authorship position normalized to the ratio among active authors overall. Each circle represents a different country analyzed in this report.

KEY	POSITION
●	Corresponding Authors
●	First Authors
●	Last Authors

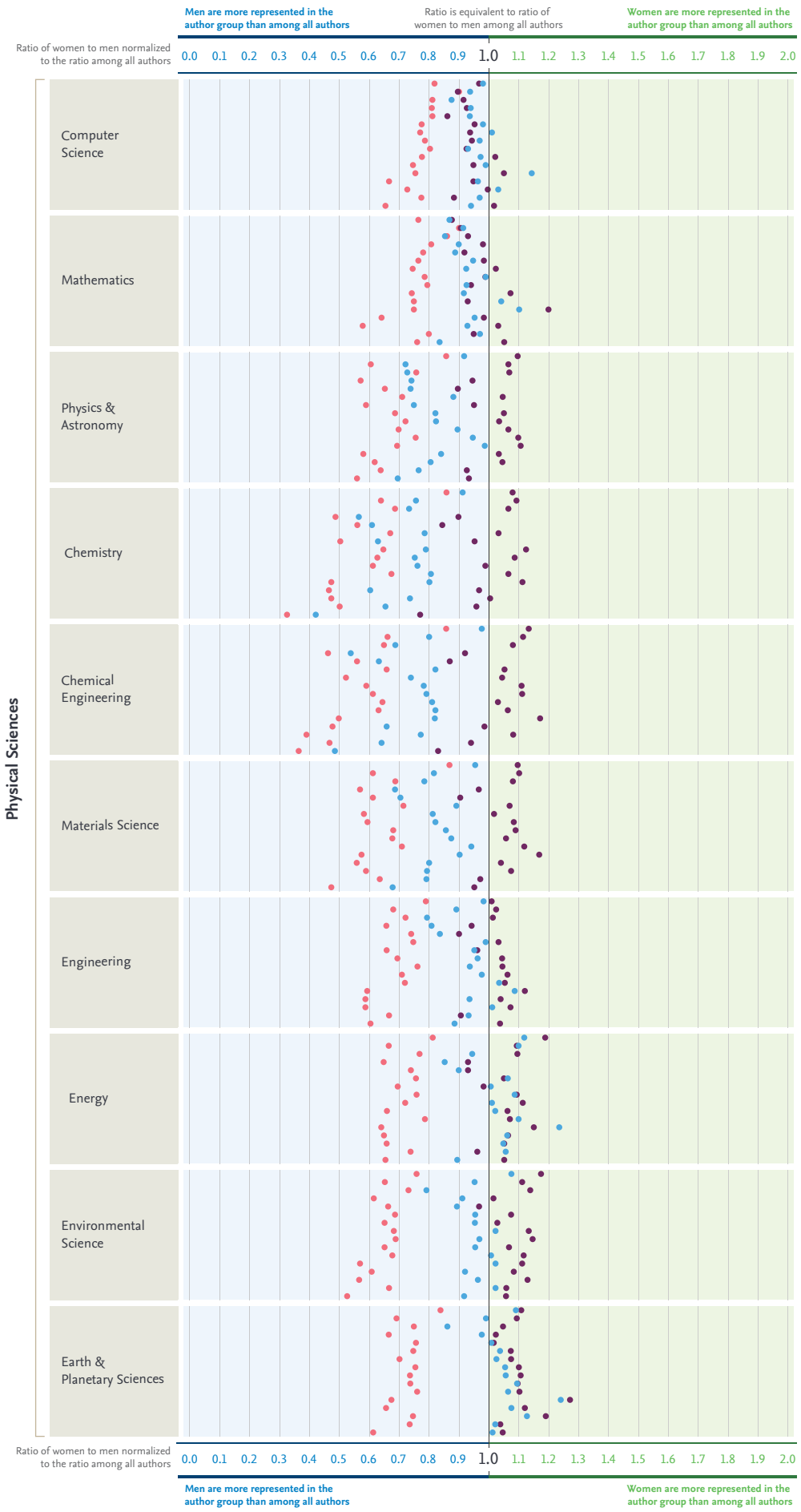


FIGURE B.7 (CON'T)

Ratio of women to men among active authors during the period 2014–2018 in each country and authorship position normalized to the ratio among active authors overall. Each circle represents a different country analyzed in this report.

KEY	POSITION
●	Corresponding Authors
●	First Authors
●	Last Authors

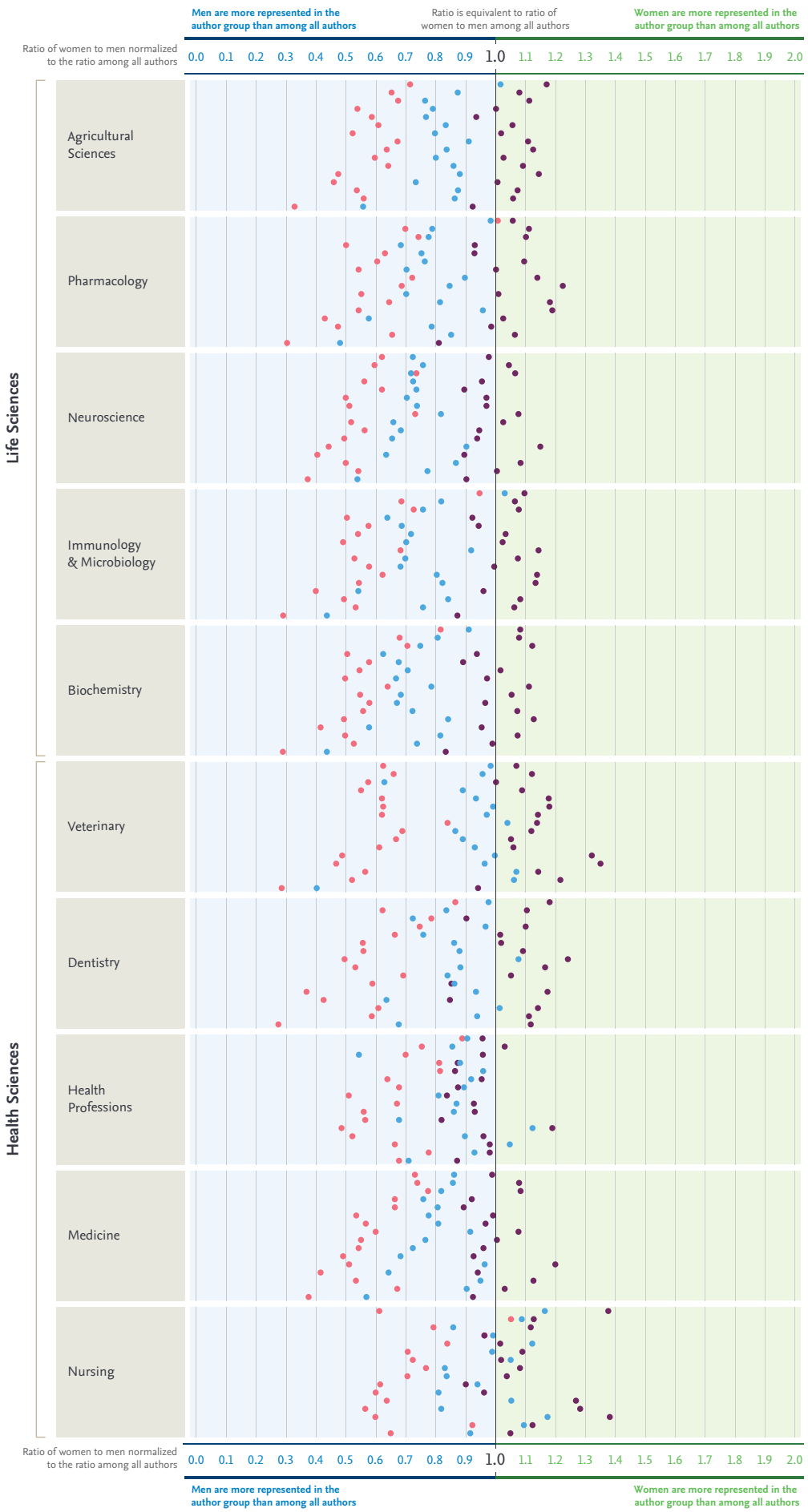


FIGURE B.7 (CON'T)

Ratio of women to men among active authors during the period 2014–2018 in each country and authorship position normalized to the ratio among active authors overall. Each circle represents a different country analyzed in this report.

KEY	POSITION
●	Corresponding Authors
●	First Authors
●	Last Authors

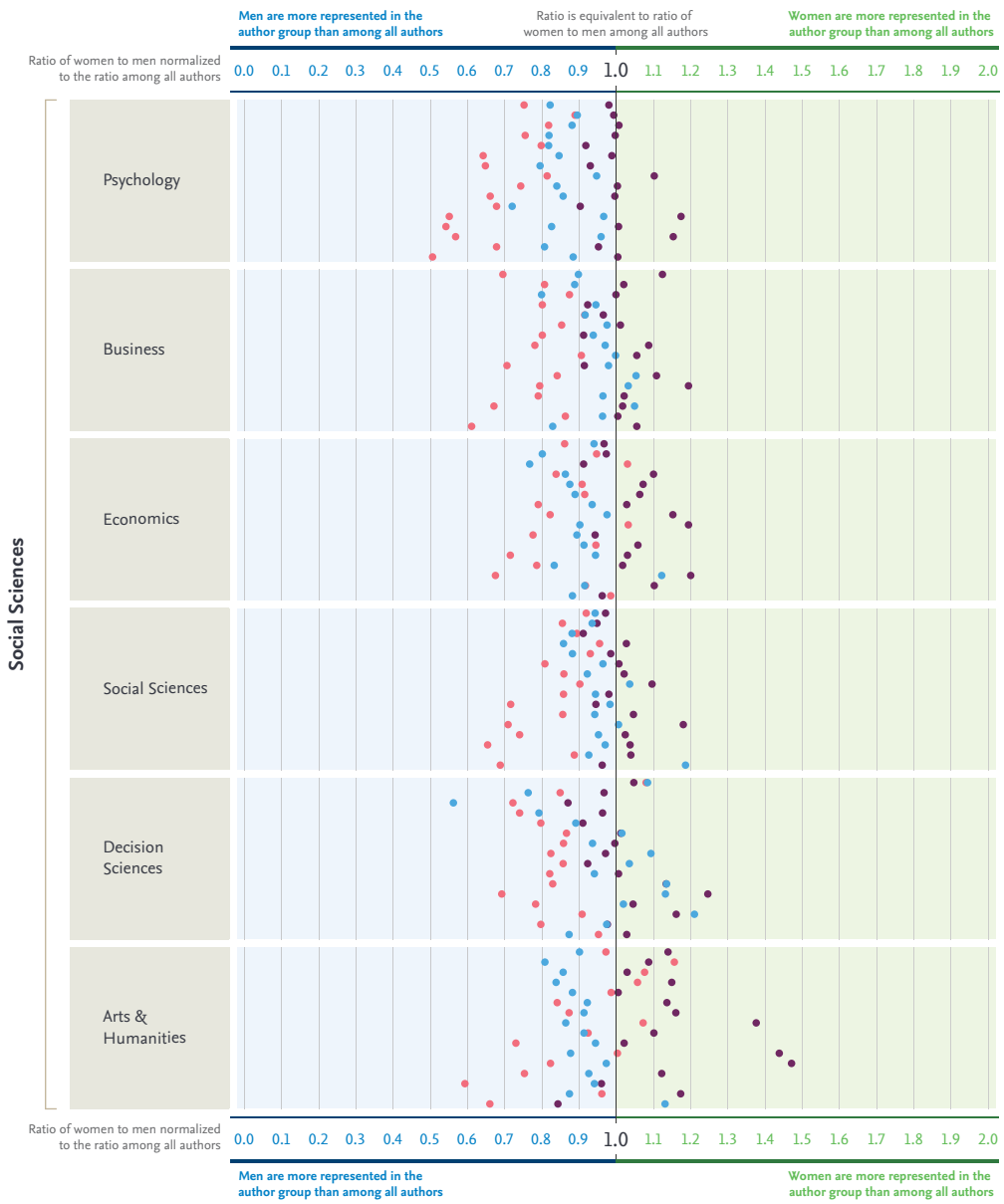


FIGURE B.8

Ratio of women to men among active authors during the period 2014–2018 in medicine and subfields of medicine.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.9

Ratio of women to men authors versus ratio of the average number of publications by women to men in each country (among authors active in the period 2014–2018). Data analyzed for authors in each authorship position as shown.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

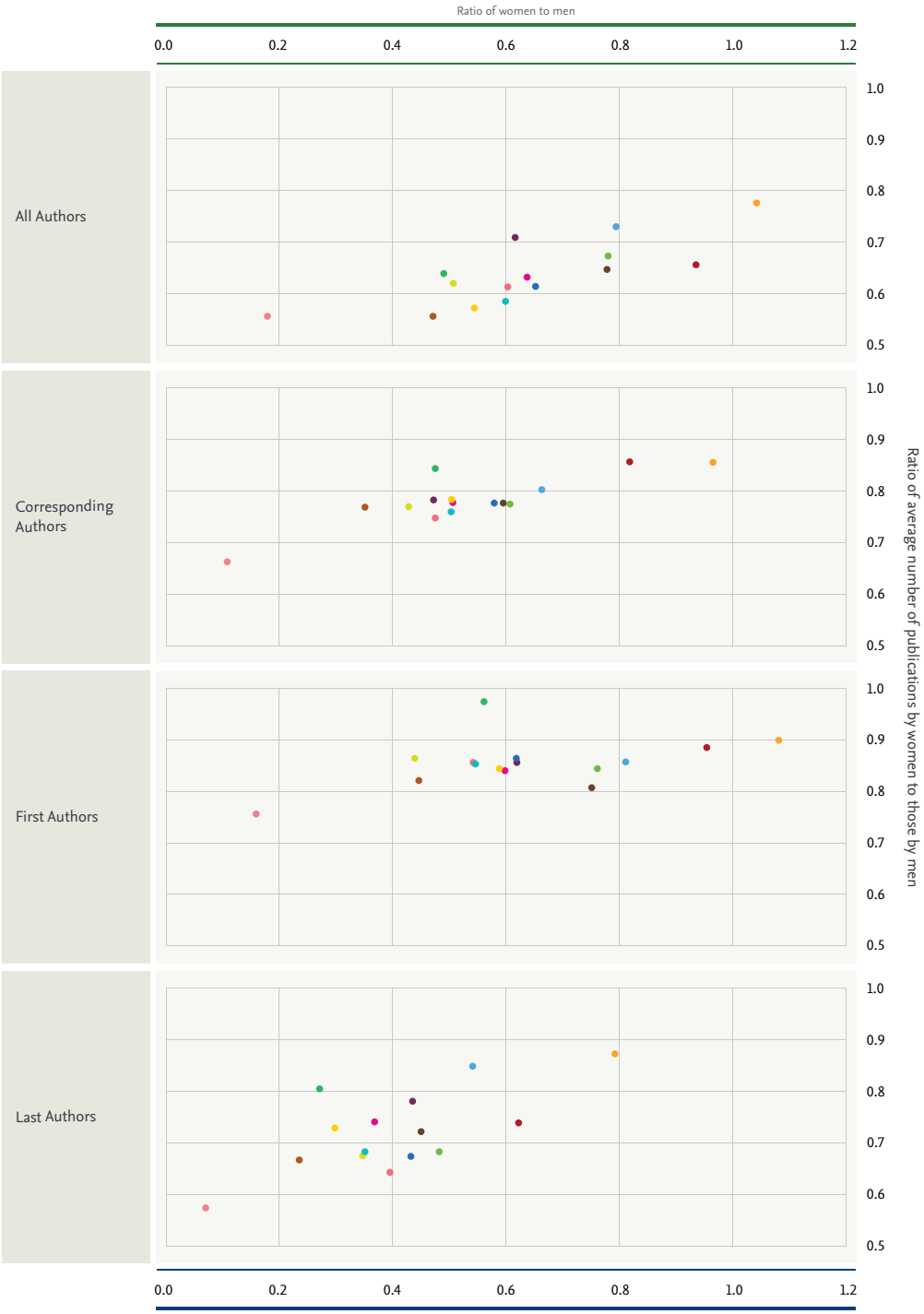


FIGURE B.10

Ratio of average publication count of men to women in each country, disaggregated by author position and year of first publication.

