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Authors and Editors in Mathematics Journals: a gender perspective

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ABSTRACT

The under-representation of women in science and especially in the upper positions of the academic career is a matter of great current concern. The aim of this paper is to assess the presence of men and women as authors of papers and as editorial board members of eight first-class international Mathematics journals and to explore inter-gender differences in scientific activity (impact and collaboration). Only 4% of the members of the editorial boards are female scientists, while 10% of authors are women and they contribute to 18% of the papers. No relationship between the share of female authors, the share of female editorial board members and journal prestige is observed. A higher presence of female authors is found in the more applied journals. Women are slightly less cited than men as measured through the number of citations per paper and their contribution to the 10% most cited papers. Very small inter-gender differences in the collaborative behaviour of authors are observed. Underlying factors for explaining the under-representation of women in editorial boards are discussed. The need to encourage female presence in journal boards is pointed out.

KEYWORDS

Editorial boards, scientific journals, women and science, bibliometric indicators, gender studies

Authors and editors in Mathematics Journals: a gender perspective

INTRODUCTION

Main statistics on science and technology in leading developed countries reveal an unequal participation of men and women in research. Indeed, women in science remain a minority, as observed by the fact that they account for 30% of researchers in the European Union (She Figures, 2009). Women's presence, in relative terms, is greater in areas such as Health Sciences, Social Science and Humanities, whereas it is seriously poor in Engineering, Computer Science or Mathematics. This fact has not only been ascertained in the European Union, but also in the United States (NSB, 2008), New Zealand or Canada, and is even more dramatic in some Asian countries (OECD, 2006).

Moreover, the proportion of women decreases as we move up in the hierarchical structure of higher education and research institutes and a shortage of female representation in top and influential positions has been described. The existence of a "glass ceiling" or invisible barrier which hinders the advancement of women towards the elite positions has been described. Among other things, it means that the presence of women in decision making bodies involved in carrying out the research agenda is low, as well as their participation in important high level scientific discussions such as those resulting in the allocation of science budgets, and the award of research grants and top scientific prizes (ETAN, 2000).

The under-representation of women in science is currently a matter of concern for national governments and supranational institutions such as the European Union. Accordingly, different activities have been undertaken to promote female participation in science, not only due to equity reasons but also because our society needs to take advantage of all potential talent. The development of studies to improve our knowledge about the situation of women in science and the collection of sex-disaggregated indicators to track the evolution over time are recommended by the EU to monitor progress.

Since scientific journals play a crucial role in science, the study of the presence of male and female scientists in scientific journals can provide interesting information about their participation in the creation and dissemination of new knowledge. In particular, the presence of men and women as authors of publications and as members of editorial boards constitute relevant topics to be addressed. The study of authorship allows us to analyse the contribution of men and women to the knowledge base, while their participation as editorial board members or editors can be understood as a sign of their scientific reputation in the field (Robinson et al, 1998).

Editorial board members have been described as the "guardians" or "gate-keepers" of science (Crane 1967, Zuckerman and Merton 1971) because they contribute to ensuring that quality standards are maintained in publications. According to Ziman (1968) the referee is the cornerstone of

science. The selection of referees is carried out by journal editors who usually give primacy to scientists' experience in the relevant field and to their knowledge in a specific area or discipline, so as to ensure sufficient authority to assess a piece of work. Generally speaking, referees receive no financial compensation for their work as reviewers, but instead, they gain prestige within the scientific community and privileged access to data. An appointment to serve on the editorial board of a leading scientific journal indicates that the incumbent has acquired a high reputation in his or her field of expertise. Board membership is a sign not only of prestige, but also of power, since editorial boards decide what deserves to be published; contribute to setting the goals and standards of their profession; and influence the shape of the discipline (Addis and Villa, 2003; Braun 2004). From this perspective, the relevance of examining whether women are well represented in these strategic positions is clear.

There are a number of studies in the literature which analyse the presence of women in the editorial board of journals, especially in the fields of medicine. The percentage of women in editorial boards can be compared with their percentage in the speciality. As an example, we can mention that less than 20% of board members in journals from different medical specialties were women in the studies of Kennedy et al. (2001) and Morton et al. (2007), and that in many cases this percentage was significantly lower than the proportion of women in the specialty. In a more recent paper dealing with 60 major medical journals, 17% of all editorial board members were women, although great variability among journals and fields was observed (Amrein et al., 2011). More positive results have been described in some social science fields, such as political science, where Steigmaier et al. (2011) concluded that women were well represented in editorial positions (26%) in proportion to their presence in the profession.

The participation of women at the editorial level has been compared in several studies with their presence as authors of papers in the corresponding journals. The development of this type of study is more difficult because the sex of the authors needs to be determined. Following this approach, women tend to be under-represented in editorial positions in different disciplines such as psychology (Robinson et al., 1998; Evans et al., 2005) or epidemiology (Dickersin et al., 1998), where fewer women hold editorial positions than were authors of papers. In general terms, the proportion of editorial board members who are women tends to increase over the years but, even in the most recent years, finding women in leading positions, such as chief editors, is extremely rare.

On the basis of the foregoing, this study analyses the presence of women in a selected set of Mathematics journals. Although different statistics show that women are under-represented in this field (low numbers of female PhD holders and female researchers),a trend towards higher balance over the years has been described (Hobbs and Koomen, 2006; She Figures, 2009). Our aim is to assess women's representation in editorial boards as compared to women's presence in the specialty —measured through their presence as authors in published journals— and explore possible inter-gender differences in scientific activity. Unlike previous research that concentrates on the composition of the editorial boards or in the authorship

of published papers from a gender perspective, this paper offers an integrated perspective including also the analysis of other aspects of scientific activity (publication based impact and collaboration measures). Some preliminary data concerning the editorial board composition were analysed elsewhere (Mauleón and Bordons, 2007). The development of this study follows international recommendations to gain insight into the status of women in science, explore inter-gender differences in research performance and, in the long term, promote their participation at all levels of the hierarchical structure of scientific bodies (Bilimoria et al., 2008; ETAN, 2000; She Figures, 2009).

