

# Forty years of gender disparities in Russian science: a historical bibliometric analysis

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## Abstract

Gender disparities persist in several areas of society and scientific research is no exception. This study describes the evolution of the place of women in Russian science from 1973 to 2012, in terms of published research output, research productivity, international and national collaboration, and scientific impact, taking into account the socioeconomic, political and historic context of the country, which was marked by the fall of the USSR in 1991. The results show that gender parity is far from being achieved. Women remain underrepresented in terms of their contribution to research output and scientific impact in almost all disciplines, with Mathematics and Physics, research areas in which Russia is specialized, having the largest gap. Men and women show different collaboration patterns on the national and international level, whereas women are preeminent on the national scene, men are on the international one. Although the impact of women's scientific output significantly increases after the fall of the USSR, the gap between both genders remains stable over time for most of the disciplines. As a result, this increase cannot be interpreted as an improvement of the women's relative influence in Russian science, but rather an improvement of Russian science impact in general.

## Keywords

Gender; Russia; Research productivity; Research impact; Collaboration

## Introduction

### *Women in science*

The gender wage gap in OECD countries has narrowed from 20% in 2000 to 15% in 2010 (OECD 2013) and women have become increasingly present during the last decades in areas and professions historically less occupied by women, such as medicine, arts, and law (Xie and Shauman 2003). Despite this economic and social progress, career stereotypes seem persistent. Recent research has shown that differences between men and women in science appear in terms of productivity, collaboration and scientific impact (Larivière et al. 2013). Even when girls study sciences, they remain underrepresented in professions of the science fields with only 43% of female science graduates working as professionals in Physics, Mathematics and Engineering, as opposed to 71% of male graduates (OECD 2013). Women underrepresentation in science

has recently been documented in the United States (Larivière et al. 2013), in Québec (Larivière et al. 2011), in Russia (Lewison and Markusova 2011), in Poland (Suchanska and Czerwosz 2013), in Italy (Abramo et al. 2009), and in France (De Cheveigné 2009). This study thus seeks to describe the evolution of female researchers' position in the specific case of Russia. The case study will allow an in-depth analysis taking into account the socioeconomic, political and historic context of contemporary Russia which was marked by the fall of the USSR and the end of the Soviet Communist regime in 1991.

Whereas Lewison and Markusova (2011) provided evidence of a gender gap in Russia, based on bibliometric data for three non-consecutive years (1985, 1995 and 2005), the present article proposes to corroborate these results and study the situation over a larger time window, with data from 1973 to 2012. More specifically, this paper assesses the place of women in the Russian scientific research system in the various disciplines and how this position has evolved during the last forty years in terms of their proportion of the published research output, research productivity, international and national collaboration and scientific impact.

### *Science in Russia*

The end of the communist regime induced deep changes to Russian science and technology. By 1992, science had entered a profound crisis. For several years, the budget allocated to scientific research decreased constantly and, thus, scientists had difficulties obtaining the equipment essential to pursue their research. Russian science survived in large part through the financial support of international funding – such as that provided by the Hungarian-American billionaire George Soros or European Union programs (e.g., INTAS). In these conditions, many male researchers left Russia or changed careers, leaving more positions for women in scientific research (Lewison and Markusova 2011). Moreover, the demilitarization reform initiated in 1992 resulted in the layoff of a significant proportion of Russian scientists. Staff working in research halved between 1992 and 1999, leading to a decrease of scientific publications and less international visibility (Milard 2009). The same bibliometric trend persisted later on (Kotsemir 2012; Pisyakov and Gokhberg 2008).

During the Cold War, the Soviet Union partly succeeded in establishing Russian as an international scientific language. Thus, its scientific production was mostly published in Russian. However, a rapid and complete shift toward Russians publishing in English occurred in 1991, resulting in a greater visibility of Russian science at the international level (Kirchik et al. 2012).

### **Sources and methods**

Data for this study are drawn from Thomson Reuters' Web of Science (WoS) (Science Citation Index Expanded, Social Sciences Citation Index and Arts and Humanities Citation Index). All articles, notes and reviews published between 1973 and 2012 are included in the analysis since they represent the subset of documents that are peer-reviewed and generally accepted as original contribution to scientific knowledge (Moed 1996). The Web of Science also indexes institutional address (institution, country, city, etc.) of each author contributing to a paper, thus allowing for the geographical distribution of papers. Papers taken into account contained at least one institutional address situated in Russia (or USSR before 1991) for a total of 1,059,939 papers.

Despite this large amount of papers, the Web of Science database does not cover all published scientific literature, especially in social sciences and humanities (SSH). The much more limited coverage of social sciences and humanities (SSH) in the Web of Science can be explained by a larger proportion of their scientific publications in books and by the often "local" aspect of their research topics which, in turn, often leads to publication in national journals that are not indexed in the Web of Science. Moreover, these limitations are amplified in the case of non-English-language journals. Thus, the Web of Science provides fragmentary data on the output of Russian research in SSH. Given these limitations of data on the social sciences and humanities (Larivière et al. 2006; Archambault et al. 2006) – especially for non-English-speaking countries and, particularly, Russia (Savelieva and Poletayev 2009) – SSH were excluded from the analysis (except for Psychology which is often considered as situated halfway between the social sciences and the natural sciences).