GROUP	YEAR OF FIRST PUBLICATION
A	2003 or prior
B	2004–2008
C	2009–2013
D	2014–2018

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

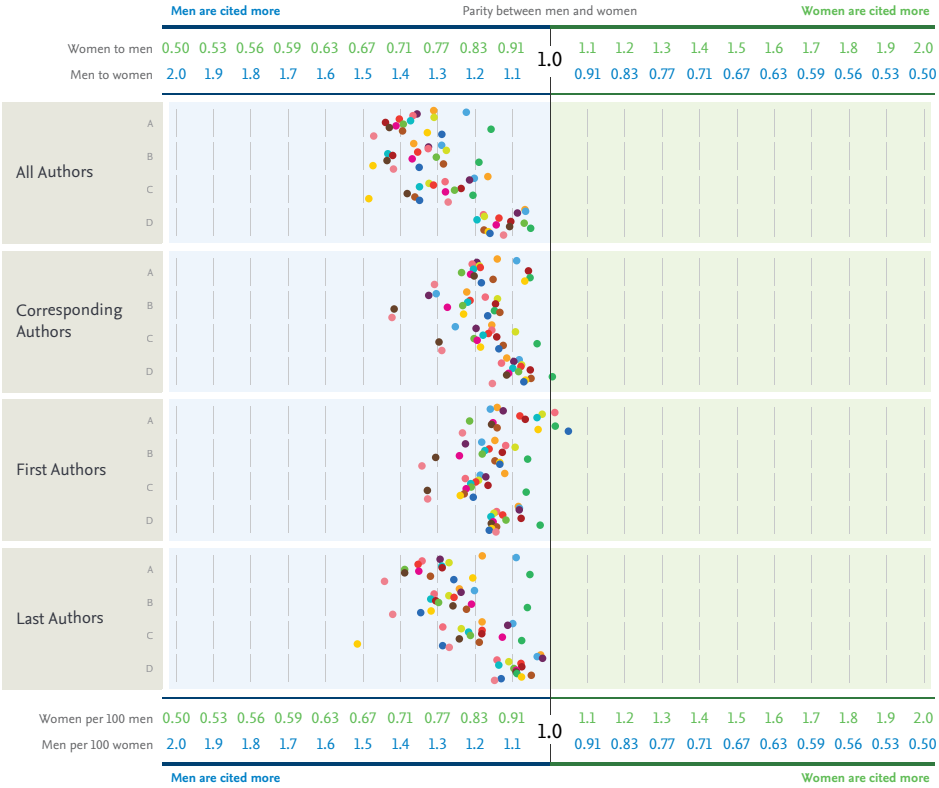


FIGURE B.11

Percent of women and men in each country relative to the number of authors in the cohort in 2000. Cohort is defined as those whose first publication was in 1999 and who published at least two publications.

- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

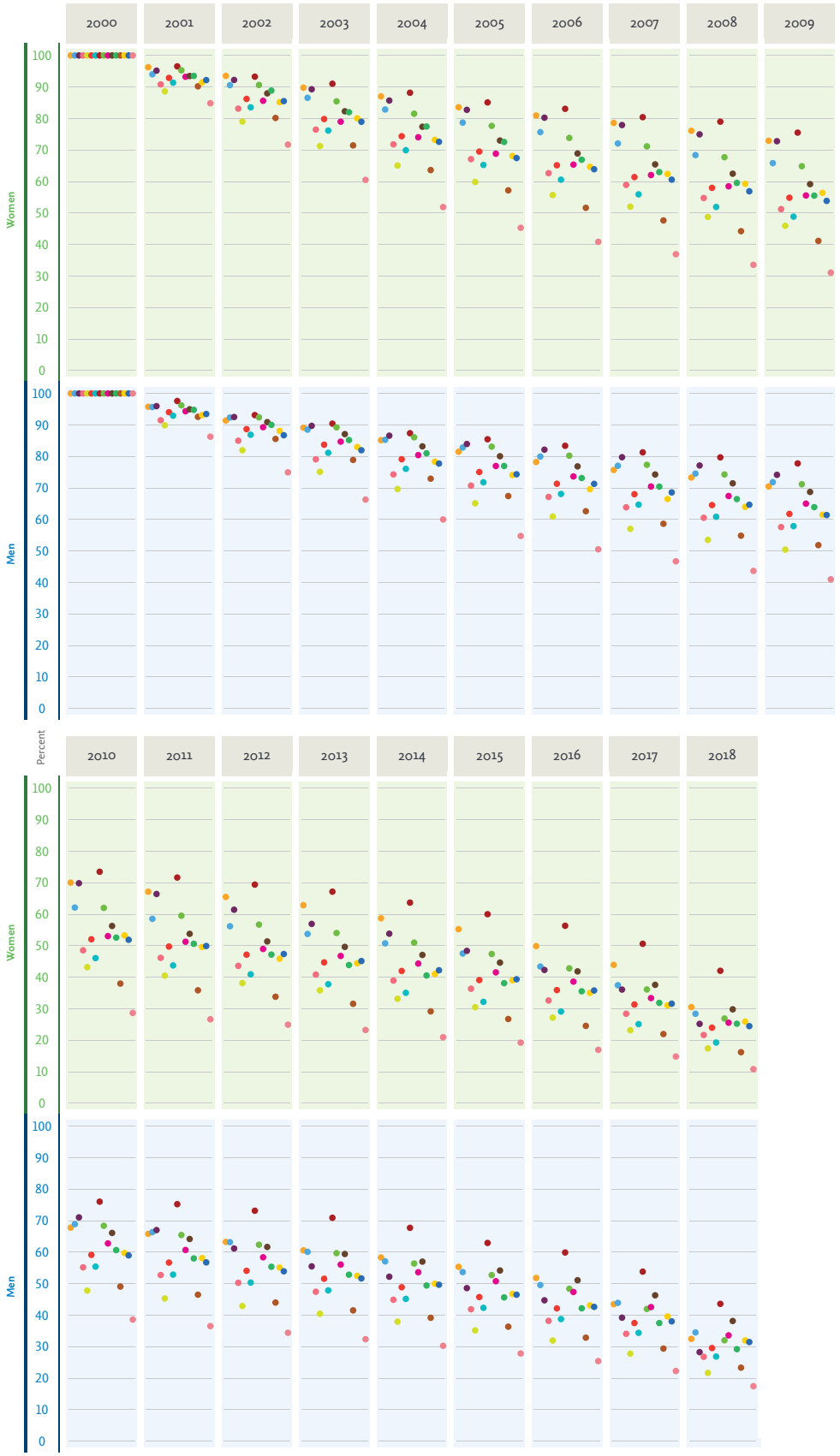
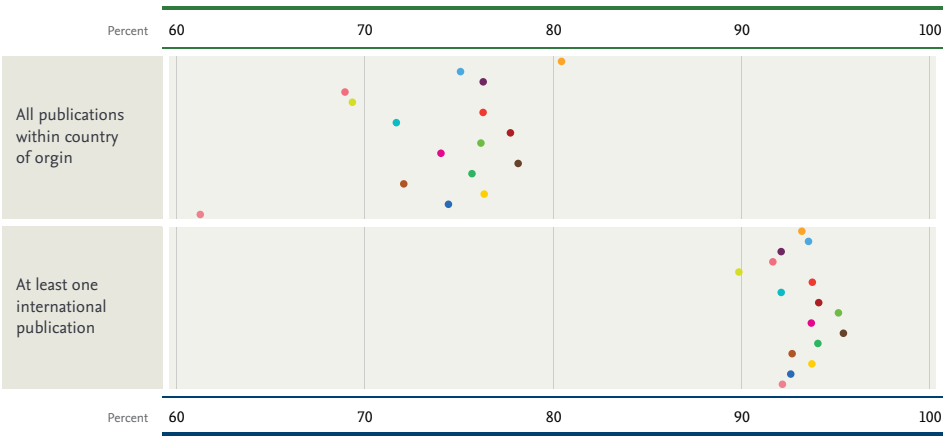


FIGURE B.12

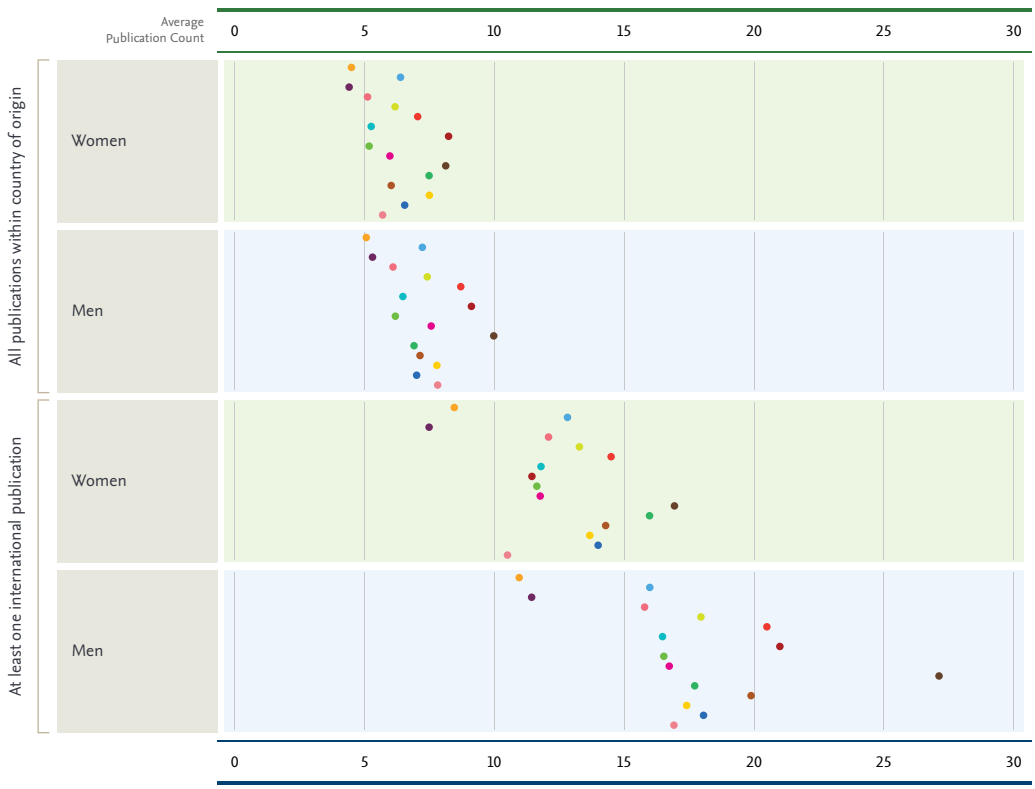
Percentage of all authors who first published in each country or the EU28 in 2009–2013 who published again during the period 2014–2018, disaggregated according to whether they have ever published outside their country of origin.



- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.13

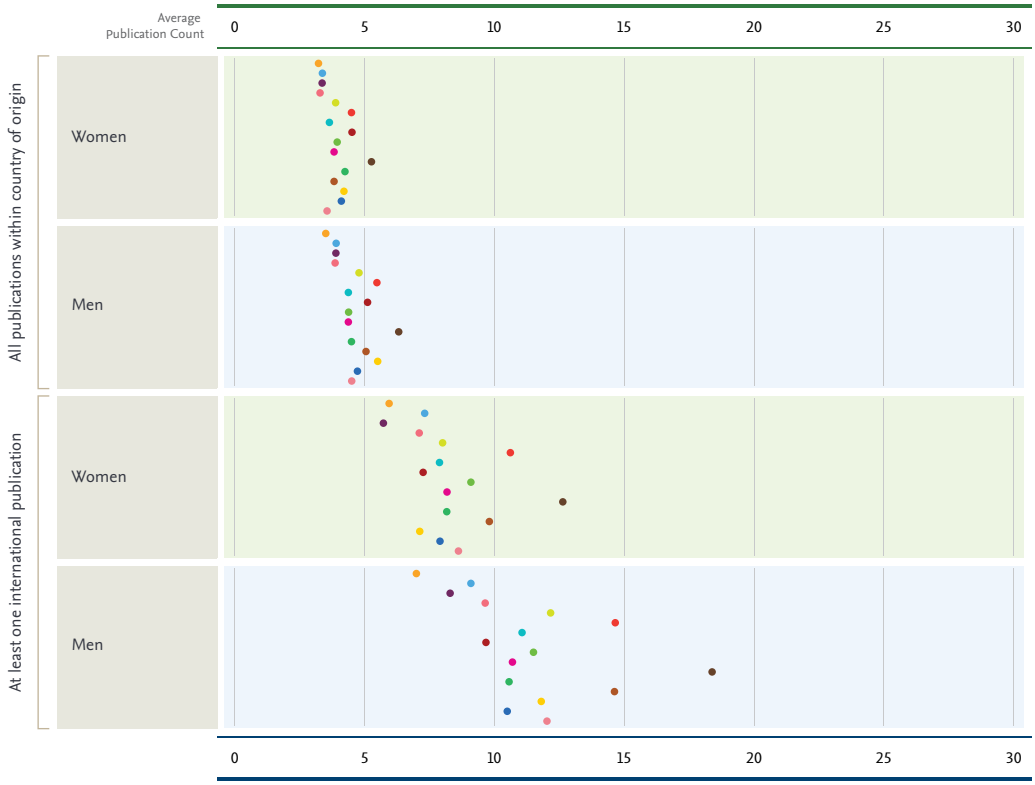
Average number of publications during the period 2014–2018 among women and men who first published in 2009–2013 and published again in 2014–2018, disaggregated based on whether they have ever published internationally.



- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.13 (CON'T)

Average number of publications during the period 2014–2018 among women and men who first published in 1999–2003 and published again in 2014–2018, disaggregated based on whether they have ever published internationally.



- Argentina
- Brazil
- Mexico
- Canada
- USA
- EU28
- UK
- Portugal
- Spain
- France
- Italy
- Netherlands
- Germany
- Denmark
- Australia
- Japan

FIGURE B.13 (CON'T)

Average FWCI based on publications during the period 2014–2018 among women and men who first published in 2009–2013 and published again in 2014–2018, disaggregated based on whether they have ever published internationally.

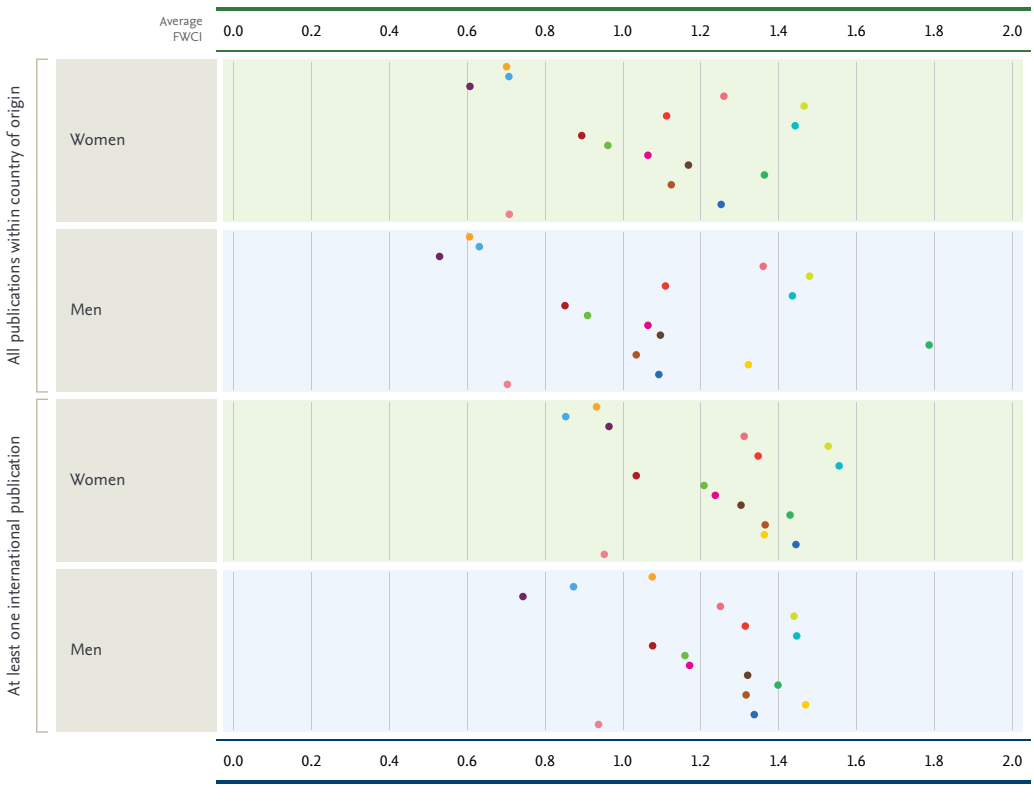


FIGURE B.13 (CON'T)

Average FWCI based on publications during the period 2014–2018 among women and men who first published in 1999–2003 and published again in 2014–2018, disaggregated based on whether they have ever published internationally.

