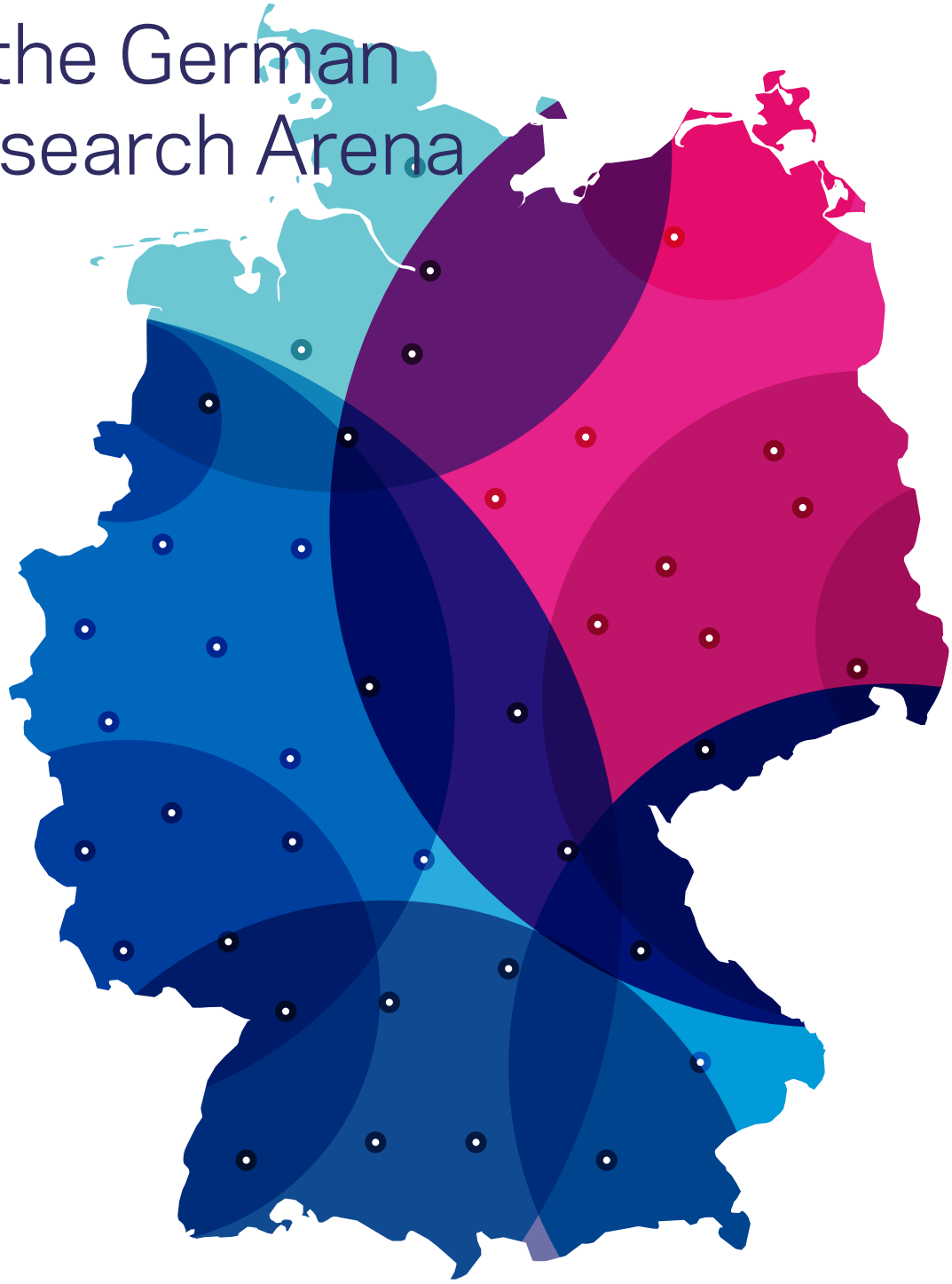
MAPPING GENDER

in the German Research Arena



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A report conducted by Elsevier

Contents

Executive Summary

"Equality is part of quality in science." Making full use of the potential of both women and men maximizes the quantity and, more importantly, quality of research.[1] Despite the policies and regulations implemented by the European Commission and within individual countries, there are prominent gaps between women and men in terms of the number of scientific researchers, decision-making positions held, and other aspects of career development such as informal networks of collaboration and access to funding.[2] It is therefore essential for future policies and interventions to act on the underlying factors causing this disparity to reduce gender differences in research systems.

The theme of gender equality is a key part of the sustainable development goals as set out by the United Nations.[3] Goal 5 aims to "achieve gender equality and empower all women and girls." Sustainability is deeply embedded within Elsevier, and this report is part of a larger initiative on sustainability.[4] Specifically, this report provides evidence and analysis on potential gender gaps in research in Germany. It combines data from Scopus®, the largest abstract and citation database in the world, with data from a large online social networking service. Linking these two sources of Big Data allows us to identify the gender of German researchers in Scopus® author profiles. The findings of the report contribute to the discussions on gender inequality in research and support the formulation of policies in the future to promote women in science.

The key findings of the report are:

1 The number and proportion of female researchers in Germany is increasing.

The number of female researchers in Germany increased from 43,728 in 2010 (28.2% of all gender-identified researchers in Germany) to 54,742 (30.9%) in 2014. A similar pattern is observed for each of the subject areas in Scopus®. However, the share of female researchers varies greatly across subject areas. In 2014, 56.6% of Germany's gender-identified researchers in Veterinary Science are female, compared to only 15.3% in Computer Science. Among senior researchers – those with more than 10 years since their first publication, the share of female researchers is almost unchanged from 2010 to 2014.

2 Female researchers in Germany tend to be less productive than their male counterparts, and their publications have lower citation impact.

The field-weighted citation impact (FWCI) of German female researchers is 1.68 in the period 2010-2014, significantly lower than that of German male researchers (1.75). We observe the same trends in research productivity: German female researchers produced on average 2.07 publications per year in the period 2010-2014 and the corresponding number for their male counterparts was 2.34. German female researchers are more productive than their male counterparts only in: Energy, Engineering, Computer Science, Material Science, the Earth and Planetary Sciences, and Physics and Astronomy, all of which are male-dominated subject areas.

1 European Commission. (2008). Mapping the maze: Getting more women to the top in research. Available at *http://ec.europa.eu/research/science-society/document_library/ pdf_06/mapping-the-maze-getting-more-women-to-the-top-in-research_en.pdf*

2 See, for example, Larivière, V., Ni, C., Gingras, Y., Cronin, B., and Sugimoto, C.R. (2013). Global gender disparities in science. *Nature* 504, 211-213, and Larivière, V., Vignola- Gagné, E., Villeneuve, C., Gélinas, P., and Gingras, Y. (2011). Sex differences in research funding, productivity and impact: An analysis of Quebec university professors. *Scientometrics*, 87(3), 483–498.

3 Information about the 17 Sustainable Development Goals can be found at *https:// sustainabledevelopment.un.org/topics*

4 See also a recently launched report conducted by Elsevier in collaboration with SciDev.net on Sustainability Science available at *http://www.elsevier.com/research- intelligence/research-initiatives/sustainability-2015*

3 Disparities in publication productivity and citation impact between female and male researchers in Germany are smaller for more senior researchers.

For German researchers who first published less than 5 years ago, the productivity of male researchers is 9.9% higher than that of female researchers. The percentage declines to 3.4% for senior researchers for whom more than 10 years have passed since their first publication. Similarly, for researchers who have been active less than 5 years, the FWCI of male researchers is 2.5% higher than that of female researchers. For researchers active for 10 or more years, the FWCI of male researchers is only 0.3% higher.

4 For Germany, female-only publications are the most internationally collaborative. Mixed-gender publications are more interdisciplinary but less internationally collaborative than mono-gender publications.

Around 48.4% of German publications with only female or only male authors in the period 2010-2014 are international collaborations (publications involving at least one co-author outside of Germany), and the corresponding number for the mixed-gender publications is only 37.6%. Female-only publications are the most internationally collaborative: 53.9% of these publications are international collaborations. In contrast, around 9.3% of the mixed-gender publications belong to the world's top 10% most interdisciplinary research (IDR), whereas only 7.5% of the mono- gender publications do.

5 In subject areas with skewed gender ratios in favor of males, female researchers are more likely to focus on similar topics as their male counterparts. In contrast, in subject areas with more balanced gender distributions, women tend to focus on different topics.

We compared key phrases appearing in the title, abstracts, and keywords of male-only publications to those in the title, abstracts, and keywords of the publications for which more than half of the authors are female. In Physics and Astronomy, a subject area with a traditionally skewed gender ratio in favor of males, female researchers tend to focus on similar topics of research as their male counterparts. In Biochemistry, Genetics and Molecular Biology, a subject area with a more balanced gender distribution, women and men focus on different topics. Women show a tendency to specialize in topics related to family and children, while men have a tendency to focus more on topics related to methodological development.

Introduction

Statistics from "She Figures 2012: Gender in Research and Innovation," published by the European Commission:

- → *In 2009, in the EU-27, women in research remained a minority, accounting for only 33% of researchers.*
- → *In 2010, the proportion of female students (55%) and graduates (59%) exceeded that of male students, but women represented only 44% of grade C academic staff, 37% of grade B academic staff, Oxford, and 20% of grade A academic staff.*
- → *The proportion of women among full professors was highest in the Humanities and Social Sciences, at 28.4% and 19.4% respectively, and lowest in Engineering and Technology, at 7.9%.*
- → *In 2010, on average throughout the EU-27, only 15.5% of institutions in the Higher Education Sector were headed by women, and just 10% of universities had a female rector.*

See http://ec.europa.eu/research/science-society/document_library/pdf_06/she- figures-2012_en.pdf for more information.

The above numbers clearly show that women are underrepresented in the scientific world in Europe. Germany is no exception: "according to the Federal Office of Statistics, around 7,945 female professors were employed in 2010. The number of female chairholders has increased from 8% to 19% since 1995, although the numbers vary considerably between individual disciplines: in Linguistics and Cultural Studies, around 30% of professors are women. In Engineering, women make up only around 9% of professorships, and around 12% in Mathematics and Natural Sciences."[5]

The literature and policy reports suggest many reasons for women's underrepresentation in the labour force in general and in academic positions in particular. In a study about gender inequality in German academia, Majcher (2002) raised women's life cycle (motherhood), segmentation of the academic labour market, institutional context (availability of childcare, organisation of work, inclusion or exclusion from informal networks), and gender discrimination as obstacles for women's career development in academia in Germany.[6] Germany has implemented various policies, programmes, and initiatives to reduce gender gaps. They include, for example, the Programme for Women Professors, initiated by the Federal Ministry of Research and Education and the 16 States of Germany, and the Centre of Excellence Women and Science,[7] which aims for the realization of equal opportunities for both women and men in science and research in Germany. Various funding bodies have specific programmes targeting women, e.g., the Christiane Nüsslein-Volhard-Foundation[8] and the UNESCO-L'ORÉAL International Fellowships for Women with Children.[9]

To properly design and implement gender equality regulations and policies, it is important to have solid data on any existing gaps and understand underlying factors. In this report, we combine rich Scopus® author data and social media gender data to identify the gender of authors in Scopus®. This report serves as a pilot project that uses this methodology to study gender related issues in research. A large-scale study on women in science at the global level will be conducted by Elsevier in the near future.

This report studies the current status of gender gaps in Germany along multiple dimensions:

- → Female-male ratio in different scientific disciplines and seniority categories (Chapter 1)
- → Publication productivity and citation impact of female and male researchers (Chapter 1)
- → Collaboration and interdisciplinarity of female- and male-authored publications (Chapter 2).
- → The relative convergence or divergence in research topics between the different genders (Chapter 3)

The results provide insights for future policies that will help achieve gender equality in the country's research base.

