"THE GENDER PRODUCTIVITY GAP. SOME EVIDENCE ON TOP PERFORMANCE"

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We are indebted to Robert Merton (1957), the founder of the modern sociology of science, for the recognition of the crucial role of the priority of discovery in the reward structure in science. Publication – a necessary step in establishing priority – is a lesser form of recognition within the reach of most scientists. As indicated by Van Raan, one of the leading researchers in scientometrics, there is little doubt that scientists who have something important to say "*do publish their findings vigorously in the open international journal ('serial') literature… The daily practice of scientific research shows that inspired scientists in most cases … 'go' for publication in the better and –if possible– the best journals*" (Van Raan, 2004, p. 26; 2005, p. 134). Therefore, everybody's research efforts become observable through publication and citation counts. Consequently, it has been argued that an advantage of using scientists as an object of study is that information about research productivity is available through bibliographic databases (Coupé *et al.*, 2006).

The productivity of individual scientists has been studied extensively since Lotka's (1926) pioneer contribution, in which the probability of an author publishing a certain number of articles in Chemistry was estimated to be an inverse square function of the number of publications. Recent results using a large dataset of 17.2 million disambiguated authors confirm that individual productivity distributions –measured by the number of publications and mean citations in the period 2003-2011–, are not only highly skewed, but also very similar across 30 broad scientific fields (Ruiz-Castillo & Costas, 2014).

On the other hand, there is a substantial body of empirical research that attempts to pin down the determinants of scientific productivity for individual researchers. In particular, since Cole & Zuckerman (1984) many studies have documented the existence of a gender productivity puzzle indicating that female scientists publish much less their male counterparts (for references, see Carrasco & Ruiz-Castillo, 2016).

However, there are few studies on what drives top research productivity. In this note, we discuss the results on this issue found in the excellent contribution by Kelchtermans & Veugelers (2013) –KV hereafter–, and our own unpublished research, Carrasco & Ruiz-Castillo (2016). The main message is that, although women are heavily underrepresented at the top, the gender productivity gap is smaller at the top than elsewhere.

• KV study top research productivity and its persistence in a unique panel of 1,036 scientists within the fields of biomedical and exact sciences from the University of Leuven, in The Netherlands, in the period 1992 to 2001. The analysis focuses on the number of publications, although KV check the robustness of the results when using citations received in a three-year window as a measure of performance. Using *k*-means clustering, KV compare for each year each scientist's performance within each of twelve scientific disciplines with colleagues who are active in that discipline. In this way, they distinguish three performance categories in each discipline: top, intermediate, and low. On average, 16% of observations are classified as a top performance, which account for 43% of all publications. This confirms the high skewness of the distribution of publications in the sample.

KV employ duration models to study the factors that influence the hazard for a researcher to achieve a first and subsequent top performance in their career, taking into account time-varying and invariant covariates and checking for the influence of past (top) performance. For our purposes, their main results can be summarized in the following four points.

1. A hazard model predicting the time toward first top performance establishes the importance of gender as a determining factor, with females –representing 11% of the total sample– being significantly less likely to reach first top performance: the hazard to become top is 2.7 times higher for males than females.

2. When analyzing subsequent top performances, KV find strong support for a cumulative process, with hazard to next top performance being significantly and (increasingly) positively affected by previous past performance.

3. Females represent 7% of persistent top performers. However, the interaction between the number of previous top performances and the gender dummy turns out to be highly significant, suggesting that the gender effect is mainly a selection problem into the first top. Once women break through to their first top performance, no gender bias hinders them in further top performances. In particular, KV show that working with larger teams increases a researcher's chances of achieving top productivity, but with a higher importance for female scientists.

4. These results are robust to corrections for unobserved individual heterogeneity. The effects of both gender and previous top performances remain sizable and significant. In addition, female scientists remain more sensitive to the cumulative advantage effect than men are: for a female researcher, each top performance increases the odds to be top again with a factor of 2.23, whereas for a male this factor is only 1.36.

