Research Output of Spanish Postdoctoral Scientists: Does Gender Matter?

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Abstract

This paper presents an analysis of the scientific output of a sample of 254 PhD holders who were awarded their doctorate at Spanish universities between 1990 and 1995. Results show that 58.7% of the sample had published at least one paper in a journal indexed by the Thomson ISI Web of Science between 1990 and 2006. No statistically significant differences in scientific output were found according to gender. When considering the degree of collaboration with other scientists, no statistically significant gender-related differences were observed, though female PhD holders were more inclined to co-author with their PhD supervisors than males. Finally, no statistically significant differences by gender were observed in the impact of the output in terms of citations received.

1 Introduction

Many studies have shown that women are underrepresented in science, especially in the highest echelons of scientific disciplines. According to statistics published by the EU (EU 2006), although women constitute half the European university student population, their proportion decreases steadily from graduation onwards. So the more senior the scientific post, the lower the presence of women. Indeed, women hold less than 15% of the full professorships. This phenomenon has been described as the "leaky pipeline" and its consequences in terms of trained females who are lost for science are well known.

In a previous study we dealt with the gender imbalance in the number of Spanish male and female students who successfully complete their PhD studies (Villarroya et al. 2008). We showed that, although the number of male and female PhD graduates in Spain is becoming more balanced, this is not yet the case among thesis supervisors and members of thesis assessment boards, which are dominated by male academics. Moreover, the gender of the PhD student is clearly related to the gender of the supervisor, and both are related to the gender of the members of the assessment boards.

This study aims to expand on previous research and determine whether there are differences in the scientific output of Spanish postdoctoral researchers and, more specifically, to study: a) whether there is a drop in female PhD holders at postdoctoral level; b) whether there are any differences in scientific output depending on gender; and c) whether there are any differences in the impact of the publications depending on gender.

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2 Literature Review

2.1 Gender differences in the access to the scientific career

Seagran, Gould and Pyke (1998) studied the issue of time to completion of doctoral degrees in a sample of graduates of several doctoral programmes at York University. Although they found no significant gender differences in time to completion, male graduates were more satisfied with their doctoral education overall and the quality of supervision they had received. Men were also more likely to collaborate with their supervisors in the preparation of research papers. These results supported the idea that inequities existed at least in the perceptions of treatment received by male and female graduate students. Although these findings could also be explained as reflections of differing expectations on the part of women and men about the nature of graduate education, they could also help to explain why more women abandon scientific study at postdoctoral level.

Another analysis, carried out in Denmark by Andersen (2001) showed a very strong overall bias in researcher recruitment, conditioned by social origin and to a lesser extent by gender. This bias seemed to explain almost entirely the unequal gender distribution of researchers in Denmark.

More recently, Bornmann and Enders (2006) analysed the extent to which social origin and gender affect selection processes in access to and in later career attainment after completing the doctoral degree. They surveyed a sample of doctoral degree holders in six disciplines at German universities. With regard to the impact of these two attributes on further career attainment, their results suggested that the influence of gender was stronger.

Ginther and Kahn (2006) found that women were less likely to take tenure track positions in science, but they suggested that the gender gap was entirely explained by fertility decisions. Family characteristics had different impacts on women's and men's promotion probabilities, so child-rearing made it less likely that women would advance up the scientific ladder beyond early post-doctorate years, while both marriage and children increased men's likelihood of advancing.

Also in the US, Martinez et al. (2007) dealt with the transition from postdoctoral fellow to faculty, a period during which a significant number of women leave academic research. Their results showed that part of this problem originated from the reluctance of women to pursue a career as independent researchers given the challenges they faced. Family considerations — having children and spending time with them and other family members — were a major deterrent.

2.2 Gender differences in scientific productivity

In the 1980s, Cole and Zuckerman referred to gender differences in productivity among academic scientists as the "productivity puzzle". In a sample of men and women scientists they found that men published almost twice the number of papers as women in the first twelve years of their careers. As many women scientists as men failed to publish a single paper during these twelve years but women were underrepresented among prolific scientists — those publishing at least sixteen papers in the twelve-year period. Citation differences between men and women seemed to be largely a function of their different rates of publication.