Raw data were transformed into a relational database in order to perform the various analyses. The NSF categorization (based upon the Science and Engineering Indicators (National Science Foundation, 2006)) was adopted instead of WoS categories since the former classifies each journal into only a single specialty and discipline, which avoids possible double counting of papers during analysis.

Based on the characteristics of Russian surnames, which contain gender-specific suffixes<sup>1</sup>, it was possible to determine gender for each authorship. Surnames which did not meet those criteria were excluded from the selected data. As a result, over the 1973-2012 period, 89% of papers contained at least one author to whom a gender was assigned. Given that Thomson Reuters only started indexing complete names in 2008, this kind of analysis can only be done for countries where surnames are gendered<sup>2</sup>.

The analysis of male and female researchers' relative contribution to published papers is based on the proportion of papers published by authors of each gender for whom gender could be assigned. The number of papers is obtained by fractional counting where each author is given  $1/x$  count of the authorship,  $x$  representing the number of authors for which gender was identified on the given paper (Larivière et al. 2013).

The productivity of male and female authors was also assessed for each gender, comparing the number of articles by one author for the years 2008 to 2012: that is the ratio of the number of articles published by one gender to the number of distinct authors of that gender. Productivity could not be measured prior to 2008, as the database did not include author's first name, making it impossible to discriminate the exact number of distinct authors, of course our measure here approximates the number of distinct male and female authors. However, there are no reasons to believe that men or women have more homonyms than the other gender and hence, these denominators are likely comparable for both genders. The proportion of female articles for which a female is the first author is also compiled.

For collaboration, we analysed for each gender the proportion of papers resulting from national collaborations, compared with those that were the result of international collaborations, all disciplines taken together. Finally, we compared the scientific impact of male and female researchers using the average of relative citations (ARC). ARC provide a field-normalized citation rates, thus allowing the comparison of data between the different specialities that have otherwise different citation practices. More specifically, the number of citations received by a given paper is divided by the average number of citations received by articles in the same discipline published that year. An average of relative citations (ARC) greater than 1 indicates that an article is cited above the world average for the same field, and an ARC below 1 means that it is cited below the world average. Citation measures used for this analysis include all citations received by a given paper, from its publication year to the end of 2012.

## Results

### *Research output*

To assess the place of women in Russian science, we evaluated their relative contribution to all papers published by Russian authors in each of the selected disciplines, between 1973 and 2012. Figure 1 shows that women's proportion of fractionalized authorships is lower than that of men in all disciplines except Psychology. Indeed, in Psychology, the contribution of women to published articles averages 45% – reaching more than 50% after 2000 – making it the most gender-equal discipline in Russia. One of the explanations for this result may be that a majority of Russian Psychology papers are published in two Russian journals. Indeed, these national journals account for 74% of Russian papers published in this discipline after 2000, where women account for 59% of fractionalized authorship against a proportion of

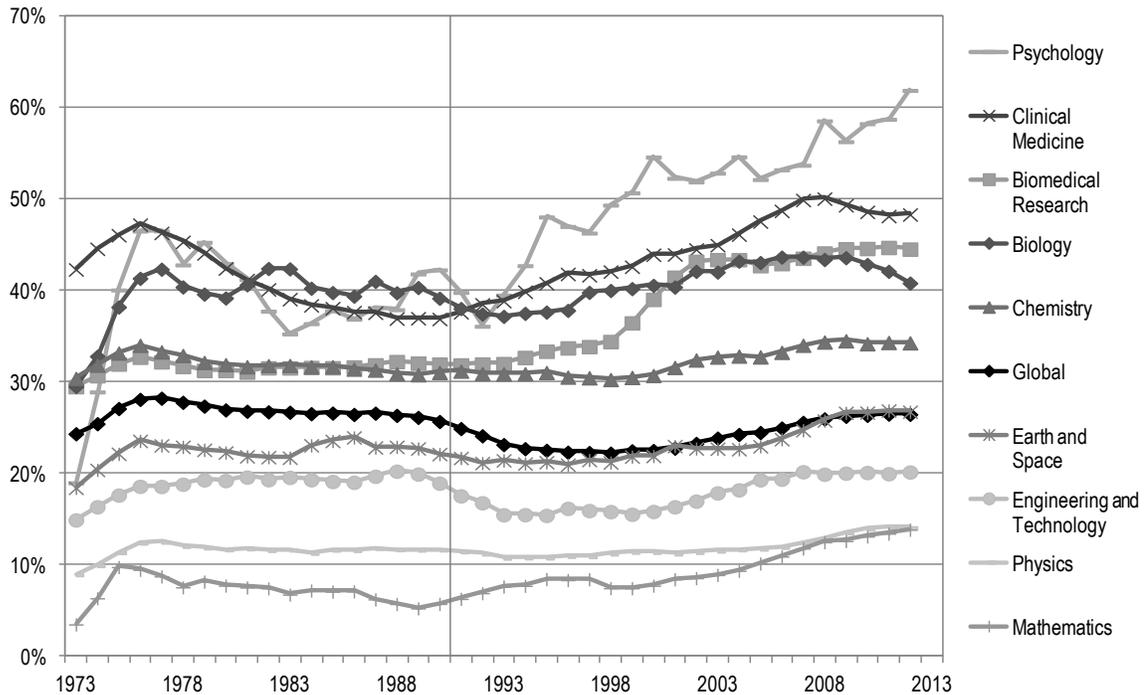
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<sup>1</sup> Suffixes associated to male gender: -ov, -in, -ev, -ky, -kii, -kiy, -yi, -ny, -oy, -oi, except -tsoi and -tsoy.