• In our case, we use a set of 2,530 highly productive economists working in 2007 in the top 81 departments worldwide according to the Econphd (2004) university ranking. We measure individual productivity in terms of a quality index that weights the number of publications from the beginning of everyone's career up to 2007 in four equivalent journal classes. These classes are assigned weights equal to 40, 15, 7, and 1 point, respectively. The resulting quality index is denoted by ***Q***.[1] The following two characteristics of this productivity measure are worth noting. Firstly, the 2,530 individuals with at least one publication in the total sample are very productive: average productivity is 307.3 quality points *per capita*, equivalent to more than seven class A articles or about 20 class B articles. Secondly, the distribution of individual productivity is highly skewed: the average productivity is 17 percentage points above the median,

[1] Classes A, B, and C consist of 5, 34, and 47 journals, while class D consists of any other journal. Class A includes the *American Economic Review*, *Econometrica*, *Journal of Political Economy*, *Quarterly Journal of Economics*, and *Review of Economic Studies*. By way of example, the following 12 journals are in class B: *Economic Journal*, *Games and Economic Behavior*, *International Economic Review*, *Journal of Econometrics*, *Journal of Economic Growth*, *Journal of Economic Theory*, *Journal of Finance*, *Journal of Labor Economics*, *Journal of Monetary Economics*, *Journal of Public Economics*, *Rand Journal of Economics*, and *Review of Economics and Statistics*. Further details concerning the selection of the sample, and the construction of the quality index can be found in Albarrán *et al.* (2014). This paper includes a listing of the 908 economists (including members from other institutions that had received a fellowship in the Econometrics Society) with above average productivity.

and the top 11.5% in category 3 account for 43.6% of all quality points. Given this high degree of skewness, in the sequel the dependent variable is always the log of the *Q* index. Our main results can be summarized in the following four points.

1. We begin by estimating an overall gender productivity gap by including a dummy variable, *Female*, that takes the value one for females. After controlling for age and cohort effects, we find that the average productivity of females –representing 14% of the total sample– is 54.7% lower than the productivity of males.

2. Next, we include a set of dummy variables that capture four new variables: the university where individuals obtain their B.A., their Ph.D., where they held their first job, and where they work in 2007. In particular, the 81 departments in the sample are classified into four categories: the top 10, the next 15, and the last 27 U.S. departments, plus the 29 departments in eleven countries different from the U.S. Interestingly, since the distribution of males and females over these variables is very similar, the gender productivity gap in the new model is barely affected and becomes 53.5%.

In order to focus on top researchers, we follow two strategies whose results are summarized as follows.

3. In a companion paper with Pedro Albarrán, we observe the existence of *department effects* in the U.S., in the sense that the average productivity of economists working in each of the three department categories defined above is hierarchically ordered (Albarrán *et al.*, 2016). Consequently, we compare the productivity of males and females within each of the four department categories. In line with KV's results, we find that the gender productivity gap decreases as we move from the departments in the countries different from the U.S. to the top 10 U.S. departments.

4. In Albarrán *et al.* (2016) we found it instructive to make productivity comparisons not only for the entire population consisting of 2,530 economists, but also for an elite consisting of 833 individuals with

above average productivity. Furthermore, given the skewness of individual productivity, restricting attention to what happens at the upper tail of the distribution is always an interesting option. Intuitively, increasing the quality threshold and reducing the sample size would tend to make elite members more homogeneous among each other in all dimensions. In our case, we find that the average productivity of females –representing 5.4% of the elite– is 15.8% lower than the productivity of males.

Our study has several limitations. In the first place, we lack information on the citation impact and the co-authorship patterns that have been found to be important in other attempts to account for individual productivity differences (see *inter alia* KV, and Combes and Bosquet, 2013). In the second place, we only have information on the productivity and characteristics of economists at a given moment in time. This precludes investigating the cumulative advantage effect that has been emphasized since the seminal contribution by Merton (1968) on the Matthew effect (see KV, and Azoulay *et al.*, 2014, as well as their references to the limited evidence provided in previous works), and controlling for unobserved heterogeneity.

On the other hand, the two contributions summarized here raise several intriguing questions. Firstly, it would be interesting to investigate whether gender differences in pay for top researchers are lower than for regular scholars. Given the findings reviewed in this note, this is what we should expect at least in countries –such the U.S.– where hiring and promotion procedures are essentially guided by meritocratic practices and competitive market forces. Similarly, women are less likely to get tenure and take longer to achieve it (Long *et al.*, 1993, and Ginther & Kahn, 2004). Thus, one wonders whether the gender tenure gap is smaller for top researchers. Secondly, the main question left unanswered concerns the characteristics distinguishing the female top researchers from the remaining female scholars. The usual suspects are marital status, presence of children –for which there are conflicting results (see *inter alia* Kyvic & Teigen, 1996, and Fox, 2005)–, and time use at home relative to their spouses during the different stages of the academic career.