5 See *http://www.bmbf.de/en/494.php* and more statistics can be found at *http://www.datenportal.bmbf.de/portal/en/ Table-2.5.82.html*

6 Majcher, Agnieszka. (2002). Gender inequality in German academia and strategies for change. *German Policy Studies/ Politikfeldanalyse*, 2(3).

7 See *http://www.gesis.org/en/cews/cews-home/*

8 See *http://www.cnv-stiftung.de/en/goals.html*

9 See *http://www.unesco.de/wissenschaft/frauen-wissenschaft/unesco-loreal.html?andL=1*

CHAPTER 1

Gender Gaps in Research Performance in Germany

What percentage of German researchers are women? Are they more or less productive than their male counterparts? Are their publications more or less impactful? This chapter investigates the distribution and research performance of female and male researchers who published in the period 2010-2014 with affiliations to German institutions. Each author in Scopus® has a unique identifier through which we can identify all the publications, affiliations, and citations of that author to form a profile. Throughout the report, we use "researchers" when referring to indicators that are based on these author profiles containing all the information we have for each author, and use "authors" to refer to the authors of each publication. Researchers that do not publish are not covered by this study. We explore the share of female researchers in different subject areas and seniority categories, and compare the productivity and citation impact of the publications by female and male researchers.

1.1 Distribution of Female Researchers

Many studies find that the research landscape is largely dominated by men, but that the share of female researchers is increasing.[10] Our findings confirm the same trend for Germany. Figure 1 (left) presents the share of female researchers out of all researchers with affiliations to German institutions who published in each subject area. In 2010, we identified 43,728 female German researchers and 111,605 male researchers, which means that 28.2% of all German researchers[11] were female in 2010. This percentage increases to 30.9% in 2014. These ratios are significantly lower than the ratio of female PhD recipients and college graduates in Germany - 50.1% in 2012 according to Eurostat.[12] Our finding is consistent with the SHE figures 2012 which shows that 25% of German researchers are female and that Germany has one of the lowest percentages of female researchers in Europe. The top three European countries with the highest share of female researchers in 2009 are Latvia (52%), Lithuania (51%), and Bulgaria (48%).[13]

Female researchers tend to concentrate in subject areas such as Medicine, the Social Sciences and related subject areas.[14] Again, our findings are in line with this. In 2014, 56.6% of Germany's researchers in Veterinary Science are female, while in Computer Science the corresponding number is only 15.3%. In general, Agriculture, Medicine, and Health related subject areas have the highest share of female researchers. Subject areas in the Natural Sciences and Engineering have the lowest shares.[15] However, across all subject areas, the share of female researchers increased from 2010 to 2014, suggesting a reduction in the gender gap in terms of the ratio between the number of female and male researchers.

If we combine the findings above, one plausible explanation of Germany's relatively low share of female researchers among European countries is its research focuses in Physical Sciences and Mathematics – traditionally male-dominated fields. According to Elsevier's report for the UK's Department of Business, Innovation and Skills, relative to the world average Germany has 18% more research activity in Physical Sciences and 12% more in Mathematics.[16]

Figure 1 (right) focuses on senior German researchers – those for which at least 10 years have elapsed since their first publication was captured in Scopus®. We see that the share of women among senior researchers (19.0% in 2014) is smaller than that among all researchers, suggesting that throughout their careers, a proportion of women move out of the world of science.[17] The percentage is almost unchanged from 2009 to 2014 (18.9% in 2009 and

10 See, for example, the She Figures 2012 and 2015 published by the European Commission at *http://ec.europa.eu/research/ science-society/document_library/pdf_06/she-figures-2012_en.pdf* and *http://ec.europa.eu/research/swafs/pdf/ pub_gender_equality/she_figures_2015-leaflet-web.pdf*, and Larivière, V., Ni, C., Gingras, Y., Cronin, B., and Sugimoto, C.R. (2013). Global gender disparities in science. *Nature* 504, 211-213.

11 For this and all subsequent analyses, when we refer to "all German researchers," we are specifically referring to German researchers whose names our algorithm was able to assign a gender. The total number of German researchers (including those whose names our algorithm was not able to assign a gender) is 491,545 for the period 2010-2014, among which we can assign gender to 405,508 researchers. See Appendix B for more details.

12 See Eurostat, Graduates in ISCED 5 and 6 (based on 1997 standard) by age and sex, at *ec.europa.eu/eurostat/ product?code=educ_grad4*

13 See *http://ec.europa.eu/research/science-society/document_library/pdf_06/she-figures-2012_en.pdf* for more information.

14 See, for example, the She Figures 2012, and Naldi, F., Luzi, D., Valente, A., and Parenti, I. V. (2005). Scientific and technological performance by gender. In Handbook of Quantitative Science and Technology Research, Springer.

15 This is consistent with Frietsch, R., Haller, I., Funken-Vrohlings, M., and Grupp, H. (2009). Gender-specific patterns in patenting and publishing. *Research Policy*, 38(4), 590–599. They found the highest share of women's publications in Biology and Bio-medicine in Germany.

16 The report is available at *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf*

17 This is consistent with the general findings in other studies that there is a "leaky" pipeline from female graduates to female postdocs to female assistant professors and to female tenured professors. See for example,
- Sheltzer, J. M., and Smith, J. C. (2014). Elite male faculty in the life sciences employ fewer women. *Proceedings of the National Academy of Sciences of the United States of America*, 111(28), 10107–12.
- Sexton, K. W., Hocking, K. M., Wise, E., Osgood, M. J., Cheung-Flynn, J., Komalavilas, P., … Brophy, C. M. (2012). Women in academic surgery: The pipeline Is busted. *Journal of Surgical Education*, 69(1), 84–90.
- Shaw, A. K., and Stanton, D. E. (2012). Leaks in the pipeline: separating demographic inertia from ongoing gender differences in academia. *Proceedings. Biological Sciences* / The Royal Society, 279(1743), 3736–41.
- Wolfinger, N. H., Mason, M. A., and Goulden, M. (2008). Problems in the pipeline: Gender, marriage, and fertility in the ivory tower. *Journal of Higher Education*, 79(4), 388–405.

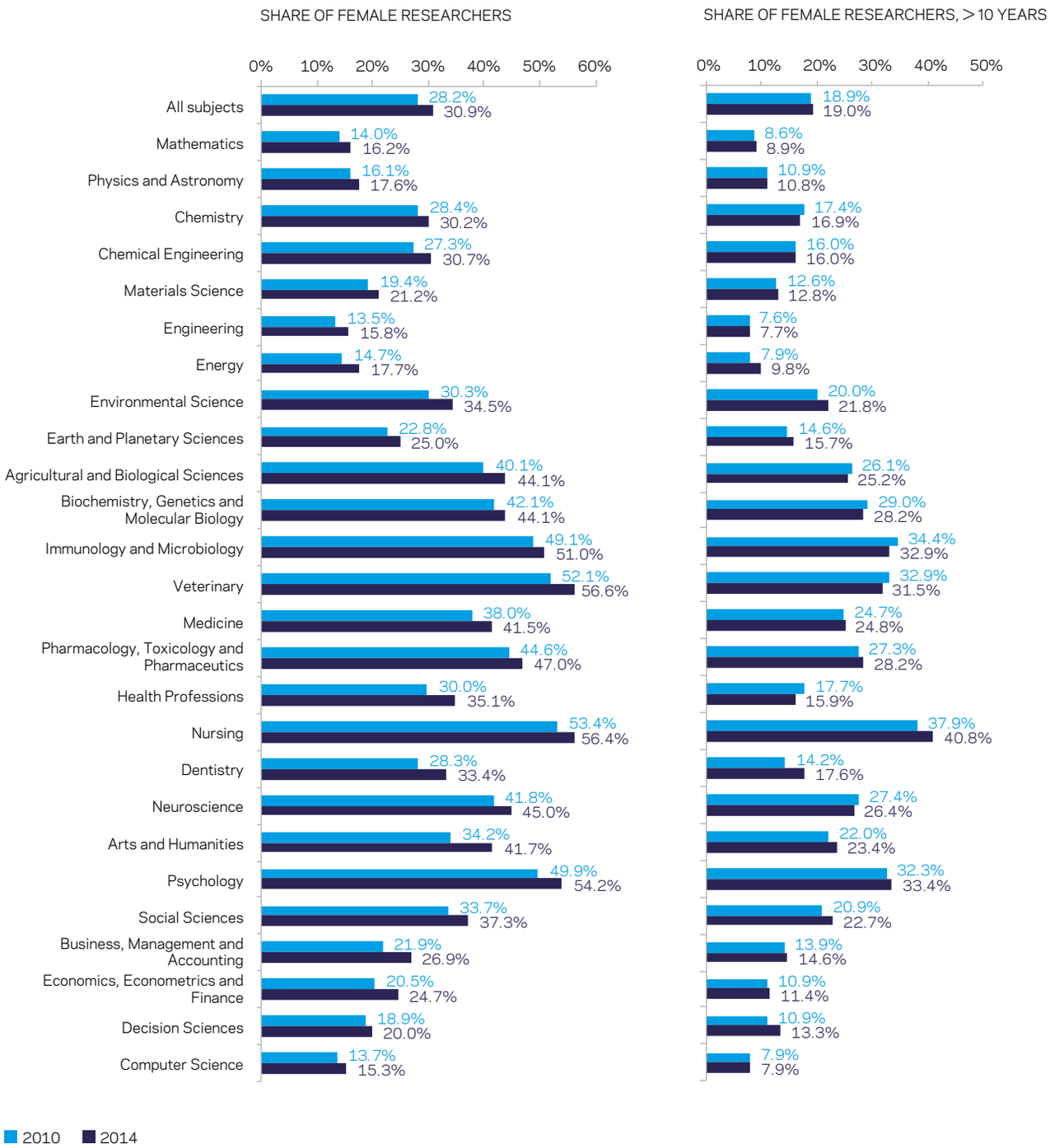


Figure 1 — *Share of female researchers out of all researchers who published in each subject area (left) and the same share but for researchers with more than 10 years since first publication (right); per subject; for Germany; 2010 and 2014. Subjects are ordered from Natural Sciences and Engineering, to Medicine and Social Sciences.*

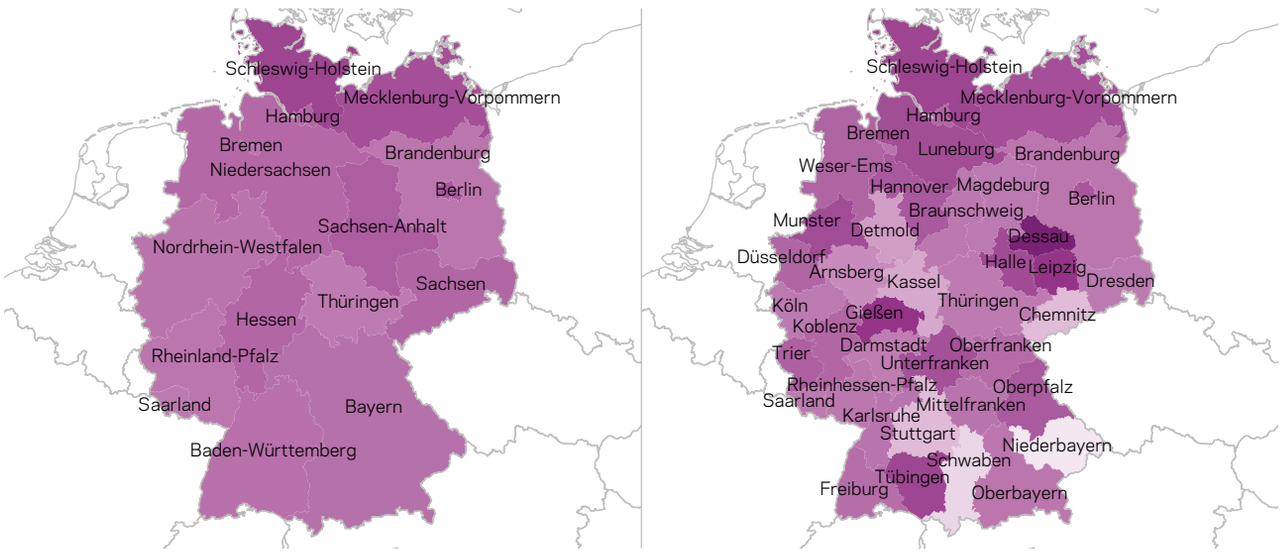


Figure 2 — *Share of female researchers per state/NUTS1 region (left) and per government region/NUTS2 region (right); all subjects; for Germany; 2010-2014.*

19.0% in 2014) for all subject areas combined. Looking at the percentage for the different subject areas, we see an increase in subject areas related to the Social Sciences and Arts and Humanities, and also in Environmental Science and Nursing.