Later on, Kyvik and Teigen (1996) found that, in a sample of researchers from four Norwegian universities, women with young children and women who did not collaborate in research with other scientists were less productive than both their male and female colleagues. According to these authors, there was a negative relationship between women's, but not men's, publishing activity and their family situation.

However, according to Wennerås and Wold (2000) family and children are not to blame for women's poor academic success. They cite studies in the US, Finland and Norway that showed that female researchers with children were actually more productive than their childless female colleagues. The reason for women scientists' sluggish careers appears to be the fact that research grants are not shared equally between the sexes.

Sax et al. (2002) showed that, although publication rates among women faculty had increased significantly in recent decades, the gender gap in research productivity remained obstinate, particularly at the highest levels of productivity. In their study, family variables contributed little or nothing to the prediction of faculty research productivity, while professional variables as academic rank, salary, orientation towards research and desire for recognition were more important.

Bordons et al. (2003) analysed the productivity and impact of scientists at the Spanish Council for Scientific Research in two areas, according to gender and professional category. They found no significant differences in productivity between genders within each category. However, productivity appeared to be related to academic rank, and the lower productivity of women could be explained by the fact that they were working at lower professional ranks than men.

Stack (2004) analysed the research productivity of more than 11,000 PhD holders employed in academia. He found that, after controlling for children, structural factors and personal characteristics, women still published less than men. The leading predictors of productivity included location in a research university and effort in terms of hours worked. Children were not a strong predictor of productivity but their influence followed a gendered pattern.

Fox (2005) analysed the relationship between marriage, parental status and publication productivity for women in academic science. Her results, obtained from a mail survey of faculty, showed that for women particularly the relationship between marriage and productivity varied according to type of marriage: women in subsequent marriages, especially if married to another scientist, had higher productivity than women in first marriages. Among types of family compositions, however, the productivity of women with pre-school children was higher than that of women without children or those with school-aged children.

Gallivan and Benbunan-Fich (2006) examined whether there were gender differences between the rates of scholarly publications of Information Systems researchers. In a sample of twelve journals, they identified the authors that had published at least three papers between 1999 and 2003. They found that 16.7% were women, but there were just three females in the top thirty scholars.

More recently, Leahey (2006) contended that the extent of research specialization can also help explain how gender affects research productivity. More specifically, she analysed how gender affected the extent of research specialization and how the extent of research specialization affected research productivity. According to her results, focused on sociology and linguistics, women specialized less than men and thereby lost an important means of increasing their productivity.

2.3 Gender differences in scientific impact

Long (1992) showed that, for biochemistry, the lower productivity of women resulted from their over-representation among non-publishers and their under-representation among the extremely productive. However, papers by females received on average more citations than those by males.

More recently, Symonds et al. (2006) examined the publication records of a cohort of life scientists in the field of ecology and evolutionary biology in British and Australian universities to assess gender differences in research performance. Their results showed that there was a clear difference in the number of publications produced by males and females in the field, with men publishing on average almost 40% more papers than women. More specifically, there were very few males with fewer than 10 publications, but almost a quarter of females fell into this category. At the other extreme, there were a few hyper-productive males (with more than 50 publications) whereas there were no women with more than 45 articles. When considering citations, their results provided support for the idea that females produced higher quality research compared to their male counterparts, who tended to produce a greater quantity of research output.

Ledin et al. (2007) recently looked at the publications of EMBO Long-Term Fellowships and Young Investigator Programme applicants and found in both cases that on average women

published fewer papers than men, but that the differences in the impact factor and citations per paper were not significant between men and women. The results of a subsequent survey indicated that the fact that women bear children and take on the majority of child care responsibilities led to career breaks and less time available for work, resulting in decreased productivity and consequently decreased competitiveness and an increased rate of drop-out. Results of the survey also suggested that women tended to receive less professional support than men in terms of mentorship.