Suffixes associated to female gender: -ova, -ina, -eva, -aia and -aya.

<sup>2</sup> Given that pre-2008 papers do not have a link between authors and addresses, it is possible that we assigned a gender to a foreign collaborator rather than a Russian author. Given the low international collaboration rate of Russian papers, however, this should not be frequent.

46% in the rest of foreign Psychology journals indexed in the database. Women are thus overrepresented in the Russian journals in terms of fractionalized authorship in Psychology, but still lag when it comes to foreign journals. Areas in which Russia has been historically very active – such as Mathematics, Physics and Engineering and Technology – are traditionally male dominated (Xie and Shauman 2003). Our results in Figure 1 show that, in these disciplines, women represent less than 20% of fractionalized authorships.



**Fig. 1** Women’s fractionalized authorships, by discipline, 1973-2012  
A 3-year moving average was applied to enhance the readability of the figure

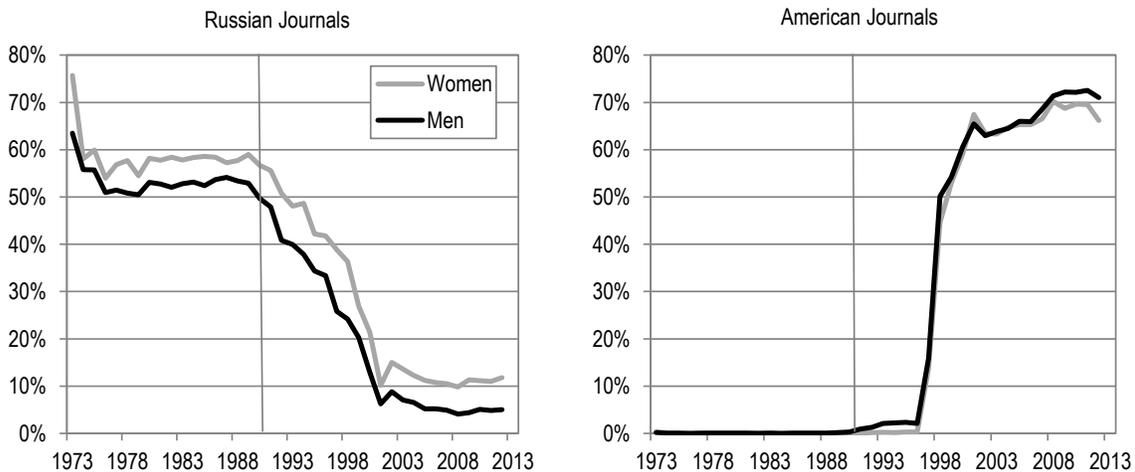
The global proportion of female scientific output ranges between 20% to 30% of fractionalized authorships, all disciplines taken together, for the 1973-2012 period (Figure 1). However, this proportion slightly decreases after the fall of the USSR in 1991. In a recent study, Larivière et al. (2013) found that Eastern European countries were among the countries that achieved the greater gender parity in terms of scientific output, including Ukraine where the female to male ratio indicates a slight female dominance. The fact that Ukraine and other formerly Communist republics were included in the USSR prior 1991 could have accounted for the decrease of the global female fractionalized authorship after the fall, with the Russian Federation as the only remaining country in the analysed data. We thus tested this hypothesis and found that between 1991 and 2012, the proportion of papers published by women was on average 10% higher in the Russian Federation than in Ukraine, thus invalidating the proposed explanation.

Variations in the proportion of female authorship can be observed over time (Figure 1). Between 1973 and 1976, we note an increase in female relative contribution in all disciplines. The inclusion process of Soviet journals to the Science Citation Index during these years could be a factor contributing to this increase, as the gender gap is less significant in the national journals than in the foreign ones. From the collapse of the Soviet Union onwards, we observe a rise of women’s proportion of fractionalized authorship in Psychology, Clinical Medicine, Biology and Biomedical Research. Unsurprisingly, several of the specialties of Psychology as well as of the two medical disciplines (Clinical Medicine and Biomedical Research) are related to domains historically considered as “feminized” and as “care” areas of research

(Witz 1992). Mathematics is the only other discipline where we can see a slight increase in female relative contribution to scientific output after 1991. A replacement hypothesis may explain this increase. In a difficult economic position, the Russian state could not support science anymore, thus leading to a large number of male scientists leaving Russia to continue their research abroad. The replacement hypothesis suggests that vacant positions were then filled by women, which might be a contributing factor of the observed increase (Lewison and Markusova 2011). On the other hand, we also see after 1991 an important decline of female relative contribution in Engineering and Technology.