The share of female researchers is similar across states in Germany (Figure 2, left). Schleswig- Holstein has the highest shares at 40.2%. Thüringen has the lowest share at 32.6%.[18] We see more variations at the government region level (Figure 2, right).[19] Dessau, Leipzig, Giessen, Schleswig-Holstein, and Tübingen have the highest shars of over 40%, but in Stuttgart, Chemnitz, Schwaben, and Niederbayern, the shares are below 25%.

18 In this analysis only the researchers affiliated with the most prolific 315 Germany institutions are included. We did not have enough geo information to locate the rest of the authors. The share of female researchers is around 34% if we restrict the sample to researchers affiliated with these 315 institutions, slightly higher than that for overall German researchers.

19 EUROSTAT divided Germany into 16 Nomenclature of Territorial Units for Statistics 1 (NUTS1) and 39 NUTS2 regions. NUTS1 matches the states in Germany and NUTS2 matches the government regions in Germany. See *http://ec.europa.eu/ eurostat/web/nuts/overview* for more information.

1.2 Research Productivity

Although more women are taking up research positions and the ratio between female and male researchers in Germany is increasing, male researchers are still more productive. In the period 2010-2014, German female researchers produced on average 2.07 publications per year, significantly lower than male researchers' 2.34 (Figure 3).[20] This applies to most of the subject areas which implies that women's lower productivity is not caused by their concentration in subject areas with a relatively low number of publications per years.

However, German female researchers are more productive than German male researchers in: Energy, Engineering, Computer Science, Material Science, the Earth and Planetary Sciences, and Physics and Astronomy, all of which are male-dominated subject areas. In Physics and Astronomy, female researchers publish 4.03 publications per year, compared to 3.27 publications per year for male researchers.

Almost all past studies have similar findings on women's productivity in research. In summarizing these findings, Larivière et al. (2011)[21] note that recent studies show that female researchers publish between 70% and 80% as many articles as their male counterparts,[22] a remarkable improvement since the 1990's, when female researchers published on average 50 to 60% as many articles as their male counterparts.[23]

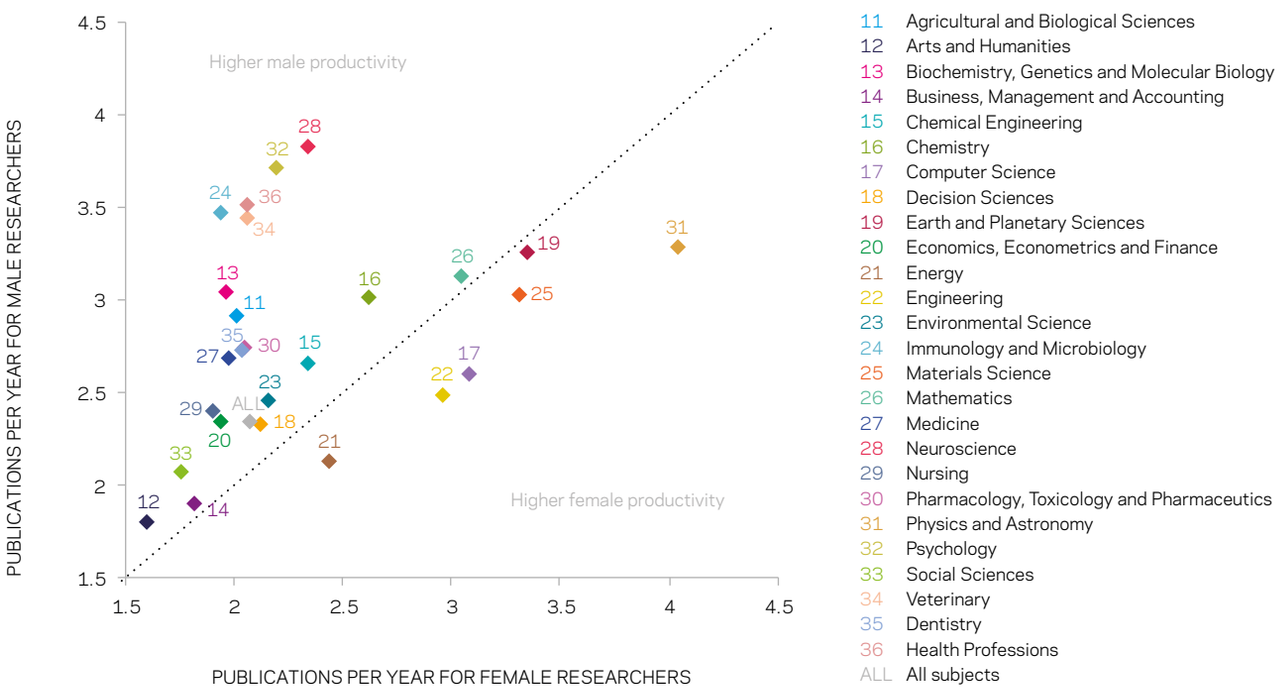


Figure 3 *— Publications per year for female and male researchers; per subject; for Germany; 2010-2014*

20 A Mann-Whitney test at the author level shows that the difference between the productivity of male and female researchers is significant at the 1% level. The difference is significant at the 10% level for all subject areas except for the subject Nursing.

21 Larivière, V., Vignola-Gagné, E., Villeneuve, C., Gélinas, P., and Gingras, Y. (2011). Sex differences in research funding, productivity and impact: An analysis of Quebec university professors. *Scientometrics*, 87(3), 483-498.

22 Fox, M. F. (2005). Gender, family characteristics, and publication productivity among scientists. *Social Studies of Science*, 35(1), 131-150, and Prpic, K. (2002). Gender and productivity differentials in science. *Scientometrics*, 55(1), 27-58.

23 Zuckerman, H. (1991). The careers of men and women scientists: A review of current research. In H. Zuckerman, J. Cole, and J. Bruer (Eds.), The outer circle: Women in the scientific community (pp. 27-56). New York: W.W. Norton and Company, and Xie, Y., and Shauman, K. A. (1998). Sex differences in research productivity: New evidence about an old puzzle. *American Sociological Review*, 63(6), 847-870.

24 Leahey, E. (2006). Gender differences in productivity. Research specialization as a missing link. *Gender and Society*, 20(6), 754-780, and Leahey, E. (2007). Not by productivity alone: How visibility and specialization contribute to academic earnings. *American Sociological Review*, 72, 533-561.

Figure 4 summarizes the total number of researchers, the share of female researchers, and the ratio between the productivity of female and male researchers in one chart. Subject areas are organized clockwise from the Natural Sciences and Engineering to Medicine and the Social Sciences. It is clear that female researchers concentrate on the left half of the chart (denoted by the length of the pie slices). However, female researchers are less productive than their male counterparts in these subject areas (denoted by the pink colour). In subject areas in which female researchers only occupy a small portion of the researcher population such as Computer Science, Physics and Astronomy, and Engineering, female researchers are more productive than their male counterparts (denoted by the blue colour of the pie slices).

Past research suggests that the selection of research topics and the level of specialization may account for the gap between male and female researchers' performance.[24] It is possible that in male-dominated subject areas, women are more likely to specialize in similar topics to men and achieve a similar or even higher level of productivity. We investigate the research topics of female and male researchers in more detail in Chapter 3.

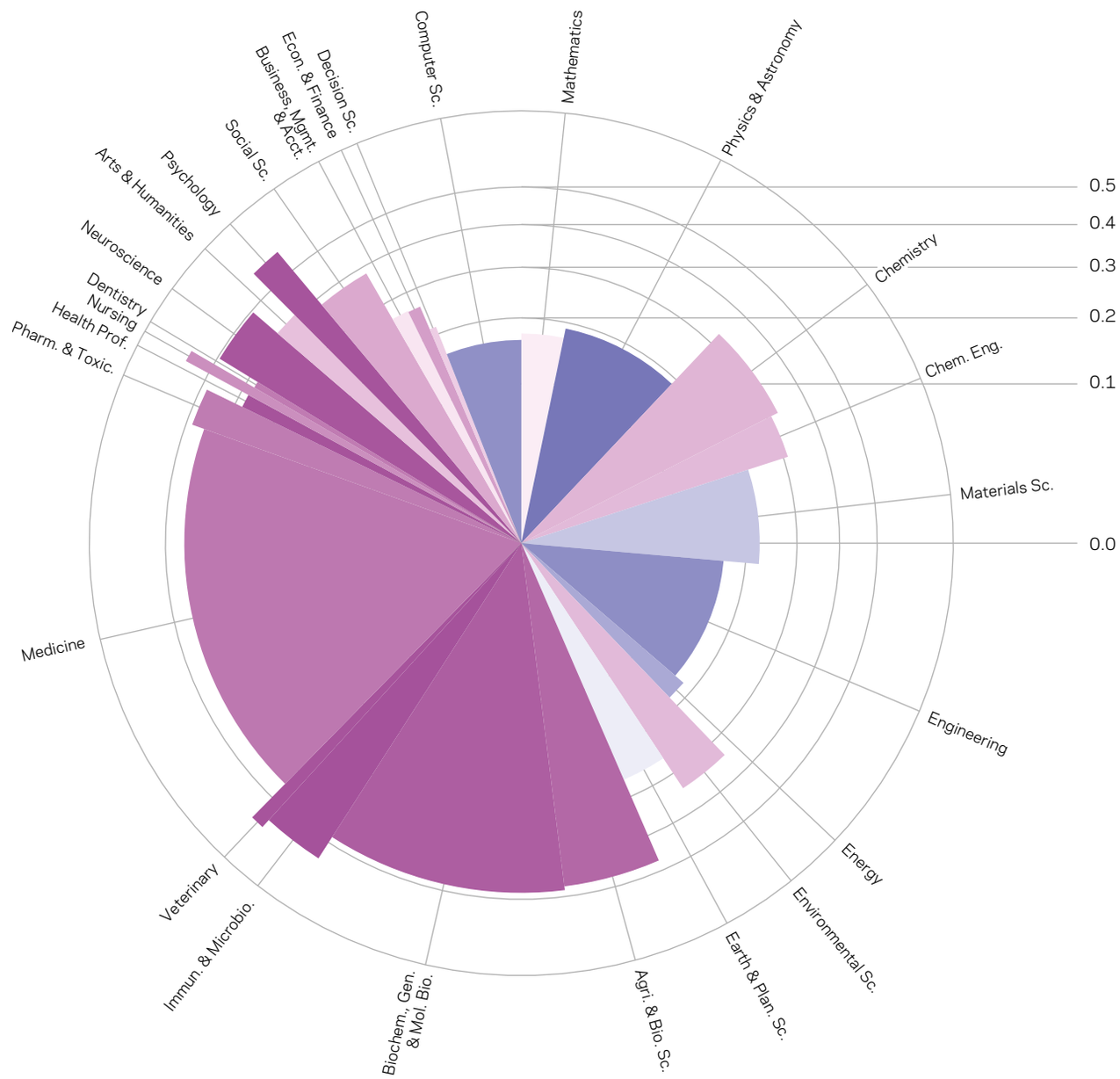


Figure 4 *— The number of researchers (denoted by the size of pie slices), the share of female researchers out of all researchers who published in each subject area (denoted by the length of pie slices), and the ratio between the productivity of female and male researchers (denoted by the colour of pie slices; the ratio between the productivity of female and male researchers increases when the colour changes from pink to blue); per subject; for Germany; 2010-2014.*