OBJECTIVES

The aim of this paper is to analyse the presence and activity of female scientists as compared to their male counterparts in a sample of mathematical journals. The following questions are addressed:

- What is the share of women and men within editorial board members? What are their roles in the editorial board?
- Are women represented in the editorial boards as frequently as they are authors of papers in the corresponding journals?
- Are there differences in the collaboration practices of men and women?
- Are there inter-gender differences in the impact of the research?

This research aims at showing the interest of publication-based indicators to assess the presence of women in science. The results of this research can be relevant for policy makers, those interested in monitoring the presence of women in science, and also for journal editors and scientists themselves.

METHODOLOGY

Source selection

The study focuses on a sample of eight journals specialising in Mathematics and selected according to various criteria: international character, high quality and accessibility. Journals covered by two prestigious international databases (Web of Science and Mathscinet), with a high impact factor in the discipline of "Mathematics" (WoS category), and full-text papers available through Science Direct were selected.

The Web of Science database, produced by Thomson Reuters (USA), is a multidisciplinary database which covers at present over 10,000 of the most prestigious and high-impact journals. This database processes the journals "cover to cover", including all the authors signing each document, and all their addresses, which allows us to conduct studies on cooperation between authors, centres and countries. It also includes bibliographic references used in the papers and citations received. On the other hand, Mathscinet, the most important database in Mathematics, produced by the American Mathematical Society, was used to verify the interest of the selected journals in the area of Mathematics. The Science Direct database, from the

European Elsevier Science distributor, was used to have access to full texts of papers and obtain the full name of the authors, since only the initials were recorded in the Web of Science for the papers analysed in this research [1].

The Web of Science classifies journals in more than 200 subfields, "Mathematics" being one of them, with 181 publications included in 2004. A total of eight journals were selected. These ranked among the 25% with the highest impact factor (first quartile) within the subfield included at the same time in the three products mentioned above (Web of Science, Science Direct and Mathscinet) were selected. The year 2004 was selected for the study to allow papers to receive citations during a relative long period of time (six years).

The list of journals studied is shown in Table 1, including country of publication, JCR impact factor in 2004 and research level. The journal impact factor represents the average citation rate of papers published in a given journal two years after publication. It is widely accepted as a measure of the journal's prestige or quality (Moed, 2005). "Position" refers to the position held by each journal in the ranking of Mathematics journals in descending order of impact factor according to the Journal Citation Reports (JCR 2004). Concerning the country of origin, four of the journals are North American, and the remaining four European. All of them are written in English, but the *Annales Scientifiques de l´École Normale Supérieure* also publishes papers in French. The last column in Table 1 includes the research level of journals according to their applied/basic nature as described under the categorisation of journals established by CHI Research Inc. (Noma, 1986), which considers four levels ranging from the most applied (level 1) to the most basic (level 4). One journal was not assigned to any of the categories above.

Journal	Country	Impact factor	Position N=181	Research Level*
Advances in Mathematics	United States	1.067	13	4
Annales Scientifiques de l'École Normale Supérieure	France	1.186	11	4
Computational Geometry-Theory and Applications	Netherlands	0.742	33	-
Journal of Combinatorial Theory, SeriesB	United States	0.618	44	4
Journal of Differential Equations	United States	0.877	24	3
Journal of Functional Analysis	United States	0.962	16	4
Journal de Mathématiques Pures et Appliquées	France	0.926	19	3
Topology	England	0.727	34	4

Source: JCR 2004. "Mathematics" category.

**Note: Level 1=applied development; Level 2= applied research; Level 3= strategic research; Level 4= basic research. Classification originally described by CHI Research Inc., see Noma, 1986, updated by ipIQ in 2007.*

Table 1. Journals studied including their country of publication, impact factor (JCR 2004), position in the Mathematics category and research level

Data processing

Papers published in 2004 by the eight selected journals were downloaded from the Web of Science (WoS) and exported to a specific database. Only scientific articles were studied. Any other type of papers, such as book reviews, editorials or news, was excluded. The number of male and female authors included in each paper was recorded.

Main indicators

The following aspects were studied for each journal:

a). Editorial boards:

- Men and women's presence in the editorial board (percentage of men and percentage of women).
- Men and women's roles in the editorial boards (participation as editor in-chief or as ordinary editorial board members).

b). Papers' characteristics

- Men's and women's contribution to papers: analysed through the percentage of male and female authorships as well as through the percentage of papers authored only by men ("only men papers"), only by women ("only women papers") and by both ("men and women papers").
- Collaboration habits: male and female relative contributions to different collaboration intensity categories of papers were analysed. Collaboration intensity categories were based on the number of authors (1, 2, 3 or at least 4 authors/paper), number

of centres (1 or more) and number of countries (1 or more – international collaboration). This analysis informs us about the comparative tendency of men and women to collaborate.

- Impact by gender: citations received by papers are a widely accepted indicator of the impact of research over the scientific community (Moed, 2005). In this paper, citations received by papers during a period of six years after publication are analysed. A long citation window is considered (6 years) because papers in Mathematics tend to be cited long after publication (long "cited half-life"). Inter-gender differences in the number of citations per paper were explored.
  The presence of men and women among non-cited papers and among the 10% most cited papers (highly cited papers, HCP) are also studied.

In many disciplines, the position of the authors in the by-line of the publications is related to the extent of their contribution to the research. However, this variable was not analysed in this study because the alphabetical order is the applicable rule in Mathematics (AMS 2009) (http://www.ams.org/employment/CultureStatement09v2.pdf).

Authors and Editorial Board members' gender

The use of the variable of gender was a challenge, as the gender of authors and editorial board members is not recorded in bibliographic databases or in journals. Different complementary approaches were followed to determine the gender of both groups of scientists.

Firstly, the gender of 22% of the authors was inferred directly from their names. However, most of the selected journals only showed the initial of the first name, which made the first approach impracticable. Thus, in these cases, the full name of the authors was obtained making use of the Internet, and the gender of 23% of the authors was identified. Two directories specialising in Mathematics were used and useful information was gathered from the researcher's curriculum vitae. Finally, the gender of 51% of the scientists was identified via e-mail, since we wrote to them informing of our ongoing research and requesting gender-related data (with a high rate of respondents). Only the gender of 4% of authors was not assigned.

