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GENDER DISCRIMINATION IN ACADEMIC CAREERS IN ITALY

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Gender discrimination

in academic careers in Italy

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Abstract

The article analyses the effect of gender in Italian professors' career advancement using data on the entire population of professors in the Italian university system, data on the National Scientific Qualification (NSQ) accreditation scheme, and data on scientific productivity (SciVal) for bibliometric scientific sectors. As NSQ accreditation is a prerequisite for career advancement in Italian universities, using this data makes it possible to rule out women's reluctance to apply for promotions and low productivity as mechanisms for explaining the gender gap in academia. In fact, candidate professors must apply for accreditation and reach a minimum level of scientific productivity established by the accreditation committees. Among academics who obtained NSQ accreditation, our findings show that gender differences in productivity do not fully explain women's lower rate of career advancement. The gender gap also remains after controlling for available resources and for the percentage of female full professors in the academic scientific sector.

Keywords: Academic career; Discrimination; Gender; Scientific productivity; Vertical segregation.

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Introduction

Though the gender gap in education has disappeared in advanced economies over the last few decades and women are often even more highly educated and obtain better academic results than men, they are still underrepresented in all countries' universities and research centres (OECD, 2012; Stoet and Geary, 2015). In particular, women are underrepresented in the highest positions of the academic ladder[1]. Italy is no exception: in 2018 only 23.7% of full professors in Italian universities were women, while the percentage increases to 38.4% for associate professors and to 46.7% for assistant professors. Naturally, there are differences between disciplinary areas: literary studies, art history, pedagogy, psychology and biology are the sectors with the highest presence of women.

In Italy, gender discrimination is still newsworthy. According to the latest Global Gender Gap Report (World Economic Forum, 2018), Italy ranks 70th (out of 144) in gender equality, slipping 29 places in the rankings with respect to the year 2015 and 20 places with respect to 2016, and thus dropping overall to more or less the same position it occupied ten years before. Notably, Italy has a low labour market participation rate for women with low to medium levels of education, but when we look at highly educated women, the female employment rate is similar to the other European countries (Del Boca *et al.*, 2012; Marino and Nunziata, 2017; Richardson *et al.*, 2018). However, even when highly educated women work, they are unlikely to reach the top ranks of Italian companies, and are underrepresented in the country's political institutions (European Commission, 2013).

In our study, we focus on the career advancement of assistant and associate professors in Italian universities over the period 2012-2016 using data downloaded from the Ministry of Universities (MIUR) website. Almost all Italian universities are public and, in public universities, career advancement has involved a two-stage procedure since 2010. In the first stage, candidate professors must apply for National Scientific Qualification[2] (hereafter NSQ) accrediting them for either associate or full professorships, which is the prerequisite for participation in the second stage. NSQ accreditation thus establishes the minimum level of academic productivity that candidates must have to access a higher position. Minimum requirements differ for the 14 macro-disciplinary areas and in

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'Being good isn't good enough' is the title of a Barbra Streisand song.

[1] See Ooms *et al.* (2018) for Germany, Howe-Walsh and Turnball (2016) for the UK, Winchester and Browning (2015) for Australia, Seierstad and Healy (2012) for Denmark, Norway and Sweden, van den Brink and Benschop (2012) for the Netherlands, Carvahlo and Santiago (2010) for Portugal.

[2] ASN (Abilitazione Scientifica Nazionale).

the sub-sectors in each area[3]. The second stage occurs at department level, where the sub-sector for which a competition will be held is decided. Competitions may be open either to all accredited applicants (Law 240/2010, Art. 18) or may involve promotion procedures reserved for current department members (Law 240/2010, Art. 24)[4].

A number of studies have shown that female researchers are less productive than their male counterparts[5], which could explain the lower percentage of women among associate and full professors in Italian universities. If this were the case, there would be no gender discrimination and policies should be promoted to sustain women's research activity. A second possible explanation of the gender gap in Italian academia could be women's reluctance to apply for promotion. Previous literature has shown that women are less self-confident than men and therefore are less likely to apply for high-responsibility jobs and career advancement[6]. Again, if this were the case, we could not claim that gender discrimination exists and policies to sustain female researchers through mentoring should be promoted.

However, previous studies also found pure discrimination in academia mainly due to gender stereotypes that affect both the evaluation of the scholarly output of male and female researchers and the different tasks assigned to men and women, which are often linked to gender roles[7]. Men, in fact, devote more time than women to research activities, while women are more often in charge of student support and administrative tasks[8].

The article investigates whether the gender gap in career advancement in Italian universities is due to discrimination. By merging the MIUR data on the entire population of professors in Italian universities with the data on the NSQ and the data on individual productivity obtained from the SciVal website (for bibliometric sectors only), we are able to rule out negative auto-selection of female candidates to career advancement and to control for the level of scientific productivity, and hence to measure pure gender discrimination in Italian academia.

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[3] See Section 2 for a detailed description of the Italian university system.
[4] The number of reserved promotion procedures at each university cannot exceed the number of open competitions.
[5] Uhly *et al.* (2017), Nielsen (2016), Beaudry and Larivière (2016), Mairesse and Pezzoni (2015), Misra *et al.* (2012), Leahey (2006) and Stack (2004) showed gender differences in publication output and discuss possible causes. For Italy, the lower productivity of female researchers has been investigated by Jappelli *et al.* (2017), Abramo and D'Angelo (2015), Abramo *el al.* (Abramo *et al.*, 2009).
[6] See Kaiser (2014). Specifically, for academia see Howe-Walsh and Turnball (2016), De Paola *et al.* (2017), Pautasso (2015), Doherty and Manfredi (2006) and Chesterman and Smith (2006).
[7] Jappelli *et al*. (2017), Bagues *et al.* (2017), De Paola and Scoppa (2015), Budden *et al.* (2008), Howe-Walsh and Turnbull (2016), Krawczyk and Smyk (2016), Seierstad and Healy (2012), Winchester and Browning (2015), Mairesse and Pezzoni (2015), van den Brink and Benschop (2012) and van den Brink *et al.* (2010).
[8] Beaudry and Larivière (2016) and Misra *et al*. (2012).

Our results show that women are less likely than men to advance in their careers in Italian universities even when we control for individual productivity. Moreover, gender discrimination is not mitigated by the resources available for recruitment and career advancement, proxied by university size, nor by having more female full professors in the academic sector in which the competition for a professorship was held.

1. Gender inequality in academia

The gender gap in academia has been widely investigated and the underrepresentation of women in the universities and research centres, especially in the higher positions, is a well-documented phenomenon. In recent years, the majority of graduates in all European countries were women (Eurostat 2015, 2016, 2017), who also accounted for almost 50% of PhD graduates, with some variation between countries (European Commission, 2015). In Italy, 53% of those who obtained a PhD in 2012 were women, compared to the European average of 47%. However, when we look at the data for the European Union's researcher population in 2011, we find that only 33% were women (European Commission, 2015, p. 62). Again, there are significant variations across countries, but Italy is perfectly in line with the overall average, with women representing 35.5% of the population.

These data show remarkable gender inequalities in career advancement and participation in academic decision-making, with "a lower concentration of women than men in grade A positions [*i.e.* full professors] compared to lower levels of the academic career path" (European Commission 2015, p.131). Moreover, the proportion of women among the heads of higher education institutions is, on average, one out of five (European Commission, 2015), and Italy is again perfectly in line with the European average (22% in 2016 in our data).