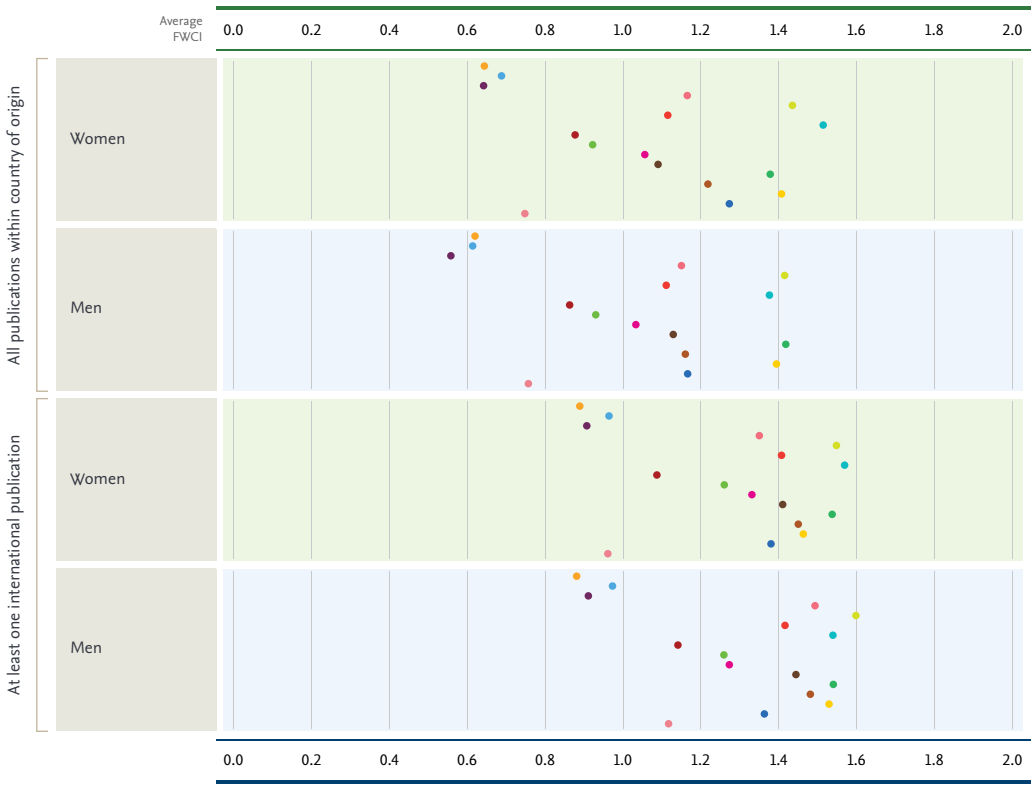


FIGURE B.14

Average share of men collaborators (y-axis) of focal authors grouped based on year of their first publication (x-axis), by region and subject area.

The share of men collaborators is computed as the ratio between the count of direct collaborators inferred to be men to the overall count of direct collaborators of a focal author. Average values corresponding to less than 10 observations were excluded from the analysis.

GROUP	YEAR OF FIRST PUBLICATION
A	1989–1993
B	1994–1998
C	1999–2003
D	2004–2008
E	2009–2013

■ **Women**

● **Men**

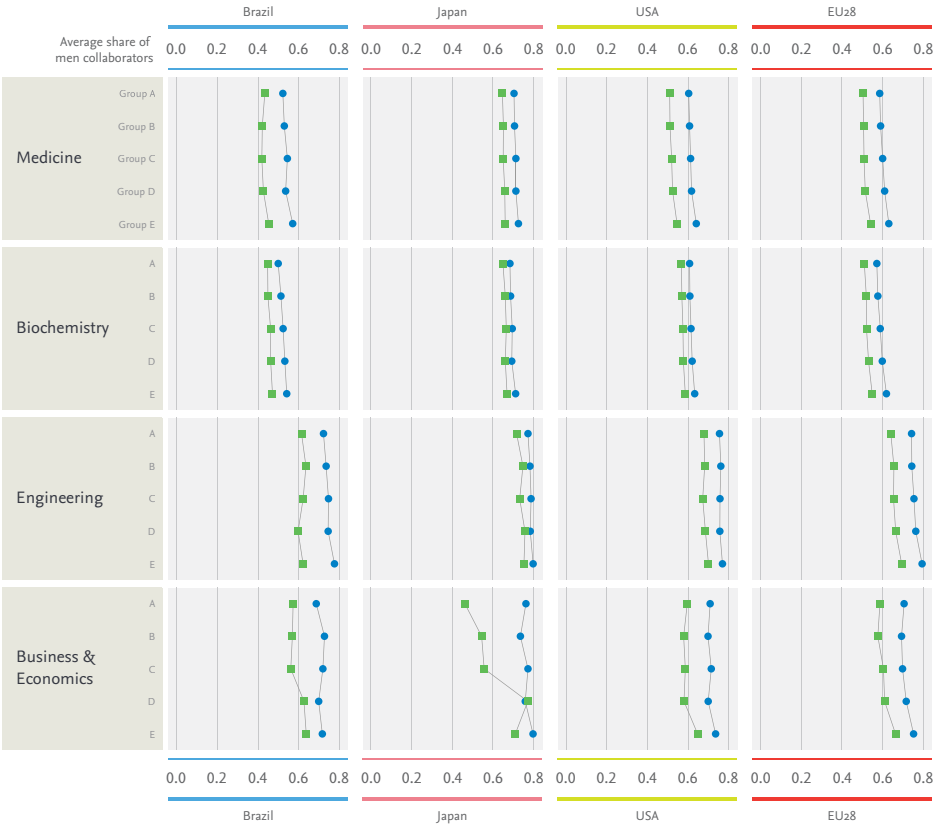


TABLE B.1

Active authors during the periods 2014–2018

Number and percent of men and women among authors in each country and the EU28 overall and in each subject area.

Subject Area	Country															
	Gender															
	% of authors															
	Number of authors															
	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
All	48.98%	51.02%	55.75%	44.25%	61.89%	38.11%	62.40%	37.60%	66.38%	33.62%	61.49%	38.51%	62.53%	37.47%	51.68%	48.32%
	23,214	24,180	195,430	155,132	57,140	35,183	134,339	80,944	1,095,391	554,911	1,430,141	895,802	232,464	139,312	30,189	28,227
Agricultural Sciences	42.21%	57.79%	54.91%	45.09%	60.20%	39.80%	61.01%	38.99%	64.01%	35.99%	54.49%	45.51%	58.72%	41.28%	43.25%	56.75%
	4,955	6,785	44,641	36,658	12,046	7,965	14,971	9,566	96,646	54,349	136,607	114,084	18,774	13,199	3,260	4,278
Arts and Humanities	48.21%	51.79%	54.75%	45.25%	56.23%	43.77%	52.57%	47.43%	57.26%	42.74%	56.90%	43.10%	55.96%	44.04%	48.14%	51.86%
	1,282	1,377	3,606	2,980	1,507	1,173	5,088	4,591	37,924	28,311	64,052	48,514	13,950	10,980	1,089	1,173
Biochemistry	39.05%	60.95%	47.25%	52.75%	53.92%	46.08%	60.22%	39.78%	64.95%	35.05%	51.49%	48.51%	58.19%	41.81%	38.82%	61.18%
	3,760	5,869	25,598	28,577	9,228	7,886	27,044	17,863	242,074	130,656	246,533	232,274	43,268	31,085	3,735	5,887
Business	58.67%	41.33%	64.26%	35.74%	64.44%	35.56%	66.29%	33.71%	70.49%	29.51%	63.20%	36.80%	66.48%	33.52%	55.20%	44.80%
	264	186	6,699	3,726	964	532	3,512	1,786	28,530	11,945	44,878	26,136	8,794	4,434	1,443	1,171
Chemical Engineering	46.75%	53.25%	55.48%	44.52%	63.00%	37.00%	76.33%	23.67%	77.54%	22.46%	64.91%	35.09%	74.18%	25.82%	46.01%	53.99%
	1,100	1,253	7,866	6,312	3,297	1,936	6,996	2,170	51,196	14,831	72,361	39,119	10,573	3,680	1,379	1,618
Chemistry	48.86%	51.14%	54.99%	45.01%	61.67%	38.33%	74.05%	25.95%	76.05%	23.95%	62.52%	37.48%	70.80%	29.20%	45.29%	54.71%
	2,124	2,223	16,004	13,100	5,236	3,254	11,512	4,035	93,019	29,293	138,618	83,087	19,861	8,190	2,322	2,805
Computer Science	74.24%	25.76%	79.61%	20.39%	77.09%	22.91%	82.35%	17.65%	82.67%	17.33%	79.67%	20.33%	81.07%	18.93%	73.74%	26.26%
	2,297	797	24,909	6,380	7,784	2,313	18,457	3,957	137,841	28,902	225,873	57,621	28,226	6,590	7,295	2,598
Decision Sciences	62.69%	37.31%	67.63%	32.37%	64.96%	35.04%	78.26%	21.74%	80.85%	19.15%	73.52%	26.48%	77.26%	22.74%	65.56%	34.44%
	205	122	5,529	2,646	482	260	1,998	555	14,017	3,321	23,420	8,436	3,350	986	813	427
Dentistry	48.10%	51.90%	47.54%	52.46%	55.58%	44.42%	64.45%	35.55%	67.58%	32.42%	59.94%	40.06%	62.31%	37.69%	51.20%	48.80%
	76	82	5,654	6,238	259	207	631	348	6,207	2,977	10,426	6,967	1,754	1,061	278	265
Earth and Planetary Sciences	54.71%	45.29%	68.65%	31.35%	69.41%	30.59%	76.42%	23.58%	79.18%	20.82%	71.05%	28.95%	74.41%	25.59%	59.56%	40.44%
	1,895	1,569	9,384	4,286	3,499	1,542	9,506	2,933	65,060	17,108	89,979	36,654	13,759	4,732	1,810	1,229
Economics	65.55%	34.45%	71.25%	28.75%	68.84%	31.16%	74.25%	25.75%	75.76%	24.24%	66.54%	33.46%	71.31%	28.69%	57.72%	42.28%
	314	165	2,312	933	727	329	2,561	888	20,764	6,644	33,278	16,737	6,628	2,667	658	482
Energy	68.60%	31.40%	76.66%	23.34%	76.03%	23.97%	84.99%	15.01%	85.80%	14.20%	77.92%	22.08%	82.69%	17.31%	69.71%	30.29%
	664	304	9,266	2,821	2,816	888	6,946	1,227	53,908	8,924	72,141	20,447	10,172	2,129	1,728	751
Engineering	67.25%	32.75%	75.49%	24.51%	76.37%	23.63%	84.06%	15.94%	84.38%	15.62%	79.26%	20.74%	83.04%	16.96%	69.83%	30.17%
	2,826	1,376	32,764	10,640	11,449	3,542	28,381	5,381	226,061	41,838	334,409	87,492	42,745	8,728	8,147	3,520
Environmental Science	43.05%	56.95%	59.19%	40.81%	61.59%	38.41%	66.15%	33.85%	68.75%	31.25%	62.08%	37.92%	66.94%	33.06%	48.49%	51.51%
	1,895	2,507	17,936	12,367	6,195	3,864	12,010	6,146	72,487	32,953	107,483	65,660	15,884	7,844	2,895	3,075
Health Professions	50.38%	49.62%	53.18%	46.82%	55.98%	44.02%	44.57%	55.43%	53.08%	46.92%	56.63%	43.37%	55.07%	44.93%	58.69%	41.31%
	199	196	5,364	4,723	323	254	2,946	3,664	21,758	19,236	24,140	18,490	4,795	3,912	780	549
Immunology and Microbiology	34.94%	65.06%	42.30%	57.70%	51.97%	48.03%	56.00%	44.00%	59.95%	40.05%	46.99%	53.01%	53.70%	46.30%	34.93%	65.07%
	1,554	2,894	9,225	12,585	3,338	3,085	5,631	4,424	51,794	34,603	57,361	64,703	10,118	8,724	1,055	1,965
Materials Science	58.50%	41.50%	66.58%	33.42%	71.06%	28.94%	82.57%	17.43%	83.47%	16.53%	74.51%	25.49%	80.58%	19.42%	59.77%	40.23%
	1,662	1,179	14,892	7,474	6,157	2,508	12,861	2,714	113,115	22,398	169,532	58,002	20,906	5,037	2,881	1,939
Mathematics	72.62%	27.38%	79.72%	20.28%	80.13%	19.87%	83.98%	16.02%	84.04%	15.96%	80.54%	19.46%	83.20%	16.80%	73.08%	26.92%
	1,541	581	11,365	2,891	4,513	1,119	8,926	1,703	66,194	12,569	123,527	29,849	15,437	3,116	2,926	1,078
Medicine	45.13%	54.87%	47.26%	52.74%	54.66%	45.34%	52.19%	47.81%	58.70%	41.30%	52.07%	47.93%	54.36%	45.64%	42.49%	57.51%
	8,173	9,938	56,150	62,666	16,594	13,764	47,176	43,210	407,756	286,876	457,409	421,024	83,582	70,162	8,528	11,541
Neuroscience	45.31%	54.69%	45.67%	54.33%	54.77%	45.23%	53.88%	46.12%	60.28%	39.72%	49.31%	50.69%	53.81%	46.19%	40.55%	59.45%
	898	1,084	4,990	5,937	1,677	1,385	7,465	6,389	56,983	37,553	52,584	54,051	10,345	8,881	888	1,302
Nursing	30.47%	69.53%	26.97%	73.03%	38.65%	61.35%	31.61%	68.39%	34.23%	65.77%	37.43%	62.57%	36.64%	63.36%	33.76%	66.24%
	181	413	3,464	9,380	841	1,335	2,402	5,197	19,630	37,719	20,804	34,770	5,187	8,968	371	728
Pharmacology	37.46%	62.54%	42.34%	57.66%	50.95%	49.05%	58.91%	41.09%	63.53%	36.47%	49.37%	50.63%	59.15%	40.85%	33.04%	66.96%
	777	1,297	7,867	10,715	2,248	2,164	4,059	2,831	50,844	29,193	46,820	48,011	8,510	5,878	814	1,650
Physics and Astronomy	67.01%	32.99%	71.10%	28.90%	75.07%	24.93%	83.43%	16.57%	84.44%	15.56%	78.65%	21.35%	81.35%	18.65%	67.96%	32.04%
	2,539	1,250	16,621	6,755	7,066	2,347	14,377	2,856	127,437	23,475	209,691	56,929	27,904	6,396	2,931	1,382
Psychology	39.85%	60.15%	37.69%	62.31%	46.68%	53.32%	39.11%	60.89%	44.26%	55.74%	41.67%	58.33%	39.98%	60.02%	33.62%	66.38%
	428	646	2,734	4,519	1,021	1,166	4,456	6,937	35,819	45,107	33,932	47,489	7,474	11,221	810	1,599
Social Sciences	43.59%	56.41%	54.80%	45.20%	55.51%	44.49%	48.63%	51.37%	52.62%	47.38%	56.00%	44.00%	54.06%	45.94%	48.08%	51.92%
	1,965	2,543	15,344	12,654	4,461	3,575	12,725	13,440	103,123	92,839	134,890	105,979	28,570	24,274	3,412	3,685
Veterinary	44.04%	55.96%	51.21%	48.79%	66.64%	33.36%	47.71%	52.29%	51.23%	48.77%	47.39%	52.61%	48.87%	51.13%	40.42%	59.58%
	617	784	9,172	8,740	1,598	800	1,145	1,255	7,346	6,992	13,230	14,685	1,950	2,040	249	367

TABLE B.1 (CON'T)

Active authors during the periods 2014–2018

Number and percent of men and women among authors in each country and the EU28 overall and in each subject area.