RESULTS

A total of 178 editorial board members and 733 papers written by 1466 authors are analysed in this paper. The editorial board size ranges from 10 to 50 members (average 22.25±13.93).

Editorial board characteristics

As regards the presence of women in the editorial board, on average, only 4% of editorial board members are women. This ratio varies from 0% (four journals) to 11% (one journal) (Table 2).

Journal	Members in editorial board		
	Men	**Women**	**Total**
Advances in Mathematics	47 (94%)	3 (6%)	50
Annales Scientifiques de l'École Normale Supérieure	10 (100%)	0 (0%)	10
Computational Geometry-Theory and Applications	34 (94%)	2 (6%)	36
Journal of Combinatorial Theory, Series B	20 (95%)	1 (5%)	21
Journal of Differential Equations	19 (100%)	0 (0%)	19
Journal of Functional Analysis	14 (100%)	0 (0%)	14
Journal de Mathématiques Pures et Appliquées	10 (100%)	0 (0%)	10
Topology	16 (89%)	2 (11%)	18
Total	**170(96%)**	**8 (4%)**	**178**

Note: Percentages in rows. Journals sorted in alphabetical order.

Table 2. Composition of journals' editorial boards by gender

Men's and women's presence in the editorial boards shows that the rate of women decreases in the positions that reflect a higher degree of prestige. Therefore, no woman was found among 18 Editors-in-chief, 9 Honorary Editors or 5 Founding Editors.

Characteristics of the papers

Presence of men and women as authors

A total of 836 research papers were published in the journals under review in 2004. Our study was limited to the 733 papers (87% of the total) whose author(s) gender had been identified. The percentage of authors identified ranged from 64% to 100%, depending on the journal.

A total of 10% of the authors were women. The share of women varied by journals, from 4% to 15% (Table 3).

Journal	No. Authors			No. Papers			
	Total no.	% Men	% Women	No. Papers	% Only Men	% Only Women	% Men & Women
Advances in Mathematics	236	92.8	7.20	131	87.79	3.82	8.40
Annales Scientifiques de l'École Normale Supérieure	48	87.5	12.50	27	81.48	11.11	7.41
Computational Geometry	138	86.96	13.04	44	65.91	2.27	31.82
Journal of Combinatorial Theory, Series B	140	95.71	4.29	60	91.67	0.00	8.33
Journal of Differential Equations	362	87.85	12.15	187	77.54	3.21	19.25
Journal of Functional Analysis	350	90.57	9.43	184	83.15	4.89	11.96
Journal de Mathématiques Pures et Appliqués	85	84.71	15.29	43	69.77	6.98	23.26
Topology	89	89.89	10.11	57	85.96	8.77	5.26
Total	1448	89.92	10.08	733	81.58	4.37	14.05

Table 3. Number of authorships and papers by gender and journal

Papers authored only by men prevail in all the journals under review. On average, 82% of the papers were authored only by men. The percentage of papers authored by both men and women amounted to 14%, while hardly 4% of papers were authored only by women (Table 3). Overall, half of the papers were authored by two or more men and 31% by one single man, while almost 4% were written by one single woman and less than 0.5% by two or more women. Differences by journals can be observed in Figure 1.

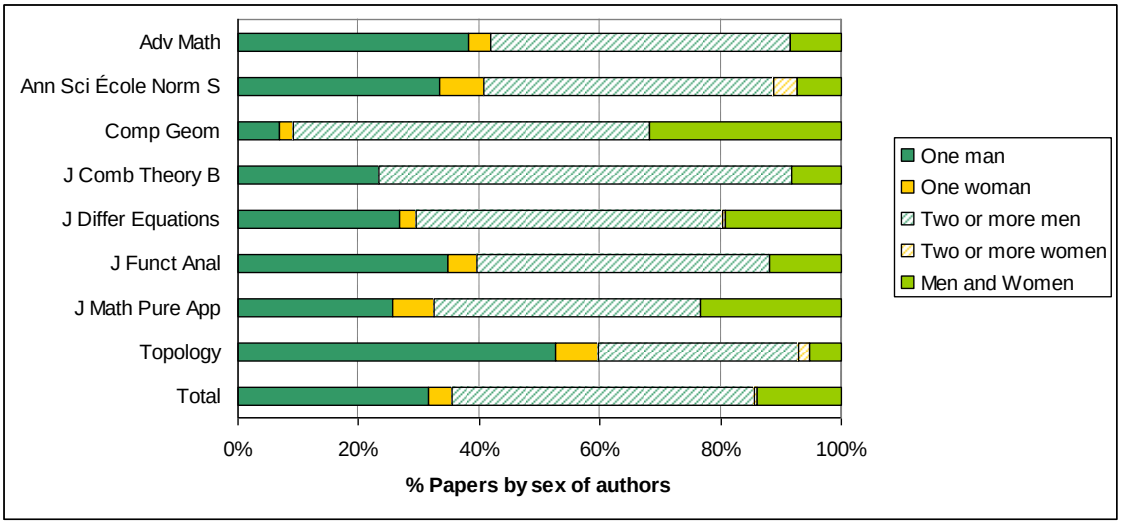

Figure 1. Distribution of papers by gender of authors

Concerning authorship, a total of 1,448 authorships were found, and 10% of them corresponded to women. Figure 2 shows the percentage of female authorships and the percentage of papers with at least one woman within each journal. It is interesting to remark that although only 10% of authors were women, they were spread over 18% of the papers ("total" values in Figure 2), because women tend to collaborate very frequently with men. The highest difference between the percentage of female authors and that of papers with at least one woman corresponds to *Computational Geometry*, *Journal de Mathématiques Pures et Appliquées* and *Journal of Differential Equations*, which means that these journals showed greater collaboration. In fact, these three journals show the highest percentage of "men and women" papers (Table 3).

