Women and science in Russia: a historical bibliometric analysis

Adèle Paul-Hus[*], Rébecca L. Bouvier[*], Chaoqun Ni[**], Cassidy R. Sugimoto[**], Vladimir Pislyakov[***] and Vincent Larivière[****]

[*] *adele.paul-hus@umontreal.ca; rebecca.l-bouvier@umontreal.ca*
École de bibliothéconomie et des sciences de l'information, Université de Montréal
C.P. 6128, Succ. Centre-ville, Montréal, QC, H3C 3J7 (Canada)

[**] *chni@indiana.edu; sugimoto@indiana.edu*
School of Informatics and Computing, Indiana University, 1320 E. 10thSt, Bloomington, IN. 47405 (USA)

[***] *pislyakov@hse.ru*
Library, National Research University Higher School of Economics, Myasnitskaya, 20, Moscow, 101000 (Russia)

[****] *vincent.lariviere@umontreal.ca*
École de bibliothéconomie et des sciences de l'information, Université de Montréal
C.P. 6128, Succ. Centre-ville, Montréal, QC, H3C 3J7 (Canada) and
Observatoire des Sciences et des Technologies (OST), Centre Interuniversitaire de Recherche sur la Science et la Technologie (CIRST), Université du Québec à Montréal, CP 8888, Succ. Centre-Ville, Montréal, QC, H3C 3P8 (Canada)

Introduction

Women in science

Gender disparities persist in several areas of society, and scientific research is no exception. Differences between men and women in science appear in terms of productivity, speciality, collaboration and scientific impact (Larivière et al., 2013). Although the position of women in Western society has improved greatly in the last century, numerous studies confirm that gender disparities in science remain, including in the United States (Xie & Shauman, 2003), Québec (Larivière et al., 2011), Russia (Lewison & Markusova, 2011), Poland (Suchanska & Czerwosz, 2013), Italy (Abramo, D'Angelo & Caprasecca, 2009) and France (De Cheveigné, 2009). This study seeks to describe the evolution of the place of female researchers in Russia, taking into account the socioeconomic, political and historic context of the country, which was marked by the fall of the USSR 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. We thus seek to evaluate 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 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 & 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; Pislyakov & 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, Gingras & Larivière, 2012).

Sources and methods

Data for this study are drawn from Thomson Reuters' Web of Science database (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. 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. Given the well-known limitations of data on the Social sciences and Humanities (Archambault et al., 2006; Larivière et al., 2006) – especially for non-English speaking countries and, particularly, Russia (Savelieva & Poletayev, 2009) – these were excluded from the analysis (except Psychology which is situated halfway between the social sciences and the natural sciences). 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. Additionally, NSF categorization provides a hierarchical structure of two levels (discipline and specialty), which allows for analysis at different levels of aggregation.

Based on the characteristics of Russian surnames, which contains gender-specific suffixes[1], it was possible to determine genders 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. 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, with x representing the number of authors for which gender was identified in the given paper (Larivière et al., 2013).

We also compared the scientific impact of male and female researchers using the average of relative citations (ARC). ARC provides 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.

[1]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.