Subject Area	Country	
	Gender	
	% of authors	
	Number of authors	

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
All	**56.19%**	**43.81%**	**61.09%**	**38.91%**	**56.24%**	**43.76%**	**67.10%**	**32.90%**	**67.98%**	**32.02%**	**64.76%**	**35.24%**	**60.54%**	**39.46%**	**84.78%**	**15.22%**
	141,085	110,017	169,294	107,837	145,603	113,292	71,255	34,940	278,272	131,043	30,789	16,756	99,355	64,763	363,941	65,323
Agricultural Sciences	**52.07%**	**47.93%**	**53.33%**	**46.67%**	**51.02%**	**48.98%**	**65.58%**	**34.42%**	**55.80%**	**44.20%**	**61.61%**	**38.39%**	**62.59%**	**37.41%**	**78.96%**	**21.04%**
	15,885	14,621	16,838	14,736	13,571	13,026	6,846	3,593	22,142	17,538	3,443	2,145	13,673	8,173	29,658	7,901
Arts and Humanities	**58.16%**	**41.84%**	**56.10%**	**43.90%**	**56.23%**	**43.77%**	**61.36%**	**38.64%**	**61.31%**	**38.69%**	**63.06%**	**36.94%**	**49.41%**	**50.59%**	**79.28%**	**20.72%**
	9,384	6,752	7,131	5,581	5,920	4,608	2,996	1,887	8,023	5,064	1,135	665	4,148	4,247	2,253	589
Biochemistry	**47.15%**	**52.85%**	**48.98%**	**51.02%**	**41.70%**	**58.30%**	**62.09%**	**37.91%**	**55.67%**	**44.33%**	**59.28%**	**40.72%**	**58.78%**	**41.22%**	**79.18%**	**20.82%**
	21,910	24,556	30,604	31,873	24,338	34,033	14,466	8,834	50,652	40,337	6,900	4,739	17,068	11,968	80,443	21,154
Business	**59.43%**	**40.57%**	**62.88%**	**37.12%**	**59.16%**	**40.84%**	**71.63%**	**28.37%**	**71.90%**	**28.10%**	**67.96%**	**32.04%**	**63.77%**	**36.23%**	**83.84%**	**16.16%**
	3,717	2,537	3,588	2,118	3,506	2,420	2,730	1,081	9,311	3,639	1,084	511	4,280	2,432	2,486	479
Chemical Engineering	**55.83%**	**44.17%**	**63.70%**	**36.30%**	**55.96%**	**44.04%**	**77.74%**	**22.26%**	**71.44%**	**28.56%**	**74.96%**	**25.04%**	**77.35%**	**22.65%**	**86.27%**	**13.73%**
	6,024	4,766	9,316	5,309	5,288	4,162	3,420	979	18,239	7,292	1,566	523	4,155	1,217	20,864	3,321
Chemistry	**55.01%**	**44.99%**	**61.79%**	**38.21%**	**52.22%**	**47.78%**	**76.90%**	**23.10%**	**70.93%**	**29.07%**	**73.34%**	**26.66%**	**74.07%**	**25.93%**	**85.07%**	**14.93%**
	11,812	9,661	18,320	11,330	10,190	9,325	5,723	1,719	34,915	14,307	2,768	1,006	7,460	2,611	45,556	7,994
Computer Science	**75.54%**	**24.46%**	**79.70%**	**20.30%**	**74.29%**	**25.71%**	**83.24%**	**16.76%**	**84.20%**	**15.80%**	**82.76%**	**17.24%**	**81.92%**	**18.08%**	**92.44%**	**7.56%**
	19,882	6,437	28,835	7,344	20,437	7,072	9,846	1,982	50,012	9,386	3,952	823	11,053	2,440	47,106	3,854
Decision Sciences	**67.96%**	**32.04%**	**75.20%**	**24.80%**	**66.50%**	**33.50%**	**79.99%**	**20.01%**	**79.73%**	**20.27%**	**79.58%**	**20.42%**	**77.85%**	**22.15%**	**91.16%**	**8.84%**
	1,754	827	2,796	922	2,009	1,012	1,191	298	5,402	1,373	456	117	1,385	394	2,320	225
Dentistry	**57.46%**	**42.54%**	**60.12%**	**39.88%**	**67.69%**	**32.31%**	**65.46%**	**34.54%**	**62.58%**	**37.42%**	**60.79%**	**39.21%**	**65.34%**	**34.66%**	**77.96%**	**22.04%**
	1,205	892	677	449	1,833	875	472	249	1,960	1,172	138	89	509	270	4,209	1,190
Earth and Planetary Sciences	**68.24%**	**31.76%**	**70.51%**	**29.49%**	**68.26%**	**31.74%**	**80.63%**	**19.37%**	**75.31%**	**24.69%**	**78.42%**	**21.58%**	**76.43%**	**23.57%**	**89.61%**	**10.39%**
	7,878	3,666	13,196	5,519	10,327	4,802	4,362	1,048	16,504	5,410	1,472	405	8,138	2,509	13,559	1,572
Economics	**62.85%**	**37.15%**	**66.42%**	**33.58%**	**63.18%**	**36.82%**	**76.82%**	**23.18%**	**72.32%**	**27.68%**	**72.11%**	**27.89%**	**72.42%**	**27.58%**	**88.86%**	**11.14%**
	2,982	1,763	3,753	1,897	3,121	1,819	1,939	585	5,990	2,293	706	273	3,059	1,165	1,810	227
Energy	**71.20%**	**28.80%**	**76.83%**	**23.17%**	**73.84%**	**26.16%**	**82.76%**	**17.24%**	**83.06%**	**16.94%**	**84.56%**	**15.44%**	**85.29%**	**14.71%**	**93.87%**	**6.13%**
	5,973	2,416	8,189	2,470	7,327	2,596	3,268	681	15,670	3,197	2,185	399	4,261	735	17,321	1,132
Engineering	**74.14%**	**25.86%**	**79.17%**	**20.83%**	**74.53%**	**25.47%**	**84.70%**	**15.30%**	**84.30%**	**15.70%**	**83.18%**	**16.82%**	**83.15%**	**16.85%**	**93.40%**	**6.60%**
	26,206	9,142	40,991	10,786	31,215	10,666	13,449	2,430	76,206	14,196	5,622	1,137	17,269	3,499	97,021	6,857
Environmental Science	**59.16%**	**40.84%**	**61.09%**	**38.91%**	**59.07%**	**40.93%**	**72.45%**	**27.55%**	**66.66%**	**33.34%**	**69.39%**	**30.61%**	**67.09%**	**32.91%**	**86.00%**	**14.00%**
	10,780	7,442	12,215	7,780	10,639	7,373	5,674	2,158	17,878	8,941	2,680	1,182	10,354	5,080	16,324	2,658
Health Professions	**61.65%**	**38.35%**	**59.83%**	**40.17%**	**49.56%**	**50.44%**	**59.01%**	**40.99%**	**61.53%**	**38.47%**	**57.21%**	**42.79%**	**47.19%**	**52.81%**	**81.51%**	**18.49%**
	3,424	2,130	2,267	1,522	1,991	2,026	1,388	964	3,404	2,128	603	451	2,998	3,355	5,078	1,152
Immunology and Microbiology	**42.69%**	**57.31%**	**45.01%**	**54.99%**	**39.75%**	**60.25%**	**57.38%**	**42.62%**	**49.42%**	**50.58%**	**56.12%**	**43.88%**	**55.07%**	**44.93%**	**76.38%**	**23.62%**
	5,189	6,965	7,879	9,626	5,442	8,250	3,607	2,679	11,573	11,843	1,678	1,312	4,125	3,366	13,388	4,140
Materials Science	**65.98%**	**34.02%**	**74.43%**	**25.57%**	**67.88%**	**32.12%**	**84.18%**	**15.82%**	**80.39%**	**19.61%**	**82.22%**	**17.78%**	**83.07%**	**16.93%**	**91.90%**	**8.10%**
	11,143	5,745	24,496	8,414	12,472	5,902	6,753	1,269	44,753	10,915	2,484	537	8,228	1,677	57,072	5,032
Mathematics	**76.97%**	**23.03%**	**80.26%**	**19.74%**	**73.70%**	**26.30%**	**85.19%**	**14.81%**	**84.64%**	**15.36%**	**87.54%**	**12.46%**	**84.56%**	**15.44%**	**92.87%**	**7.13%**
	10,132	3,031	18,374	4,520	11,461	4,089	5,441	946	27,695	5,025	2,058	293	5,077	927	19,659	1,510
Medicine	**48.36%**	**51.64%**	**49.81%**	**50.19%**	**48.06%**	**51.94%**	**58.35%**	**41.65%**	**56.80%**	**43.20%**	**55.07%**	**44.93%**	**51.71%**	**48.29%**	**80.66%**	**19.34%**
	52,226	55,777	48,384	48,744	57,425	62,054	28,390	20,264	73,547	55,934	11,608	9,470	36,726	34,293	134,044	32,133
Neuroscience	**44.73%**	**55.27%**	**47.21%**	**52.79%**	**41.15%**	**58.85%**	**55.90%**	**44.10%**	**51.70%**	**48.30%**	**54.86%**	**45.14%**	**52.37%**	**47.63%**	**78.21%**	**21.79%**
	4,075	5,035	5,921	6,620	5,939	8,495	3,419	2,697	12,213	11,412	1,258	1,035	4,248	3,863	12,361	3,443
Nursing	**37.69%**	**62.31%**	**35.23%**	**64.77%**	**38.56%**	**61.44%**	**43.47%**	**56.53%**	**46.08%**	**53.92%**	**35.47%**	**64.53%**	**28.94%**	**71.06%**	**63.78%**	**36.22%**
	3,995	6,606	2,641	4,855	1,694	2,699	1,152	1,498	2,081	2,435	476	866	2,348	5,765	3,627	2,060
Pharmacology	**43.10%**	**56.90%**	**47.34%**	**52.66%**	**39.67%**	**60.33%**	**60.90%**	**39.10%**	**55.03%**	**44.97%**	**55.39%**	**44.61%**	**58.36%**	**41.64%**	**76.90%**	**23.10%**
	4,280	5,650	5,314	5,911	4,794	7,290	2,544	1,633	7,952	6,497	1,212	976	2,820	2,012	18,829	5,655
Physics and Astronomy	**74.15%**	**25.85%**	**77.80%**	**22.20%**	**74.10%**	**25.90%**	**84.71%**	**15.29%**	**82.93%**	**17.07%**	**85.55%**	**14.45%**	**82.53%**	**17.47%**	**92.66%**	**7.34%**
	14,844	5,176	32,759	9,349	20,126	7,035	8,695	1,569	54,622	11,244	3,577	604	8,349	1,767	64,534	5,114
Psychology	**44.84%**	**55.16%**	**41.39%**	**58.61%**	**35.36%**	**64.64%**	**47.54%**	**52.46%**	**43.37%**	**56.63%**	**48.17%**	**51.83%**	**35.93%**	**64.07%**	**72.32%**	**27.68%**
	4,310	5,303	3,218	4,557	2,786	5,093	2,776	3,063	5,908	7,713	567	610	3,217	5,737	2,814	1,077
Social Sciences	**56.74%**	**43.26%**	**56.41%**	**43.59%**	**55.20%**	**44.80%**	**61.44%**	**38.56%**	**60.93%**	**39.07%**	**60.99%**	**39.01%**	**48.00%**	**52.00%**	**81.59%**	**18.41%**
	19,260	14,684	11,519	8,900	11,048	8,968	7,938	4,982	18,315	11,744	2,758	1,764	12,134	13,144	8,560	1,932
Veterinary	**49.70%**	**50.30%**	**49.77%**	**50.23%**	**45.34%**	**54.66%**	**59.23%**	**40.77%**	**41.97%**	**58.03%**	**46.75%**	**53.25%**	**52.62%**	**47.38%**	**77.16%**	**22.84%**
	1,402	1,419	1,311	1,323	1,655	1,995	462	318	1,648	2,279	302	344	1,106	996	2,558	757

TABLE B.1 (CON'T)

Active authors during the periods 1999–2003

Number and percent of men and women among authors in each country and the EU28 overall and in each subject area.

Subject Area	Country															
	Gender															
	% of authors															
	Number of authors															
	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
All	53.49%	46.51%	64.70%	35.30%	69.19%	30.81%	72.48%	27.52%	75.50%	24.50%	70.73%	29.27%	72.20%	27.80%	61.44%	38.56%
	8,224	7,152	30,073	16,407	12,077	5,377	57,263	21,741	519,241	168,538	632,082	261,533	114,706	44,168	6,682	4,193
Agricultural Sciences	46.84%	53.16%	63.90%	36.10%	67.18%	32.82%	73.85%	26.15%	75.14%	24.86%	65.69%	34.31%	71.24%	28.76%	49.67%	50.33%
	1,631	1,851	5,476	3,093	2,299	1,123	7,348	2,602	46,128	15,262	57,862	30,228	10,596	4,277	824	835
Arts and Humanities	50.31%	49.69%	60.47%	39.53%	58.99%	41.01%	61.81%	38.19%	65.33%	34.67%	67.96%	32.04%	66.37%	33.63%	53.29%	46.71%
	82	81	153	100	82	57	1,685	1,041	14,139	7,503	14,367	6,773	5,046	2,557	89	78
Biochemistry	42.40%	57.60%	51.43%	48.57%	57.50%	42.50%	66.56%	33.44%	70.54%	29.46%	59.95%	40.05%	65.96%	34.04%	45.10%	54.90%
	1,951	2,650	4,956	4,680	2,029	1,500	13,568	6,818	125,888	52,582	135,314	90,394	25,380	13,097	1,118	1,361
Business	59.52%	40.48%	80.67%	19.33%	74.62%	25.38%	75.17%	24.83%	77.39%	22.61%	76.56%	23.44%	74.67%	25.33%	74.27%	25.73%
	50	34	242	58	97	33	1,202	397	14,006	4,091	10,849	3,322	4,069	1,380	127	44
Chemical Engineering	56.28%	43.72%	64.32%	35.68%	72.60%	27.40%	83.00%	17.00%	84.85%	15.15%	73.88%	26.12%	80.38%	19.62%	56.75%	43.25%
	551	428	1,372	761	710	268	3,437	704	23,226	4,146	32,068	11,337	5,179	1,264	429	327
Chemistry	50.12%	49.88%	62.12%	37.88%	68.40%	31.60%	79.06%	20.94%	81.95%	18.05%	70.90%	29.10%	79.63%	20.37%	51.76%	48.24%
	1,086	1,081	3,173	1,935	1,357	627	5,496	1,456	46,369	10,215	74,620	30,620	11,868	3,036	882	822
Computer Science	66.80%	33.20%	80.66%	19.34%	84.71%	15.29%	88.53%	11.47%	87.73%	12.27%	86.37%	13.63%	86.27%	13.73%	83.71%	16.29%
	340	169	2,790	669	1,053	190	6,552	849	57,086	7,986	66,206	10,451	10,527	1,675	1,269	247
Decision Sciences	50.00%	50.00%	74.82%	25.18%	82.56%	17.44%	85.32%	14.68%	85.92%	14.08%	83.32%	16.68%	84.78%	15.22%	74.85%	25.15%
	22	22	211	71	71	15	651	112	5,126	840	6,095	1,220	1,393	250	122	41
Dentistry	32.35%	67.65%	57.35%	42.65%	64.29%	35.71%	78.27%	21.73%	78.84%	21.16%	72.67%	27.33%	72.46%	27.54%	76.92%	23.08%
	22	46	663	493	27	15	299	83	3,454	927	4,201	1,580	1,050	399	10	3
Earth and Planetary Sciences	62.18%	37.82%	79.19%	20.81%	78.03%	21.97%	85.12%	14.88%	86.32%	13.68%	80.04%	19.96%	83.11%	16.89%	67.34%	32.66%
	740	450	1,591	418	1,115	314	4,787	837	36,450	5,775	40,086	9,998	7,781	1,581	431	209
Economics	84.93%	15.07%	90.13%	9.87%	74.77%	25.23%	85.64%	14.36%	83.31%	16.69%	80.97%	19.03%	80.48%	19.52%	69.17%	30.83%
	62	11	137	15	83	28	1,109	186	9,962	1,996	8,805	2,069	2,754	668	83	37
Energy	69.29%	30.71%	85.20%	14.80%	81.05%	18.95%	90.67%	9.33%	91.90%	8.10%	86.31%	13.69%	90.35%	9.65%	79.26%	20.74%
	194	86	1,232	214	556	130	1,633	168	13,865	1,222	13,960	2,214	2,368	253	172	45
Engineering	67.55%	32.45%	82.95%	17.05%	84.82%	15.18%	89.56%	10.44%	89.90%	10.10%	86.22%	13.78%	89.13%	10.87%	79.07%	20.93%
	920	442	5,644	1,160	2,313	414	11,896	1,387	122,044	13,704	129,112	20,627	20,964	2,557	1,836	486
Environmental Science	53.85%	46.15%	66.49%	33.51%	66.12%	33.88%	77.72%	22.28%	80.07%	19.93%	72.60%	27.40%	76.46%	23.54%	52.47%	47.53%
	595	510	1,673	843	1,081	554	5,521	1,583	37,654	9,370	41,650	15,717	8,577	2,640	489	443
Health Professions	58.82%	41.18%	59.33%	40.67%	67.50%	32.50%	56.43%	43.57%	64.28%	35.72%	66.06%	33.94%	58.02%	41.98%	56.98%	43.02%
	50	35	213	146	54	26	1,022	789	9,370	5,207	9,384	4,821	1,920	1,389	49	37
Immunology and Microbiology	39.02%	60.98%	46.92%	53.08%	55.57%	44.43%	62.36%	37.64%	65.51%	34.49%	55.18%	44.82%	61.86%	38.14%	42.36%	57.64%
	787	1,230	2,337	2,644	883	706	2,944	1,777	29,532	15,550	34,924	28,370	7,165	4,417	352	479
Materials Science	62.78%	37.22%	74.86%	25.14%	80.17%	19.83%	87.03%	12.97%	88.79%	11.21%	80.89%	19.11%	85.62%	14.38%	68.63%	31.37%
	823	488	3,663	1,230	1,799	445	5,757	858	60,829	7,679	83,966	19,839	12,101	2,032	1,015	464
Mathematics	67.18%	32.82%	81.15%	18.85%	86.35%	13.65%	89.16%	10.84%	89.37%	10.63%	85.70%	14.30%	88.18%	11.82%	78.81%	21.19%
	436	213	2,144	498	1,120	177	4,253	517	37,027	4,402	54,289	9,056	7,700	1,032	900	242
Medicine	52.17%	47.83%	56.06%	43.94%	61.22%	38.78%	62.54%	37.46%	67.74%	32.26%	64.10%	35.90%	64.66%	35.34%	52.62%	47.38%
	3,284	3,011	9,689	7,595	3,830	2,426	18,148	10,870	176,903	84,254	234,333	131,255	40,889	22,348	1,707	1,537
Neuroscience	47.36%	52.64%	53.92%	46.08%	59.62%	40.38%	63.49%	36.51%	67.38%	32.62%	60.52%	39.48%	63.06%	36.94%	54.29%	45.71%
	323	359	1,631	1,394	508	344	3,289	1,891	26,096	12,631	27,581	17,993	5,543	3,247	171	144
Nursing	37.60%	62.40%	37.44%	62.56%	44.19%	55.81%	37.18%	62.82%	41.32%	58.68%	50.17%	49.83%	44.61%	55.39%	42.37%	57.63%
	47	78	243	406	95	120	667	1,127	7,217	10,250	6,689	6,643	2,152	2,672	25	34
Pharmacology	39.80%	60.20%	47.50%	52.50%	53.61%	46.39%	63.61%	36.39%	70.98%	29.02%	60.08%	39.92%	68.67%	31.33%	43.69%	56.31%
	466	705	1,766	1,952	617	534	2,447	1,400	27,992	11,442	29,542	19,631	6,182	2,821	277	357
Physics and Astronomy	68.16%	31.84%	79.22%	20.78%	82.42%	17.58%	87.69%	12.31%	89.28%	10.72%	83.63%	16.37%	87.11%	12.89%	73.53%	26.47%
	1,310	612	4,925	1,292	2,598	554	6,810	956	80,266	9,636	110,927	21,715	15,335	2,270	1,228	442
Psychology	44.23%	55.77%	48.63%	51.37%	50.76%	49.24%	51.90%	48.10%	56.01%	43.99%	58.04%	41.96%	52.41%	47.59%	64.84%	35.16%
	46	58	160	169	201	195	1,992	1,846	18,104	14,220	11,379	8,225	3,166	2,875	59	32
Social Sciences	52.82%	47.18%	66.04%	33.96%	69.84%	30.16%	62.41%	37.59%	63.02%	36.98%	69.62%	30.38%	64.85%	35.15%	63.99%	36.01%
	159	142	558	287	359	155	4,072	2,453	38,253	22,447	30,689	13,393	11,489	6,228	263	148
Veterinary	48.87%	51.13%	60.15%	39.85%	63.73%	36.27%	64.90%	35.10%	65.35%	34.65%	62.95%	37.05%	65.23%	34.77%	46.88%	53.13%
	217	227	984	652	239	136	795	430	5,350	2,837	8,057	4,742	1,452	774	45	51

TABLE B.1 (CON'T)

Active authors during the periods 1999–2003

Number and percent of men and women among authors in each country and the EU28 overall and in each subject area.