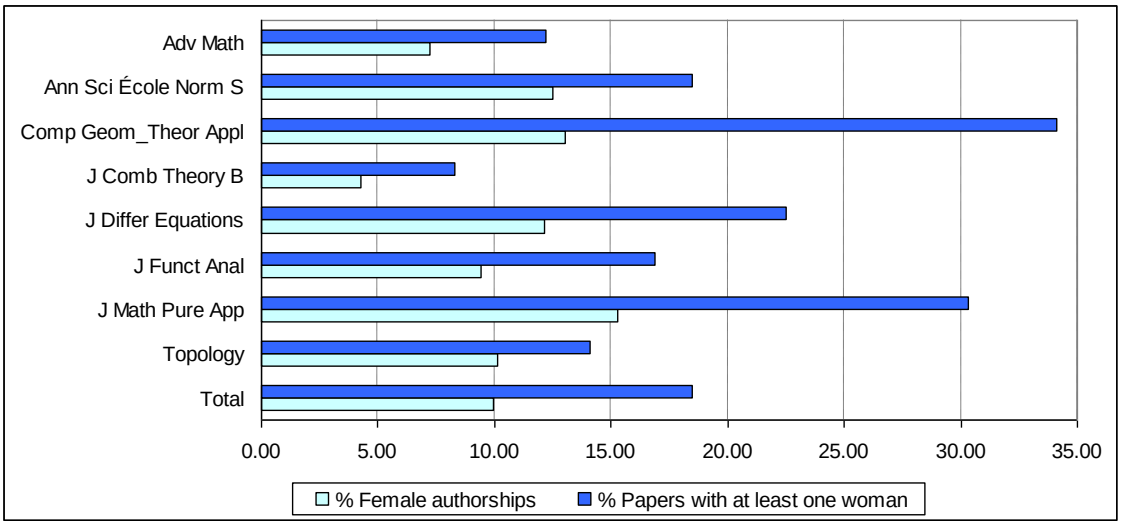

Figure 2. Proportion of female authorships and proportion of female papers by journal

Collaboration practices

Research in the set of mathematics journals under study is not very collaborative, as shown by the high percentage of papers with a single author (35%) or with a single centre (46% of papers, 337 out of 733). Papers present an average of 1.97+/- 0.97 authors/paper (median=mode=2, range=1-7) and 1.74+/-0.82 centres/paper (median=2, mode=1, range=1-5).

Interestingly enough, some differences in the collaborative practices of scientists by journals have been observed (Annex I). The most outstanding finding is the high collaboration rate found in *Computational Geometry*, where only 9% of papers are single-authored (vs. 35% for the overall set of journals) and papers had an average of 3.14 authors/paper (vs. 1.98 for the overall set).

Our results show that cross-gender papers are more frequent in the most collaborative journals, although the rate of female authorships existing in each journal is also a factor that has to be taken into account. Accordingly, an average of 21.78% of multi-authored papers had cross-gender collaboration, but it ranged from 10.9% in *Journal of Combinatorial Theory-B* (a journal with low female authorship) to around 35% in *Computational Geometry* and in the *Journal des Mathématiques Pures et Appliquées* (journals with a relatively high female authorship rate) (Annex I).

It should be noted that women tend to be in a minority within teams. The average size of cross-gender teams is 2.8 authors per paper, with only one woman among them. Differences among journals are shown in Figure 3. The share of female authors decreases as team sizes grow, because the larger size of teams is mainly accomplished through the inclusion of new male authors.

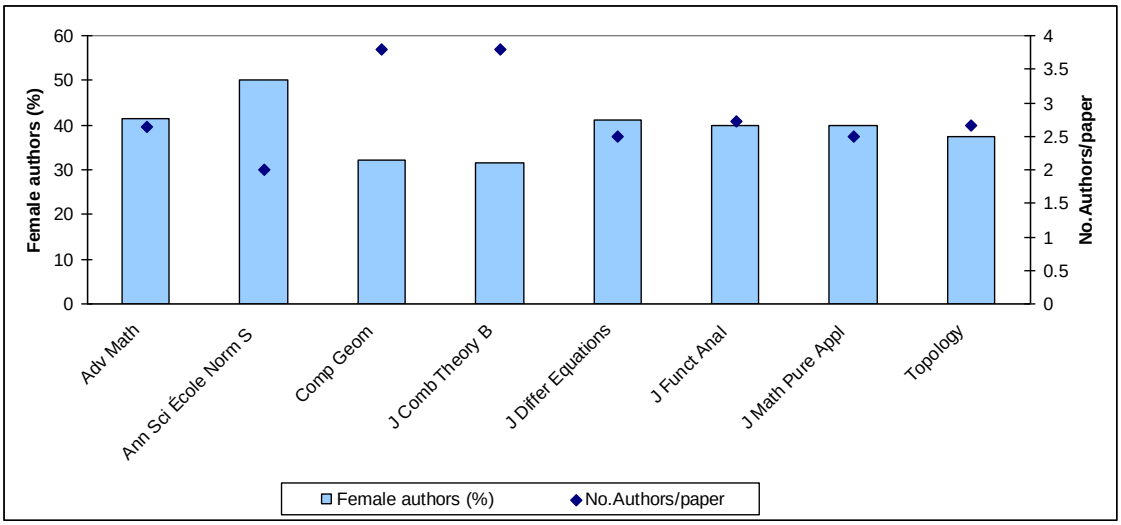

Figure 3. Share of female authorships and team size in cross-gender papers by journal

To explore possible inter-gender differences in scientific collaboration trends, an analysis of the relative contribution of men and women to different categories of papers –determined by increasing numbers of authors, centres and countries- is conducted (Table 4). An index of the relative presence of men and women depending on the type of existing collaboration is calculated in the last column of table 4. The relative presence of women in each collaborative class is the ratio between the share of women in the given class (for example, in single authored papers) and the share of women in the total set of papers taken as a baseline (10.08%). Values above one indicate that women are present in the analysed class in a higher proportion than in the total set of papers. The relative presence of men is calculated in the same way. We observe that women are more likely to write alone or in highly multi-authored papers where the percentage of women is 11% above the average figure. Furthermore, it seems to be easier to find a woman in papers with more than 4 centres, where the percentage of women is 17% above the average rate (last column in table 4). In any case, inter-gender differences found in the collaborative behaviour of authors are very small.