This scenario confirms, on the one hand, the 'leaky pipeline' phenomenon, *i.e.* the larger number of female graduates does not lead to more women in academia and in research centres (Blickenstaff, 2005) because women are more likely to leave the academic career path than men (Bozzon *et al.*, 2017). On the other hand, it indicates that there is a 'glass ceiling' that makes it more difficult for women to reach the highest positions in academic research, as in most other sectors. The glass ceiling is a well-known and extensively studied phenomenon. Women face more difficulties than men in entering the labour market (Hassink and Russo, 2010), are more likely to be employed with temporary or (involuntary) part-time contracts, receive lower wages on average and have fewer career

opportunities (OECD, 2018). The leaky pipeline and the glass ceiling are the result of the gender gap in recruitment and promotion processes. Previous literature has dedicated considerable attention to studying gender and discrimination in academic recruitment and promotion, a topic that still draws scholarly interest (Bystydzienski *et al.*, 2017; Tiainen and Berki, 2019). In Germany, male researchers are more likely to obtain an early career position than female ones, but no differences emerge in the probability of becoming an assistant professor. However, gender differences reappear in the transition to full professorship (Ooms *et al*., 2018). In the Netherlands, transparency in the recruitment and selection processes does not seem to be sufficient to guarantee gender equity in the outcomes (van den Brink *et al*., 2010).

The lack of women on the highest rungs of the academic ladder is not *per se* a sign of gender discrimination. According to the literature, two main factors can explain the gender gap: the different productivity of male and female researchers, and women's reluctance to apply for promotion. Gender differences in productivity have been investigated widely. Scholarly productivity has mainly been measured using three indicators: number of publications (Abramo *et al*., 2009; De Paola *et al*., 2017; De Paola and Scoppa, 2015; Mairesse and Pezzoni, 2015; Nieddu and Pandolfi, 2018), number of citations (Nielsen, 2016) and citation indexes (Abramo *et al*., 2009; De Paola *et al*., 2017; De Paola and Scoppa, 2015). According to these measures, female researchers show lower productivity than their male colleagues (Abramo and D'Angelo, 2015; Abramo *et al*., 2009; Jappelli *et al*., 2017; Mairesse and Pezzoni, 2015; Nielsen, 2016; Ooms *et al*., 2018). This can be explained as the result of their family responsibilities, and this is especially true for women with children (Fox *et al.*, 2011; Mairesse and Pezzoni, 2015). In a country like Italy, where the role of principal caregiver in the household is mainly assigned to women and the welfare system is weak, making reconciliation of work and family difficult (Del Boca *et al*., 2012), the negative effect of children on productivity can be significant. In fact, as a consequence of their family responsibilities, female academics have fewer collaborations and are less likely to participate in international networks (Beaudry and Larivière, 2016; Uhly *et al*., 2017), with negative effects on their research funding (Beaudry and Larivière, 2016) and therefore on the number of publications, number of citations and IF of the journal in which they publish (Nielsen, 2016). In Italy, moreover, connections with the selection committee members matter more than productivity for obtaining a position or advancing in an academic career (Abramo and D'Angelo, 2015; Checchi *et al.*, 2019; Checchi *et al.*, 2018; De Paola and Scoppa, 2015), and smaller or weaker networks or a restricted number of collaborations might negatively affect women's careers.

However, the gender gap in academic productivity persists even after controlling for the presence of children (Stack, 2004). For Italian academics, articles authored by women frequently received worse evaluations in the national research assessment and this might produce fewer citations and lower *h*-index values (Jappelli *et al*., 2017).

Finally, the lower productivity of female university researchers is also the consequence of the fact that more teaching and administrative tasks are assigned to women: the data, in fact, show that men devote more time to research than women, while the opposite is true for mentoring activities and service hours (Beaudry and Larivière, 2016; Misra *et al*., 2012).

Because female researchers have lower productivity, hiring or promoting a woman has a negative effect on the university's ranking and thus on its ability to attract public and private funding. In Italy, in the last decade, the amount of money the universities receive from the Ministry has been partly determined by the evaluation of their research output production (Abramo and D'Angelo, 2015), and all universities have thus begun to monitor their departments' productivity closely.

Lower productivity is not the only possible cause of the gender gap in academia. Women's relative reluctance to apply for promotion, especially in male-dominated occupations (Antecol and Cobb-Clark, 2013), is well documented in research across a number of countries. This is explained by women's lack of self-confidence, their higher risk aversion and their tendency to shy away from negotiations (Grund, 2015). Women also often underestimate their abilities because the gender discrimination they observe at the workplace makes them pessimistic about their career opportunities (Kaiser, 2014). The reported situation in Italian academia seems no different: De Paola *et al.* (2015) found that, even after controlling for scholarly productivity, Italian female assistant and associate professors are about 4 percentage points less likely to apply for NSQ accreditation than their male colleagues.

In our analysis, we are able to rule out both these factors by considering only assistant and associate professors who had obtained accreditation. In fact, candidate professors must apply for accreditation (no self-selection) and reach a minimum level of scholarly productivity as established by the accreditation boards (no low productivity). However, we cannot rule out the possibility that fewer accredited female professors have applied for competitions for promotion at department level, but we believe that having obtained accreditation, which is valid only for a limited period of time (six years), is a strong incentive to apply for career advancement competitions.

Lastly, gender composition in academia might play a role in the gender gap's persistence. Male-dominated workplaces might provide a context where women face higher obstacles to being

promoted. There could be several underlying mechanisms: as they are a minority, female researchers might perceive social and intellectual exclusion, or might be less likely to apply for promotion in those fields where women have rarely been promoted in the past, as they expect to be discriminated against in competitions in which most committee members are male. However, the hypothesis of 'women helping woman' did not find strong support in the previous literature (Bagues *et al*., 2017).

The resources available for recruitment and career advancement can be an important factor affecting gender discrimination. In fact, previous studies found less gender discrimination in larger universities (*i.e.* where more resources are available).

2. The Italian university system: career advancement and gender gap

Academic staff in Italian universities is divided into four categories: full professors, associate professors, assistant professors with permanent contracts and assistant professors with temporary contracts. Before the year 2005, all assistant professors were hired with permanent contracts, while after 2010 they have been employed only on a temporary contract basis[9]. Each professor is included in a macro scientific area that defines the general academic fields of his/her research, and in a scientific sub-sector that, within the macro area, specifies the research fields in further detail[10].

Over the last 20 years, the Italian university system has experienced many reforms to the recruitment and career advancement rules. The most recent reform, in 2010 (Law 240/2010, known as the Gelmini reform, from the name of the Minister who promulgated it), introduced a two-step system in the process for career advancement. The first step is the NSQ: assistant professors who want to be promoted associate professors and associate professors who aspire to become full professors apply for accreditation. In each academic sub-sector, a national committee of five scholars (four full professors from Italian universities and one full professor affiliated with a non-Italian academic institution in an OECD country randomly drawn from a list of eligible scholars) sets the criteria for accreditation and then evaluate the applicants' CVs. Accreditation is awarded to a

[9] The Moratti reform (Law 230/2005), in fact, introduced a degree of flexibilization in early career stages that has been confirmed and reinforced by the subsequent reforms (Bozzon *et al*., 2017).