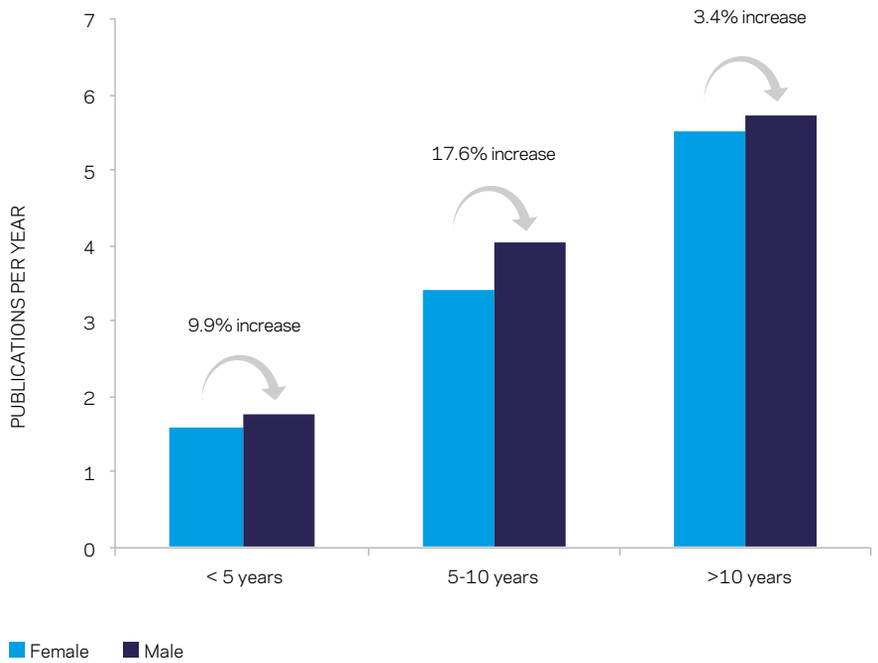


Figure 5 *— Publications per year by seniority category; all subjects; for Germany; 2010-2014.*

When talking about gender gaps, past research suggests that seniority is a key moderating variable that may explain the differences between the research performance between male and female researchers: due to changing historic trends in the shares of female researchers who receive doctorates and pursue academic careers, females researchers tend to be more junior (Figure 1) and, therefore, are less productive than male researchers who are more senior.[25] Because of cohort replacement, the differences between women and men will be reduced when the younger generations of female researchers reach a more senior level. In Figure 5, we present the productivity of German female and male researchers by seniority category. Researchers are divided into three categories: those for which less than 5 years have elapsed since their first publication, 5 to 10 years since first publication, and more than 10 years. Naturally, more senior researchers are more productive. Across all three categories of seniority, male researchers have higher productivity than female researchers. However, the difference between the productivity of female and male researchers varies by their level of seniority. For the most junior category (< 5 years), male researchers are 9.9% more productive than their female counterparts. The percentage increases to 17.6% for researchers in the category of 5 to 10 years, and dropped significantly to 3.4% for the most senior category.

The biggest gap appears at the middle-senior level (5-10 years). At this level, 32.9% of the researchers are women, which is not a big decline from the 39.4% at the junior level (< 5 years). However, the gender productivity gap increases dramatically at this level, and subsequently, women encounter major difficulties in the career ladder: only 19.0% of the German senior researchers (those with more than 10 years of publishing history) are female.

Women who do reach the senior level have very similar productivity levels as men (5.53 versus 5.72 publications per year in the period 2010-2014).

1.3 Citation Impact

In the previous section, we show that female researchers, especially junior and middle-senior female researchers, are less productive than their male counterparts. Do female and male researchers also differ in the citation impact of their research? Past findings in the literature are mixed. Some found similar and even higher levels of impact of women's publications in certain subject areas,[26] and some indicated lower citation impact of women's research.[27]

We use an indicator called field-weighted citation impact (FWCI) to measure citation impact. It is a normalized citation count that takes into consideration the differences in citing behaviour across disciplines, years, and different document types, and is one of the most sophisticated indicators in the modern bibliometric toolkit.

In the period 2010-2014, across all subject areas, the average FWCI of German female researchers is 1.68 (Figure 6), significantly lower than that of male researchers (1.75).[28] However, the FWCI of female researchers' output in Business, Management and Accounting, Nursing, Decision Science, Earth and Planetary Sciences, Physics and Astronomy, and the Arts and Humanities, was higher than that of their male counterparts.[29] The difference is the largest in the Arts and Humanities in which the FWCI of female researchers is 1.42 and that of male researchers is 1.20.

Gender gaps in FWCI mainly occur at the junior and middle-senior levels and almost disappear at the senior level (Figure 7). These findings suggest the critical

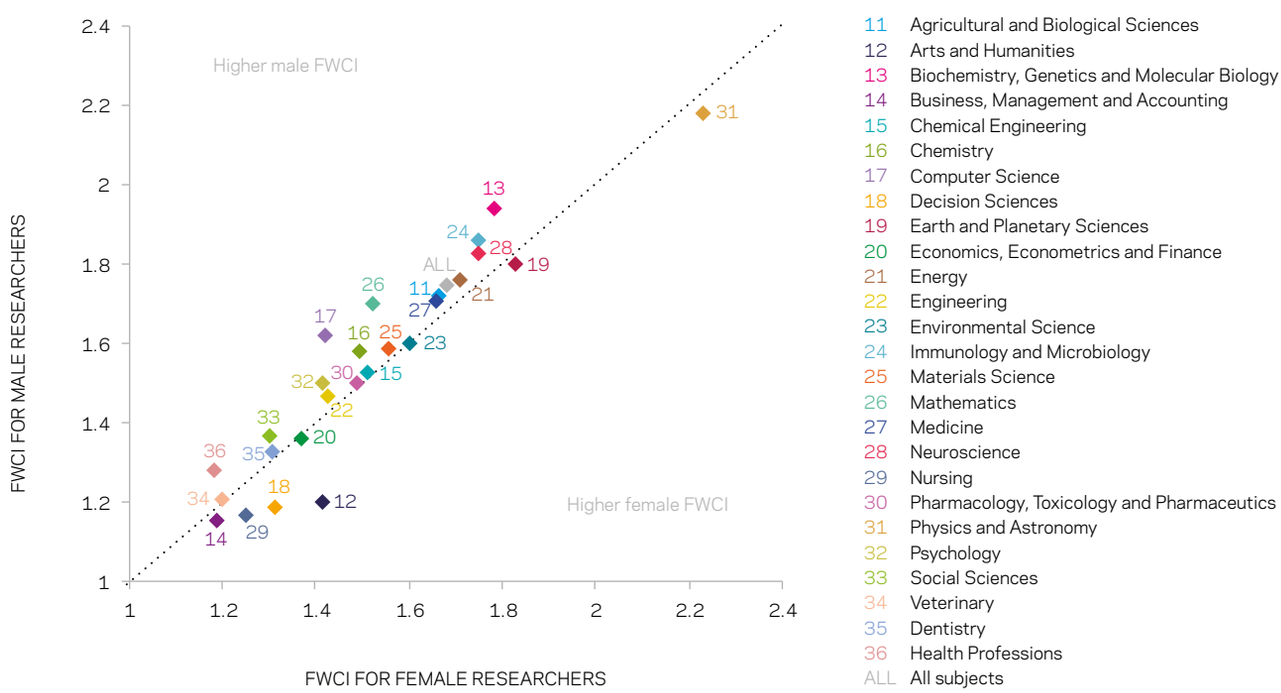


Figure 6 *— FWCI for female and male researchers; per subject; for Germany; 2010-2014.*

25 Van Arensbergen, P., van der Weijden, I., and van den Besselaar, P. (2012). Gender differences in scientific productivity: a persisting phenomenon? *Scientometrics*, 93(3), 857-868.

26 Bordons, M., Morillo, F., Fernández, M. T., and Gómez, I. (2003). One step further in the production of bibliometric indicators at the micro level: Differences by gender and professional category of scientists. *Scientometrics*, 57(2), 159-173, and Borrego, A., Barrios, M., Villarroya, A., and Ollé, C. (2010). Scientific output and impact of postdoctoral scientists: A gender perspective. *Scientometrics*, 83(1), 93-101.

27 Peñas, C. S., and Willett, P. (2006). Brief communication: Gender differences in publication and citation counts in librarianship and information science research. *Journal of Information Science*, 32, 480-485.

28 A Mann-Whitney test at the researcher level shows that the difference between the FWCI of German female and male researchers is significant at the 1% level.

29 Mann-Whitney tests show that the difference is significant at the 10% level for all subject areas except Economics, Econometrics and Finance, Physics and Astronomy, Psychology, Veterinary, Dentistry, and Health Professions.

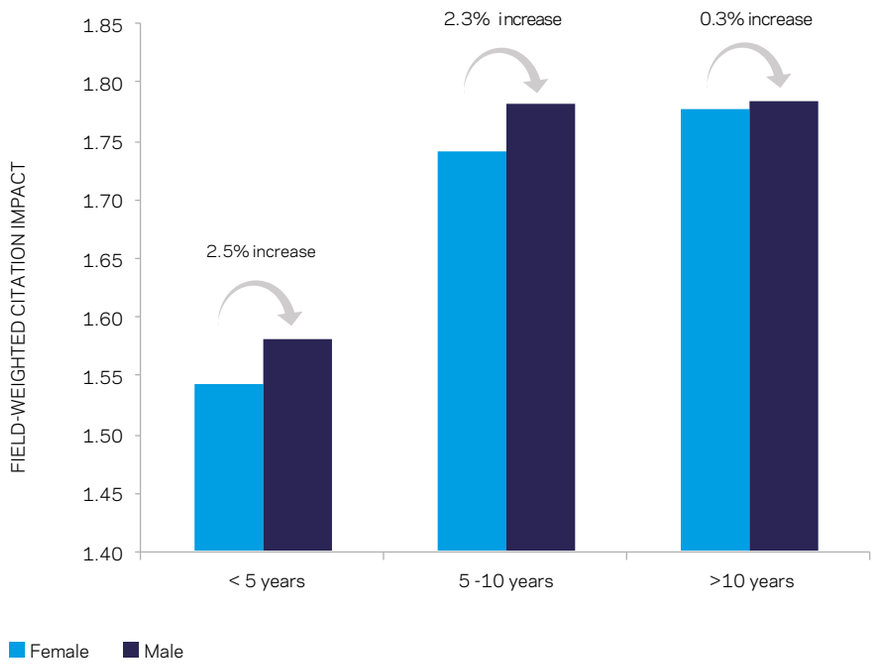


Figure 7 *— FWCI by seniority category; all subjects; for Germany; 2010-2014.*

importance and necessity of supporting junior and middle-senior female researchers so they do not lag behind their male counterparts at these two levels. In Germany, there are multiple programmes targeted at young/junior researchers but none of them target female junior researchers in particular.[30] Future funding programmes may need to take this into consideration to support junior female researchers pursuing academic career.

30 See "German Funding Programmes for Scientists and Researchers" which listed the funding opportunities available for German researchers, available at *http://www.research-in-germany.org/en/research-funding/funding-programmes.html*

INTERVIEW WITH PROF MARTINA SCHRAUDNER

"A real business case to include more women in science"

Martina Schraudner, PhD, is a professor of Gender and Diversity in Organisations at the Department of Engineering Design, Micro and Medical Technology (IKMM) at the Technical University of Berlin. Originally trained on Biology and Biotechnology, her research currently focuses on the integration of different perspectives in the innovation process. Martina Schraudner is also the Head of the Fraunhofer Center for Responsible Research and Innovation and has served in several innovation committee of the German government. She is a member of the Expert Group "Structural Change" of the EU as well as of the advisory board of the association "total equality e.V." which stands for Total Quality Management (TQM) with the addition of the gender component "equality". It bestows awards for exemplary activities in terms of human resource management aimed at providing equal opportunities.