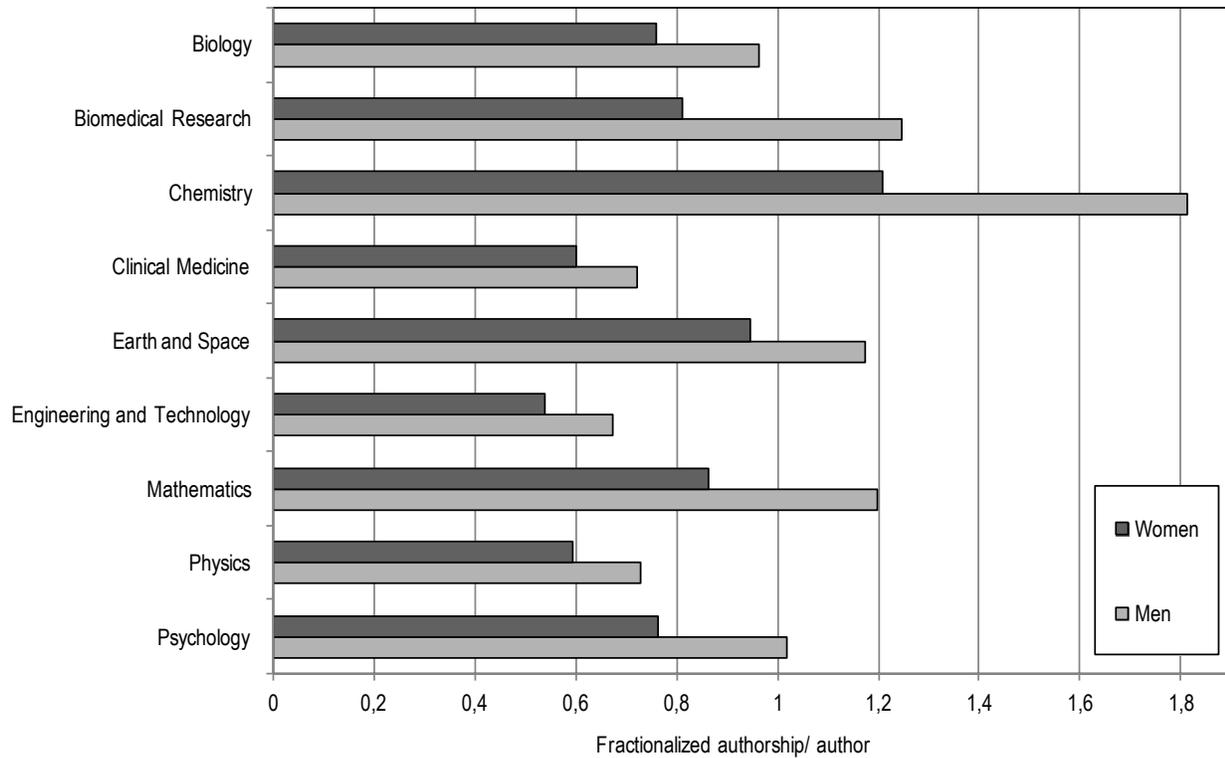
Figure 1 also shows, from 2008 onwards, stabilization of women’s proportion of authorship in all disciplines, except Psychology – the discipline in which their proportion of the output is the largest. This stabilization could in part be explained by the return to Russia of exiled scientists, mostly male, who left after 1991. Indeed, as the Russian state started again to finance science after 2000, a certain proportion of expatriate researchers who had left after the collapse of the Soviet Union returned to Russia. As a result, fewer positions were available for new researchers in institutes and universities and, thus, to women. With a global research output of less than 30% in Russia, between 1973 and 2012, women’s relative contribution is significantly below the level of men, especially in Mathematics, Physics and Engineering and Technology where they account for less than 20% of the published research output.

Figure 2 shows that women proportionally published more often in Russian journals than men for the 1973-2012 period and that the gender gap persists after the fall of the USSR. As the proportion of papers published in national journals significantly decreases for both men and women after 1991, the proportion of papers published in American (USA) journals goes through an equivalent growth.