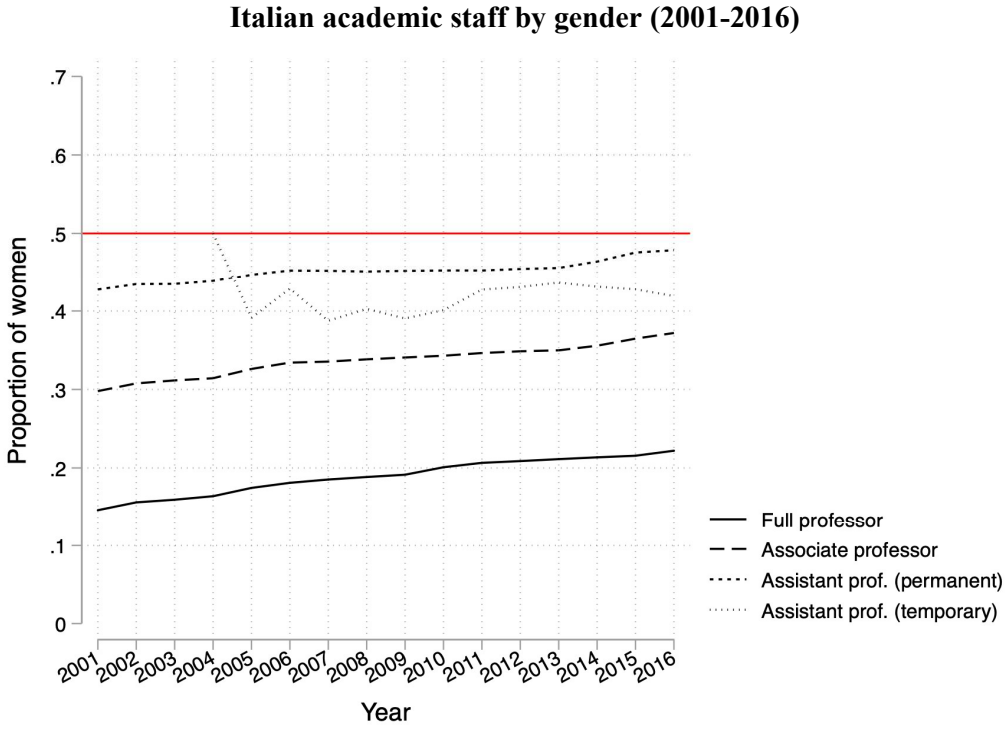
[10] Mathematics and informatics (10 sub-sectors)s, Physics (8 sub-sectors), Chemistry (12 sub-sectors), Earth sciences (12 sub-sectors), Biology (19 sub-sectors), Medicine (50 sub-sectors), Agricultural and veterinary sciences (30 sub-sectors), Civil engineering and architecture (22 sub-sectors), Industrial and information engineering (42 sub-sectors), Antiquities, philology, literary studies, art history (67 sub-sectors), History, philosophy, pedagogy and psychology (34 sub-sectors), Law (21 sub-sectors), Economics and statistics (19 sub-sectors), Political and social sciences (14 sub-sectors).

candidate with the agreement of four out of five committee members[11]. In the second step, accredited professors can participate in open selections at department level (Law 240/10, Art. 18) or in promotion procedures reserved for department members (Law 240/10, Art. 18).

The declared aim of introducing the NSQ as the first step was to limit local favouritism (Nieddu and Pandolfi, 2018; Sala and Bosisio, 2017) and to improve the quality of the of the Italian university system's scholarly production by allowing only the most productive scientists to advance in their careers. This was intended as an incentive for all academic staff to be more productive in their research activity, and to reduce forms of discrimination, including gender biases. Italian academia was, in fact, known to be a system where career advancement depended more on personal connections and networks than on actual scholarly productivity (Checchi *et al.*, 2019; De Paola and Scoppa, 2015).

Figure 1 shows the gender composition of Italian academic staff in the period 2001-2016. While none of the categories show gender balance, the percentage of women among full professors is extraordinarily low throughout the period, exceeding 20% only after 2010.

Figure 1



Source: MIUR data. Authors' calculations

[11] The composition of the committees and the rules on the number of positive evaluations needed to obtain NSQ accreditation changed after the first two years of implementation. However, those reported in the text were the rules in force for the accreditation process for the individuals in OUR dataset.

The picture of gender bias is not homogeneous across the fourteen different macro disciplinary areas, as shown in Table 1[12]. The disciplinary area with the lowest percentage of women in all categories, particularly among full professors, is *Industrial and information engineering*, followed by *Physics*. The macro disciplinary areas with the highest percentage of women are *Antiquities, philology, literary studies, art history* followed by *History, philosophy, pedagogy and psychology*, and by *Biology*. In these areas, the percentage of women among full professors is respectively 42%, 32% and 30%. In the *Medicine* sector, which is the most numerous area (17.5% of all academic staff) women account for 40% of assistant professors, but only 25% of associate professors and 13% of full professors.

Table 1

Gender gap in the different macro disciplinary areas

Macro disciplinary areas (code)	ERC group, bibliometric Y/N	Full professor	Associate professor	Assistant professor	N	% (N/Total)
		% of women (2012)			(2012)	
Mathematics and informatics (1)	PE, yes	17.9	39.9	39.4	3,171	5.5
Physics (2)	PE, yes	9.4	18.5	25.7	2,232	3.9
Chemistry (3)	PE, yes	20.3	41.8	57.2	2,919	5.1
Earth sciences (4)	PE, yes	18.0	31.0	33.2	1,055	1.8
Biology (5)	LS, yes	30.5	49.1	63.1	4,866	8.5
Medicine (6)	LS, yes	13.3	25.0	40.9	10,026	17.5
Agricultural and veterinary sciences (7)	LS, yes	15.4	36.9	47.5	3,046	5.3
Civil engineering and architecture (8)	PE, yes (not all*)	16.8	24.6	39.1	3,572	6.2
Industrial and information engineering (9)	PE, yes	6.6	16.0	21.0	5,292	9.2
Antiquities, philology, literary studies, art history (10)	SH, no	42.3	55.2	61.3	5,198	9.1
History, philosophy, pedagogy and psychology (11)	SH, yes (not all*)	32.1	46.3	52.2	4,618	8.1
Law (12)	SH, no	20.9	36.1	46.8	4,793	8.4
Economics and statistics (13)	SH, no	20.2	36.5	45.2	4,786	8.4
Political and social sciences (14)	SH, no	25.8	36.3	45.5	1,733	3.0

Source: MIUR data. Authors' calculations

*Not all sub-sectors of the disciplinary areas are bibliometric

Our empirical analysis tests whether female professors with NSQ accreditation are less likely than their male colleagues to advance in their careers, *i.e.* if there is gender discrimination in Italian universities. For the bibliometric sub-sectors, we also investigate whether the low percentage of

[12] Data refer to the initial year of our observational period.

women in the highest ranks of Italian academia can be explained by their lower scientific productivity. Furthermore, we investigate whether a higher proportion of female full professors in a scientific sector decreases gender discrimination in career advancement.

3. Data and method

For our empirical analysis, we used data on the entire population of academic staff in Italian public universities downloaded from the MIUR web site[13]. Data are available from the year 2001 onwards[14], and for each year it is possible to download the list of all assistant, associate and full professors with information on their gender, macro disciplinary area and academic scientific sub-sector, as well as their university and department of affiliation.

We merged the data on the entire population (MIUR) with the NSQ data for the assistant and associate professors who were accredited for associate and full professorships respectively in the first two years of implementation (2012 and 2013). Unfortunately, only the lists of accredited individuals for each scientific sub-sector are available, since the lists of those who failed to receive accreditation are removed from the website for privacy reasons 120 days after being posted.

