Gender Representation in Academia:

Evidence from the Italian Education System Reform

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Abstract

This paper examines the “glass ceiling” effect in the Italian education system and explores the determinants of success for researchers who applied and qualified for promotion to associate and full professor positions. Using the 2010 Italian national scale promotion qualification system, I scraped and mined demographic and research productivity information from the researchers’ CVs and bibliometric databases such as Scopus to see whether the researcher’s gender plays a role in the probability of qualifying, holding other factors constant. Findings confirm that there exists not enough evidence to conclude that gender has any effect on the qualification probability, controlling for research productivity measures, candidate characteristics, and university location. The results remain the same after testing their robustness through a different research productivity measure, probit regression models, and clustering at the university level. However, this paper also notes the relatively low proportion of female researchers in the applicant pool. Therefore, to understand the reasons behind the glass ceiling, the paper discusses the importance to develop scientific productivity metrics that account for diversity in researchers and their outputs.

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I. Introduction

"The title for my remarks today, "So We All Can Succeed," was inspired by Malala Yousafzai, the advocate for girls' and women's education, who said, "We cannot all succeed when half of us are held back."

- *Janet Yellen, now the 78th Secretary of the Treasury of the United States, at 125 Years of Women at Brown Conference held in 2017*

Starting from the late 1980s, formal discussions in gender discrimination, gender division of labor, gender equality and equity, and gender mainstreaming have started to become more apparent in economic research projects and government policies in many developing and developed countries (Birdsall, Sabot, and World Bank 1991; Seager 2000; Anker 1998; Albelda 1995; Razavi and Miller 1995; Adepoju, Oppong, and International Labour Office 1994). An organizational strategy to bring a gender perspective to all features of an institution's policies and activities, through promoting gender equality and eliminating gender bias, has appeared to be one of the common themes within this literature.

Promoting gender diversity at all levels is necessary, but where do people need to look to understand gender representation better? This question leads me to colleges and universities where ideas about the economy and the world are formed, debated, and cultivated. Here, sharing ideas and knowledge with others becomes an essential factor in eliminating barriers to advancement. However, the concern lies in understanding if women are, in reality, represented enough in academic positions. If not, why is this so?

This paper aims to expand the state of knowledge in topics concerning gender representation and promotion to top-level academic positions by taking evidence from the 2010 Italian education system reform (Law 240/2010). The reform introduced a national scientific qualification (ASN)[1] for researchers and it works as a prerequisite for promotion to tenured associate and full professor positions at state-recognized universities. It becomes meaningful to examine the proportion of men and women in this environment to see if the measures introduced by the reform affect individuals differently.

The next section presents the literature review and defines this paper's contribution to the growing literature to date. The third section describes the data and summary statistics. The fourth section includes the empirical specification. The fifth section presents robustness checks. The sixth section includes the discussion. The seventh and eighth sections present limitations to the present study and concludes.

II. Literature Review

2.1 Glass Ceiling: Gender Representation

Despite the notable progress in women's educational attainment since the 1960s (Hek, Kraaykamp, and Wolbers 2016), women are still underrepresented in top-level academic positions (Cech and Blair-Loy 2019). In most European countries, the ratio between men and women is relatively equal up to the doctorate level; however, as one moves up the ladder, the gender differences start to stand out significantly. Why is this the case? Even though women make up about 40% of the Ph.D. graduates (CAUT 2002), only about 20-30% of the applicants for tenure jobs are female (Anders 2004). In an ideal scenario, an increase in female Ph.D. degree holders is more likely to lead to an increase in women in top-level academic positions. However, if this does not happen, can we assume that there are systematic barriers associated with such as parenting and

[1] ASN is an abbreviation for "Abilitazione Scientifica Nazionale", translated as National Scientific Qualification

family responsibilities that discourage women's productivity and limit them from pursuing academic careers? Do they self-select to opt-out because of these systematic barriers?

To better understand the "leaky pipeline" or the "glass ceiling effect" that metaphorically describes the decreasing number of women at each stage of career progress, one strand of literature focuses on gender differences in research productivity and its effect on women's probability of attaining senior positions.

Older literature on this topic shows that even though the concentration of women researchers publishing a single article is significantly higher than men researchers, women representation among the "star" scientists - measured by output and impact - seems to be less than men (Lemoine 1992). To understand this difference in research productivity, Ceci et al. (2014) and Miller (2011) look at the effect of childbearing and motherhood. Prpić (2002) studies the effect of marriage on men and women, explaining married men receive greater productivity benefits than married women. Lack of role models in higher academic positions (Hale and Regev 2014) and lack of mentorship (Carrell, Page, and West 2010) are also significant factors that contribute to discrepancies in research productivity – the main qualification for promotion. Even though these studies present heterogeneous conclusions with different causal factors, all aim to explain the lower research productivity in women and the reduced probability of them achieving promotion and obtaining senior positions.

However, what the above strand of literature does not seem to emphasize is the credibility of the metrics system that measures scientific productivity. For instance, Lemoine (1992) shows that women tend to lag behind men in research productivity and their representation among "star" scientists is significantly less. Yet, what indicates who becomes the "star" scientist has been heavily determined by bibliometric indicators. Unless these bibliometric indicators are fair measures for research productivity, demographic factors, such as gender, might also play a role in the final decisions for promotion, eluding to gender bias and gender discrimination.