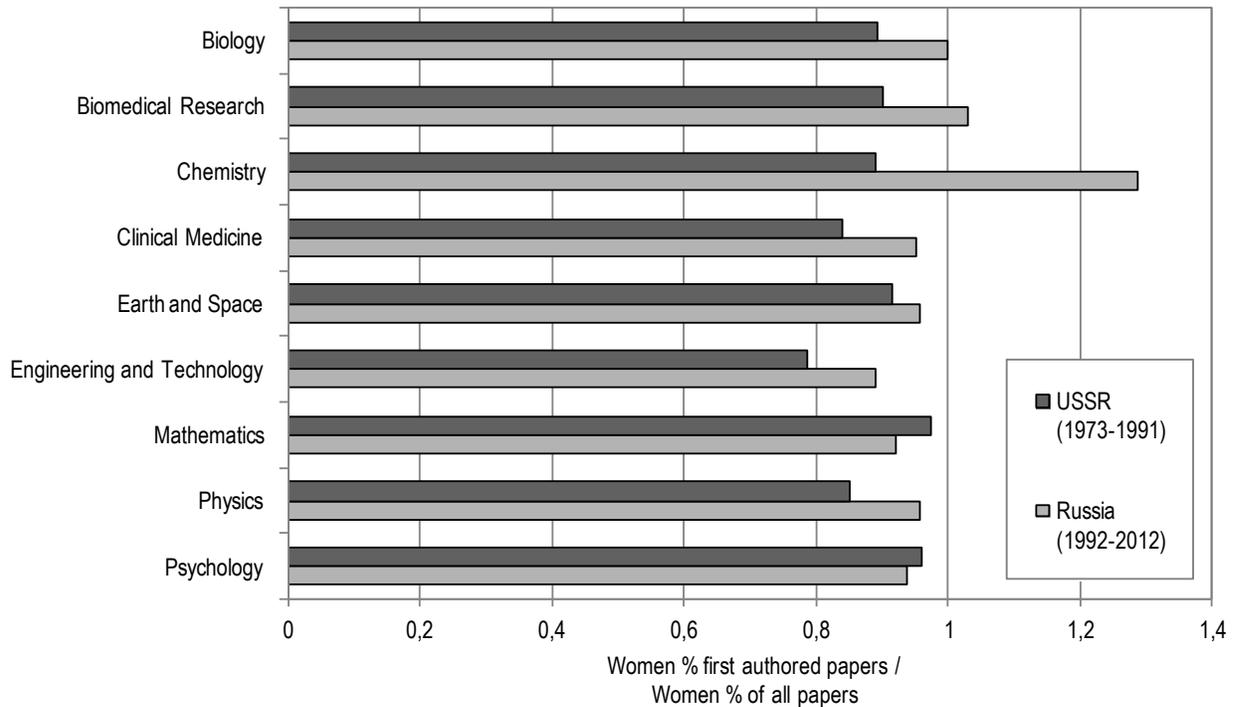
**Fig. 2** Proportion of Russian papers which were published in Russian and in American (USA) journals, by gender of the first author, 1973-2012

The lower proportion of female authorships could be due to their overall lower proportion in the Russian scientific community. To test whether women were less productive, we examined the productivity of each gender in terms of fractionalized authorship per distinct author, between 2008 and 2012. Here we approximate “scientific community” by those scientists who have at least one paper in WoS, “mutes” are disregarded. Figure 3 shows that women are less productive than men in all disciplines. On average, women publish 30% fewer papers than men. However, in Physics and in Engineering and Technology, two disciplines where women account for a smaller proportion of published articles, the productivity gap is less important. The productivity gap between women and men is the largest in Chemistry, Biomedical Research and Mathematics. Even in Psychology where women have attained gender parity in terms of their proportion of research output (Figure 1), they contribute, on average, to fewer papers than men.



**Fig. 3** Research productivity by gender (fractionalized authorship/author), 2008-2012

Figure 4 presents women’s proportion of first authored papers amongst all papers to which they contributed. This ratio allows us to see if women are proportionally more often first author of the papers to which they contribute, which is indicated by a ratio above 1. All disciplines taken together, we see that women are only slightly more often first author than men, with a ratio of 1.02. In the fields of Biology, Biomedical Research, and Chemistry, women are more often first author. While in Clinical Medicine, Earth and Space, Engineering and Technology and in Mathematics women are less often first author proportionally to articles to which they have contributed. Physics and Psychology are approximately on a par. With the exception of Clinical Medicine and Physics, these results tend to confirm the traditional division between “feminized” areas of research (Biology, Biomedical Research, Clinical Medicine and Psychology) and male dominated fields (Earth and Space, Engineering and Technology, Mathematics and Physics).

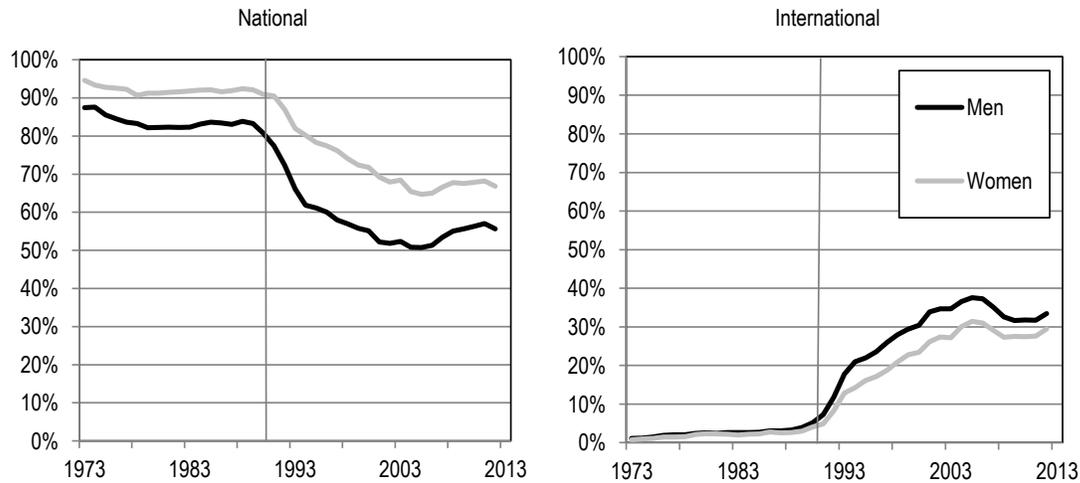


**Fig. 4** Proportion of papers first authored by women against all papers to which women have contributed, 1973-2012

### *Collaboration*

Figure 5 presents national and international collaboration of men and women since 1973. It shows that national collaboration remains the principal type of collaboration for women, even with the decrease observed in the years following 1991. This decrease of national collaboration, which can be attributed to the collapse of the Soviet Union, is present for both men and women but at a different level, maintaining a constant gender gap from 1973 to 2012. Indeed, national collaboration peaks for men at 90% in 1974 and drops to 50% in 2005; female collaborative rates are similar with a high of 93% in 1974 and a low of 65% in 2005.