In order to include individual's seniority in our analysis, we selected only individuals who were hired under a permanent contract between 2002 and 2011 (*i.e.* who were not included in the database in the first year, 2001, but are included afterwards), and who were continuously employed in an Italian public university for the whole period we consider (2002-2016). We selected assistant and associate professors in 2012 who were thus eligible to participate in the first two waves of the NSQ. Hence, we considered the careers of those who entered an Italian university between 2002 and 2011 and were still in Italian academia in 2016. We did not consider the years after 2016, when new accreditation waves began (the first results of which were released in April 2017), as the observational window is too short to investigate career advancement.

MIUR data on the Italian academic population were merged with the NSQ data on the basis of the individual's name, surname and academic scientific macro area[15], with two possible sources of error.

[13] The web site is cercauniversita.cineca.it

[14] Data on the entire Italian academic population are available since the year 2000, but information on each individual's academic scientific sub-sector has been available only since 2001.

[15] In some cases, individuals belonging to one academic scientific sub-sector were accredited in a different sub-sector within the same macro area. For this reason, we used the macro area (and not the sub-sector) to merge the two databases.

First, we could have merged two people with the same name, one employed in an Italian university and one outsider who applied for accreditation in the same macro area. We could thus have attributed the outsider's accreditation to an insider of the same name belonging to the same macro area. We were unable to correct for this error but, since the percentage of outsiders who obtained accreditation has been very low[16], we assumed that this error did not affect our results. Second, we could have considered two insider individuals of the same name to be accredited in the same macro area, as we cannot be sure which of them obtained accreditation. To avoid this second possible error, we excluded all namesakes in the same macro disciplinary area from our sample. We also excluded individuals who changed scientific macro area in the period we consider. The total number of dropped cases is 150. Our final sample consists of 16,216 assistant professors (45.4% of whom are women) and 3,522 associate professors (32.3% women). Among these, the total number of assistant professors who obtained accreditation in our sample is 8,208 (40.8% of whom are women), while for the associate professors it is 1,817 (30.0% women).

We first show the probability of obtaining NSQ accreditation for men and women in the different macro disciplinary areas. We then estimate the probability of being promoted to the higher rank for assistant and associate professors who obtained accreditation without controlling for scientific productivity. Lastly, we re-estimate the model while controlling for productivity on the subsample of individuals belonging to bibliometric sub-sectors. We estimate logit models in which the dependent variable is the probability of career advancement in the period 2012-2016 for those professors who were accredited in 2012 or in 2013. The independent variable of interest is gender and we control for seniority, academic scientific macro areas (14 dummies with *Mathematics and informatics*, coded as Macroarea 1, used as reference category), a set of five dummy variables for the size of the university (as a proxy for resources available for recruitment and promotions) and a set of dummy variables, one for each university. These last controls are crucial, as recruitment and career advancement depend on the number of positions available as well as on merit.

Individuals who receive NSQ accreditation exceed a minimum threshold. However, the individual's actual productivity can affect the probability of career advancement. Accordingly, we consider three different indicators of scientific productivity for each individual in the restricted sample of accredited individuals in the bibliometric sectors: the *h*-index[17], the number of citations

[16] See for example https://www.lavoce.info/archives/18356/universita-professori-universitari-concorsi-abilitazione/ and https://www.roars.it/online/asn-2012-ecco-le-statistiche-finali-diverse-da-quelle-anvur/.

[17] The *h*-index, proposed in 2005 by Jorge Hirsch, a physicist at the University of California, is a numerical indicator to measure a researcher's productivity and how influential his/her research is. According to Hirsch's definition, a scientist

and the number of publications up to the year 2015. We downloaded this information from the SciVal web site[18]. Since there is still no metric for measuring scholarly productivity in the non-bibliometric sectors, these indicators are clearly relevant for bibliometric scientific sectors only, and they are commonly used for evaluating candidates in the procedures that take place at department level. Moreover, since these bibliometric measures are highly correlated[19], we first introduce them one at a time and then, to consider all of them simultaneously avoiding multicollinearity problems, we perform a principal component analysis to obtain a comprehensive measure of individual productivity which captures as much as possible of the variation in the original variables. The principal component analysis allows us to create a new set of variables as linear combinations of the original set of variables, but we consider only the first component (which we called *Productivity*) that is the combination of the original variables that explains the maximum amount of variation.

Finally, we introduce in our models a variable measuring the percentage of female full professors in the scientific sub-sectors. The gender composition of the sector is important as, we assume, a larger proportion of female full professors can result in greater institutional attention to female assistant and associate professors and therefore in a greater promotion potential for female researcher.

Descriptive statistics of the variables used are given in Table A1 in the Appendix.

4. Main results

As we discussed in Section 2, having NSQ accreditation is the prerequisite for becoming an associate or full professor. Figure 2 shows the percentage of assistant and associate professors who obtained NSQ accreditation over the population of all potential candidates (*i.e.* in the population of all assistant and associate professors). In almost all macro disciplinary areas (MDA), with the sole exception of *Agricultural and veterinary sciences* (code 7) and *Civil engineering and architecture* (code 8), more men than women were accredited, and this is true both in the areas in which a high

has index h if h of his/her N_p papers have at least h citations each, and the other ($N_p - h$) papers have no more than h citations each (Hirsh, 2005).

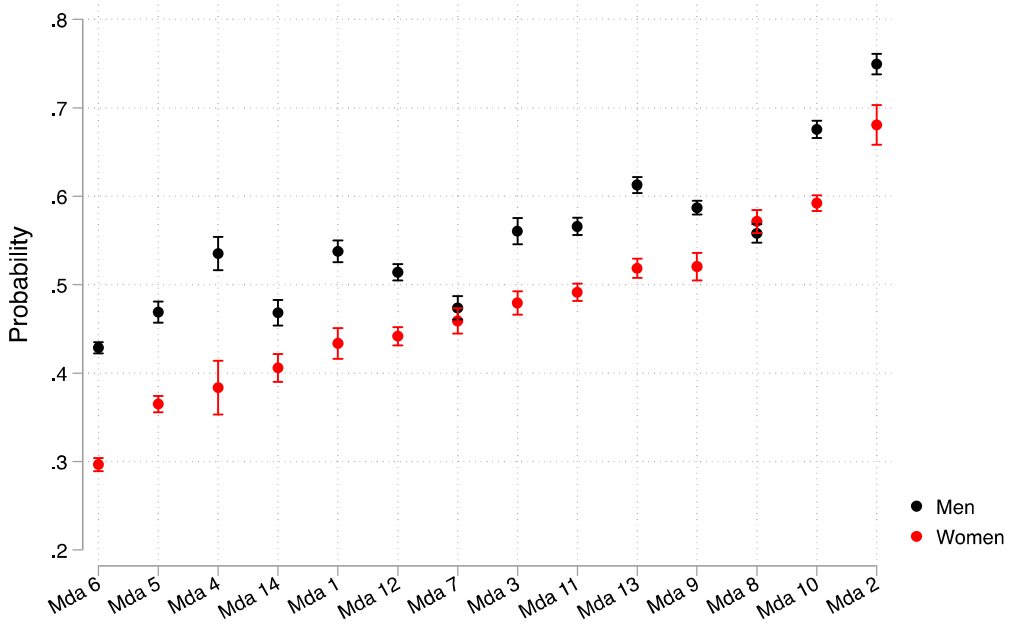
[18] SciVal is a modular integrated platform offered by Elsevier for the analysis of research results based on scientific production data. In particular, it provides information on more than 12,400 research institutions and their associated researchers from 230 nations worldwide.