	Number of authors			Share of authors		Index of relative presence by sex	
	Men (M)	Women (W)	Total	% Men	% Women	% M in row/ % M in total	% W in row/ % W in total
By Authors							
1 author	231	29	260	88.85	11.15	0.99	1.11
2 authors	538	56	594	90.57	9.43	1.01	0.94
3 authors	343	37	380	90.26	9.74	1.00	0.97
At least 4	190	24	214	88.79	11.21	0.99	1.11

By centres							
1 centres	390	46	436	89.45	10.55	0.99	1.05
2 centres	553	60	613	90.21	9.79	1.00	0.97
3 centres	277	29	306	90.52	9.48	1.01	0.94
At least 4	82	11	93	88.17	11.83	0.98	1.17
By countries							
1 country	644	78	722	89.20	10.80	0.99	1.07
More than 1	658	68	726	90.63	9.37	1.01	0.93
Total	1302	146	1448	89.92	10.08	1.00	1.00

Note: cells in the last column are shaded when female percentage is at least 10% higher than that of men.

Table 4. Women involvement in papers by collaboration intensity: female authorships and index of relative presence by sex

It is interesting to point out that inter-gender collaboration is present in 97% of multi-authored papers with at least one woman, but only accounts for 22% of multi-authored papers with at least one man. From this we cannot infer inter-gender differences in the trend to collaborate with the same or with the opposite sex, because these data are strongly influenced by the smaller population of women as compared with men, which makes collaboration among individuals of the same sex more difficult for women. Thus, it is much easier for men to find other male partners than for women to team up with female collaborators. To explore this issue, the expected frequencies of collaboration between authors were calculated using as a sample the set of papers with two authors (which accounts for 63% of multi-authored papers) taking into account the number of men and women present in those papers. A total of 594 authorships (56 women and 538 men) were identified in 297 papers with two authors. The probability of the female-female combination (0.01) was lower than that of male-female (0.16) and much lower than that of male-male (0.82) [2]. Significant differences were not found between these expected frequencies and those observed. In fact, the male-male combination was present in 244 out of 297 two-author papers (82%), while female-male co-authors wrote 50 papers (17%) and female-female collaboration was observed in only three papers (1%). So, inter-gender differences in the trend to collaborate with the same or with the opposite sex cannot be inferred from our study.

Impact by gender

To measure research impact, the percentage of non-cited papers, the number of citations per paper and the percentage of highly cited papers (HCP) were studied. Approximately 7% of papers had not received any citation six years after publication. This rate varies from 0% to 12%, across journals under study. A total of 5,557 citations were distributed among 727 papers. Therefore, on average, each paper received 7.64 citations.

Six year citation counts have been assigned to men and women on fractional count basis. Accordingly, in a paper with 10 citations and 4 authors (two men and two women), five citations are assigned to men and

five to women. The total citation count for each of the groups (men and women) is divided by the fractional total contributions within each gender to obtain the average number of citations per paper (Lewison and Markusova, 2011).

The number of citations per paper was around 16% higher for men than for women (7.76 vs. 6.67). The greatest differences by sex are observed in the French journal *Annales Scientifiques de l'Ecole Normale Supérieure*. On the other end of the spectrum we find the English title *Topology*, where women get more citations than men (Figure 4).

It is interesting to observe than single-authored papers, either written by women or by men (4.76 and 5.83 citations/paper respectively) receive fewer citations than multi-authored papers (an average of 8.73 citations/ paper), which suggests interest in developing collaborative strategies in the field.

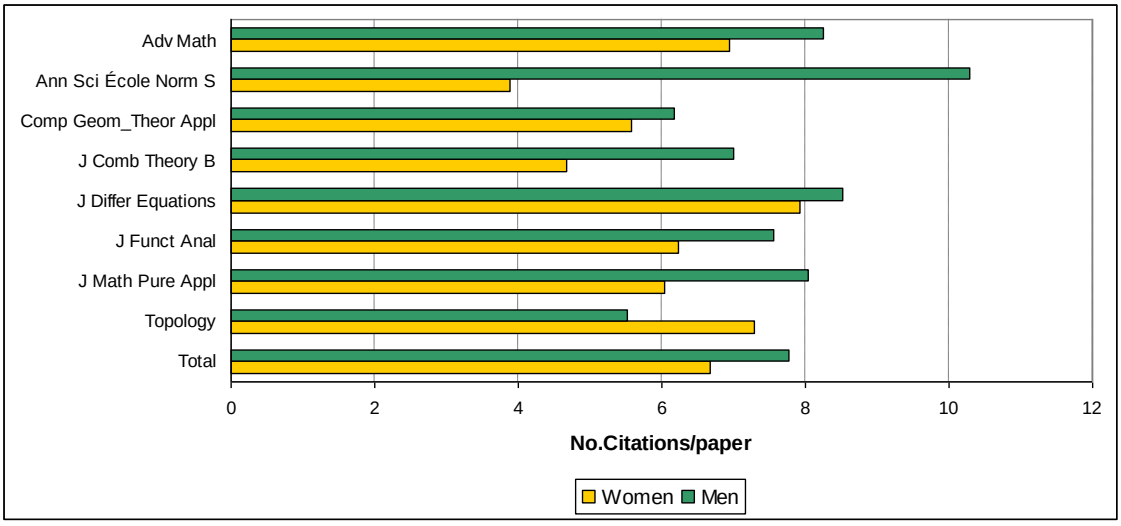

Figure 4. Average number of citations per paper by journal and gender of the authors

Finally, male and female contribution to the 10% most cited papers was analysed (fractional count). The contribution of women to this set of highly cited papers was slightly lower than in the remaining set of papers (7.97% vs 10.59%) while their presence among non-cited papers was slightly lower (6.8% vs 10.54%).

Relationship between female presence and journal characteristics

Correlations between variables at journal level are shown in Table 5. The Spearman rank correlation coefficient, which is a non-parametric technique, is used to measure the degree of linear association between variables. A negative correlation between the percentage of female authors and the research level of journals is observed, which means that the presence of women tends to rise in the more applied journals. In addition, the presence of cross-gender papers is negatively correlated with the research level because the more applied journals show a higher share of cross-gender

papers. No relationship between the share of women in editorial boards and the share of women authors or the size of the editorial board is observed, and neither is the presence of women in journals related with their impact factor. In any event, we should keep in mind the small number of journals analysed. The Spearman rank correlation coefficient is used in this paper as an exploratory tool, but the study of larger samples of journals would be required to enable a more comprehensive and sound analysis of data.