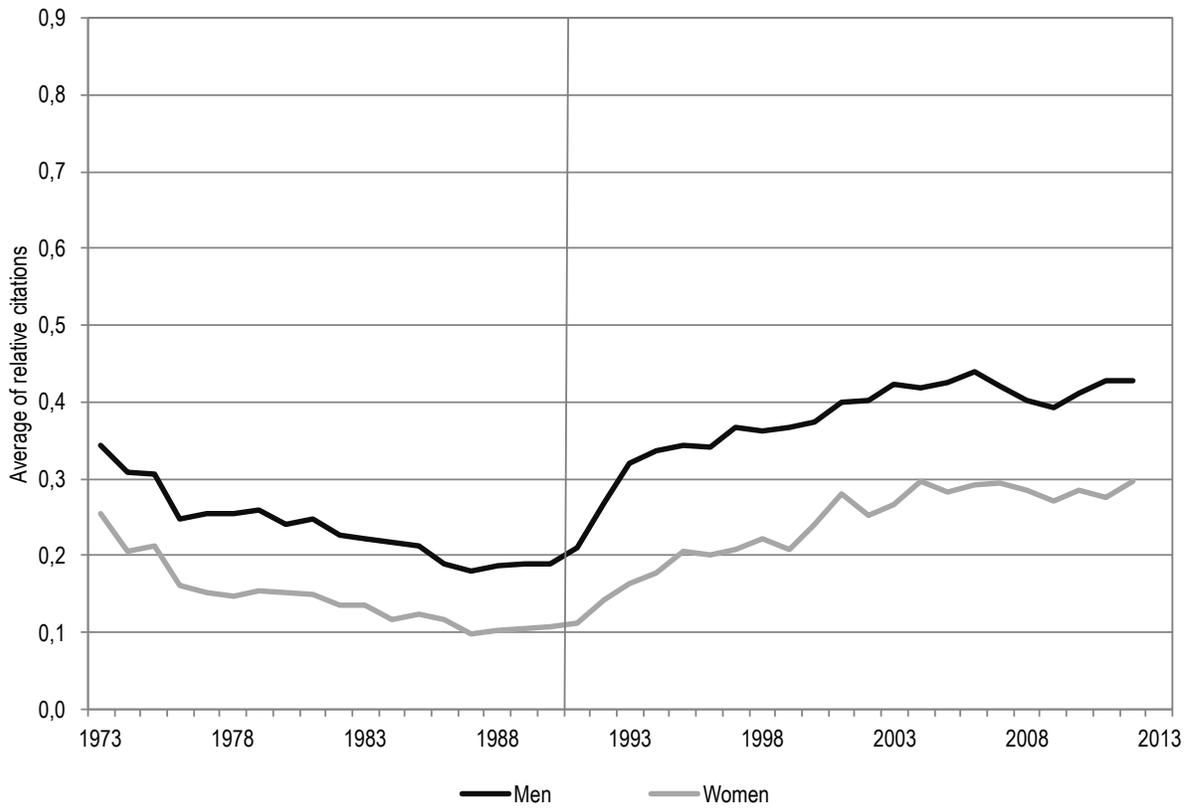
On the other hand, international collaboration is virtually nonexistent for both men and women before 1991. The fall of the USSR provided an opening of the Soviet scientific community to the rest of world. Figure 5 also shows that collaboration within USSR (1973-1991) is almost exclusively national and constant, representing nearly 90% of the Soviet production of scientific papers. International collaboration for both men and women is, however, under 5% of the proportion of scientific output. After 1991, researchers began to write and publish in English, which is likely a consequence of their more robust international networks (Kirchik et al. 2012), at least in WoS-indexed journals. The increase of the international collaboration is constant until 2008, where we can see a slight decrease that stabilizes up to 2012. In the early 1990's, men's international collaboration rises more rapidly than women's. Finally, it appears that women play a more active role on the national scene than men who are more active on the international level since the USSR collapse in 1991.



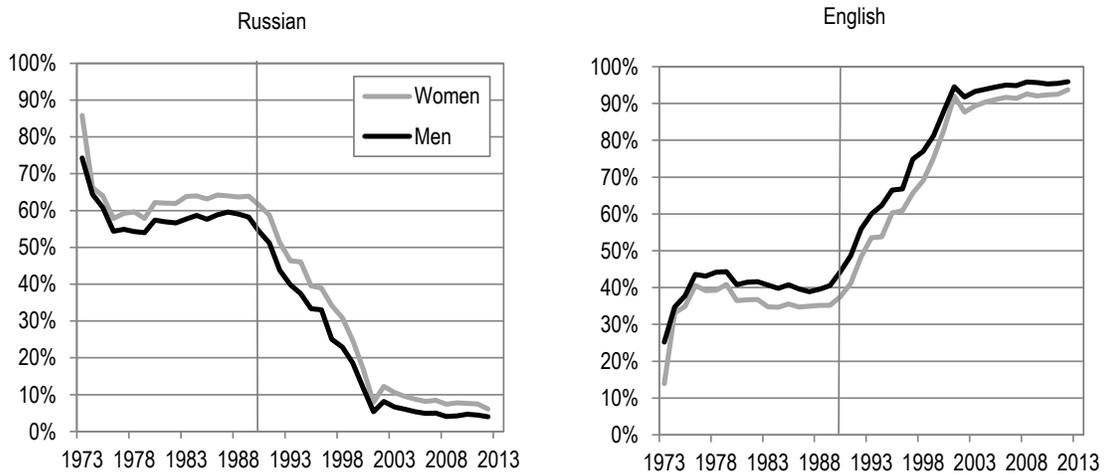
**Fig. 5** National and international collaboration, by gender