[19] The correlation between publications and citations is 0.87, while it is 0.65 between publications and the h-index.

percentage of applicants received accreditation (over 60%) and in the macro areas where the percentage is low (under 50%).

Figure 2

Probability by gender of obtaining NSQ accreditation for the population of assistant and associate professors (2012-2013)

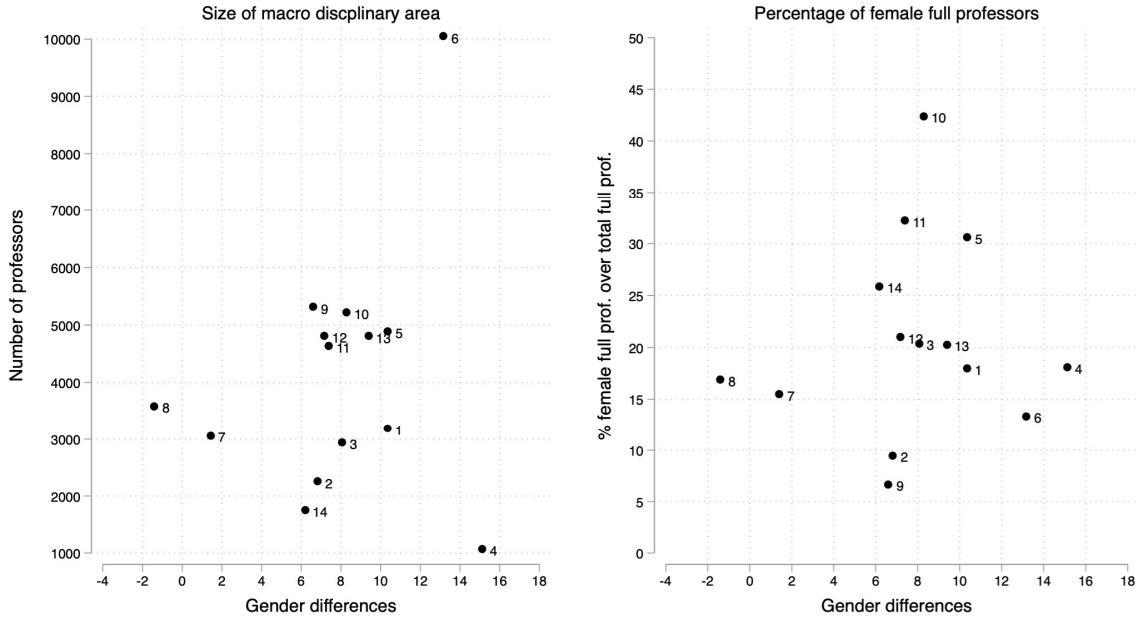


Source: MIUR. Authors' calculations

The gender gap in the probability of obtaining accreditation could depend on factors related to the specific macro disciplinary area, such as the area's size. Moreover, the percentage of female full professors in the macro area, as a measure of the area's lower or higher masculinization, might also have affected the gender gap in the accreditation process. As shown in Figure 3, none of these contextual factors seem to have reduced the gender difference in the probability of obtaining accreditation. If we compare the difference in terms of percentage points between men and women who received accreditation with the size of the macro area (Figure 3, left graph) and with the percentage of female full professors in the same area (Figure 3, right graph), we observe that there is no apparent relationship.

Figure 3

Gender gap in NSQ accreditation (2012-2013), size of macro area and % of female full professors in the macro area (in 2012)



Source: MIUR data. Authors' calculations

Descriptive statistics, however, are unable to show if the gender gap in accreditation is due to female researchers' lower scholarly productivity, to the lower number of applications for accreditation submitted by women, or to the lower rate of accreditation among female applicants, possibly due to a low proportion of women in the accreditation committees (De Paola *et al*., 2017) or to the weaker ties between candidates and committee members (Checchi *et al.*, 2018). We cannot test these hypotheses because data on individuals who did not receive accreditation are not available. We thus focused only on the population of accredited professors, observing those who were promoted to see if any gender discrimination emerges.

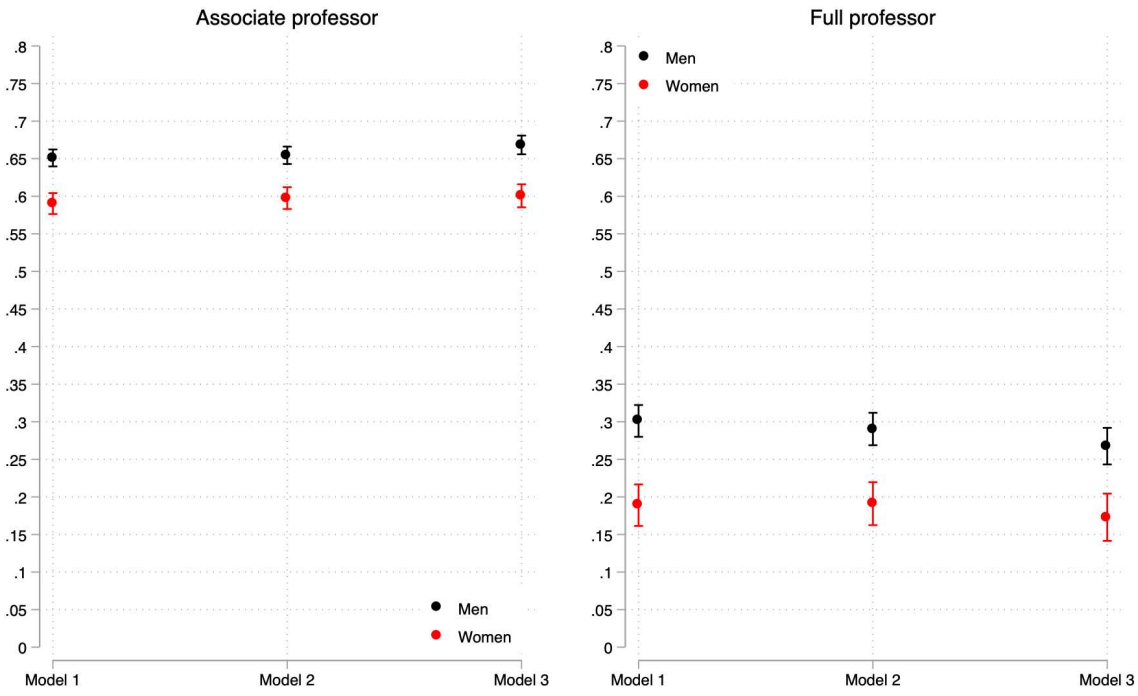
We use logit models to estimate the probability of obtaining an associate professorship by 2016 for those who were assistant professors in 2012 and were accredited in 2012 or in 2013. Similarly, we estimated the probability of becoming full professor by 2016 for those who were associate professors in 2012 and were accredited in 2012 or in 2013.

We estimate three different models. In Model 1 we include only the variable related to gender to estimate the overall effect of being women on the probability of career advancement. In Model 2 we add controls for the years of seniority, the scientific macro area and the size of the individual's

university of affiliation, while in Model 3 we substitute a set of dummy variables, one for each university, for the dummies for the size of the university. The estimated average probabilities are plotted in Figure 4 for ease of interpretation, while the full set of results is shown in Table A2 in the Appendix. Results show that being female decreases the probability of career advancement in all specifications. The effect seems to be stronger for promotions of associate professors to full professorships. Female assistant professors have a 6 percentage point lower probability of becoming associate professor, but the difference between women and men increases to more than 10 percentage points when we consider the transition from associate to full professor. Gender differences remain unchanged when we add controls.