The German Funding Agency DFG stated in their Research-Oriented Standards on Gender Equality in 2008 that Gender equality enhances research quality because it enlarges the talent pool, promotes diversity of research perspectives, and eliminates blind spots regarding the significance of gender in research contents and methods. Germany has been struggling for some years now to increase the number of women in research. Multiple measures have been developed to promote gender equality: 1) government financed instruments, such as support for working mothers and infrastructure for care duties; 2) commitment from top institutional level, for example by the German Rectors' Conference (HRK); 3) targeted governmental funded programmes, for instance the Professorinnenprogramm; and even 4) quotas for women in decision making bodies and promotion boards in research organisations and universities. These are important steps and make slow and uneven progress towards increasing the share of women in research.

"Hot spots" for women in research

This report shows what an increased share of women in science mean for the German research landscape: not only the number of female researchers, but also the number of female authors has increased significantly in the last four years. It is good news that in regions with a longer tradition of equal opportunity efforts, the proportion of female authors is higher than in other regions. This report has identified "hot spots" for women in research where more significant progress has been made.

Difference in productivity between male and female researchers

However, the report also shows that women do not seem as productive as men, especially female researchers at Post Doc level (up to five years after first publication). This is an important time slot in scientific career, because during that period the decision to stay in sciences is made not only by women themselves, but also by the promotion bodies.

This difference in publication productivity is especially large in female dominated fields such as Nursing, Dentistry, Psychology, and Social Sciences. In selected male-dominated fields, surprisingly, women seem to be more productive than men. This indicates that the small number of women that make it to this level is highly performing. This effect seems to be dependent on the size of the group. More research is necessary to understand the reasons behind these effects.

Female researchers provide added value

The most exciting results of the report are how team composition affects the outcome of research: the findings indicate that publications from teams with both men and women are more interdisciplinary than those authored by researchers of the same gender. And secondly, that publications with a high female-author ratio tend to focus on different topics compared to male-only publications in a subject area, in which the gender ratio is more balanced. This finding outlines a real business case to include more women in science and delivers evidence-based arguments for stronger participation of women in science.

Many research organizations and universities strive to support more interdisciplinary research and to explore new research fields. In 2006, the German Rectors' Conference already announced that "insufficient participation by women compromises efficiency and excellence in academia." This report provides new insights to governments and the European Commission by showing that the goal to promote interdisciplinary research and to open up new research fields will be achieved more quickly by including more women in science.

CHAPTER 2

The Impact of the Gender Composition of Research Teams on Performance

Past research shows that diversity in teams leads to greater performance in a variety of contexts.[31] In particular, recent research suggests that gender-mixed research teams produce publications that achieve higher citation impact than all-male or all-female researcher teams.[32] In this chapter, we investigate this further by exploring the relationship between gender-author ratio and the performance of publications in terms of their citation impact. We further analyse whether gender-mixed research is more likely to involve international collaborators or be interdisciplinary.

2.1 Citation Impact

The great majority of the world's publications (87.9% in 2014) have more than one author. This implies that the majority of publications either involve collaborations among multiple male or female researchers, or are mixed-gender publications. We divided all German publications in the period 2010-2014 into 22 ordinal categories accordingly to their female-author ratio. The first category includes publications with no female authors (i.e., female-author ratio equal to zero). The second category consists of publications with no male authors (i.e., female-author ratio equal to one). Out of 708,786 publications produced by at least one author affiliated with German institutions in the period 2010-2014, we can identify the gender of at least one author for 681,361 publications.[33] Out of these publications, 162,437 (23.8%) are male-only publications and 20,950 (3.1%) are female-only publications. We then divided the rest of the mixed-gender publications into 20 categories based on their female-gender ratio, i.e., 0-0.05, 0.05-0.1,..., 0.95-1.

Figure 8 shows the relation between female-author ratio and the FWCI of the publications. The x-axis presents the average female-author ratio in each of the 22 categories and the y-axis presents the corresponding average FWCI of the publications belonging to the category. We see a negative relation between the two variables, suggesting that the higher the ratio of women among authors, the lower the FWCI of the publication. Publications from male-only teams have an FWCI of 1.40, similar to Germany's average FWCI in the same period, but the FWCI of publications from female-only teams is only 1.23.[34]

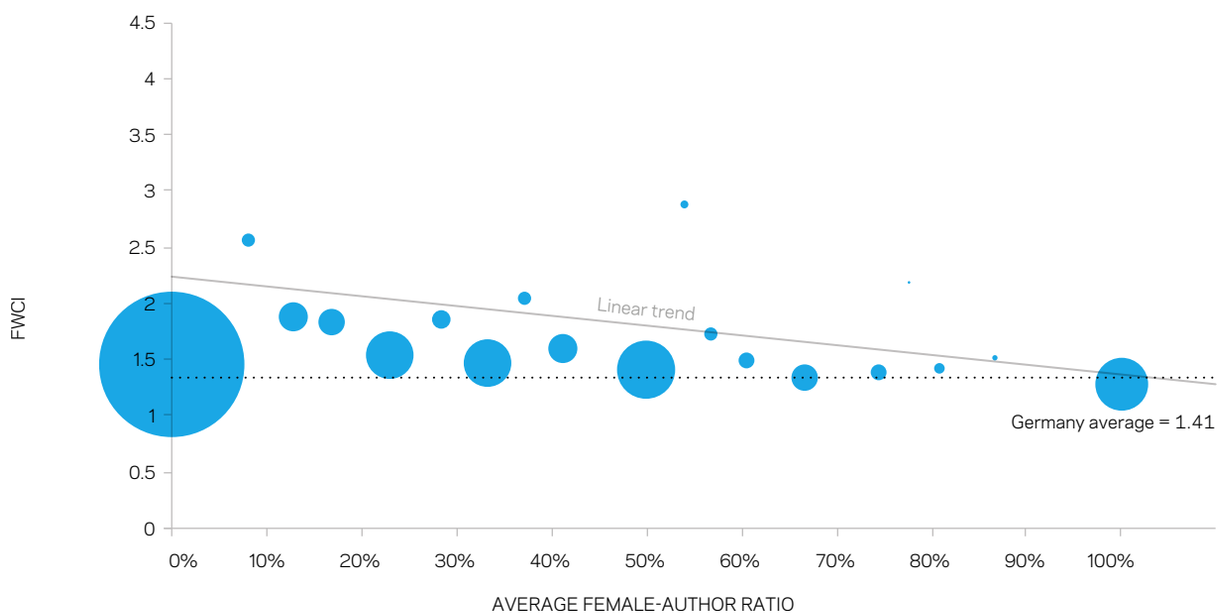


Figure 8 *— The relation between FWCI and female-author ratio for publications; all subjects; for Germany; 2010-2014. Bubble size denotes the number of publications belonging to the female-author ratio category. The line in grey is the linear trendline.*

31 Herring, C. (2009). Does diversity pay?: Race, gender, and the business case for diversity. *American Sociological Review*, 74(2), 208 -224; Hong, L., and Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences of the United States of America*, 101(46), 16385-9.

32 Campbell, L. G., Mehtani, S., Dozier, M. E., and Rinehart, J. (2013). Gender-heterogeneous working groups produce higher quality science. *PloS One*, 8(10), e79147.

33 For 255,765 publications, the gender of all authors is identified. All results in Chapter 2 were conducted using both samples of publications (at least one author's gender is identified and all authors' gender is identified). The conclusions in this chapter are robust to which sample is used; for simplicity, in the main text, we report only the results using the first and larger sample.

34 We performed two tests at the publication level to see whether the result is significant. We first regressed FWCI on female- author ratio and the number of authors. The result shows a significantly negative relationship between the first two variables at the 1% level - the higher the female-author ratio the lower the FWCI. We also conducted a Mann-Whitney test to see whether the FWCI of female-only publications is statistically equal to that of male-only publications. The hypothesis of equality is rejected at the 1% significance level, implying that on average publications with only female authors have significantly lower FWCI than the ones with only male authors.

2.2 International Collaboration

Germany's research is highly internationally collaborative. In the period 2010-2014, 45.5% of Germany's publications involve at least one author with a foreign affiliation.[35] Many studies suggest that international collaboration is associated with higher citation impact because internationally collaborative publications are more likely to be exposed to a larger researcher network and therefore are more likely to be read and cited.[36]

How does the female-author ratio affect the rate of international collaboration? Figure 9 shows the relation between female-author ratio and the share of internationally collaborative publications out of all publications in each female-author ratio category. In general, publications from male-only and female-only teams have a higher share of international collaborations: 48.4% of these publications from mono-gender teams involve international collaborations, whereas the corresponding number for publications from mixed-gender teams is only 37.6%.[37] One possible reason is that researchers may view international collaboration and cross-gender collaboration as achieving the same goal of increasing the diversity of the team. Therefore, when male and female researchers already collaborate on research, they may have less incentive to search for opportunities for international collaboration.

If we compare only the extent of international collaboration of publications with female-only or male-only teams, there is a higher share of international collaborations among publications from female-only teams: 53.9% of publications from female-only teams involve international collaborations compared to only 47.7% from male-only teams.[38] Although international collaboration is usually associated with higher FWCI, publications from female-only teams are more likely to be international collaborations, and such publications are associated with a lower FWCI than those from male-only teams.

The literature has indicated the existence of "old boy networks", in which access to collaboration is heavily influenced by informal networks composed exclusively of male academics that comprise a large portion of senior academics.[39] This may increase the obstacles for women to collaborate with top researchers and reduce the benefits from collaboration.

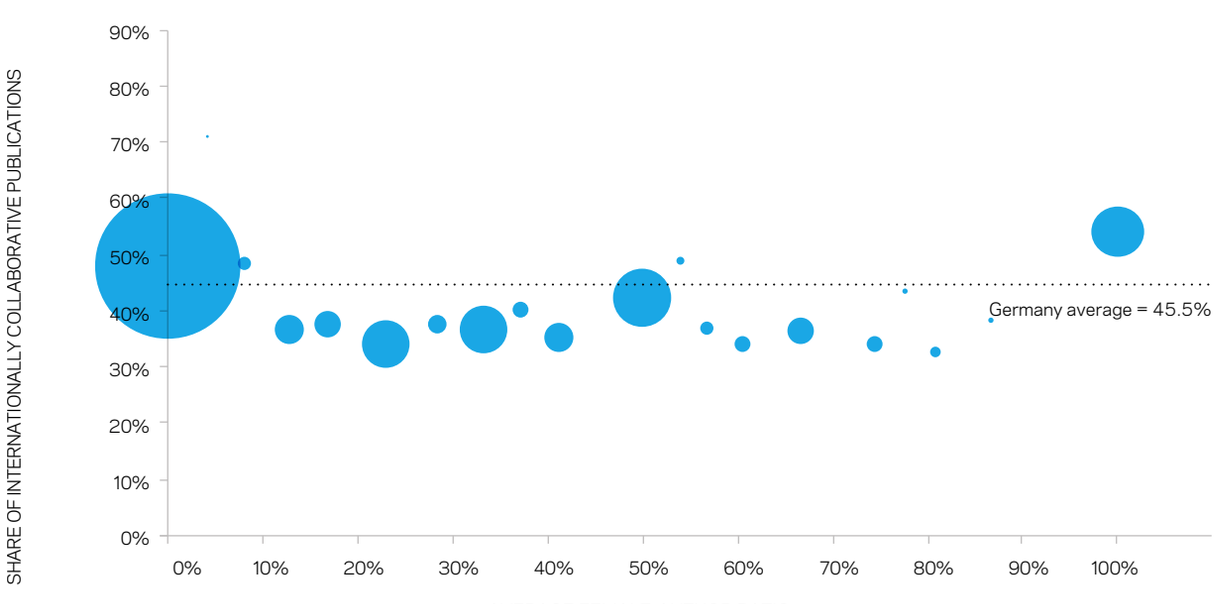


Figure 9 *— The relation between international collaborations and female-author ratio for publications; all subjects; for Germany; 2010-2014. Bubble size denotes the number of publications in the female-author ratio category.*

2.3 Interdisciplinary Research

Interdisciplinary research (IDR) that integrates knowledge from multiple disciplines has great potential to generate breakthroughs in science and research and to tackle the most difficult challenges the world is facing today.[40] Past studies however also raise the challenges of conducting IDR which may lead to lower FWCI of IDR.[41]

Are publications from mixed-gender teams more likely to be interdisciplinary? Figure 10 shows the relation between female-author ratio and the share of the world's top 10% most IDR. Our measure of IDR is based on the diversity of article references. The further apart in terms of discipline the journals in which the references of an article are published, the more likely the article belongs to IDR.