3 Methodology

For our study, we established a cohort of PhD graduates and then analysed what proportion of these men and women had published in scholarly journals. More specifically, we analysed the scientific output — in terms of articles available through the Thomson ISI Web of Science — of a sample of graduates awarded their PhD at Spanish universities between 1990 and 1995. This sample was derived from a previous study on gender imbalance in the number of Spanish male and female students who successfully complete their PhD studies (Villarroya et al. 2008).

An advantage of our method is that our baseline included all PhD graduates, rather than just researchers who had published in scholarly journals. We were thus able to examine the broader picture of career paths for individuals after receiving their PhD, in order to establish whether graduates published in scholarly journals. Obviously when analysing the results we have to take into account that many PhD graduates do not choose academic careers, but enter industry or follow other career paths that do not require them to publish in scholarly journals.

The difficulties in identifying the gender of authors through the Thomson ISI Web of Science database — due to the fact that authors are usually identified by their initials — are well known. In order to overcome this difficulty, in this study we identified an *a priori* list of male and female scientists and then retrieved their publication output. The search for the authors' output was performed by two independent observers and, in the case of divergences between them, a third observer decided on the strategy.

Although in our previous study we covered all scientific disciplines, Humanities were excluded at this stage of the project due to the specific publishing habits of researchers in this field. We were also forced to exclude Engineering as only one female was present in the sample of PhD holders in this area during the six years analysed. Finally, a total of 254 PhD holders (59.6% males and 41.3% females) in three branches — Experimental Sciences, Health Sciences, and Social and Legal Sciences — were surveyed.

All searches in the Thomson ISI Web of Science were performed between October and December 2007 and were limited to a 17 year time span (1990-2006).

4 Results

A total of 149 PhD holders (58.7% of the sample) had published at least one paper in a journal indexed by the Thomson ISI Web of Science between 1990 and 2006, while 105 PhD holders (41.3%) had failed to do so (Table 1).

Table 1: Output by gender.

Gender	0 articles	>= 1 article	Total
Male	61 (40.9%)	88 (59.1%)	149
Female	44 (41.9%)	61 (58.1%)	105
Total	105 (41.3%)	149 (58.7%)	254

As shown in Table 2, there were no statistically significant differences according to gender between PhD holders with no output.

Table 2: PhD holders with no output.

Gender	%	z	p
Male	40.9	-0.159	ns
Female	41.9		

z: z value of the Mann-Whitney U test, ns: non significant

Similarly, no statistically significant differences in the scientific output of male and female PhD holders were observed (Table 3). A great degree of dispersion was observed in the data of both groups.

Table 3: Output by gender (PhD holders with at least 1 article).

Gender	n	Mean articles (SD)	z	p
Male	88	15.18 (23.29)	1.073	ns
Female	61	10.64 (15.99)		
Total	149	13.32 (20.68)		

SD: Standard deviation, z: z value of the Mann-Whitney U test, ns: non-significant

In order to analyse the results separately by degrees of output, the individuals were classified into three groups: low producers, i.e. those publishing between 1 and 10 articles between 1990 and 2006, medium producers, those publishing between 11 and 30 articles between 1990 and 2006, and high producers, those publishing more than 30 articles between 1990 and 2006. Data did not show differences in the proportion of subjects in the three groups ($\chi 2 = 2.34$, d.f. = 2, p = ns), indicating that the distribution of males and females in the three groups of production was balanced (Table 4).

Table 4: Range of production by gender.

	Gender	n (%)
Low producers	Male	56 (54.9%)
	Female	46 (45.1%)
Medium producers	Male	20 (71.4%)
	Female	8 (28.6%)
High producers	Male	12 (63.2%)
	Female	7 (36.8%)

Although there were no statistically significant differences according to gender in the output of scientists with low or high productivity, there were significant differences by gender in the range of medium producers — i.e., those publishing between 11 and 30 articles between 1990 and 2006. There, the mean of articles published by females was significantly lower than the mean of articles published by males (Table 5).

Table 5: Output by gender and range of production.