Figure 4

Probability of career advancement by gender

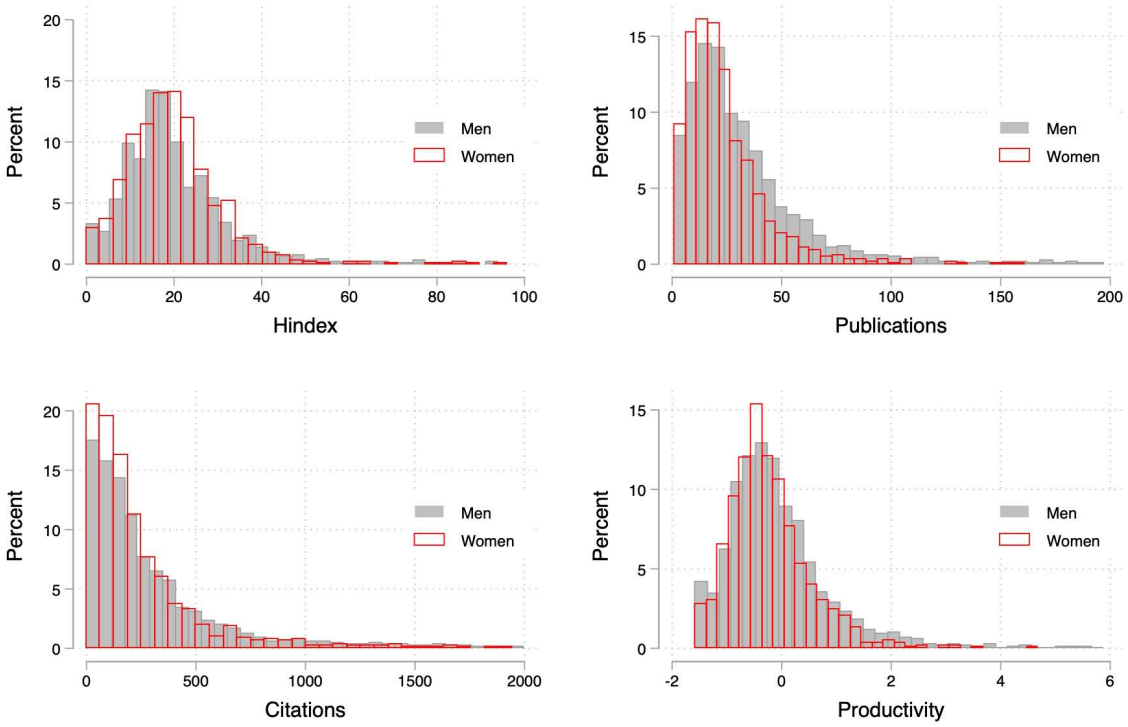


Note: Model 1 considers only gender. Model 2: control for seniority in Italian academia, macro disciplinary area, and size of the university of affiliation (2012). Model 3: control for seniority in Italian academia, macro disciplinary area, and university of affiliation (2012).

To introduce individual's productivity in our model, we restricted our sample to professors in the bibliometric academic scientific sectors only. Our sample is reduced to 4,218 observations, 34.3% of which are women. Figure 5 shows the distribution of our four measures of scientific productivity for accredited male and female professors in the sample. When we consider the *h*-index, female scientists seem to be slightly more productive, while if we look at number of publications and at the number of citations the opposite seems true. Thus, no significant gender differences emerge in our indicator of productivity.

Figure 5

Distribution by gender of measures of accredited professors' scientific productivity



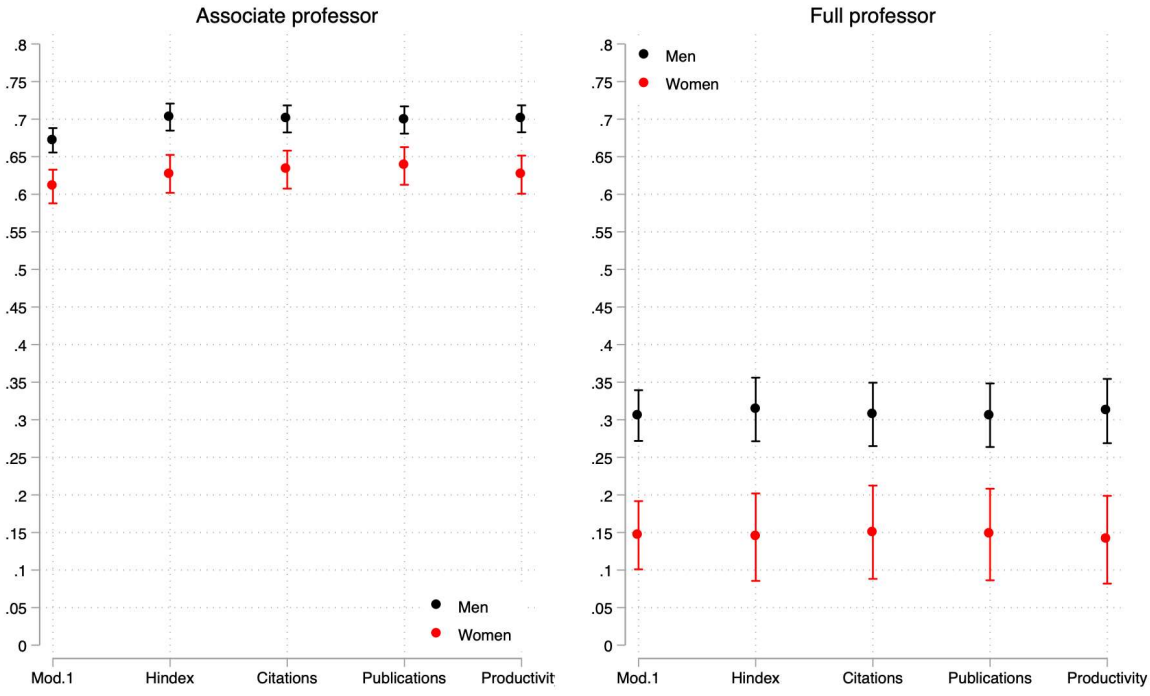
Source: SciVal data. Authors' calculations

Figure 6 shows the the estimated average probabilities of career advancement to associate and full professor computed at the mean values of the logistic regressions in which we introduced our measures of productivity (results are reported in Table A3 in the Appendix). Model 1 is the overall effect of gender for the sub-sample of individuals in bibliometric academic scientific sectors. The other four models are controlled for years of seniority, macro disciplinary area, university of

affiliation and individual's scientific productivity measured using four different indicators: the standardized *h*-index (Model 2), the standardized number of citations (Model 3), the standardized number of publications (Model 4) and an overall measure of productivity (Model 5)[20]. No matter how scientific productivity is measured, the gender gap in the probability of career advancement remains significant in all model specifications. On average, female assistant professors have a probability of advancement to associate professorships which is 8 percentage points lower than their male colleagues. This difference increases to 17 percentage points when we consider associate professors' probability of becoming full professors. At the same level of scientific productivity, female professors thus have a lower probability of career advancement. We can define this as gender discrimination.