Figure 10 indicates that publications from mixed-gender teams comprise a higher share of the world's top 10% most IDR: around 9.3% of publications from mixed-gender teams belong to the world's top 10% IDR, while the number for mono-gender publications is 7.5%.[42] This implies that the diversity in gender composition is associated with the integration of knowledge from different disciplines. We also see in Figure 10 that publications from female-only or male-only teams do not show significant differences in the share of world's top 10% most IDR.[43]

The literature has offered many explanations why women researchers are more likely to conduct IDR than male researchers, which may shed light on our findings.[44] They argue that women are more apt to connect ideas to a larger context, less bound to the norms of science, more inclined towards group work, and more likely to be attracted to a new discipline. Our results however suggest that it is not women researchers who are more likely to conduct IDR, but the increased interaction and collaboration between men and women on mixed-gender teams that are more likely to lead to IDR. Policies that aim to stimulate IDR and those that foster gender equality through providing collaboration opportunities to women may achieve both of these two objectives at once.

35 The world average is 17.4%.

36 See for example Elsevier's report for the UK's Department for Business, Innovation and Skills "International Comparative Performance of the UK Research Base – 2013", available at *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative- performance-of-the-UK-research-base-2013.pdf*

37 A Binomial Proportion Test conducted at the publication level show that the mono-gender publications have significantly (at the 1% significance level) higher share of international collaborations than the ones with mixed-gender authors. We also regress a dummy variable indicating the publication is international collaboration on a dummy variable indicating whether it is a mono-gender publication and the number of authors. The results suggest that there is a significantly positive relation between international collaboration and whether publications have mono-gender authors.

38 A Binomial Proportion Test at the publication level shows that publications with only female authors have a significantly (at the 1% significance level) higher share of international collaborations.

39 Fox, M. F. (1991) Gender, environmental milieu, and productivity. In H. Zuckerman, J. Cole, and J. Bruer (Eds.), The Outer Circle: Women in the Scientific Community (pp. 188–204). New York: W.W. Norton and Company.

40 See, for example, Heinze, T., Shapira, P., Rogers, J. D., and Senker, J. M. (2009). Organizational and institutional influences on creativity in scientific research. *Research Policy* 38, 610-623, and Hemlin, S., Allwood, C. M., and Martin, B. R. (Eds) (2004). Creative knowledge environments: the influences on creativity in research and innovation. Edward Elgar, Cheltenham, UK.

41 See, for example, Bruce, A., Lyall, C., Tait, J., and Williams, R. (2004) Interdisciplinary integration in Europe: the case of the Fifth Framework programme. *Futures* 36, 457-470.

42 A Binomial Proportion Test conducted at the publication level show that the publications with only male or female authors have significantly (at the 1% significance level) lower share of interdisciplinary research than the ones with mixed-gender authors. We also regressed a dummy variable indicating the publication belongs to the world's top 10% IDR on a dummy variable indicating whether it is a mono-gender publication and the number of authors. The results suggest that there is a significantly positive relation between IDR and whether a publication has mixed-gender authors.

43 A Binomial Proportion Test shows that there is no significant difference between male-only and female-only publications in terms of the share of world's top 10% IDR.

44 See Rhoten, D., and Pfirman, S. (2007). Women in interdisciplinary science: Exploring preferences and consequences. *Research Policy*, 36(1), 56–75 for a review.

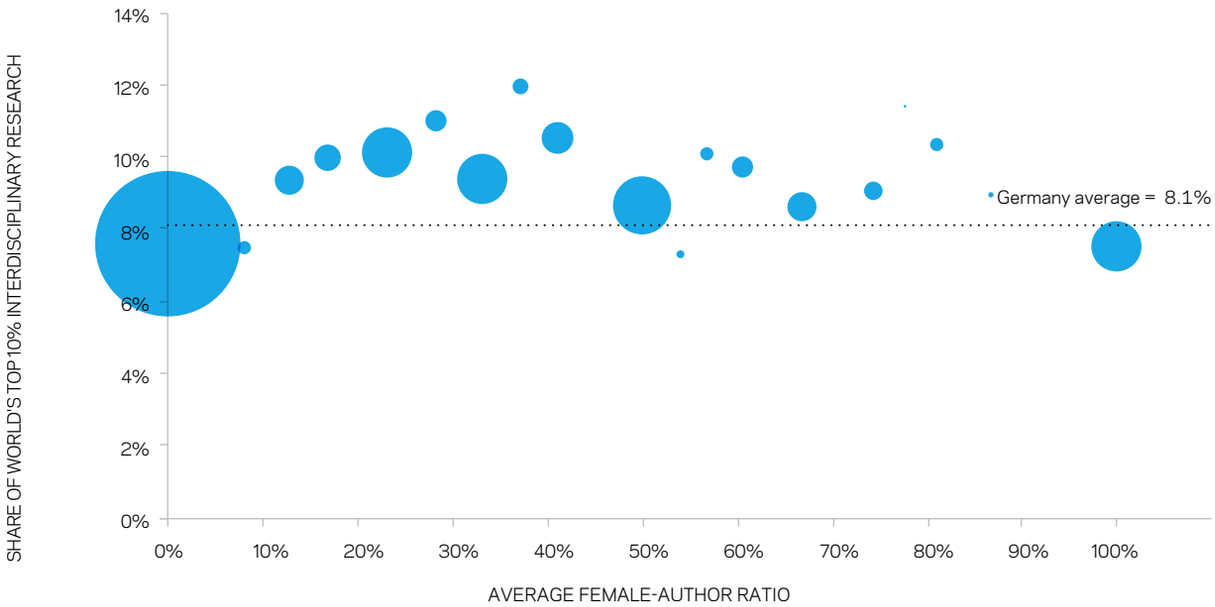


Figure 10 — *The relation between interdisciplinary research and female-author ratio for publications; all subjects; for Germany; 2010-2013.*[45] *Bubble size denotes the number of publications in the female-author ratio category.*

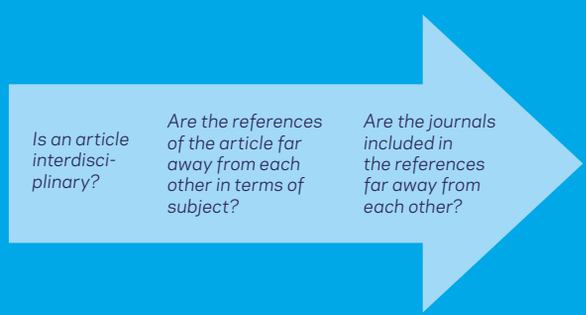
Our measure of IDR

In this report, we measure IDR at the article level using a citation-based approach. Our approach assigns an IDR score to an article based on its references. Articles that reference other articles that are relatively 'far' from each other in terms of discipline are considered more interdisciplinary. If an article references other articles that are relatively 'close' to each other, this suggests that the original article is situated or categorized within a single discipline.

To define how 'far' or 'close' the references of an article are, we look at the journals in which they are published. If these journals are 'far' from each other, these references are also 'far' from each other. If the journals are 'close', we class the references as being 'close'.

How, then, do we define whether two journals are 'far' from or 'close' to one another? We count the frequency in which two journals are co-cited in the references of all Scopus® publications for a certain period. The more often those journals occur together, the more likely that they are close to each other. The figure below summarizes the logic behind our method.

One major advantage of our approach is the lack of reliance on any pre-defined subject classification to define interdisciplinarity. It is also flexible enough to capture the dynamics of the research landscape in which subjects are constantly emerging and changing.



The text in this box is drawn from "A Review of the UK's Interdisciplinary Research using a Citation-based Approach: Report to the UK HE funding bodies and MRC by Elsevier" published at http://www.hefce.ac.uk/pubs/rereports/Year/2015/interdisc/Title,104883,en.html.

45 This analysis is restricted to 2010-2013 data because our IDR measures are currently updated to 2013.

INTERVIEW WITH DR ELIZABETH POLLITZER

"Society is ambivalent with regard to gender role attitudes"

Elizabeth Pollitzer, PhD, is the co-founder and Director of Portia, an organisation devoted to improving gender equality in STEM and promoting the inclusion of the gender dimension in STEM. She has 20 years of experience teaching and researching in the Departments of Computing and Management at Imperial College, University of London. Her original training was in Biophysics. She now applies this scientific background to her work as director of Portia.

Even today, it is harder for women to realize their career aspirations than for men because society is ambivalent with regard to gender role attitudes. On the one hand, women's career aspirations and employment opportunities have increased through greater participation in higher education. On the other hand, there are not enough structures to help women participate in the workforce in the same capacity as their male peers. Although this is a societal problem, science institutions reproduce this ambivalence by caring less about the development of the human capital of female researchers than that of male researchers. There is no other explanation for the figures collected in this report showing an overall increase in participation across all fields between 2010-2014 while in half of these fields the share of female researchers with more than 10 years of experience has actually fallen or stayed the same.

More gender equality at more senior levels

The report shows that gender equality exists at more senior levels, so the obstacles preventing women getting there must lie along the career pipeline. The fact that this is happening across all fields but with different degrees of intensity suggests that systemic and field-related forces are at hand. It is interesting to see that in a 'feminized' field such as Veterinary Science, the share of female researchers increased by 4.5% between 2010 and 2014. However, at the senior level, the share of female researchers dropped by 1.4%. Similarly, for Health Professionals, the overall share went up by 5.1% but at senior level it decreased by 1.8%. This contrasts with the figures for Energy, where both the overall share and the senior share rise by 3% and 1.9%.

Varying productivity and citation impact of male and female researchers

The results of the report indicate that female researchers do not seem to perform as well as their male counterparts in terms of productivity and the citation impact of their publications. For me the cheering aspect of these figures is that women are more productive in the mathematics-dependent areas that are important for innovation. Coincidentally, these areas are also where the share of female researchers has stayed below or around 20% during 2010-2014. Also, it appears that the highest productivity of men is in areas where the share of women is around 50%. This would suggest that different field-related cultural effects have an important role in influencing productivity.

Focus of female researchers in gender balanced and male-dominated subject areas

The report finds some evidence that female researchers seem to focus on different topics compared to their male counterparts in gender-balanced subject areas but not in male-dominated subject areas. This is an interesting observation; however, in my opinion, personal "choice" is not the main explanation because researchers respond to funding opportunities. Combined with the fact that in gender-balanced fields men

publish more papers per year than women, this suggests that if a topic is covered more frequently, this affects the "success" of a paper on the topic.

Consequences for universities, funders and policy makers

This report provides evidence that there is a need to look more closely at what happens at the field level and overall. The 'leaky pipeline' will not stop leaking if improvements achieved at earlier stages are (apparently systematically) reversed at senior levels. How can it be explained that in Veterinary Sciences, where the overall share of female researchers has increased from 52.1% to 56.6% during 2010-2014, the share of women at senior levels has dropped by 1.4%?

The strength of this report is its focus on Germany and the comparisons based on the fields women and men are active in. The 315 German institutions covered by the report can now collect and compare their own statistics. Additionally, conducting similar analyses for other countries would help determine if the patterns observed for Germany are field related, systemic with regard to the culture of science, or specific to the socio-cultural conditions of a given country.