Results

Research output

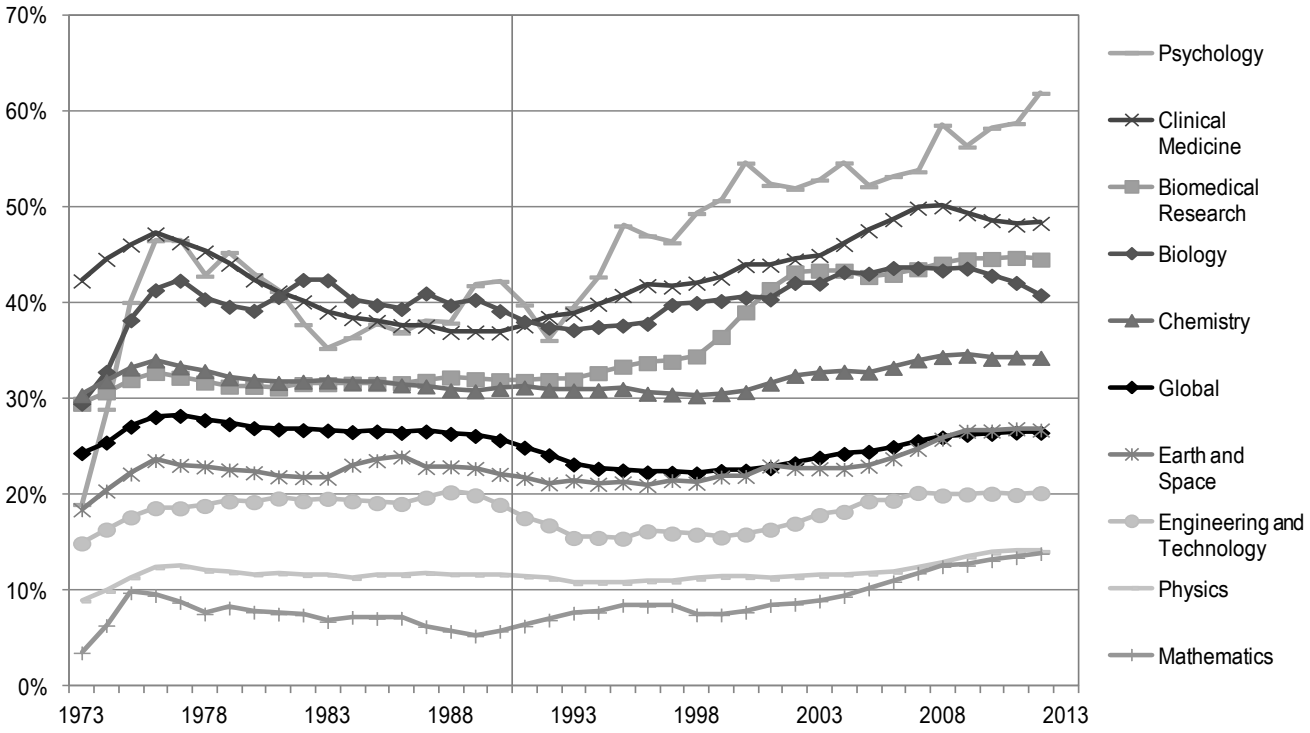
To assess the place of Russian women in science, we evaluated their relative contribution to all papers that were published in Russia in each of the selected disciplines, between 1973 and 2012. Figure 1 shows that women's proportion of fractionalized authorship is lower than that of men in all disciplines except Psychology. All disciplines taken together, women account for less than 30% of fractionalized authorship over the studied period. However, for Psychology, the contribution of women to published articles averages 45%, reaching more than 50% after 2000, making it the most gender-equal discipline of those in the analysis. 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 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, between 2000 and 2012. On the other hand, areas in which Russia has been historically very active – such as Mathematics, Physics and Engineering and Technology – are traditionally male dominated (Xie & Shauman, 2003, p. 33). Our results show that, in these disciplines, women represent less than 20% of fractionalized authorships.

Variations in the proportion of female authorship can be observed over time. 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 contributing factor to this increase. The gender gap being less significant in the national journals than in the foreign ones, then the inclusion of national journals in the database should lead to an effect like that shown in Figure 1. However, data of the years preceding 1973 would be necessary in order to better understand the observed increase in the proportion of female scientific output between 1973 and 1976.

From 1991 onwards, we observe a rise of the 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 "feminized" and "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. In a difficult economic position, the Russian state could not support science anymore, a large number of male scientists left Russia to continue their research abroad, which might explain part of this increase (Lewison & Markusova, 2011). On the other hand, we see after 1991 a significant decline of female relative contribution in Engineering and Technology. However, one should keep in mind that after 1991, our statistics lose all papers from other USSR republics, except the Russian Federation. If the authors' gender structure in these republics differed from that in Russian Federation, their removal might also disturb at this point the curves in Figure 1.

Figure 1 also shows, from 2008 onwards, stagnation in the female proportion of authorship in all disciplines, except Psychology – the discipline in which their proportion of the output is the largest. We should nonetheless acknowledge the fact that the total number of Russian papers in Psychology is relatively small with an average of 110 published papers per year for the 1973-2012 period, compared to an average ranging between 875 papers per year in Biology and 7527 papers per year in Physics.

Figure 1.Women's fractionalized authorships, by discipline, 1973-2012. A 3-year moving average was applied on all disciplines to enhance the readability of the figure.