Figure 6

Probability of career advancement by gender considering scientific productivity



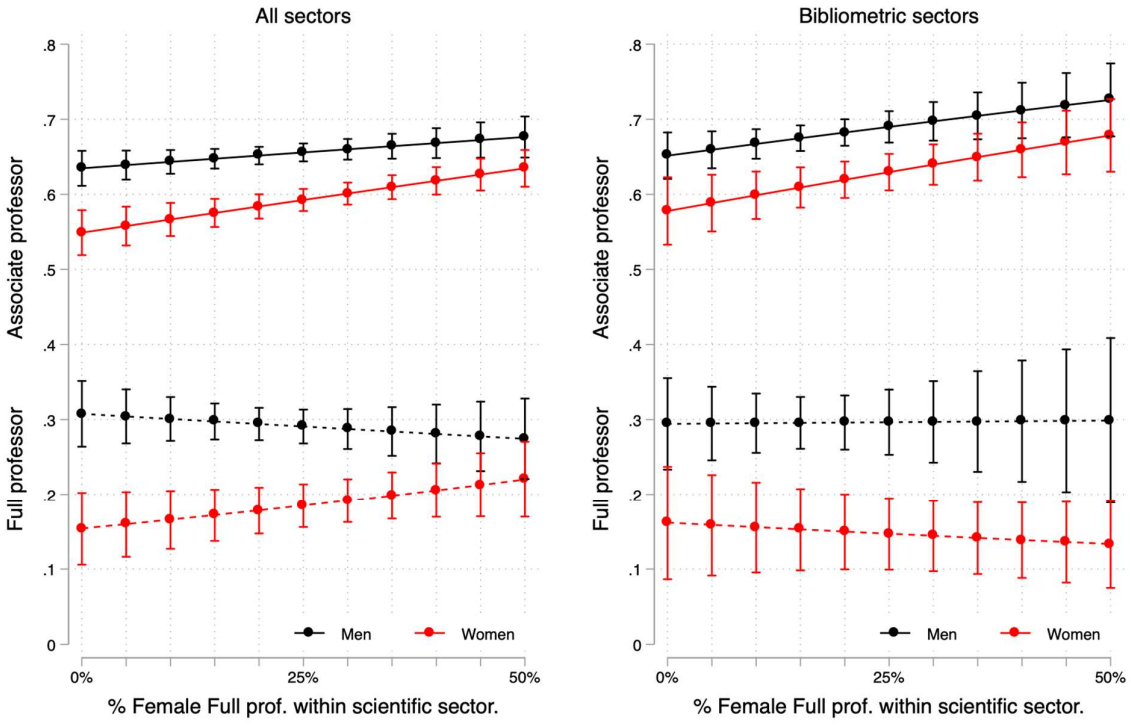
Note: Model 1 considers only gender in the subsample of bibliometric academic scientific sectors. Model 2: controls for seniority in Italian academia, macro disciplinary area, university of affiliation (2012), and *h*-index. Model 3: controls for seniority in Italian academia, macro disciplinary area, university of affiliation (2012) and citations. Model 4: controls for seniority in Italian academia, macro disciplinary area, university of affiliation (2012) and publications. Model 5: controls for seniority in Italian academia, macro disciplinary area, university of affiliation (2012) and productivity index.

[20] Results are unchanged when the three indicators (*h*-index, number of publications, number of citations) are controlled for simultaneously.

Lastly, gender discrimination can be more or less pronounced depending on the gender composition of the specific academic scientific sub-sector. Less male-dominated sectors, in fact, might entail more chances for women's careers. Figure 7 shows the estimated average probabilities of career advancement to associate and full professorships considering the percentage of female full professors in the sub-sector. We run logit models both on the full sample and on the sub-sample of individuals in the bibliometric sectors (results are reported in Table A4 of the Appendix). Given the low proportion of female full professors in Italian academia, we consider the variable *percentage of female full professors* only in the range of 0-50%, which includes 95% of the values observed. Our results show that, although discrimination between men and women persists, the gap is no longer statistically significant in the academic scientific sectors where there are more female full professors.

Figure 7

Probability of career advancement by gender considering the percentage of female full professors in the academic scientific sub-sectors (in 2012)



Note: Models 1 and Models 2 consider the entire sample. Models 3 and Models 4 refer to the subsample of bibliometric academic scientific sectors. All models control for seniority in Italian academia, macro disciplinary area, and university of affiliation (2012). Model 2 also controlled for the productivity index.

Conclusions

The article investigates gender discrimination in Italian academia in recent years using administrative data and data on researchers' productivity. The underrepresentation of woman in the Italian university system could be related to several factors that have been extensively investigated in the literature, such as the reluctance in apply for higher positions and low productivity. Having obtained NSQ accreditation in order to be promoted implies having applied for it and being above a certain threshold of scholarly productivity. However, there are still different chances for men and women of being promoted. Our results indicate that the observed lower likelihood that women will be promoted to associate and full professorships in Italian universities cannot be explained by their lower scientific productivity, nor by a negative self-selection of women who are less inclined to apply for promotion. The type of data we used and the mechanism for career advancement in Italian academia allow us to rule these factors out as causes of the gender gap.

The existence of discrimination in Italian universities leads to questions about how men and women can be given equal opportunities of career advancement. Unfortunately, it is still not clear which mechanisms effectively produce gender discrimination. Some scholars have pointed to the need for clear guidelines and specificity in promotion and tenure documentation, together with mentoring by senior colleagues to ensure that junior academics' personal goals are consistent with the institution's expectations (Sutherland, 2017). In line with this, our findings show that the gender gap is narrower when the percentage of female full professors in the sub-sector is higher. The other well-known policy for solving female underrepresentation is the introduction of quotas. Gender quotas can be introduced for selection committees, but previous evidence has shown that this does not guarantee a positive impact on women's careers (Bagues *et al*., 2017). Gender quotas can be introduced more effectively by reserving a percentage of full professorships for female researchers. However, this would come at a cost in terms of equity and efficiency, as anti-quota arguments state.

Without any specific policy intervention, there can be no doubt that the road to gender equality is a long one. Gender equality will not come about on its own, and more research is needed to better understand all the possible mechanisms behind the gender gap in Italian universities. Certain potential limitations should be borne in mind in connection with the results of our study. Considering the productivity of female researcher in the bibliometric sectors provides relevant insights for more than half of the Italian academic population, but it also means that our findings cannot be generalized to all macro disciplinary areas. Research evaluation in the bibliometric sector is definitely more

quantitative then qualitative, while in the non-bibliometric sectors we can expect more discrimination due to the greater discretion given to the committees in department level competitions. We suggest that future research should incorporate a measure to quantify the productivity of non-bibliometric researchers. In addition, further investigation is required to explore the impact of individual factors on women's career advancement in Italy. A study of the influence of family conditions may prove a fruitful avenue of research. Further research should thus solve the problem of measuring productivity in non-bibliometric sectors and include variables on individuals' characteristics (especially marital status and presence of children) for a better understanding of the mechanisms behind gender discrimination in academia.