CHAPTER 3

The Impact of the Gender Composition of Research Teams on Research Topics

Past studies suggest that the choice of research topics, in particular the level of specialization, is an important factor that contributes to the differences in research performance between women and men. We focus on two subject areas in this chapter: Biochemistry, Genetics and Molecular Biology, in which 48.2% of the researchers are female in Germany in the period 2010-2014, and Physics and Astronomy, in which the corresponding number is only 18.9%.

3.1 The Impact of the Gender Composition of Research Teams on Research Topics

To study the impact of the gender composition of research teams on research topics, we extracted the key phrases from male-only publications and from publications for which more than half of the authors are female. To investigate the topics these key phrases present, we plotted them in co-occurrence network maps in Figure 11 to Figure 14. Key phrases that occur together frequently are plotted close to each other. Intensity is indicated by the length of the connecting lines – the closer two nodes are, the more frequently they occur together. We also identify clusters of key phrases based on their similarity in topic, indicated by the node colour.

If we compare Figure 11 (topics associated with male-only publications) and Figure 12 (topics associated with publications in which more than half of the authors are female), we see many similarities. The blue cluster in both figures feature phrases such as "stars", "galaxies", and "mass". The pink cluster has phrases such as "spectroscopy", "behaviour", "x-rays". "Cancer", "tumours" appear in the dark blue cluster, and "crystal structure", "hydrogen" and "benzene" appear in the purple cluster. It seems that in a male-dominant subject area such as Physics and Astronomy, publications with high female-author ratio cover similar topics as male-only publications.

Comparing Figure 13 and Figure 14, it is difficult to find matching key phrases in clusters in these two figures. Male researchers focus a lot more on methodology; in contrast, phrases such as "probability" and "theoretical models" appear less frequently in the publications of female researchers. In Figure 14, we see key phrases such as "family", "child", "women", "infant", and "pregnancy", which are closely linked to family and children.

How were the key phrases selected?

We used the Elsevier Fingerprint Engine to extract distinctive key phrases. Text mining was done by applying a variety of Natural Language Processing techniques to the titles and abstracts of the publications in order to identify important key phrases.

Key phrases were matched against the most relevant thesaurus. For Biochemistry, Genetics and Molecular Biology, they were mapped against the Medical Subject Headings (NIH MESH), and for Physics and Astronomy the National Aeronautics and Space Administration (NASA) thesaurus was used.

For publications from male-only teams from Biochemistry, Genetics and Molecular Biology, for example, we took all the publications that satisfied the conditions of belonging to the right subject and having no female authors, and obtained the key phrases. We then calculated, for each key phrase, the percentage of the publications in this publication set having this phrase and the percentage of all German publications in Biochemistry, Genetics and Molecular Biology having this phrase. We then calculated the difference between the two percentages and selected the top 100 phrases with the largest difference. These top 100 phrases are the phrases that are the most specific to each publication set relative to all German publications in that subject area.

We then calculated how frequently each pair of key phrases co-occurs in the publication set (Germany's Biochemistry, Genetics and Molecular Biology publications in the period 2010-2014 with no female authors). The more often they occur together, the more likely that they are on closely related topics. The intensity of the co-occurrences of two key phrases was measured using an index equal to the number of co-occurrences divided by the geometric mean of the occurrences of each key phrase.

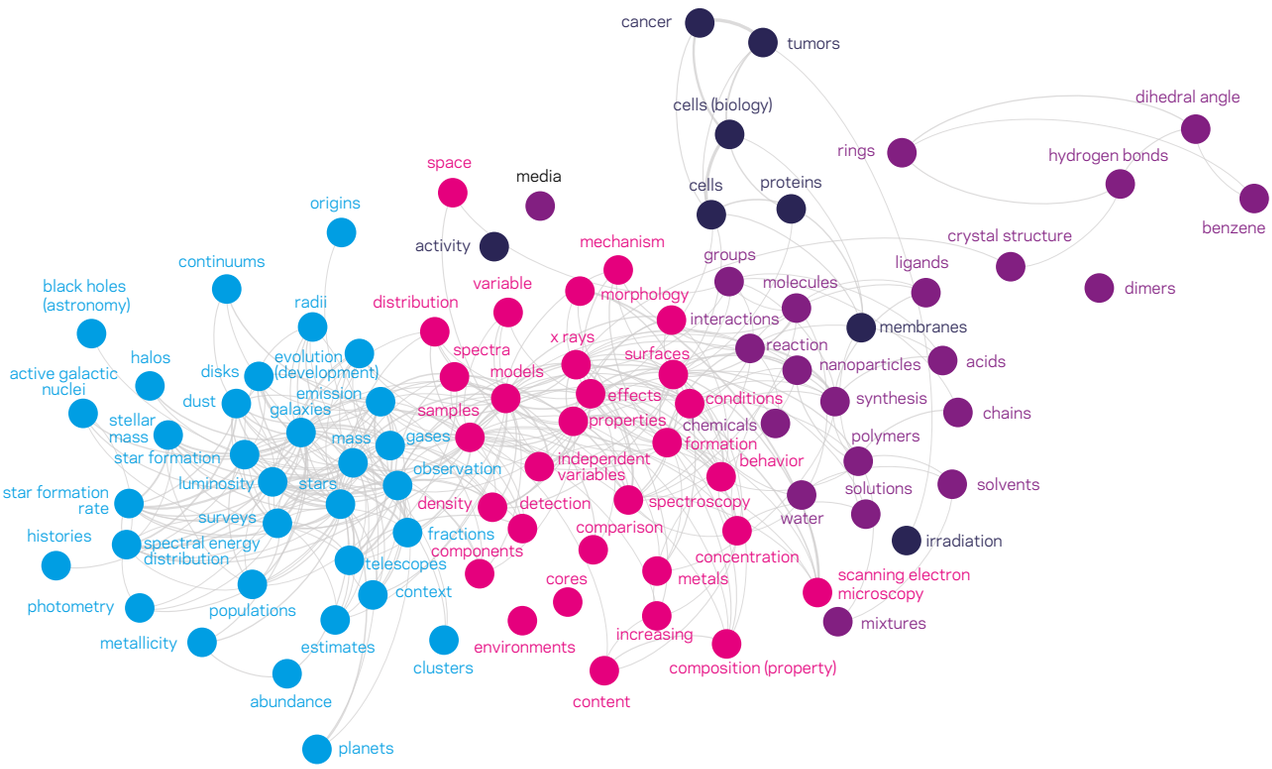


Figure 11 *— Key phases for publications with male-only teams; Physics and Astronomy; for Germany; 2010-2014.*

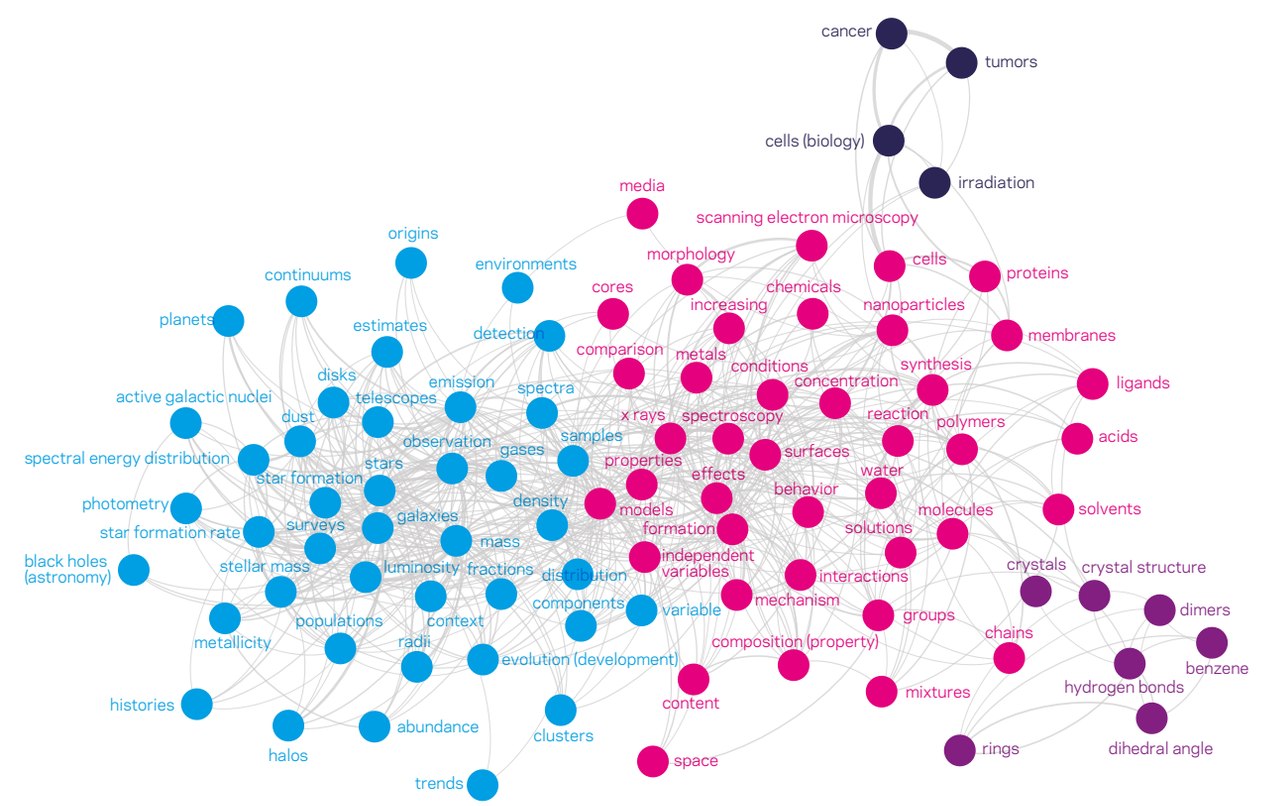


Figure 12 *— Key phases for publications for which more than half of the authors are female; Physics and Astronomy; for Germany; 2010-2014.*

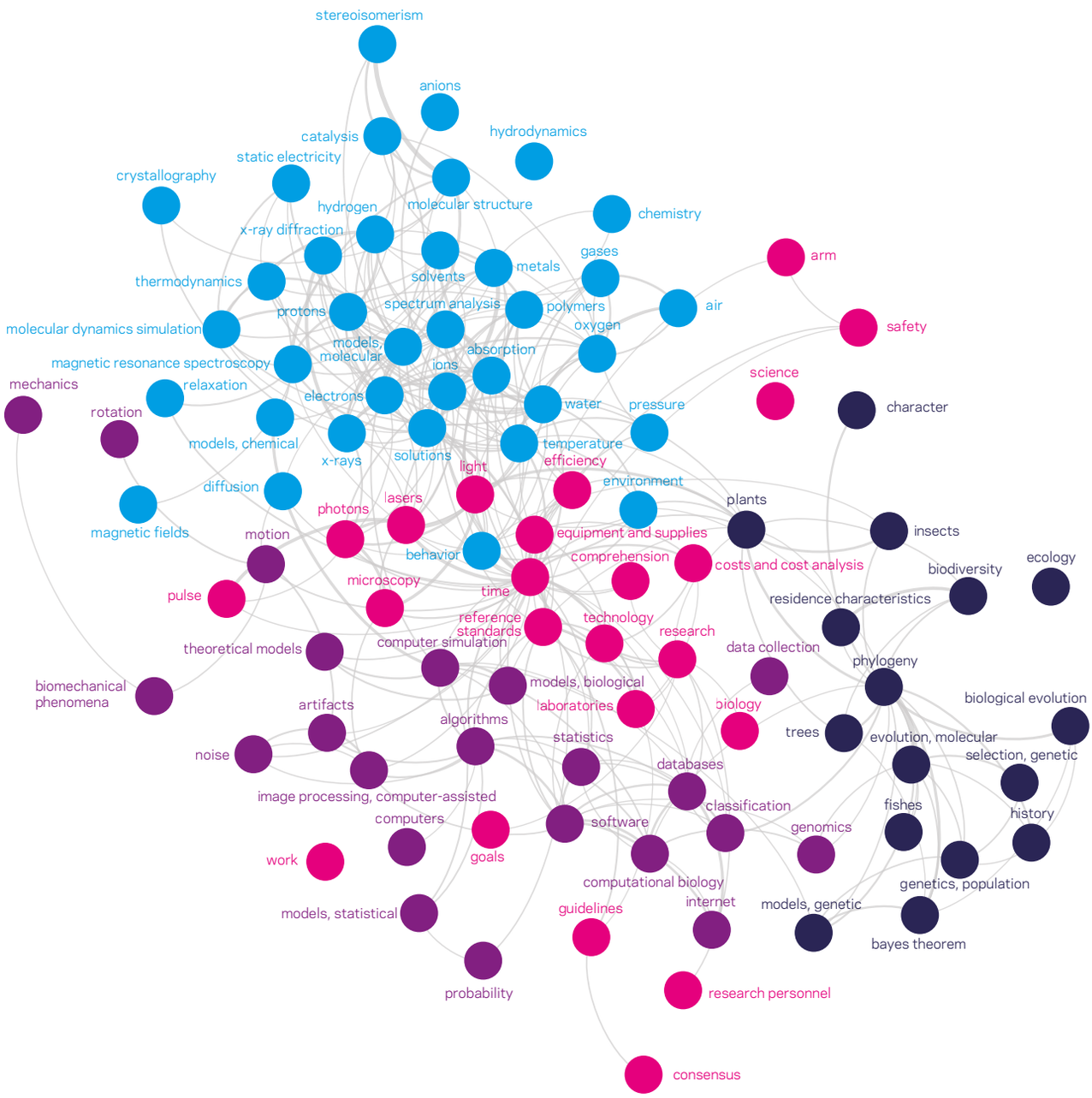


Figure 13 — *Key phases for male-only publications; Biochemistry, Genetics and Molecular Biology; for Germany; 2010-2014.*