### *Scientific Impact*

Figure 6 shows the evolution, between 1973 and 2012, of the relative scientific impact of Russian papers, according to the gender of the first author. It shows that, despite important variations in the overall impact of Russian papers, the difference between the scientific impact of men and women remains relatively stable throughout the period, except after the fall of the Soviet Union in 1991, where it seems to widen. This historic period is also associated with a transition of the main publication language of Russian researchers which shifted from Russian to English (Kirchik et al. 2012), as shown in Figure 7. Therefore, the scientific impact of Russian articles published after 1991 increases substantially, as articles written in English have a broader readership and, thus, a larger international impact, than papers published in Russian (Kirchik et al. 2012). As proposed by Lewison and Markusova (2011) and illustrated in Figure 7, this increasing impact difference can be attributed to the lesser propensity of women to publish in English, as compared to their male counterparts. One can also notice the decrease in scientific impact of Russian papers between 1973 and 1990 (Figure 6), which is likely due to the economic decline of the USSR initiated in 1971 (Freeze 2002), as well as the fading impact of Russian language in science, accompanied by the increasing number of Soviet journals in the database.

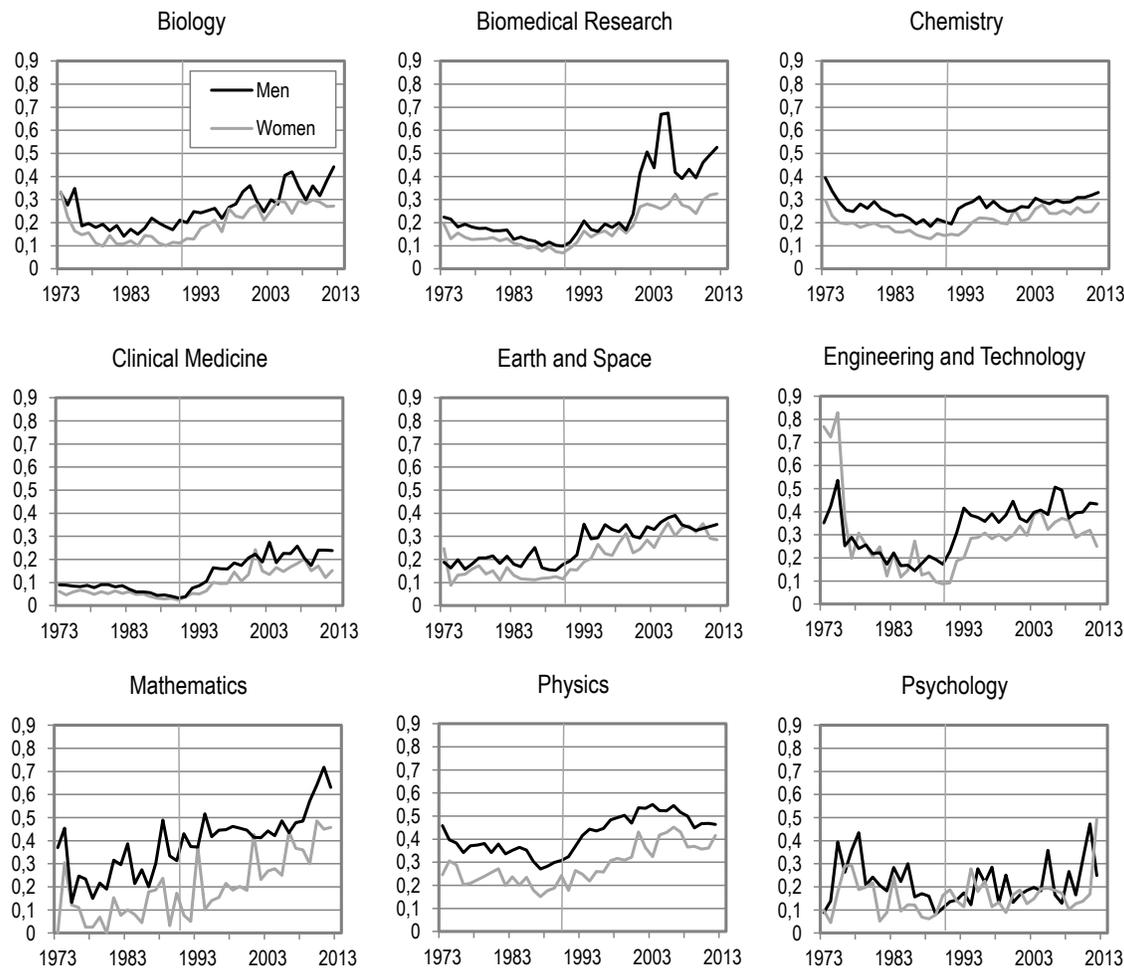


**Fig. 6** Average of relative citations of Russian papers, by gender of the first author, 1973-2012



**Fig. 7** Proportion of papers written in Russian and in English, by gender of the first author, 1973-2012

Figure 8 presents the evolution of the scientific impact of men's and women's first-authored papers by discipline. It shows, for each discipline, an increase of the scientific impact of Russian papers after the fall of the Soviet Union in 1991; a trend which is likely due to the transition of the language of scientific publications from Russian to English. The extent of the gender gap in terms of impact varies greatly by discipline.