Subject Area	Country	
	Gender	
	% of authors	
	Number of authors	

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
All	**64.62%**	**35.38%**	**67.23%**	**32.77%**	**62.23%**	**37.77%**	**80.17%**	**19.83%**	**79.51%**	**20.49%**	**75.77%**	**24.23%**	**70.55%**	**29.45%**	**89.87%**	**10.13%**
	50,054	27,401	89,058	43,404	68,821	41,765	34,880	8,630	129,717	33,437	12,175	3,893	35,465	14,806	209,979	23,671
Agricultural Sciences	**58.09%**	**41.91%**	**62.46%**	**37.54%**	**56.59%**	**43.41%**	**79.21%**	**20.79%**	**71.29%**	**28.71%**	**72.19%**	**27.81%**	**74.27%**	**25.73%**	**85.95%**	**14.05%**
	5,574	4,022	8,633	5,188	5,019	3,850	3,639	955	9,482	3,818	1,763	679	6,310	2,186	13,903	2,273
Arts and Humanities	**67.85%**	**32.15%**	**65.32%**	**34.68%**	**58.65%**	**41.35%**	**76.93%**	**23.07%**	**74.88%**	**25.12%**	**72.93%**	**27.07%**	**61.39%**	**38.61%**	**86.99%**	**13.01%**
	859	407	1,844	979	919	648	1,044	313	2,054	689	264	98	1,180	742	903	135
Biochemistry	**52.90%**	**47.10%**	**54.16%**	**45.84%**	**48.25%**	**51.75%**	**73.04%**	**26.96%**	**68.19%**	**31.81%**	**70.28%**	**29.72%**	**63.53%**	**36.47%**	**85.20%**	**14.80%**
	9,463	8,424	20,590	17,429	15,029	16,119	8,335	3,077	28,535	13,309	3,311	1,400	7,085	4,068	56,275	9,776
Business	**71.37%**	**28.63%**	**75.57%**	**24.43%**	**72.22%**	**27.78%**	**85.42%**	**14.58%**	**87.26%**	**12.74%**	**85.66%**	**14.34%**	**70.49%**	**29.51%**	**85.26%**	**14.74%**
	648	260	857	277	468	180	861	147	1,610	235	239	40	1,302	545	810	140
Chemical Engineering	**61.09%**	**38.91%**	**69.10%**	**30.90%**	**64.65%**	**35.35%**	**86.41%**	**13.59%**	**84.13%**	**15.87%**	**81.79%**	**18.21%**	**82.96%**	**17.04%**	**91.00%**	**9.00%**
	2,434	1,550	4,687	2,096	2,270	1,241	1,908	300	8,321	1,570	530	118	1,305	268	12,434	1,230
Chemistry	**57.58%**	**42.42%**	**67.65%**	**32.35%**	**59.55%**	**40.45%**	**85.71%**	**14.29%**	**82.39%**	**17.61%**	**77.36%**	**22.64%**	**80.87%**	**19.13%**	**89.45%**	**10.55%**
	5,897	4,344	11,737	5,613	6,160	4,184	3,467	578	18,047	3,858	1,189	348	2,807	664	30,803	3,633
Computer Science	**80.99%**	**19.01%**	**83.31%**	**16.69%**	**79.31%**	**20.69%**	**90.68%**	**9.32%**	**92.21%**	**7.79%**	**91.59%**	**8.41%**	**85.70%**	**14.30%**	**95.67%**	**4.33%**
	4,981	1,169	10,238	2,051	6,079	1,586	3,456	355	14,032	1,185	948	87	3,501	584	17,958	813
Decision Sciences	**73.74%**	**26.26%**	**80.64%**	**19.36%**	**71.38%**	**28.62%**	**90.67%**	**9.33%**	**90.70%**	**9.30%**	**90.12%**	**9.88%**	**83.09%**	**16.91%**	**94.27%**	**5.73%**
	483	172	779	187	459	184	544	56	1,014	104	146	16	516	105	543	33
Dentistry	**68.15%**	**31.85%**	**72.83%**	**27.17%**	**74.31%**	**25.69%**	**83.79%**	**16.21%**	**80.41%**	**19.59%**	**69.35%**	**30.65%**	**77.03%**	**22.97%**	**87.79%**	**12.21%**
	336	157	260	97	483	167	274	53	788	192	86	38	228	68	2,394	333
Earth and Planetary Sciences	**74.68%**	**25.32%**	**77.03%**	**22.97%**	**72.87%**	**27.13%**	**88.78%**	**11.22%**	**85.82%**	**14.18%**	**86.06%**	**13.94%**	**84.04%**	**15.96%**	**94.27%**	**5.73%**
	2,726	924	6,939	2,069	4,582	1,706	2,359	298	7,992	1,321	846	137	3,312	629	7,306	444
Economics	**74.06%**	**25.94%**	**76.41%**	**23.59%**	**75.67%**	**24.33%**	**90.81%**	**9.19%**	**87.13%**	**12.87%**	**87.55%**	**12.45%**	**81.75%**	**18.25%**	**94.82%**	**5.18%**
	728	255	1,027	317	650	209	771	78	1,158	171	232	33	887	198	476	26
Energy	**77.35%**	**22.65%**	**82.48%**	**17.52%**	**83.23%**	**16.77%**	**91.98%**	**8.02%**	**92.66%**	**7.34%**	**88.63%**	**11.37%**	**90.72%**	**9.28%**	**96.61%**	**3.39%**
	915	268	2,185	464	1,290	260	700	61	3,066	243	265	34	616	63	7,458	262
Engineering	**78.86%**	**21.14%**	**82.78%**	**17.22%**	**80.59%**	**19.41%**	**92.94%**	**7.06%**	**91.63%**	**8.37%**	**90.14%**	**9.86%**	**88.11%**	**11.89%**	**96.23%**	**3.77%**
	7,007	1,878	20,275	4,219	11,928	2,873	6,449	490	30,891	2,822	1,646	180	5,348	722	57,770	2,264
Environmental Science	**62.86%**	**37.14%**	**68.81%**	**31.19%**	**64.14%**	**35.86%**	**85.00%**	**15.00%**	**80.60%**	**19.40%**	**76.61%**	**23.39%**	**77.12%**	**22.88%**	**89.94%**	**10.06%**
	2,941	1,738	4,923	2,231	3,130	1,750	2,822	498	8,258	1,988	1,176	359	3,758	1,115	7,643	855
Health Professions	**62.86%**	**37.14%**	**64.74%**	**35.26%**	**63.40%**	**36.60%**	**76.00%**	**24.00%**	**75.64%**	**24.36%**	**74.27%**	**25.73%**	**56.99%**	**43.01%**	**86.22%**	**13.78%**
	462	273	1,219	664	920	531	624	197	2,009	647	179	62	901	680	1,690	270
Immunology and Microbiology	**49.91%**	**50.09%**	**48.24%**	**51.76%**	**43.23%**	**56.77%**	**68.54%**	**31.46%**	**62.23%**	**37.77%**	**66.56%**	**33.44%**	**61.04%**	**38.96%**	**83.12%**	**16.88%**
	2,779	2,789	5,185	5,563	3,261	4,283	2,697	1,238	6,724	4,081	1,047	526	2,167	1,383	11,321	2,299
Materials Science	**69.44%**	**30.56%**	**77.69%**	**22.31%**	**72.11%**	**27.89%**	**91.20%**	**8.80%**	**88.72%**	**11.28%**	**88.81%**	**11.19%**	**85.90%**	**14.10%**	**94.86%**	**5.14%**
	4,545	2,000	14,608	4,194	6,578	2,544	3,815	368	22,959	2,920	897	113	3,077	505	42,476	2,300
Mathematics	**80.83%**	**19.17%**	**83.51%**	**16.49%**	**75.39%**	**24.61%**	**91.41%**	**8.59%**	**91.45%**	**8.55%**	**93.06%**	**6.94%**	**88.15%**	**11.85%**	**95.11%**	**4.89%**
	4,677	1,109	9,404	1,857	5,079	1,658	2,619	246	11,862	1,109	832	62	2,396	322	10,319	530
Medicine	**62.52%**	**37.48%**	**58.88%**	**41.12%**	**57.64%**	**42.36%**	**73.66%**	**26.34%**	**72.98%**	**27.02%**	**69.72%**	**30.28%**	**62.07%**	**37.93%**	**87.02%**	**12.98%**
	22,828	13,685	27,879	19,472	33,315	24,481	14,066	5,030	42,482	15,725	4,836	2,100	12,450	7,608	79,152	11,806
Neuroscience	**53.91%**	**46.09%**	**54.52%**	**45.48%**	**49.66%**	**50.34%**	**72.58%**	**27.42%**	**69.35%**	**30.65%**	**70.57%**	**29.43%**	**62.66%**	**37.34%**	**84.13%**	**15.87%**
	1,684	1,440	3,660	3,053	3,494	3,542	1,609	608	6,703	2,963	494	206	1,490	888	9,189	1,734
Nursing	**49.56%**	**50.44%**	**46.85%**	**53.15%**	**52.08%**	**47.92%**	**64.44%**	**35.56%**	**66.58%**	**33.42%**	**56.58%**	**43.42%**	**36.79%**	**63.21%**	**75.21%**	**24.79%**
	558	568	639	725	762	701	453	250	1,020	512	159	122	596	1,024	1,089	359
Pharmacology	**50.14%**	**49.86%**	**55.94%**	**44.06%**	**48.19%**	**51.81%**	**74.15%**	**25.85%**	**70.41%**	**29.59%**	**68.00%**	**32.00%**	**64.12%**	**35.88%**	**84.11%**	**15.89%**
	2,334	2,321	4,311	3,396	3,283	3,530	1,664	580	5,408	2,273	576	271	1,149	643	15,325	2,895
Physics and Astronomy	**76.53%**	**23.47%**	**80.26%**	**19.74%**	**77.33%**	**22.67%**	**91.18%**	**8.82%**	**89.79%**	**10.21%**	**90.53%**	**9.47%**	**86.67%**	**13.33%**	**95.13%**	**4.87%**
	6,142	1,884	20,193	4,968	11,659	3,418	4,965	480	29,118	3,310	1,492	156	3,575	550	47,063	2,408
Psychology	**58.10%**	**41.90%**	**55.73%**	**44.27%**	**48.55%**	**51.45%**	**70.25%**	**29.75%**	**67.11%**	**32.89%**	**64.06%**	**35.94%**	**52.27%**	**47.73%**	**77.15%**	**22.85%**
	875	631	1,279	1,016	788	835	1,197	507	2,208	1,082	123	69	1,139	1,040	878	260
Social Sciences	**69.18%**	**30.82%**	**67.55%**	**32.45%**	**63.96%**	**36.04%**	**78.82%**	**21.18%**	**79.51%**	**20.49%**	**76.81%**	**23.19%**	**61.43%**	**38.57%**	**87.28%**	**12.72%**
	1,598	712	2,920	1,403	1,441	812	2,475	665	4,178	1,077	616	186	3,321	2,085	2,148	313
Veterinary	**55.84%**	**44.16%**	**60.03%**	**39.97%**	**57.98%**	**42.02%**	**76.04%**	**23.96%**	**65.09%**	**34.91%**	**65.88%**	**34.12%**	**67.23%**	**32.77%**	**84.06%**	**15.94%**
	641	507	787	524	654	474	546	172	1,225	657	278	144	595	290	1,872	355

TABLE B.2

Average publication count of men and women who were actively publishing in any authorship position and as corresponding author, first author or last author. Data provided for active authors in each country and the EU28.

	Country
	Gender
Position	Average publication count

Average publication count during the period 2014–2018

	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	4.59	3.56	4.27	3.11	4.18	2.96	6.92	4.24	6.61	4.10	8.10	5.04	7.71	4.51	7.16	4.70
Corresponding	2.44	2.09	2.49	2.00	2.65	2.07	3.57	2.67	3.26	2.51	3.08	2.42	3.04	2.31	3.09	2.65
First	1.94	1.74	1.76	1.51	1.83	1.57	2.28	1.95	2.23	1.93	2.42	2.08	2.27	1.94	2.42	2.14
Last	2.89	2.52	3.12	2.65	2.42	1.89	4.52	2.91	3.98	2.69	4.17	2.89	4.10	2.80	4.38	3.24

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	6.67	4.48	8.28	5.23	10.60	6.85	8.70	5.56	8.16	4.54	8.59	4.91	8.28	5.09	5.92	3.29
Corresponding	3.03	2.35	2.86	2.23	3.67	2.85	3.09	2.60	3.07	2.36	3.12	2.45	3.57	2.77	3.11	2.06
First	2.48	2.09	2.31	1.94	3.03	2.44	2.39	2.32	2.32	1.90	2.45	2.07	2.56	2.22	2.16	1.64
Last	3.67	2.51	3.86	2.86	4.44	3.21	5.14	4.14	4.84	3.23	5.14	3.75	4.83	3.26	4.39	2.52

Average publication count during the period 1999–2003

	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	5.318	4.168	5.296	3.729	5.238	3.732	7.108	4.409	7.400	4.773	7.873	5.035	7.730	4.761	6.469	4.580
Corresponding	2.825	2.276	2.734	2.119	2.930	2.294	3.757	2.718	3.585	2.752	3.449	2.563	3.609	2.643	3.118	2.428
First	2.037	1.852	2.013	1.700	2.108	1.783	2.263	1.895	2.313	1.959	2.484	2.099	2.323	1.974	2.371	2.129
Last	2.848	2.391	2.793	2.251	2.436	1.883	3.370	2.163	3.496	2.340	3.848	2.360	3.656	2.349	3.434	2.638

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	6.976	5.056	7.848	5.280	8.765	5.853	8.425	4.852	8.281	4.602	7.930	4.831	7.249	4.586	7.547	4.494
Corresponding	3.331	2.555	3.190	2.443	3.720	2.728	3.308	2.560	3.602	2.598	3.334	2.499	3.592	2.633	3.296	2.248
First	2.487	2.171	2.348	2.025	2.813	2.274	2.481	2.382	2.603	2.025	2.365	2.109	2.317	2.015	2.547	1.927
Last	3.480	2.391	3.819	2.586	3.645	2.271	4.592	2.858	4.474	2.405	3.819	2.409	3.287	2.232	4.597	2.693

TABLE B.3

Average FWCI of women and men who were active authors in the period 2014–2018 and 1999–2003. Data provided for each country and the EU28.

	Country	
	Gender	
Position		Average FWCI

Average FWCI 2014–2018

	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	0.658	0.630	0.619	0.619	0.580	0.579	1.194	1.173	1.388	1.354	1.118	1.096	1.386	1.452	0.903	0.898
Corresponding	0.579	0.547	0.602	0.564	0.482	0.477	1.009	0.965	1.100	1.025	0.980	0.899	1.171	1.128	0.860	0.807
First	0.694	0.672	0.679	0.646	0.580	0.592	1.270	1.131	1.485	1.278	1.214	1.083	1.529	1.408	1.006	0.917
Last	0.639	0.618	0.565	0.512	0.523	0.515	1.161	1.084	1.271	1.208	1.060	0.987	1.311	1.343	0.892	0.799

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	0.936	0.925	1.055	1.059	1.124	1.082	1.432	1.403	1.172	1.197	1.364	1.356	1.232	1.232	0.720	0.699
Corresponding	0.831	0.788	0.918	0.808	0.989	0.915	1.260	1.229	1.001	0.933	1.256	1.165	1.109	1.083	0.639	0.571
First	1.030	0.961	1.138	1.048	1.188	1.086	1.523	1.359	1.279	1.166	1.468	1.263	1.371	1.251	0.758	0.683
Last	0.895	0.842	1.006	0.956	1.118	1.072	1.329	1.296	1.114	1.065	1.267	1.255	1.225	1.220	0.665	0.622

Average FWCI 1999–2003

	Argentina		Brazil		Mexico		Canada		USA		EU28		UK		Portugal	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	0.714	0.621	0.651	0.630	0.700	0.687	1.278	1.400	1.513	1.626	1.085	1.101	1.306	1.462	0.946	0.919
Corresponding	0.608	0.532	0.584	0.534	0.582	0.527	1.097	1.102	1.287	1.220	0.962	0.871	1.152	1.127	0.856	0.767
First	0.743	0.626	0.702	0.663	0.694	0.665	1.413	1.353	1.714	1.614	1.213	1.119	1.534	1.514	0.960	0.918
Last	0.666	0.630	0.646	0.592	0.624	0.634	1.333	1.347	1.558	1.603	1.098	1.032	1.376	1.515	0.898	0.890

	Spain		France		Italy		Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Any	0.839	0.889	1.055	1.095	0.926	0.965	1.415	1.512	1.159	1.267	1.424	1.391	1.150	1.233	0.826	0.851
Corresponding	0.774	0.731	0.938	0.859	0.813	0.758	1.259	1.270	0.994	0.919	1.246	1.229	1.026	1.006	0.692	0.567
First	0.899	0.913	1.180	1.130	0.950	0.931	1.550	1.541	1.279	1.248	1.563	1.373	1.336	1.236	0.869	0.798
Last	0.830	0.811	1.073	1.079	0.922	0.901	1.371	1.405	1.165	1.187	1.387	1.353	1.248	1.236	0.788	0.714

TABLE B.4

Average number of research grants won by women and men during the period 2014–2018.