Scientific impact

Figure 2 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 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 to a transition of the main publication language of Russian researchers which shifted from Russian to English (Kirchik et al., 2012). Therefore, the scientific impact of articles published after 1991 in Russia increases substantially, as articles written in English have a broader readership and, thus, a larger international impact, than papers published in Russian. As proposed by Lewison and Markusova (2011), this increasing 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, 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 increase of the Soviet journals in the database.

Figure 2. Average of relative citations of Russian papers,
by gender of the first author, 1973-2012

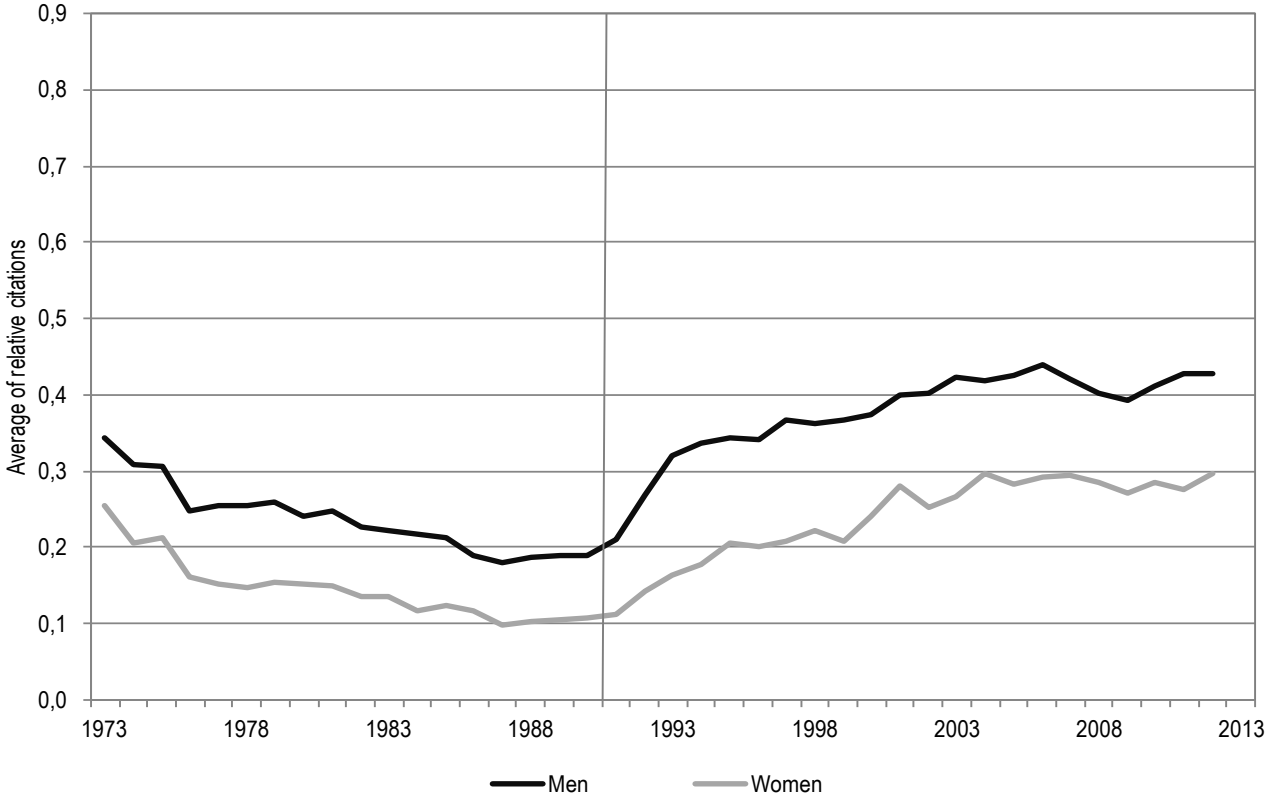


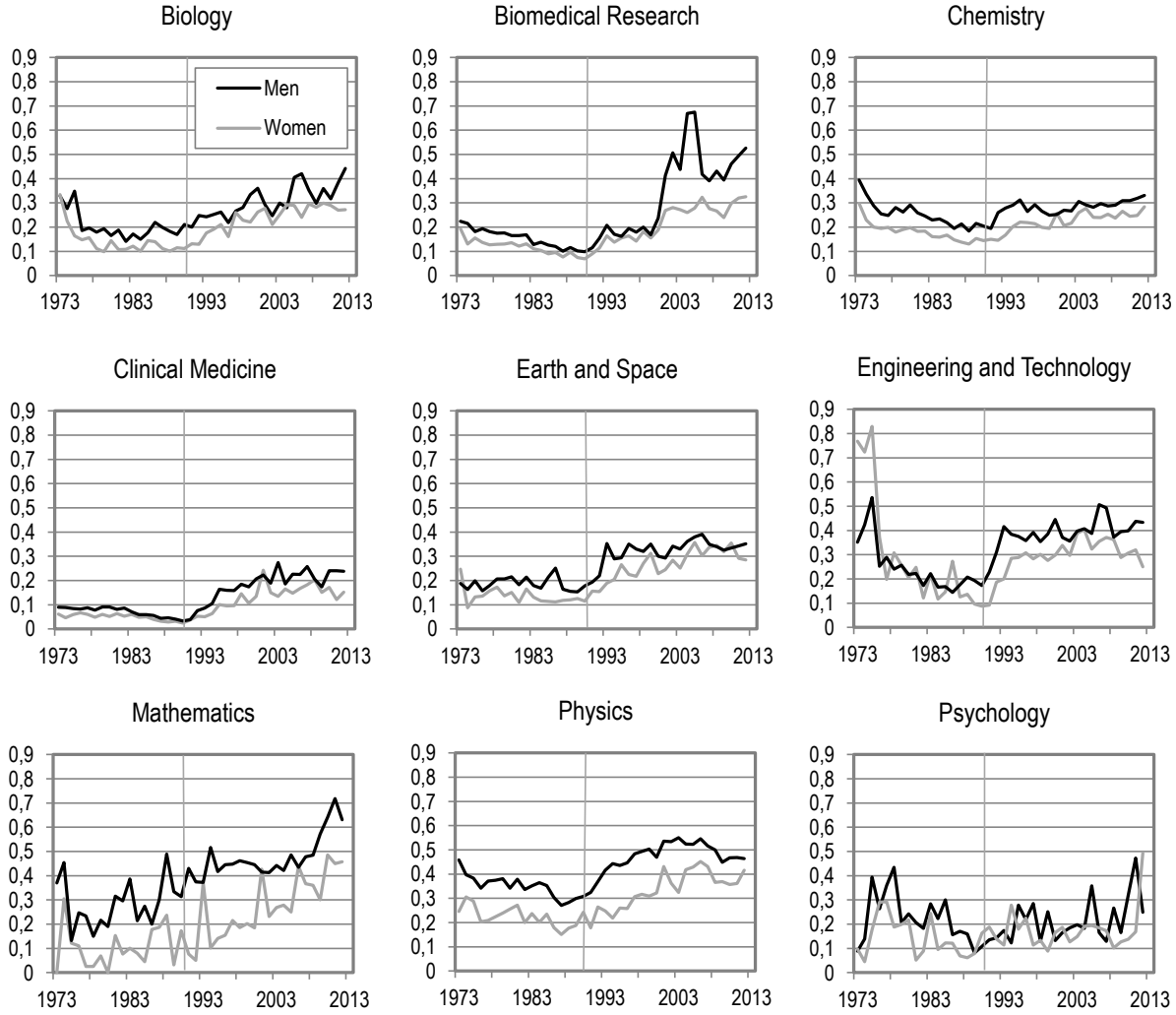
Figure 3 presents the evolution of the scientific impact of men's and women's first-authored papers by discipline. It shows, for each discipline, an increase of the scientific impact of Russian papers after the fall of the Soviet Union in 1991; a trend which is likely due to the transition of the language of scientific publications from Russian to English. The extent of the gender gap in terms of impact varies greatly by discipline. In Biology, Chemistry, Earth and Space sciences and Physics, the difference between men's and women's impact remains consistent over time, with men's impact being higher globally. In Biomedical Research and Clinical Medicine, articles published by men show a slightly higher relative impact until the 1990s for Clinical Medicine and the beginning of the 2000s for Biomedical Research. After that, men's papers' impact grows rapidly, increasing the gender gap in terms of impact.