		1	2	3	4	5	6	7	8
1	% Women authors	1	-0.294	-0.732*	0.190	0.190	0.143	-0.479	0.524
2	% Women in editorial board			0.242	-0.472	-0.128	-0.690	0.642	-0.281
3	Journal Research Level			1	0.169	-0.620	-0.056	0.000	-0.845**
4	Journal Impact Factor				1	-0.429	0.762*	-0.323	0.000
5	No.Authors/paper					1	-0.214	0.311	0.762*
6	No.Citations/paper						1	-0.275	0.024
7	Editorial board size							1	0.156
								.	
8	% Cross-gender papers/tot.papers								1

Note. *p<0.05; ** p< 0.01.

Table 5. Spearman correlations between variables at the journal level

It is remarkable that the more applied journals (level 3) show a higher average share of female authors than the more basic ones (level 4) (13.49% vs 8.71)(Mann-Whitney test; Z=-1.938, p<0.05) and a higher share of cross-gender multi-authored papers (32.25% vs 14.14%)(Z=-2.236, p<0.05) [3].

DISCUSSION AND CONCLUSIONS

Since scientific journals play an important role in the communication and advancement of science, exploring the presence and activity of women as editors and authors in these journals is an interesting way of assessing the participation of women in science. This study quantifies the participation of men and women as editors and authors in a sample of Mathematics journals, analyses their impact and collaboration habits from a bibliometric perspective and points out the main methodological problems which need to be solved in the elaboration of this type of study. These three issues are addressed below.

Methodological aspects

The main difficulty observed in the development of this study was the identification of the gender of the authors. The fact that their full names were not included in the by-line of bibliographic records downloaded from Web of Science or in the editorial board composition was an additional problem, since we had to collect full names from the original publications or from web-based searches within the institutional settings of the authors. Although the full names of authors were not included in Web of Science for 2004 records, the year analysed in this study, it has been progressively added since 2006. At present, the most prestigious multidisciplinary databases, such as the Web of Science or Scopus, include the full name of authors -if available in the journals- as well as a dictionary of author names and even an on-going system to identify authors with a specific number (see for example, http://wokinfo.com/researcherid/; http://www.info.sciverse.com/scopus/scopus-in-detail/tools/authoridentifier/). Also in Mathscinet special tools have been developed to allow authors to be uniquely identified. If successfully introduced in different databases, these improvements will make the development of gender studies much easier in the future.

It should be noted that the simple inspection of names did not allow us to identify the gender of the authors in all cases. Some difficulties observed were attributable to the country of origin of the scientists. It can be relatively easy to identify the gender of scientists from some countries, either because their name could be clearly linked to a specific gender or because gender was built-in in it, as is the case in Polish and Icelandic surnames (Webster, 2001; Lewison, 2001;), but it can be very difficult for certain specific names, such as those of Chinese nationals. It should be noted that the identification of author gender was a strenuous and time-consuming task. In fact, only for 22% of the authors, their gender was derived from the author's name. Searching the Internet was successful in another 23% of the cases. Finally, in half of the cases the data were obtained directly from the author. The development of databases including first names and gender information by countries would make this task much easier (Biosoft, 2001) (ftp://ftp.cordis.europa.eu/pub/indicators/docs/ind_report_biosoft1.pdf).

In relation to the composition of journal editorial boards, the lack of standardization of the information provided by journals themselves was also evident. According to our data, journals from the United States furnish more complete information than their European counterparts, but we should be cautious given the low number of journals studied. The inclusion of the full name of the members of the editorial boards and their institutional affiliation would be desirable to identify scientists properly.

To sum up, we would like to remark the interest of encouraging authors, journals and databases to include the full name of authors in papers and records and to standardize them. Some initiatives in this direction can be currently viewed in some leading journals and databases, but shared policies on how to index authors' names are needed. This would contribute to increasing the quality of databases, facilitating bibliometric studies at the micro level and obtaining sex-disaggregated indicators. The standardization

of authors' names could make male and female researchers' works more visible and could help the scientific community to identify men's and women's contributions to science properly. The development of a digital author identifier (see for example, the ORCID initiative: http://about.orcid.org/) is an interesting option which would greatly help to conduct these types of studies in the future.

Editorial boards

Our results show that only 4% of the members of the editorial boards are women, a figure which is much lower than the presence of female scientists in the area of Mathematics. As a proxy for the latter we can consider the percentage of women as authors in the papers (10%) or their percentage in the academic field. In 2005 the proportion of women in mathematical research was around 23% in France, 17% in the UK and 10% in the Netherlands (Hobbs and Koomen, 2006), while 18% of US full-time faculty researchers were women in 2006 (NSB, 2008). Although we are dealing with international journals, which include papers from a wide variety of countries, female presence in academia either in the EU or in the US can be an appropriate reference given the countries of origin of the journals under study (four from European countries and four from the US).

The low number of women in senior positions -below 10% in most of the EU countries (Hobbs and Koomen, 2006) - may be a determinant factor of the under-representation of women in editorial boards, since the most prestigious scientists are most likely to be invited for editorships of journals. Different reasons, such as the later entrance of women in science, their lower productivity or social and personal factors, have been argued to explain the scarce female presence in senior and decision-making positions (European Commission, 2008).

Studies in different fields have shown that the later entrance of women in science might contribute to the lower female presence in the upper categories, and the fact that women are younger than men in many academic fields is pointed out. From this standpoint, it would be just a question of time before women attain the highest positions in the academic hierarchy. However, this is not the only explanation as, after controlling for the age or number of years at the institution, differences in the distribution of men and women by professional categories have been described in a few studies. Thus, women were less likely than men to be in the upper categories in a study of the Spanish CSIC in Materials Science (Mauleón and Bordons, 2006) and Biology (Mauleón, Bordons and Oppenheim, 2008) whilst women´s probability of being promoted was lower than that of their male colleagues in the Italian CNR (Palomba and Menniti, 2001). Moreover, female scientists and engineers were less successful than their male counterparts in travelling along the academic career path in a study conducted using data from the Survey of Doctorate Recipients in the United States (NSF, 2004). Various authors have pointed out that the low number of women in Mathematics, which has been historically a male field, does not facilitate the progression of women to the upper positions, in part due to the lack of female role models and the more difficult integration of women in the field scientific networks (see for example, Hill et al., 2010). Indeed, different studies suggest that women are less frequently involved in the

informal networks that lead to editorships and invitations to appear on programs or serve on governing boards of professional societies (Dickersin et al., 1998).