Country
Gender
Average Award Count

	Canada		USA		EU28		UK		Germany		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Average number of research grants won	3.623	2.535	3.428	3.083	1.119	1.069	1.977	1.631	1.478	1.243	1.663	1.447	1.049	1.019

TABLE B.5

Average number of patent applications by women and men inventors and assignees in each country and the EU28 during the periods 2012–2016 and 1999–2003.

	Country
	Gender
Position	Average number of patents

2012–2016

	Brazil		Canada		USA		EU28		UK		Spain		France		Italy	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Inventor	3.57	3.06	5.45	4.43	6.31	4.54	7.06	5.68	6.72	5.70	3.93	3.58	7.06	6.01	5.41	5.02
Assignee	2.71	1.86	2.83	2.13	4.35	3.31	4.79	2.93	3.32	2.74	2.65	1.80	5.67	2.34	2.80	2.78

	Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Inventor	6.98	5.91	8.27	6.75	5.97	5.29	4.73	3.79	10.57	7.07
Assignee	7.18	2.34	5.73	4.07	3.26	2.16	2.85	1.99	10.04	4.64

1999–2003

	Brazil		Canada		USA		EU28		UK		Spain		France		Italy	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Inventor	3.86	3.25	5.08	4.63	5.12	4.58	8.07	7.17	6.70	6.17	5.33	5.52	7.75	7.36	7.26	7.74
Assignee	2.55	1.37	2.45	1.96	4.44	2.98	4.52	2.37	2.60	1.97	2.73	1.89	4.05	2.22	2.96	2.59

	Netherlands		Germany		Denmark		Australia		Japan	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Inventor	6.23	5.41	9.48	8.31	7.21	6.86	4.81	6.31	8.79	5.90
Assignee	6.60	1.73	5.87	2.96	2.80	2.00	2.29	5.92	7.98	3.30

TABLE B.6

Statistics on cohorts of authors whose first publication was in 2009 and who published again at least once in any year up to 2018. Decline in authors (count and percent decline) during the period 2010–2018 is shown.

	Argentina		Australia		Brazil		Canada		Germany		Denmark		Spain		EU28	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Number of Authors in Year 2	1,105	1,191	4,227	3,161	9,185	7,181	6,838	4,239	15,618	7,730	1,356	764	6,884	5,748	72,269	48,250
Decrease in Authors Per Year	-80	-94	-311	-250	-749	-624	-564	-374	-1,330	-721	-97	-63	-533	-464	-5,711	-4,041
Percent Decrease	-7.24	-7.89	-7.36	-7.91	-8.15	-8.69	-8.25	-8.82	-8.52	-9.33	-7.15	-8.25	-7.74	-8.07	-7.9	-8.38
Difference in Percent Decrease	0.65		0.55		0.53		0.57		0.81		1.09		0.33		0.47	
Difference	10%		4%		3%		4%		6%		9%		3%		4%	
N	808		2,653		4878		3232		6513		777		4281		39373	
DF	1		1		1		1		1		1		1		1	
X_2	8.93		4.396		5.073		5.638		23.235		5.686		4.23		67.013	
P	0.0028		0.036		0.0243		0.0176		<0.0001		0.0171		0.0397		<0.0001	

	France		UK		Italy		Japan		Mexico		Netherlands		Portugal		USA	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Number of Authors in Year 2	8,737	5,929	11,222	6,912	6,653	6,127	19,905	3,765	2,373	1,400	3,682	1,855	1,406	1,288	51,333	26,443
Decrease in Authors Per Year	-694	-593	-874	-586	-483	-484	-1,833	-371	-182	-114	-287	-153	-104	-94	-4,485	-2,399
Percent Decrease	-7.94	-10	-7.79	-8.48	-7.26	-7.9	-9.21	-9.85	-7.67	-8.14	-7.79	-8.25	-7.4	-7.3	-8.74	-9.07
Difference in Percent Decrease	2.06		0.69		0.64		0.65		0.47		0.45		0.1		0.34	
Difference	4%		6%		5%		4%		3%		3%		1%		3%	
N	4755		5935		4710		4973		1243		1892		1013		20374	
DF	1		1		1		1		1		1		1		1	
X_2	8.063		21.617		12.515		5.52		1.15		1.637		0.108		20.62	
P	0.0045		<0.0001		0.0004		0.02		0.2836		0.2008		0.7426		<0.0001	

Appendix C

Elsevier's 2019 Researcher Survey Results

FIGURE C.1

Summary of survey responses to the question, "Why do you think there is a lack of gender balance in your field?"

Responses were collected from 948 researchers, including 338 women and 594 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

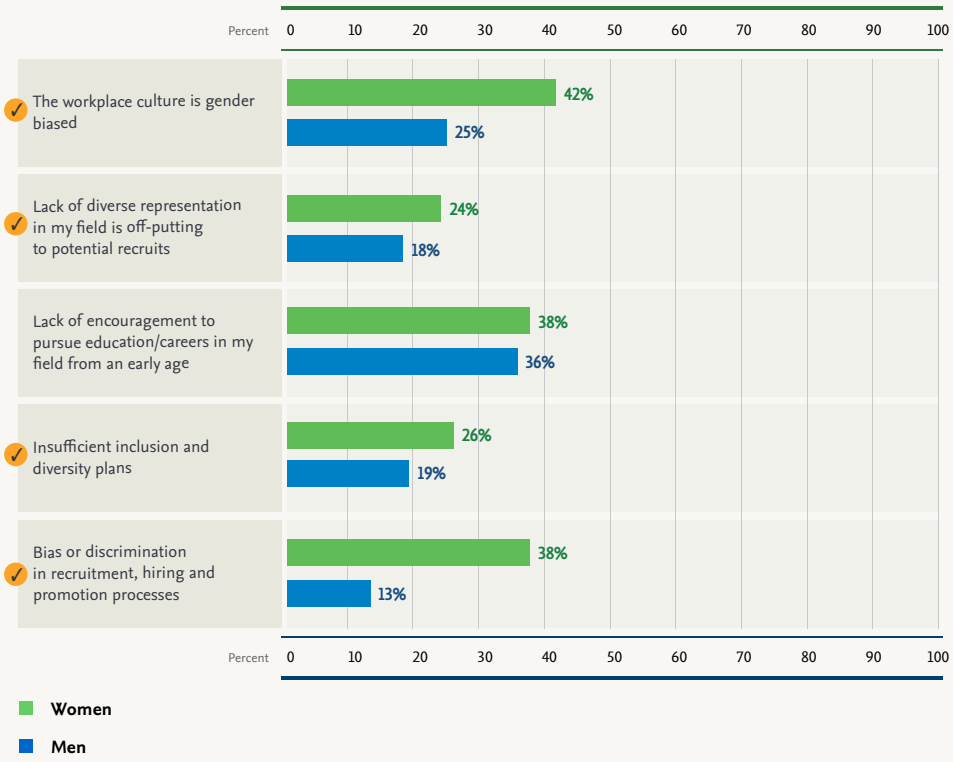


FIGURE C.2

Summary of survey responses to the question, "Do you feel the proportion [of women to men in your field] has changed over the past 10 years?"

Responses were collected from 863 researchers, including 299 women and 551 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

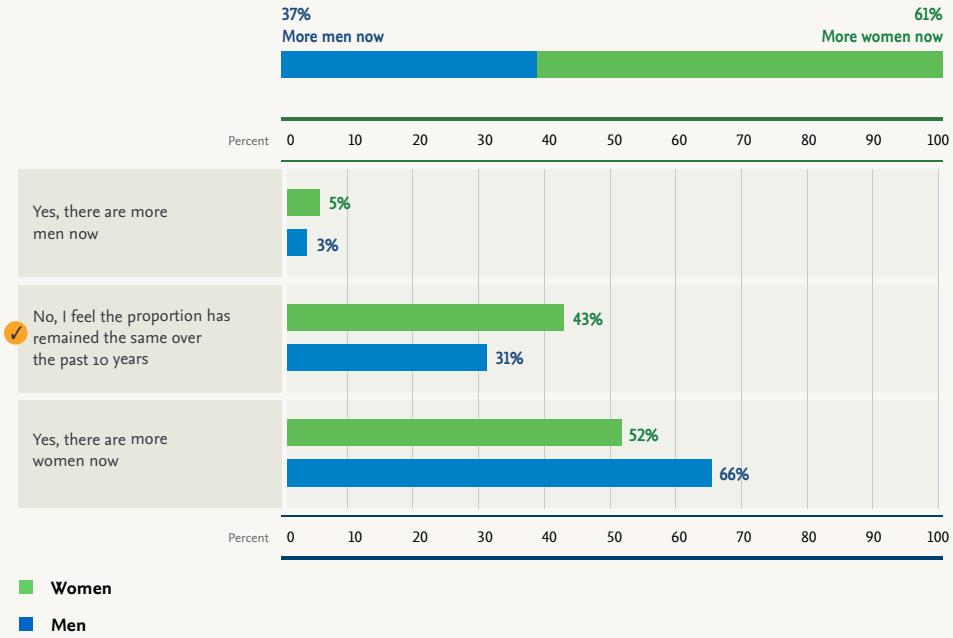


FIGURE C.3

Self-identified subject area and gender of survey respondents.

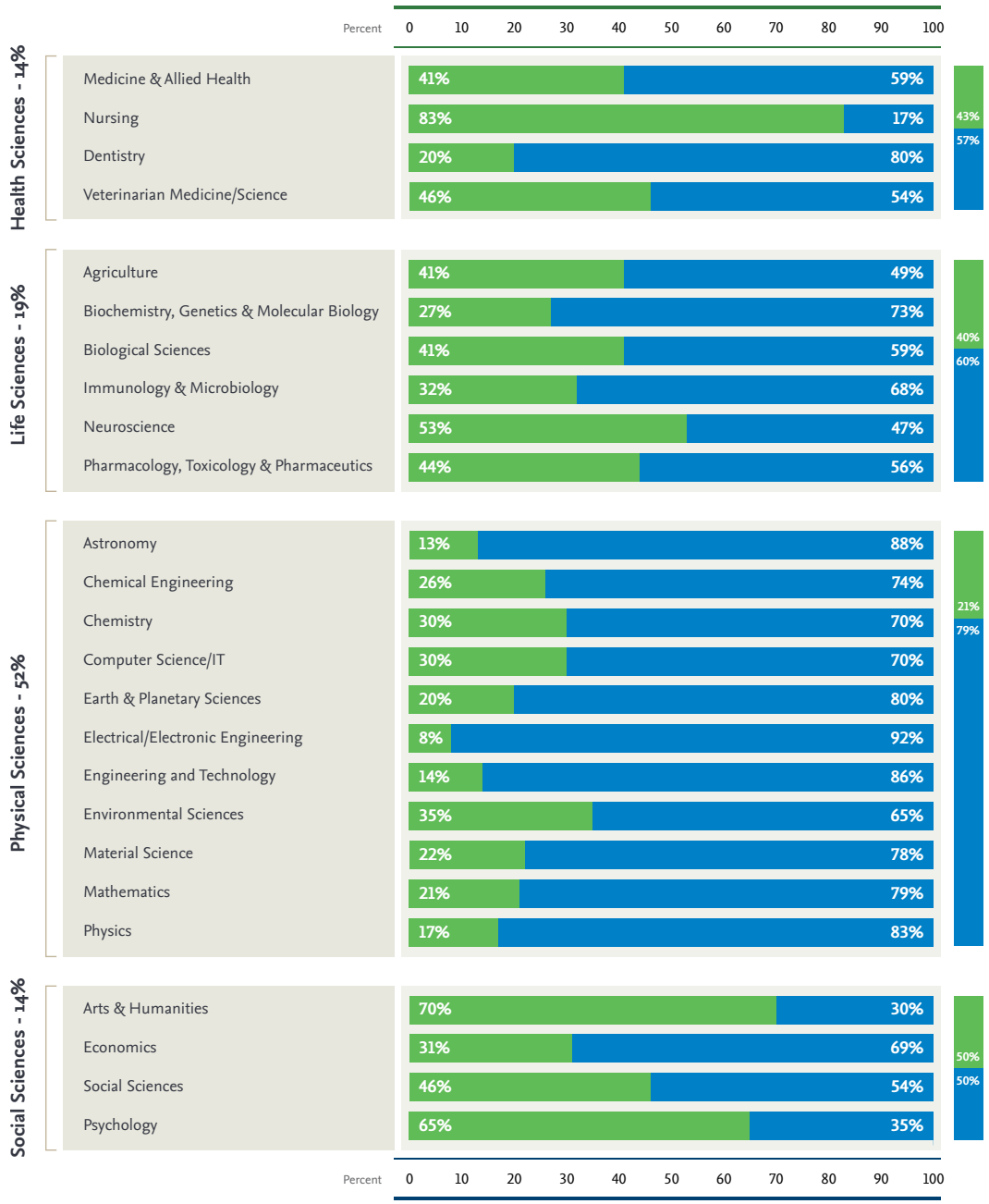


FIGURE C.4

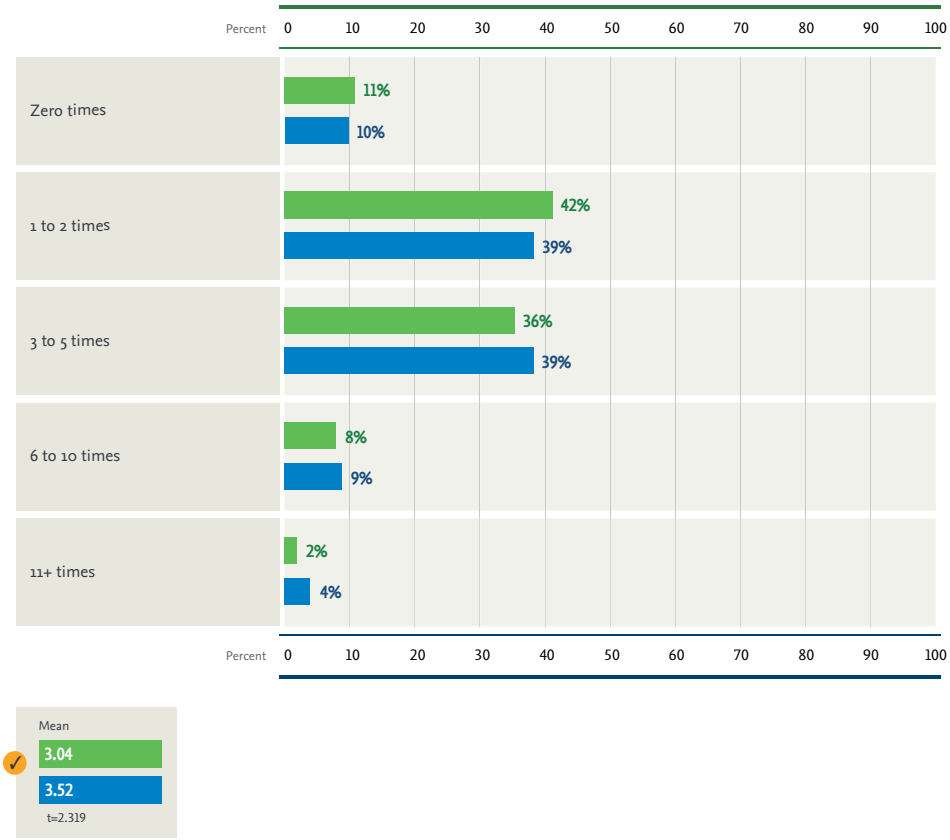
Summary of survey responses to the question, "Approximately how many times in the past year have you been invited to collaborate on a research project that could lead to a publication?". (Top) Summary of survey responses to the question, "Have you had the opportunity to be the coordinator of a collaborative research project in the last year?". (Bottom)

Responses collected from 1212 researchers, including 417 women and 773 men (Top) and 1153 researchers, including 401 women and 733 men. (Bottom) Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). A check mark indicates that the difference was statistically significant based on t-test and we can be 90% confident the difference is explained by gender ($t > 1.645$).