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 3 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, 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 disciplines.

As observed with genders' contribution to the Russian research output (Figure 1), Psychology is also the most gender-balanced discipline in terms of scientific impact, with male researchers' impact being only slightly greater than that of female authors. However, after 1991, women's impact increases to reach that of men. We should nonetheless acknowledge the fact that the total number of Russian papers in Psychology is relatively small which explains the significant variations observed from one year to another.

Figure 3. Average of relative citations of Russian papers,
by gender of the first author, by discipline, 1973-2012



Conclusion

Our analyses of Russian productivity and scientific impact over the last 40 years clearly show that gender parity is far from being achieved. Women remain underrepresented in terms of relative contribution to scientific output across disciplines, although it is in Mathematics and in Physics, both research areas in which Russia has specialized, 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 a "brain drain" of male researchers 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, it is in Mathematics and Physics, the most traditionally male disciplines, that they have the highest impact (Figure 3).

After 1991, we observe an increase of both men's and women's papers' scientific impact (Figure 2). 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, we cannot interpret this increase as an improvement of the women's relative influence in Russian science.

The patterns presented here are not specific to Russia. As demonstrated in recent study (Larivière et al., 2013), gender disparities in science remain widespread across the world. Over the 2008-2012 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 less strong than that of their male counterparts, as articles published by female authors attract fewer citations. 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.

References

Abramo, G., D'Angelo, C. A. & Caprasecca, A. (2009). Gender differences in research productivity: A bibliometric analysis of the Italian academic system. *Scientometrics, 79*(3), 517-539.

Archambault, É., Vignola-Gagne, É., Côté, G., Larivière, V. & Gingras, Y. (2006). Benchmarking scientific output in the social sciences and humanities: The limits of existing databases. *Scientometrics, 68*(3), 329-342.

De Cheveigné, S. (2009). The career paths of women (and men) in French research. *Social studies of science, 39*(1), 113-136.

Freeze, G. (2002). *Russia: a history*: Oxford University Press.

Kirchik, O., Gingras, Y. & Larivière, V. (2012). Changes in publication languages and citation practices and their effect on the scientific impact of Russian science (1993–2010). *Journal of the American Society for Information Science and Technology, 63*(7), 1411-1419.

Kotsemir, M. N. (2012). Publication Activity of Russian Researches in Leading International Scientific Journals. *Acta Naturae, 4*(13), 14-34.

Larivière, V., Archambault, É., Gingras, Y. & Vignola-Gagné, É. (2006). The place of serials in referencing practices: Comparing natural sciences and engineering with social sciences and humanities. *Journal of the American Society for Information Science and Technology, 57*(8), 997-1004.

Larivière, V., Ni, C. Q., Gingras, Y., Cronin, B. & Sugimoto, C. R. (2013). Global gender disparities in science. *Nature, 504*(7479), 211-213.

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

Lewison, G. & Markusova, V. (2011). Female researchers in Russia: have they become more visible? *Scientometrics, 89*(1), 139-152.

Milard, B. (2009). L'héritage soviétique dans la nouvelle organisation de la science en Russie. *Revue d'anthropologie des connaissances, 2*(3), 391-411.

National Science Foundation. (2006). Science and Engineering Indicators. Chapter 5: Academic Research and Development. Data and Terminology.

Pislyakov, V. & Gokhberg, L. (2008). Assessing the relative standing of Russian science through a set of citation and publication indicators. *Excellence and Emergence. Book of Abstracts. 10th International Conference on Science and Technology Indicators.* (pp. 400-403). Vienna: ARC.

Savelieva, I. M. & Poletayev, A. V. (2009). Publications of Russian humanity scholars abroad: A sociometric analysis. *Journal of Educational Studies, 4*, 199–217.

Suchanska, M. & Czerwosz, E. (2013). *Women in technical universities in Poland*. Paper presented at the AIP Conference Proceedings.

Witz, A. (1992). *Professions and Patriarchy*: Routledge.

Xie, Y. & Shauman, K. A. (2003). *Women in science: Career processes and outcomes* (Vol. 26): Harvard University Press Cambridge, MA.