A lower performance level of women as compared to men could account for their lower promotion rates and prestige and, consequently, to be selected less often than men for positions of authority. The lower productivity found for women in different disciplines and countries ("productivity puzzle") (see for example Abramo et al., 2009; Lariviére et al., 2011; Palomba and Menniti, 2001; Prpic, 2002; Puuska, 2010), and described specifically for Mathematics in some studies (Aksnes et al., 2011), can be an underlying factor. The higher relative concentration of men among "star scientists" is a factor contributing to the higher average productivity described for men in some of these studies (Abramo et al., 2009). In our research, the fact that women are under-represented among authors when compared with the rate of women scientists in academia might support the lower female productivity mentioned above. Regarding impact, contradictory results have been described in the literature. A higher impact of female scientists has been observed by some authors (Feller, 2004; Sonnert and Holton, 1996; Zuckerman, 1987), while others conclude that female publications are less cited than those of men (Aksnes et al., 2011) and some studies have found that women publish fewer but high quality papers (Long, 1992). In our data, female impact was slightly lower than that of men, as measured by the average number of citations per article, and women were slightly under-represented in the set of highly cited papers. These findings can hinder their "attractiveness" as editorial board members.

Personal and social factors might also contribute to explain inter-gender differences in research performance and in the subsequent prestige of scientists. Family responsibilities such as the presence of children, less access to resources and higher involvement in teaching over research has been described for women and may hinder their dedication to research (NSF, 2004). Again, the influence of these factors can be especially relevant in a male dominant field such as Mathematics, since young women may have difficulty in finding role models or mentors who help them in advancing in their careers and in achieving work-life balance (Hill et al., 2010).

As the presence of members from different countries in the editorial board of journals may favour its international dimension, since they can invite scientists from their respective countries to submit papers for publication in the journals, the presence of women in the editorial boards might favour the participation of female scientists as authors in the journals. However, in our study, journals with a higher presence of women as editorial board members do not show a higher percentage of papers published by female scientists. In fact, no woman sat on the editorial board of the journal with the highest percentage of papers written by female scientists.

Moreover, note should be taken that women are not present at all in the editorial boards of half of the eight journals analysed. This is especially striking in the case of the two journals edited in France, since they show the highest values of female authorship and relative high values of women in

academia have been described for the country (Hobbs and Koomen, 2006). The small size of the editorial boards of these two journals (10 people each) can be an underlying reason, since a positive correlation between editorial board size and the share of female editorial board members has been described in the literature (Mauleón et al, 2012; Metz and Harzing, 2009). In addition, it should be noted that none of the eight journals analysed has a female editor-in-chief and that having a woman in this key position has been positively associated with the share of women in editorial boards in previous studies (Mauleón et al., 2012; Metz and Harzing, 2009). The explanatory reason argued for the positive influence of a female editor-in-chief is that journal editors are more likely to appoint same-sex scientists who are probably part of their social and professional network.

Although previous research has described a higher proportion of women in editorial boards of the most prestigious journals (Metz and Harzing, 2009; Miqueo et al. 2011), no relationship between the prestige of the journal (as measured by the impact factor) and the presence of women as authors or editorial board members was observed in our study. Further research including a larger sample of journals would be required for an in-depth analysis of this issue. The generalist/specialised scope of journals and their basic/applied orientation can then be taken into account since these factors may have an influence on the impact factor of journals.

Finally, we would like to mention the interest of studying the attitude of women on the issue of access to editorial board membership. The possibility that women are less likely to nominate themselves for editorships than men has been mentioned in the literature (Dickersin et al., 1998). On the other hand, it would be interesting to explore whether women are more likely than men to refuse when asked to serve on editorial boards. Since the pool of women who have achieved enough scientific recognition and expertise to deserve an invitation to join an editorial board is limited, senior women might decline invitations if they are overloaded with different academic activities and appointments (Jagsi et al., 2006).

Impact and collaboration

The indicators show a low level of collaboration in the set of Mathematics journals analysed (46% papers written by a single centre; 35% by a single author), which is consistent with the data described for this field in previous studies (Gazni et al, 2012). An exception to this is found for the journal *Computational Geometry*, which shows highly collaborative research (only 9% of single-authored papers and almost 82% of multi-centre papers). This different behaviour can be partly explained by the closeness of this mathematical subfield to Computer science [4], which is more collaborative (Gazni et al., 2012) and more interdisciplinary than Mathematics (Morillo et al., 2003).

In our work, only slight differences in the distribution of male and female authors by collaboration classes were found: women tended to be slightly over-represented in single-authored and highly multi-authored papers as well as in single-country papers over those with international collaboration. However, the differences are so small that they hardly support the lower

integration of women in scientific networks described in the literature (Kemelgor and Etzkowitz, 2001).

Previous research, such as the works by Ferber and Teiman (1980), McDowell and Smith (1992) and McDowell et al. (2001), has shown differences in collaboration patterns depending on gender. In particular, a higher tendency of scientists to collaborate with colleagues of the same gender was described in economics (Ferber and Teiman, 1980). Inter-gender differences in the trend to collaborate with the same or with the opposite sex cannot be inferred from our study, since the observed frequencies of collaboration by sex were similar to those expected according to the number of men and women existing in our sample. The fact that women constitute a minority in the mathematical scientific community does not mean that they are isolated, as least as far as their collaboration practices concern.

In our study, multi-authored papers obtained greater citation rates than single-authored ones (either written by women or by men) pointing out at the importance of team work also in a mainly theoretical science field such as Mathematics. Improving cross-gender collaboration can be especially positive for women, since as long as the number of women active in this field remains so low, it would be easier for them finding colleagues of the other sex with common scientific interests.