Women

Men

Number of times in the past year, I have been invited to collaborate



Number of times in the past year, I have invited a collaborator to collaborate

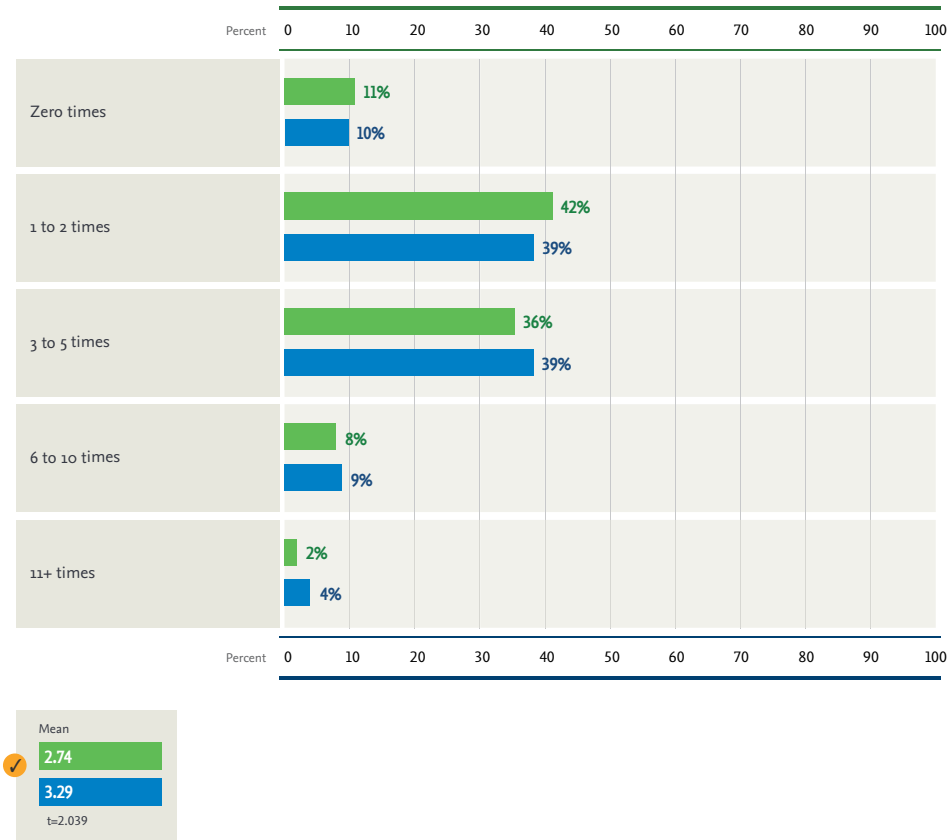


FIGURE C.5

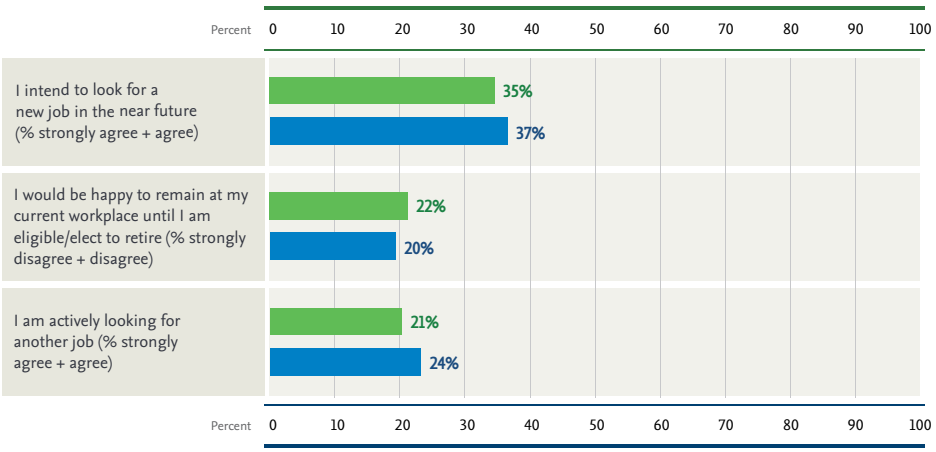
Summary of survey responses to the question, "How much do you agree/disagree with the below statements?" with possible responses being: "Strongly disagree," "Disagree," "Neutral," "Agree," "Strongly agree" and "Don't know." Responses were collected from 380 women and 685 men.

Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

Women

Men

Do you intend to change your job/workplace?



At any point as an active researcher have you contemplated changing career?

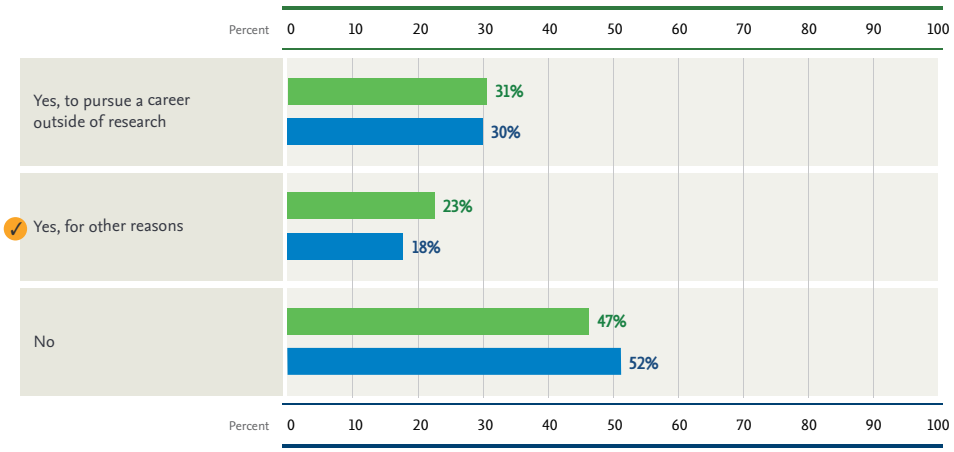


FIGURE C.5 (CON'T)

Summary of survey responses to the question, "How much do you agree/disagree with the below statements?" with possible responses being: "Strongly disagree," "Disagree," "Neutral," "Agree," "Strongly agree" and "Don't know." Responses were collected from 380 women and 685 men.

Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

Women

Men

Why have you contemplated changing careers?

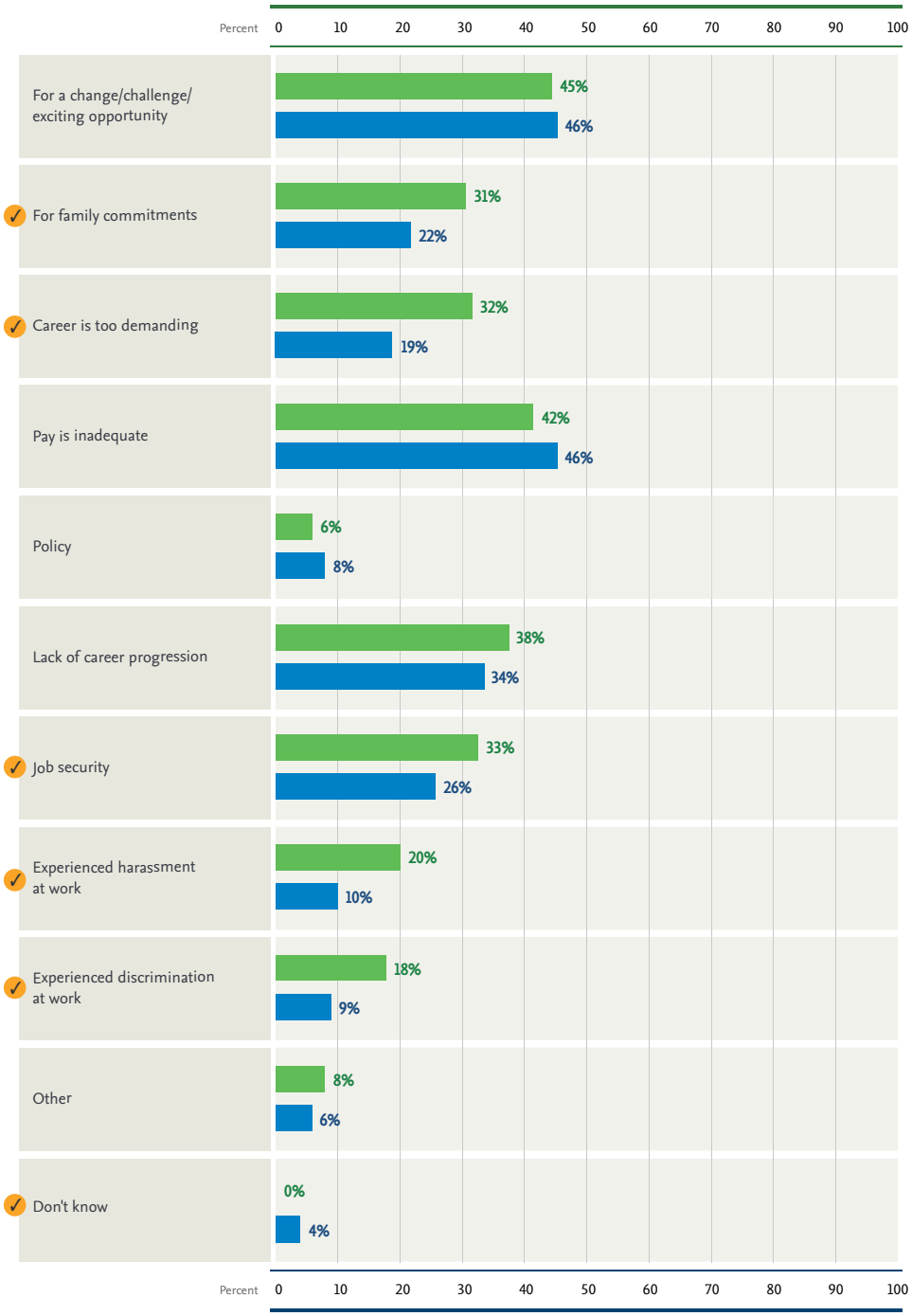
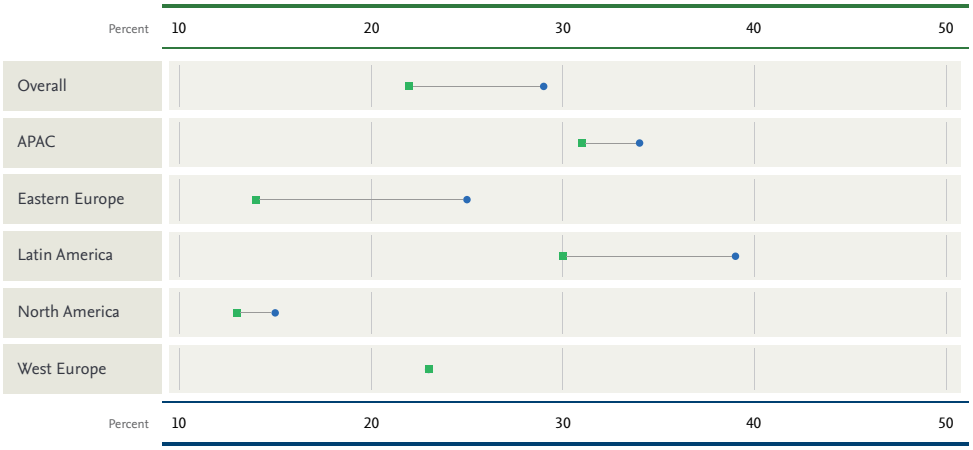


FIGURE C.6

Summary of survey responses to the statement "I am considering moving to another country to further my career in research." The figure shows the gender distribution of those respondents who agreed with the statement.

Responses were collected from 432 researchers. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data).



Women

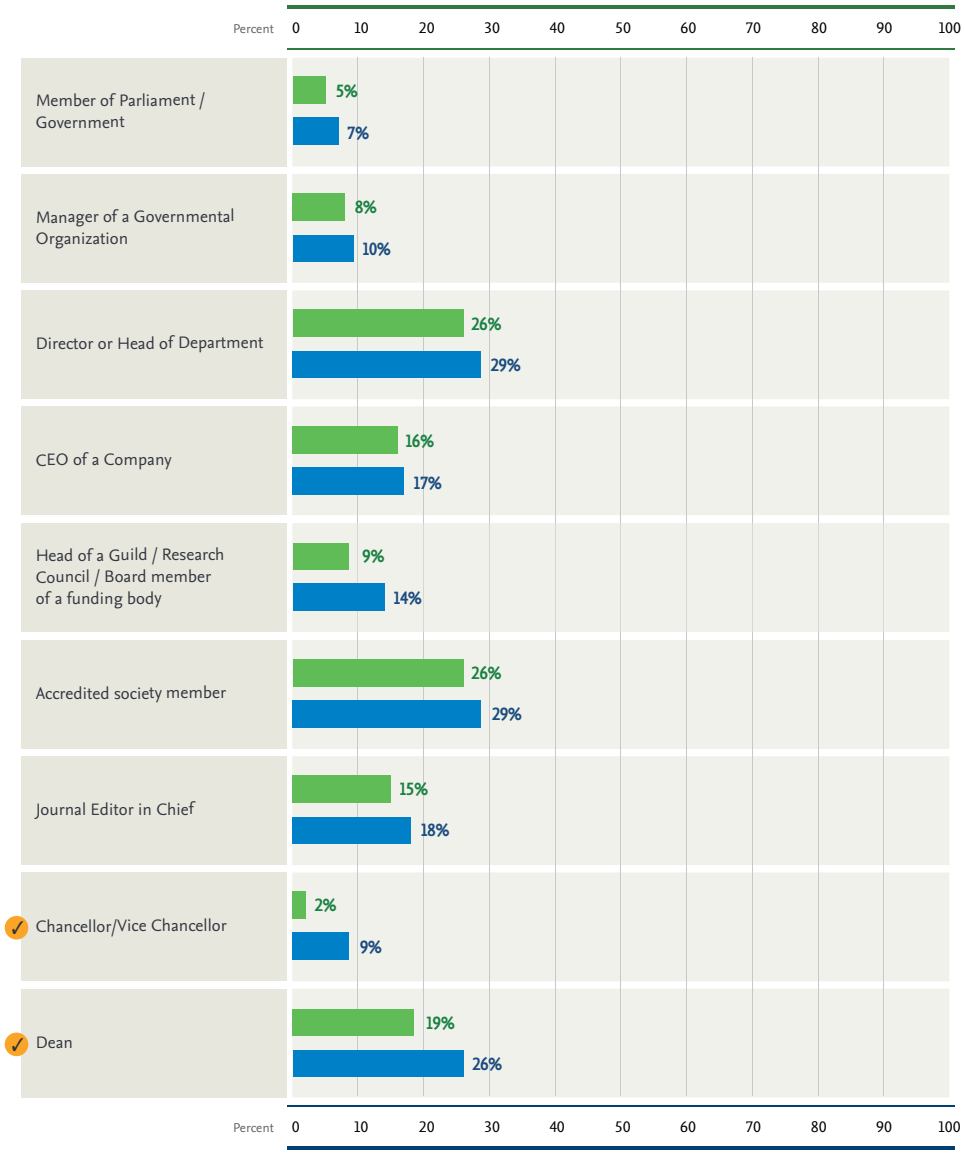
Men

FIGURE C.7

Summary of survey results to a question about who researchers "know," where "knowing" was defined as being able to remember the name of the person (job holder) and easily start a conversation when encountering them. The question was worded, "Do you know anyone who is a/an/at [this position]?" with possible responses being: "No," "Yes, as an acquaintance," "Yes, as a close friend" and "Yes, as a close family member."

Results shown here are based on those respondents who indicated knowing an individual in [this position] as a close friend or family member. Responses were collected from 1213 researchers, including 417 women and 774 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

High prestige positions



Women

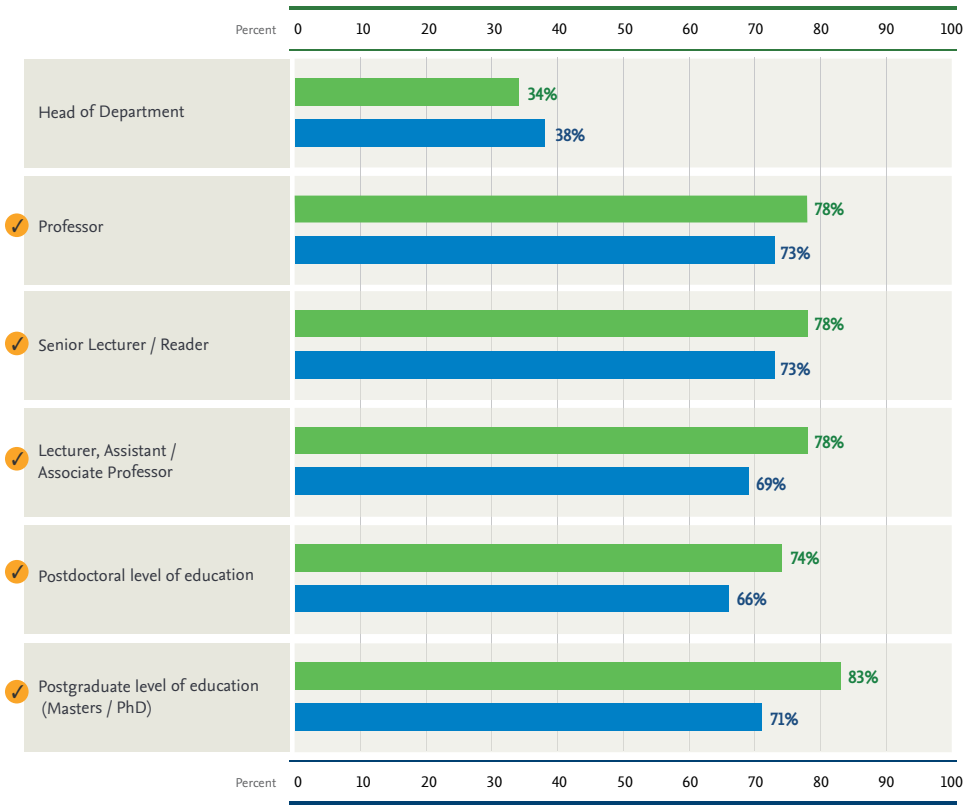
Men

FIGURE C.7 (CON'T)

Summary of survey results to a question about who researchers "know," where "knowing" was defined as being able to remember the name of the person (job holder) and easily start a conversation when encountering them. The question was worded, "Do you know anyone who is a/an/at [this position]?" with possible responses being: "No," "Yes, as an acquaintance," "Yes, as a close friend" and "Yes, as a close family member."