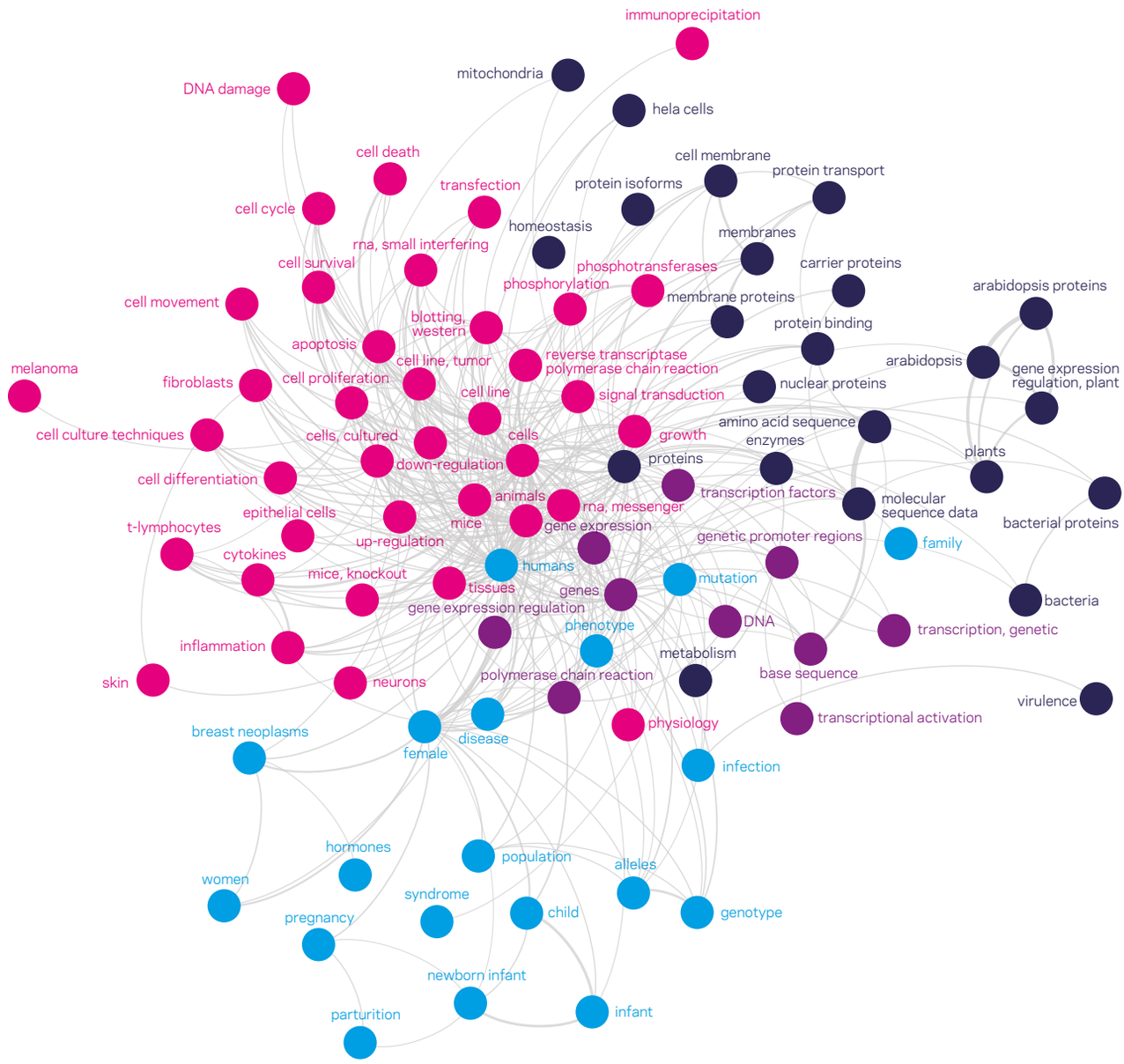


Figure 14 *— Key phases for publications for which more than half of the authors are female; Biochemistry, Genetics and Molecular Biology; for Germany; 2010-2014.*

CONCLUSIONS

Conclusions

Gender gaps exist in research in Germany. The number of female researchers in Germany is increasing in absolute and relative terms. However, female researchers are less productive in terms of publications output, and that output tends to have lower citation impact. Maximizing the potential of female researchers is an important question for regulations, policies, and funding programmes. It is key to have funding programmes and policies to support junior and middle-senior female researchers so they do not lag behind their male counterparts due to family responsibilities and other obstacles during their career development. At the senior level, the productivity and citation impact of female researchers are close to those of their male counterparts. The key question here is how to ensure a strong base of female researchers at the middle-senior level so more women can achieve senior positions and not be underrepresented in the highest ranks.

The gender diversity (or lack thereof) of a research team may play an important role in determining what kind of research is performed. Our findings suggest that the higher the female-author ratio, the lower the citation impact of the publications. On the other hand, publications authored by female-only research teams show the highest degree of international collaboration. Publications authored by both men and women are more interdisciplinary than publications authored by researchers of the same gender. Our analysis further shows that publications with a high female-author ratio tend to focus on different topics compared to male-only publications in a subject area in which the gender ratio is more balanced.

These findings suggest that:

- maintaining gender diversity in research is key to knowledge integration from multiple disciplines;
- a potential direction for future policies is to stimulate collaboration between female researchers and strong research partners, producing more impactful publications;
- while designing programmes, it is important to recognize that some women may focus on different topics compared to their male counterparts and should not be left out because of the thematic focus of funding programmes.

For future studies, it will be important to explore the underlying mechanisms driving the findings. For instance, why did international collaboration not lead to female-only publications achieving a higher citation impact? Why do female researchers tend to be more productive in male-dominated subject areas than subject areas with more balanced gender ratios, and how does this relate to the fact that they focus on similar topics as male researchers in these subject areas? Why are mixed-gender publications more interdisciplinary? Understanding these issues will be key to design interventions that successfully address the causes that lead to gender inequality in research.

APPENDICES

Appendix A
Data Sources and Key Terms

Scopus® (www.Scopus.com)

Scopus® is Elsevier's abstract and citation database of peer-reviewed literature, covering 58 million documents published in more than 22,000 journals, book series and conference proceedings by some 5,000 publishers.

Scopus® coverage is inclusive across all major research fields, with 11,500 titles in Physical Sciences, 12,800 in Health Sciences, 6,200 in Life Sciences and 9,500 in Social Sciences.

Titles that are covered are predominantly serial publications (journals, trade journals, book series and conference material), but considerable numbers of conference papers are also covered from stand-alone proceedings volumes – a major dissemination mechanism, particularly in Computer Sciences. Acknowledging that a great deal of important literature in all fields, but especially in Social Sciences and Arts and Humanities, is published in books, Scopus® began to increase book coverage in 2013, aiming to cover 120,000 books by the end of 2015.

Publications

We count the following types of documents as publications: articles, reviews and conference proceedings.

Full counting is used. For example, if a paper has been co-authored by one author in Germany and one author in the USA, the paper counts towards both the publication count of Germany and the publication count of the USA. The total count for each country is the unique count of publications.

One publication may belong to multiple subject areas. The publication then counts toward each subject area it belongs to. These duplicates are removed when we count the total number of publications.

Field-weighted citation impact (FWCI)

Citations accrue to published articles over time, as articles are first read and subsequently cited by authors in their own published articles. Citation practices, such as the number, type and age of articles cited in the reference list, may also differ by research field. As such, in comparative assessments of research output citations must be counted over consistent time windows, and field-specific differences in citation frequencies must be accounted for.

FWCI is an indicator of mean citation impact, and compares the actual number of citations received by an article with the expected number of citations for articles of the same document type (article, review or conference proceeding paper), publication year, and subject field. When an article is classified in two or more subject fields, the harmonic mean of the actual and expected citation rates is used. The indicator is therefore always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (reviews typically attract more citations than research articles, for example), as well as subject-specific differences in citation frequencies. FWCI is one of the most sophisticated indicators in the modern bibliometric toolkit.

To count citations, a five-year window is used. For publications in 2010, their citations in the five-year period 2010-2014 are counted. For publications in 2014, their citations to date are counted.

Appendix B
The Methodology to Identify the Gender of Authors

Each author in Scopus® has a unique identifier through which we can identify all the publications, affiliations, and citations of an author to form a profile for each author. Throughout the report, we use "researchers" when referring to indicators that are based on author profiles containing all the information we have for each author, and use "authors" to refer to the authors for each publication.

In order to conduct the analysis to investigate the relation between the gender of researchers/authors and the various indicators on research performance, we need to identify the gender of each researcher in Scopus®. This was done by combining Scopus® data with data from a large online social networking service. In this online networking service, users disclose information such as their country of origin and their gender. Therefore, for each country, we can obtain a list of first names, and the number of people with this first name being male and being female. We used this information to calculate the probability that each first name is a female or male name.

All Scopus® author profiles were matched to this dataset according to their country of origin (i.e., the country where the researcher published his/her first publication) and first name. If the first name appears at least 5 times in the data and with more than 85% probability that the first name is a male or female name, we can assign the gender associated with this first name to the researcher. Otherwise the gender of the researcher is not identified.

In the period 2010-2014, 491,545 researchers published with German affiliations. We identified the gender of 82.5% of them, or in other words, 405,508 researchers. Among these identified researchers, 135,385 are female and 270,123 are male.

It should however be noted that identifying the gender of 82.5% of German researchers is not equivalent to identifying the female-author ratio of 82.5% of German publications in the period 2010- 2014. If a publication has 10 authors and we identify the gender of eight of them, strictly speaking we still do not know the female-author ratio of this publication because the gender of the two unidentified authors will affect the female-author ratio of this publication. Additionally, because of international collaborations, German publications are not authored only by German researchers. For some countries, first names do not always tell the gender of a person, e.g., China. We can identify the gender for a much lower percentage of researchers for these countries. This will also reduce the percentage of German publications for which we can identify the gender of all authors. In this report, we use two samples of German publications in the period 2010-2014: the first sample consists of publications with at least one gender-identified author (681,361 out of 708,786 publications) and the second sample consists of publications for which the gender of all authors is identified (255,765 publications).

Appendix C
Project Team and Acknowledgements

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Quality control

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