The lower citation rate of women compared with men might suggest that women's research is less influential than that of their male colleagues. However, different factors should be taken into account. Firstly, it should be noted that gender differences in citation rates may be explained by differences in productivity (Aksnes et al., 2011) since there is a cumulative advantage effect of increasing publication output on citation rates. If women tend to publish less than men, they would benefit less from this effect. Secondly, differences in the specialisation profile of men and women may contribute to explain differences in their citations rates. In fact, the preference of women for less competitive topics (Fox, 1999) and for more applied research has been described in the literature (Lewison, 2001). This claim is consistent with the higher presence of women authors in the most applied journals found in our study. Thirdly, Leahey (2006) suggests that women tend to specialise less than men and, as a result, greater professional expertise and influence is attributed to men when compared with women. This might reduce the citations received by women, since among all potential references, authors tend to select those coming from the most prestigious and influential scientists (Moed, 2005). Studying potential differences in the specialisation of male and female scientists in Mathematics emerges as an interesting topic for further research. Finally, the lower integration in professional networks described for women (Kemelgor and Etzkowitz, 2001) may have an adverse effect on their productivity and visibility and reduce the likelihood of being cited. In particular, previous studies have described a lower mobility for women leading to lower international collaboration and more restricted international networks (Lewison, 2001; Prpic, 2002) which in the long term may result in lower citation rates. However, our results do not show clear evidence of smaller international collaboration for women scientists.

In summary, our results show that women are under-represented in the Mathematical journals studied, both as authors and as editorial board members. Strengthening the presence of women among editorial board members is advisable since it is even below female presence among senior scientists in the field, which can be used as a proxy for those scientists eligible for editor board positions. A higher presence of women in editorial boards may have different positive effects such as contributing to increase diversity among editorial board members which may provide a wider range of perspectives on research (Stegmaier et al., 2011), facilitate women integration in networks, and foster the visibility of outstanding women scientists who can serve as role models for female junior scientists.

The fact that the presence of women among authors is lower than expected suggests that women publish less than men and it could have a negative influence on their visibility and citation rates. Women are slightly less cited than men as measured through the number of citations per paper and their contribution to the 10% most cited papers. Further research is needed to explore potential inter-gender differences in specialisation profiles which may help to account for inter-gender differences in citation rates. Very small inter-gender differences in the collaborative behaviour of authors are observed, but an increase in collaborative research, especially with foreign scientists, would be positive for improving female visibility and participation in scientific networks.

Concerning the limitations of this study, we would like to mention that the study focuses on only eight journals. Although they were selected to include international journals from different countries of publication and with various specialisation profiles, broader analyses would be needed to have a more comprehensive view of the whole field of Mathematics. On the other hand, it should be noted that self-citations were not removed in our analysis, so citation-related results need to be read with caution. In fact, the positive correlation described in the literature between number of authors and number of citations has been sometimes attributed to self-citations and not to a genuine positive effect of collaboration. However, it is interesting to remark that only a limited influence of self-citations was described in a previous study at the macro level (Glänzel and Thijs, 2004), in which multi-authorship increased above all the probability of being cited by others. On the other hand, there is no evidence of differences in self-citations practices between male and female authors (Hutson, 2006).

This study shows the usefulness of publication-based indicators for monitoring the presence and activity of scientists by gender in a given field. An interesting implication is the possibility of detecting changes over time in response to educational and research policies. The combination of quantitative studies –as the one here presented- and qualitative approaches (based on interviews or questionnaires) can be especially relevant to identify main personal, social and institutional factors that may hinder women’s advancement in science.

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END NOTES

[1] In recent years, the full names of authors in the bibliographic records of the Web of Science database are being introduced by Thomson-Reuters.

[2] Probability of female-female collaboration=(56/594)*(55/594)=0.01; Probability of male-male collaboration=(538/594)*(537/594)=0.82; Probability of female-male collaboration=(56/594)*(538/594)=0.08; Probability of male-female collaboration=(538/594)*(56/594)=0.08. Papers with two authors account for 63% of multi-authored papers.

[3] Although no research level is assigned to *Computational Geometry* in the original classification, it is considered here in the more applied group of journals according to the description of the journal contents (journal web page) and its inclusion in WoS in two different categories: *Mathematics* and *Mathematics-applied.*

[4] A great deal of the papers in *Computational Geometry* come from Computer Science departments as observed by visual inspection of the address of reprint authors.

	No. Papers	Journal Level	% of Papers by no.of authors				% Papers in national collaboration	% Papers in international collaboration	No. Authors/paper Av.(SD)	No. Instit./paper Av.(SD)	%Cross-gender papers/ collab.papers
			1 au	2 au	3 au	>=4 au					
Advances in Mathematics	131	4	41.98	41.22	11.45	5.34	46.56	35.11	1.81 (0.84)	1.63 (0.79)	14.47
Annales Scientifiques de l'École Normale Supérieure	27	4	40.74	44.44	11.11	3.70	55.56	33.33	1.78 (0.80)	1.78 (0.85)	12.50
Computational Geometry	44	-	9.09	18.18	43.18	29.55	81.82	45.45	3.14 (1.29)	2.23 (0.94)	35.00
Journal of Combinatorial Theory, Series B	60	4	23.33	43.33	20.00	13.33	58.33	38.33	2.33 (1.23)	1.90 (1.00)	10.87
Journal of Differential Equations	187	3	29.41	49.20	19.25	2.14	57.75	35.83	1.94 (0.76)	1.74 (0.75)	27.27
Journal of Functional Analysis	184	4	39.67	36.96	18.48	4.89	51.09	41.85	1.90 (0.93)	1.72 (0.84)	19.82
Journal de Mathématiques Pures et Appliqués	43	3	32.56	46.51	11.63	9.30	55.81	37.21	1.98 (0.91)	1.74 (0.76)	34.48
Topology	57	4	59.65	29.82	5.26	5.26	40.35	28.07	1.56 (0.82)	1.51 (0.68)	13.04
Total	733		35.47	40.52	17.33	6.68	54.02	37.38	1.98 (0.97)	1.74 (0.82)	21.7

Annex I. Description of collaborative practices of authors by journal

Note: Av.(SD) = Average (standard deviation)

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