Results shown here are based on those respondents who indicated knowing an individual in [this position] as a close friend or family member. Responses were collected from 1213 researchers, including 417 women and 774 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

Moderate prestige positions



Women

Men

FIGURE C.8

Analysis of responses to a survey question about who researchers "know," where "knowing" was defined as being able to remember the name of the person (job holder) and easily start a conversation when encountering them. The question was worded, "Do you know anyone who is a/an/at [this position]?" with possible responses being: "No," "Yes, as an acquaintance," "Yes, as a close friend" and "Yes, as a close family member."

Results shown here are based on those respondents who indicated knowing an individual in [this position] as a close friend or family member. Responses were collected from 1213 researchers, including 417 women and 774 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). The analysis was conducted for early-career researchers (ECR), defined as those who have been in research for up to 10 years, and late-career researchers (LCR), defined as those who have more than 10 years of experience. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

Seniority differences by years in research

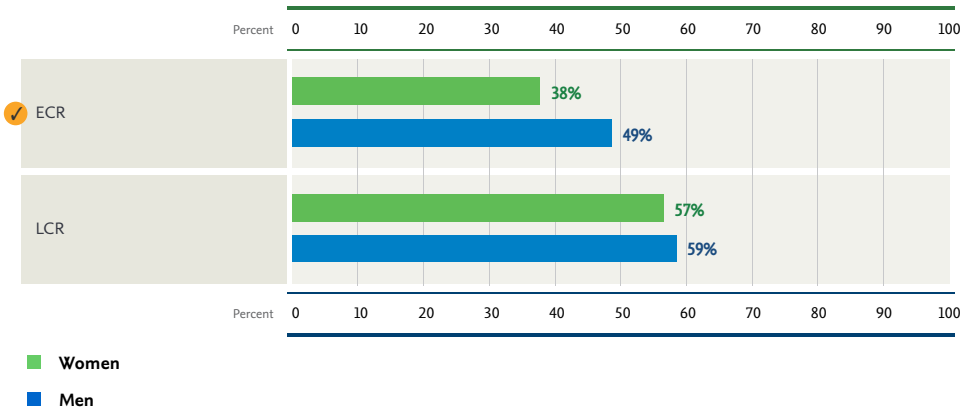
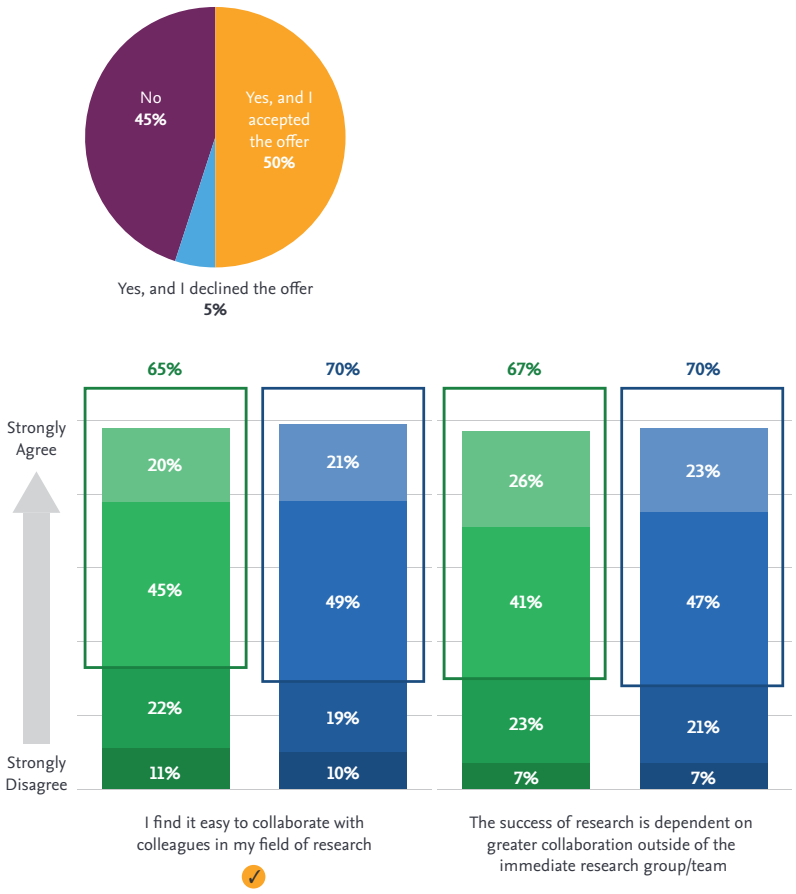


FIGURE C.9

Summary of survey responses to the question, "Have you had the opportunity to be the coordinator of a collaborative research project in the last year?" with possible responses being: "Yes, and I accepted the offer," "Yes, and I declined the offer," "No" and "Don't know."

Responses were collected from 1,153 researchers, including 401 women and 733 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).



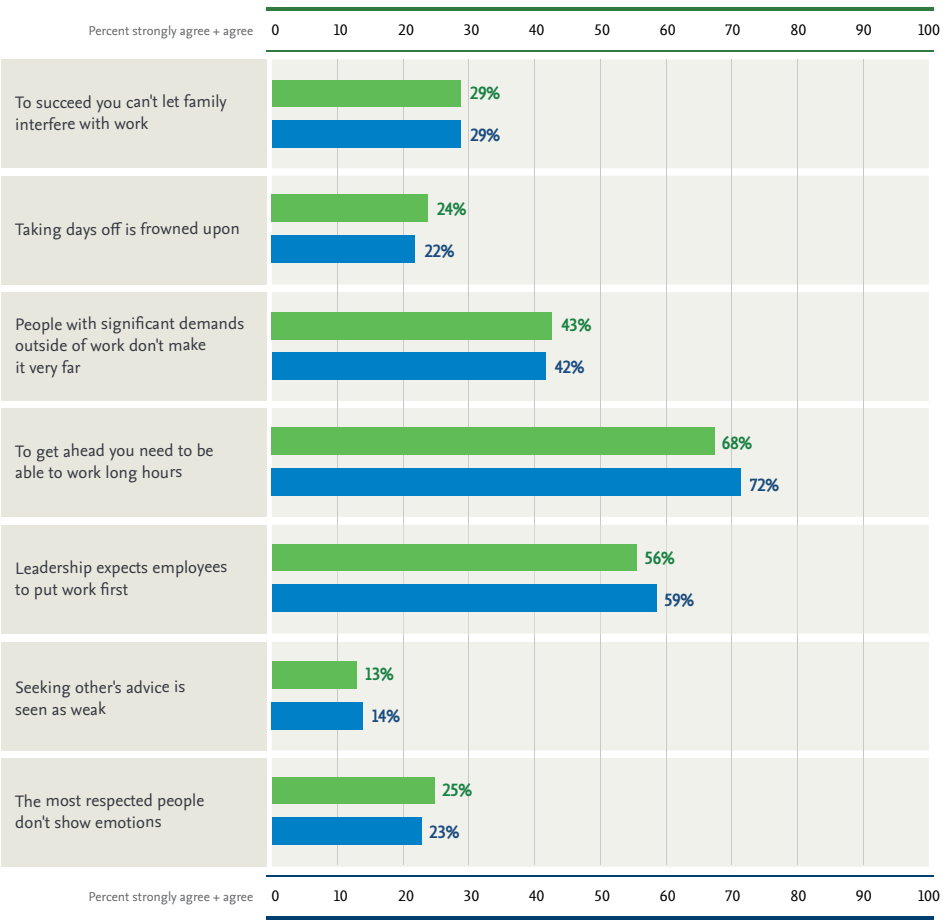
Women

Men

FIGURE C.10

Summary of survey responses to the question, "To what extent do you agree or disagree with the following statements about your work environment?" with possible responses being: "Strongly disagree," "Disagree," "Neutral," "Agree," "Strongly agree" and "Don't know."

Responses were collected from 1,158–1,207 researchers, including 400–416 women and 737–769 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. ($p < 0.10$).



Women

Men

FIGURE C.11

Summary of survey responses to the question, "What do you feel, if any, are the biggest barriers to your career progression?"

Responses were collected from 1,213 researchers, including 417 women and 774 men. Results were disaggregated by gender and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).

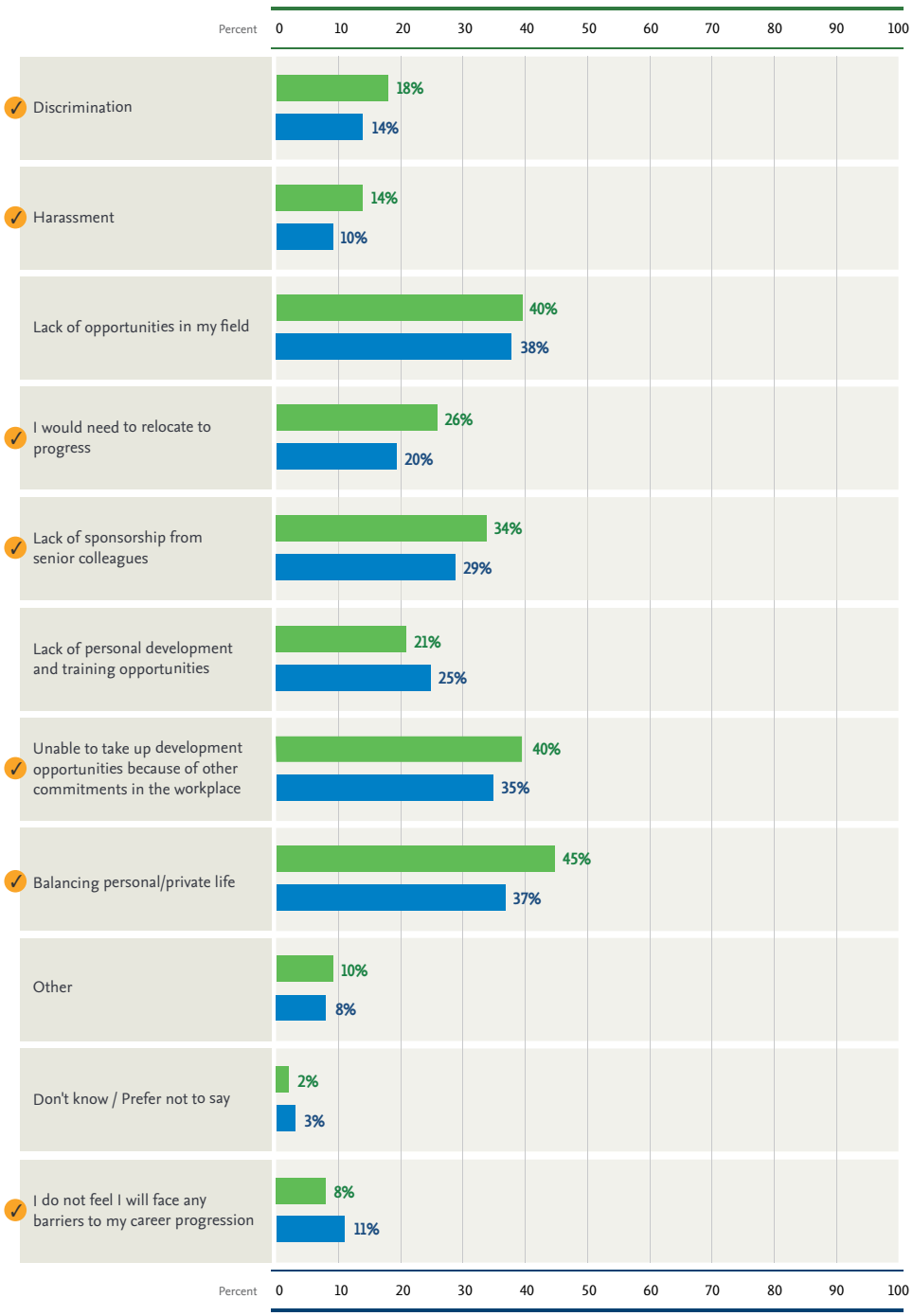
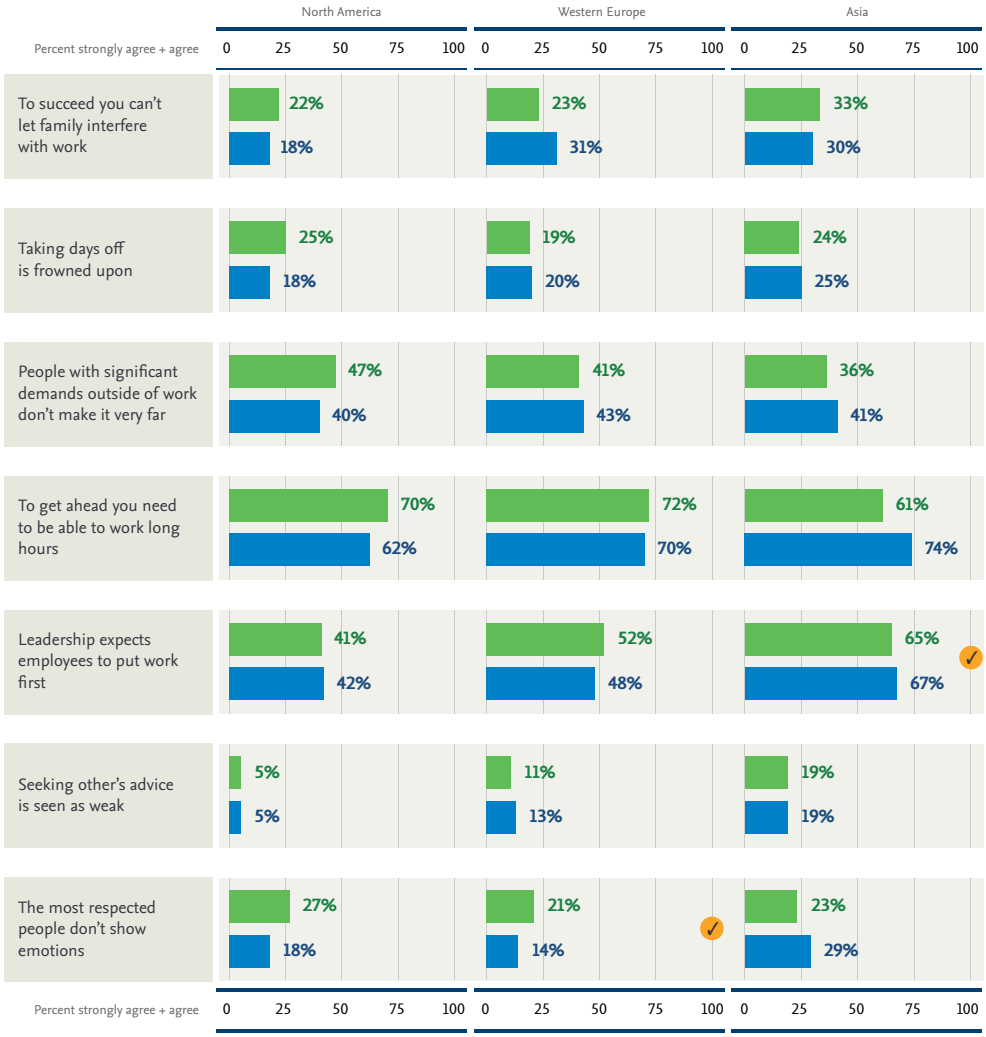


FIGURE C.12

Summary of survey responses to the question, "To what extent do you agree or disagree with the following statements about your job?" with possible responses being: "Strongly disagree," "Disagree," "Neutral," "Agree," "Strongly agree" and "Don't know."

Responses were collected from 400–416 women and 736–768 men. Results were disaggregated by gender and region and responses were weighted to be representative of the global researcher population by country (UNESCO 2014 data). Those who responded "Don't know" were excluded from the analysis. A check mark indicates that the difference was statistically significant based on Z-test of proportion and that we can be 90% confident the difference is explained by gender ($p < 0.10$).



Women

Men

Appendix D

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