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Appendix

Table A1

Sample descriptive statistics

		All	Qualified	Bibliometric sector
Role				
	Assistant professor	17.8	18.1	15.8
	Associate professor	82.2	81.9	84.2
Sex				
	Male	56.9	65.7	65.7
	Female	43.1	34.3	34.3
Macro disciplinary area				
	Mathematics and informatics (1)	4.4	4.4	8.6
	Physics (2)	3.3	4.7	8.6
	Chemistry (3)	4.5	4.5	7.5
	Earth sciences (4)	1.7	1.7	3.1
	Biology (5)	8.0	6.4	12.5
	Medicine (6)	16.1	12.2	22.2
	Agricultural and veterinary sciences (7)	4.6	4.3	8.4
	Civil engineering and architecture (8)	6.6	7.2	4.6
	Industrial and information engineering (9)	9.2	10.3	19.3
	Antiquities, philology, literary studies, art history (10)	9.8	12.1	-
	History, philosophy, pedagogy and psychology (11)	9.3	9.7	5.2
	Law (12)	9.4	8.9	-
	Economics and statistics (13)	9.0	10.2	-
	Political and social sciences (14)	4.0	3.4	-
Years of tenure				
	Seniority in the Italian academia	10.9	10.9	10.9
Size of university				
	I quintile	21.9	20.9	16.4
	II quintile	20.3	20.9	20.9
	III quintile	21.6	20.6	20.7
	IV quintile	18.0	17.5	18.7
	V quintile	18.2	20.1	23.3
Productivity				
	Hindex	-	-	19.8
	Citations	-	-	31.5
	Pubblications	-	-	414.4
	Productivity index	-	-	0
% of Female Full professor within scientific sector (2012)				
	Median	20.6	20.6	20.6
N		19,738	10,025	4,218

Table A2

Logistic regression models for the likelihood of being promoted

	Associate professor			Full professor		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Sex						
Male	-	-	-	-	-	-
Female	-0.258***	-0.244***	-0.292***	-0.615***	-0.550***	-0.558***
Macro disciplinary area						
Mathematics and informatics (1)		-	-		-	-
Physics (2)		-0.456**	-0.470**		-0.414	-0.677
Chemistry (3)		-0.185	-0.184		-0.695	-0.441
Earth sciences (4)		-0.717***	-0.702**		-0.026	0.388
Biology (5)		-0.498***	-0.460**		-0.283	-0.068
Medicine (6)		-0.672***	-0.554***		-0.386	-0.261
Agricultural and veterinary sciences (7)		-0.724***	-0.654***		-0.659	-0.634
Civil engineering and architecture (8)		-0.261	-0.457**		-0.118	-0.062
Industrial and information engineering (9)		-0.125	-0.358*		-0.46	-0.779*
Antiquities, philology, literary studies, art history (10)		-0.681***	-0.630***		-0.958**	-0.65
History, philosophy, pedagogy and psychology (11)		-0.350*	-0.299*		-0.37	-0.273
Law (12)		-0.507***	-0.439**		-0.18	-0.024
Economics and statistics (13)		-0.332*	-0.224		-0.211	-0.103
Political and social sciences (14)		-0.301	-0.311		0.144	0.161
Seniority in the Italian academia		0.117***	0.151***		-0.013	0.002
Size of university						
I quintile		-			-	
II quintile		0.261***			-0.524**	
III quintile		-0.210**			-0.115	
IV quintile		0.088			-0.295	
V quintile		-0.197**			-0.629***	
University of affiliation (dummy vars)			Yes			Yes
Constant	0.624***	-0.159	-0.361	-0.842***	-0.065	-1.05
N	8,208	8,208	8,105	1,817	1,817	1,702

* p<0.05, ** p<0.01, ***p<0.001

Table A3

Logistic regression models for the likelihood of being promoted (only bibliometric sectors)

	Associate professor					Full professor				
	Model 1	Hindex	Citations	Publications	Productivity	Model 1	Hindex	Citations	Publications	Producivity
Sex										
Male	-	-	-	-	-	-	-	-	-	-
Female	-0.268***	-0.340***	-0.304***	-0.276**	-0.334***	-0.943***	-1.001**	-0.918**	-0.937**	-1.019**
Macro disciplinary area										
Mathematics and informatics (1)		-	-	-	-		-	-	-	-
Physics (2)		-0.519**	-0.478*	-0.465*	-0.768***		-1.294*	-1.271*	-1.189*	-1.873**
Chemistry (3)		0.143	0.100	0.062	0.005		-1.276	-1.369	-1.356	-1.507
Earth sciences (4)		-0.724**	-0.727**	-0.733**	-0.776**		0.201	0.081	-0.098	0.097
Biology (5)		-0.580***	-0.586***	-0.597***	-0.672***		-0.075	-0.008	-0.032	-0.189
Medicine (6)		-0.611***	-0.631***	-0.641***	-0.777***		-0.34	-0.395	-0.355	-0.629
Agricultural and veterinary sciences (7)		-0.779***	-0.785***	-0.818***	-0.820***		-0.66	-0.804	-0.596	-0.64
Civil engineering and architecture (8)		-0.329	-0.580*	-0.678**	-0.347		0.711	0.318	0.306	0.649
Industrial and information engineering (9)		-0.405*	-0.381*	-0.404*	-0.475**		-0.998*	-0.952	-0.992*	-1.089*
History, philosophy, pedagogy and psychology (11)		-0.108	-0.405	-0.578*	-0.144		-0.166	-0.5	-0.565	-0.095
Seniority in the Italian academia		0.146***	0.155***	0.158***	0.149***		-0.042	-0.046	-0.044	-0.046
University of affiliation (dummy vars)		yes	yes	yes	yes		yes	yes	yes	yes
Productivity										
Hindex		0.354***					0.235**			
Citations			0.318***					0.337***		
Pubblications				0.382***					0.399***	
Productivity index					0.164**					0.215**
Constant	0.716***	0.208	0.06	-0.052	0.359	-0.821***	-1.398	-1.311	-1.506	-1.640
N	3,550	3,527	3,527	3,527	3,527	668	547	547	547	547

* p<0.05, ** p<0.01, ***p<0.001

Table A4

Logistic regression models for the likelihood of being promoted

	Associate professor		Full professor	
	Model 1	Model 2	Model 1	Model 2
Sex				
Male	-	-	-	-
Female	-0.356***	-0.312*	-0.893***	-0.771*
% of Female full professor				
% over full professor *within scientific sector*	0.370	0.695	-0.323	0.043
Sex % of Female full professor*				
Female*High level	0.342	0.171	1.201	-0.498
Macro disciplinary area				
Mathematics and informatics (1)	-	-	-	-
Physics (2)	-0.446**	-0.715***	-0.403	-0.886
Chemistry (3)	-0.230	-0.070	-0.621	-1.355
Earth sciences (4)	-0.693***	-0.761***	-0.060	-0.104
Biology (5)	-0.566***	-0.842***	-0,193	-0.061
Medicine (6)	-0.695***	-0.923***	-0.340	-0.474
Agricultural and veterinary sciences (7)	-0.749***	-0.871***	-0.539	-0.570
Civil engineering and architecture (8)	-0.345*	-0.202	-0.016	0.760
Industrial and information engineering (9)	-0.28	-0.213	-0.432	-0.514
Antiquities, philology, literary studies, art history (10)	-0.813***		-0.878**	
History, philosophy, pedagogy and psychology (11)	-0.445**	-0.514*	-0.304	-0.272
Law (12)	-0.542***		-0.028	
Economics and statistics (13)	-0.344*		-0.069	
Political and social sciences (14)	-0.343*		0.216	
Seniority in the Italian academia	0.120***	0.112***	-0.021	-0.070
Productivity				
Productivity index		0.157*		0.169*
Constant	-0.242	-0.011	-0.263	0.321
N	8,208	3,550	1,817	668

* p<0.05, ** p<0.01, ***p<0.001