But there are other measurable possibilities. Leahey (2006) studies the extent to which scholars in linguistics and sociology are specialized in terms of subject matter, that is, the focus on one or a few subfields rather than spanning many. She finds that the degree of specialization among males is greater than among females, and that the gender gap in specialization helps accounting for the gender productivity gap. In turn, Dolado *et al.* (2012) study the gender distribution of research fields in economics using a dataset of 1,900 researchers affiliated to the top 50 economics departments according to the same Econphd (2004) university ranking we used in our research. Their main findings are the following three: there are large differences between male and female economists in terms of research-field choices; the probability that a woman chooses a given field is positively related to the past share of women in that field, and the female share in a given field is negatively related to an index of how competitive is that field (proxied by the proportion of papers in each field that are published in highly prestigious journals). The findings from these two papers suggest investigating whether differences in the extent of specialization and research field choice among top and regular scholars of both genders help accounting for the differences in the gender productivity gap documented in this note.

REFERENCES

Albarrán, P., Carrasco, R., and Ruiz-Castillo, J. (2014), "The Elite in Economics", Working Paper 14-14, Universidad Carlos III (http://hdl.handle.net/10016/19151).

Albarrán, P., Carrasco, R., and Ruiz-Castillo, J. (2016), "Are migrants more productive than stayers? Some evidence for a set of highly productive academic economists", Working Paper 16-12**,** Universidad Carlos III, July 2016 (http://hdl.handle.net/10016/23424).

Azoulay, P., Stuart, T., and Wang, Y. (2014), "Matthew: Effect or Fable?", *Management Science*, **60**:92-109.

Carrasco, R., and Ruiz-Castillo, J. (2016), "The Gender productivity Gap. Some Evidence for a Set of Highly Productive Economists", Working Paper 16-13**,** Universidad Carlos III (http://hdl.handle.net/10016/23525).

Cole, J. R., and Zuckerman, H. A. (1984), "The Productivity Puzzle: Persistence and Change in Patterns of Publication of Men and Women Scientists", *Advances in Motivation and Achievement*, Volume 2, JAI Press, Greenwich, 217-258.

Combes, P. and Bosquet, C. (2013), "Are academics who publish more also more cited? Individual determinants of publication and citation records", *Scientometrics*, **97**: 831–857.

Coupé, T., Smeets, V., and Warzynski, F. (2006). Incentives, Sorting and Productivity along the Career: Evidence from a Sample of Top Economists. *Journal of Law, Economics, & Organization*, *22*, 137-167.

Dolado, J.J., Felgueroso, F., and Almunia, M. (2012), "Are Men and Women-economists Evenly Distributed across Research Fields? Some New Empirical Evidence", *SERIEs*, **3**: 367-393.

Econphd.net rankings (2004), http://econphd.econwiki.com/rank/rallec.htm.

Fox, M. F. (2004), "Gender, Family Characteristics, and Publication Productivity among Scientists", *Social Studies of Science*, **35**: 131-150.

Ginther, D. K, and Kahn, S. (2004), "Women in Economics: Moving up or Falling off the Academic Career Ladder?", *Journal of Economic Perspectives*, **18**: 193-214.

Kelchtermans, S. and Veugelers, R. (2013), "Top Research Productivity and Its Persistence", *Review of Economics and Statistics*, **95**: 273-285.

Kyvic, S., and Teigen, M. (1996), "Child Care, Research Collaboration, and Gender Differences in Scientific Productivity", *Science, Technology & Human Values*, **21**: 54-71.

Lehaey, E. (2006), "Gender Differences in Productivity: Research Specialization as a Missing Link", *Gender and Society*, **20**: 704-780.

Long, J. S., Allison, P. D., and McGinnis, R. (1993), "Rank Advances in Academic Careers: Sex Differences and the Effects of Productivity", *American Sociological Review*, **58**: 703-722.

Lotka, A. J. (1926), "The Frequency Distribution of Scientific Productivity", *Journal of the Washington Academy of Science*, **16**: 317-323.

Merton, R. K. (1957), "Priorities in Scientific Discovery: A Chapter in the Sociology of Science", *American Sociological Review*, **39**: 663-671.

Merton, R. K. (1968). "The Matthew Effect in Science: The Reward and Communication Systems of Science Are Considered", *Science*, **159**: 56-63.

Ruiz-Castillo, J., and Costas, R. (2014), "The Skewness of Scientific productivity", *Journal of Informetrics*, **8**: 917-934.

Van Raan, A. F. J. (2004), "Measuring Science", in H. F. Moed, Glänzel, W. and Schmoch, U. (Eds.), *Handbook of Quantitative Science and Technology Research. The Use of Publication and Patent Statistics in Studies of S&T Systems*, Dordrecht: Kluwer Academic Publishers.

Van Raan, A. F. J. (2005), "Fatal Attraction: Conceptual and Methodological Problems in the Ranking of Universities By Bibliometric Methods", *Scientometrics*, **62**: 133-143.