**Fig. 8** Average of relative citations of Russian papers, by gender of the first author, by discipline, 1973-2012

In Biology, the scientific impact of men and women shows a light and steady increase from 1980 to 2012. The difference between male and female author's ARC values remains consistent over time, with men's impact being higher globally. However, women's impact eventually reaches and surpasses that of men in 1973, 1997 and in 2004. For Biomedical Research, we see a slightly higher relative impact for articles published by men until 2000. After that, men's ARC values grow rapidly, increasing the gender gap in terms of scientific impact. The evolution of scientific impact in Chemistry remains stable over time. Although men's ARC values are slightly higher, the difference between men and women relative impact decreases from the end of 1990s, with women's impact outstripping men's in 2000. As in Biomedical Research, we see slightly higher relative impact for articles published by men in Clinical Medicine and in Earth and Space sciences. After 1991, the impact tends to increase for both genders, with the difference between men and women being relatively stable over time, although women's impact in Earth and Space sciences outstrips men's in 2007 and 2010.

Engineering and Technology is the only discipline where articles published by women have an impact similar to that of men before the collapse of the USSR in 1991. This bibliometric trend could suggest that the increased need of researchers in military areas, during the arms' race period of the Cold War, was mostly filled by women. After 1991, the gap between both genders widens and male author's impact surpasses that of female authors. Mathematics and Physics are both disciplines in which Russia has specialized and Figure 8 confirms the disparity in terms of scientific impact between men and women in these traditionally female underrepresented domains, as the lower proportion of women in these fields might have an effect on their scientific impact. The largest difference is found in Physics and remains stable over time. In Mathematics, however, ARC values show considerable annual variations and women's impact reaches men's impact a few times throughout the period. Nonetheless, the limited number of articles published in Mathematics can likely explain the significant variations seen from one year to another. Although it may appear contradictory, among all the disciplines it is in Mathematics and Physics that women's papers have the highest impact, as a consequence of the highest overall ARC of Russian papers in these scientific fields.

As observed with genders' contribution to the Russian research output (Figure 1), Psychology is the most gender-balanced discipline and this result is corroborated in terms of scientific impact, with similar impact for male and female papers. Furthermore, after 1991, women's impact increases to reach that of men. We should nonetheless acknowledge the fact that the total number of Russia papers in Psychology is relatively small, which explain the variations observed from one year to another.

## **Conclusion**

Our analyses of Russian research output, productivity, collaboration and scientific impact over the 1973 to 2012 period clearly show that gender parity is far from being achieved. Women remain underrepresented in terms of relative contribution to research output across disciplines, although it is in Mathematics and in Physics, both Russian specialities, that we observed the greatest gap (Figure 1). The Soviet Union's fall in 1991 is associated in some disciplines with a slight increase of the relative contribution of female authors, increase that could be explained by the male "brain drain" that followed the fall.

Our results also show that, while it is in Psychology, Clinical Medicine and Biomedical Research that women's contribution to research is the most important in terms of fractionalized authorship, it is in Mathematics and Physics, the traditionally male dominated disciplines, that they have the highest relative impact (Figure 8). The first author proportions suggest that disciplines in which women have the highest fractionalized authorships are not necessarily the ones where they are most frequently first author, as presented in Figure 4. Regarding collaboration, our analyses show that men are more present on the international scene than women who are therefore relatively more active on the national side (Figure 5). Our results also confirm the great impact of the fall of the USSR on the Russian scientific community. After 1991, we observe a significant decrease in publications in Russian (Figure 7) and an increase in the impact of all authors, regardless of gender (Figure 6). Although the impact of women's research output significantly increases after the fall, the gap between genders remains stable over time for most of the disciplines. As a result, we cannot interpret this increase as an improvement of the position of women in Russian science.

The patterns presented here are not specific to Russia. As demonstrated in a recent study (Larivière et al. 2013), gender disparities in science remain widespread across the world. Over the 2008 to 2012 period, men accounted for more than 70% of fractionalized authorship worldwide, which approximately coincides with our results for Russia (Figure 1, 'Global'). Scientific impact of women is also invariably weaker than that of their male counterparts, as articles published by female authors attract fewer citations. The so-called "glass ceiling" keeping women from equal positions and opportunities seems persistent, measures and policies implemented so far have still not achieved equality between genders. As the Russian government has taken a more interventionist approach since 2006 and has increased the funding for science, it seems that women's proportion of the Russian scientific community has flattened. Time will tell if their proportion will start to increase or decrease again.

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