	Gender	Mean articles (SD)	t	p
Low producers	Male	3.57 (2.64)	t = 0.160 (d.f. = 100)	ns
	Female	3.65 (2.39)		
Medium producers	Male	21.25 (5.39)	t = 2.324 (d.f. = 26)	0.028
	Female	15.88 (5.89)		
High producers	Male	59.25 (36.52)	t = 0.597 (d.f. = 17)	ns
	Female	50.57 (14.21)		

SD: Standard deviation, t: value of the Student's t test, d.f.: degrees of freedom, ns: non-significant

When considering the degree of collaboration with other scientists, no statistically significant differences by gender were observed (Table 6).

Table 6: Co-authorship

Gender	Mean number of authors per article (SD)
Male	4.52 (1.98)
Female	4.78 (1.65)

SD: Standard deviation

However, data indicated that women are more inclined to co-author with their PhD supervisors than males. While more than half of the articles published by female PhD holders were co-authored with their supervisors, this fraction was just one third in the case of male PhD holders (Student's t = 2.199, d.f. = 125, p = 0.03).

Table 7: Co-authorship with PhD supervisor

Gender	% of articles with PhD supervisor
Male	34.46
Female	50.24

When considering the number of citations received by the authors, no statistically significant differences by gender were observed (Table 8).

Table 8: Number of citations

	Gender	Mean (SD)	Md (IQR)
Citations	Male	8.92 (15.26)	5.00 (9.36)
	Female	9.52 (12.12)	6.86 (9.83)
Citations (without self-citations, all authors)	Male	7.17 (13.33)	3.70 (6.50)
	Female	7.06 (9.41)	3.71 (8.42)
Citations (without self-citations, PhD holder)	Male	8.40 (14.97)	4.20 (9.00)
	Female	8.82 (11.95)	6.00 (9.22)

SD: Standard deviation, Md: Median, IQR: interquartile range

Similarly, no statistically significant differences by gender were observed when analysing the number of citations received by range of production (Table 9).

Table 9: Number of citations by range of production

	Gender	Mean (SD)	Median
Low producers	Male	5.06 (5.92)	3.00 (7.36)
	Female	9.36 (13.53)	5.12 (8.08)
Medium producers	Male	19.51 (27.49)	7.67 (14.12)
	Female	10.89 (7.35)	9.73 (9.28)
High producers	Male	9.28 (8.17)	6.16 (8.93)
	Female	9.08 (5.41)	7.50 (9.82)

SD: Standard deviation

Finally, no statistically significant differences by gender were observed when analysing the number of self-citations, both considering all authors and only considering the PhD holder (Table 10).

Table 10: Self-citations

	Gender	Mean (SD)
Self-citations (all authors)	Male	1.74 (2.73)
	Female	2.47 (3.34)
Self-citations (PhD holder)	Male	0.51 (0.66)
	Female	0.70 (1.44)

SD: Standard deviation

5 Conclusions

We analysed the scientific output, in terms of articles published between 1990 and 2006 available through the Thomson ISI Web of Science, of a sample of 254 PhD holders who got their doctorate in Experimental Sciences, Health Sciences or Social and Legal Sciences at Spanish universities between 1990 and 1995.

Out of this sample, 149 PhD holders (58.7%) had published at least one single article in a journal indexed by the Thomson ISI Web of Science, while 105 PhD holders (41.3%) had failed to do so.

We found no statistically significant differences by gender between PhD holders with no productivity, nor in the scientific output of male and female PhD holders who published their research.

When analysing the results by ranges of productivity, the data showed no differences in the proportion of subjects in the three ranges —low, medium and large producers. However, there were significant differences by gender in the range of medium producers — i.e. those publishing between 11 and 30 articles between 1990 and 2006 — where the mean of articles published by females was significantly lower than the mean of articles published by males.

When considering the degree of collaboration with other scientists, no statistically significant differences by gender were observed, al-

though women PhD holders were more inclined to co-author with their PhD supervisors than males.

Finally, when considering the number of citations received by the authors, no statistically significant differences according to gender were observed either globally or by range of production. Again, no statistically significant differences by gender were observed when analysing the number of self-citations.

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