2.2 Gender Bias in Academic Promotion

If the research productivity in men and women are similar and gender differences exist, can we assume that it is gender bias and discrimination that makes promotion to tenure positions challenging for women? In other words, is this more like the Price Waterhouse v. Hopkins case where women like Ann Hopkins are not being given promotions because of gender stereotypes?

The second strand of literature on gender representation focuses on gender bias and its effect on recruitment and promotion in tenure tracks. Gender bias from male-dominated networks (Addis and Villa 2003), gender stereotyping (Gawad et al. 2020), and not being given promotion even with the same years of training and research productivity measures (Moss-Racusin et al. 2012) have been apparent in literature to date.

In this paper, using evidence from the 2010 Italian university reform, I aim to test whether the probability of qualifying to associate and full professor positions varies for men and women. If differences exist, will they hold after controlling for research productivity measures, candidate characteristics, and university location?

Quantitative analyses explaining the heavy use of productivity indicators in academic promotion systems have been carried out by Marini (2017) but not a lot of work exists that explains this trend from a gender perspective. Marini (2017), using similar evidence from the 2010 Italian university reform, tests the effect of a researcher's seniority - years after last promotion - on qualifications to full professor positions. Even though these qualifications are mostly based on bibliometric evaluation, Marini (2017) says that there are circumstances where younger scientists have higher probabilities of qualifying than their older peers with the same or more indicators of productivity. This idea leads researchers to study factors, other than research productivity that influence the academic promotion system. Paola and Scoppa (2015) try to uncover exactly this idea by testing whether gender plays a role in Italian academic promotion eligibility. Their sample consists of 130 competitions held in two research fields – economics and chemistry. Compared to their analysis, I will estimate the probability of being qualified for high-level positions by including all 184 research fields[2] defined by the ASN and will compare results across STEM (hard sciences) and non-STEM (social sciences) fields. Adopting this approach will help find the determinants that influence the probability of candidates achieving associate and full professor positions in different fields, controlling for individual and location characteristics.

2.3 Background: Italy

Italy, like other countries, exhibits features, such as severe gender gap (Mussida and Picchio 2014), massive use of bibliometric indicators (Lukman, Krajnc, and Glavič 2010; Baccini, De Nicolao, and Petrovich 2019), and a bibliometric system of research evaluation (Marini 2017). However, Italy's example is instructive as the country shows substantial historical evidence in changing the way people are recruited and promoted in academia (Zacchia 2017).

Among those changes, the less studied, the 2010 reform of the university system, called Law 240 of 2010, implemented in 2012, attracts a special interest. According to Marini (2017), a candidate who is trying to achieve a full professorship position is evaluated based on scientific profile – reviewed by randomly selected panel committee – and government-mandated bibliometric criteria based on research productivity measures, such as the number of high-quality journal articles, the number of articles published in any journal, the number of books and book chapters, the number of citations received, and the h-index. It is also important to note that qualification is a requirement to a professorship and does not guarantee a position itself. In some cases, the evaluation committee

[2] Research fields and the number of subfields are listed in Table 1a of the Appendix.

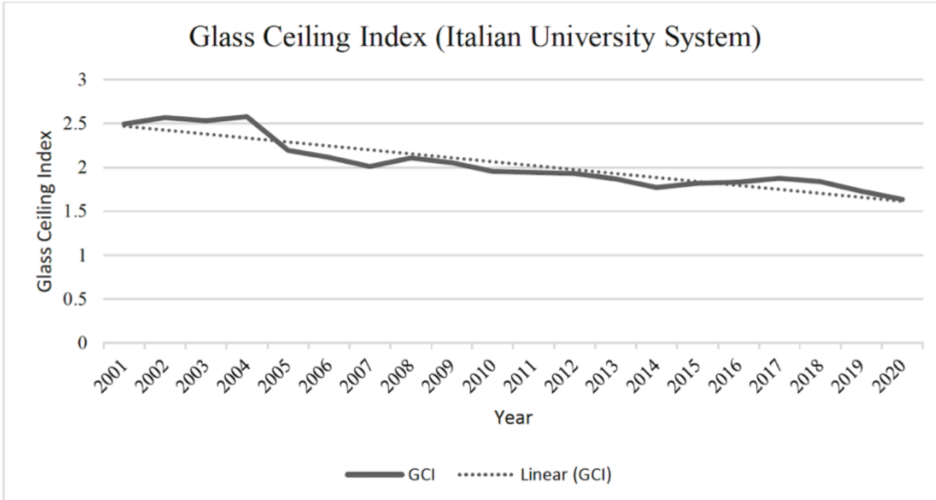
can grant qualifications to candidates who do not meet the criteria but have an excellent research profile.

In one respect, the 2010 university reform "creates a tougher pool of candidates and a more selective examination" (Marini 2017). Compared to other Nordic countries, Italy is the only country that has a national-scale bibliometric assessment (Jappe 2020). Most European countries use both bibliometrics and peer review, or bibliometrics evaluations to inform peer review for promotion purposes (Jappe 2020). However, to find factors that impact promotion decisions to top-level academic positions, Italy and its 2010 university reform, compared to other countries, provide well-documented, transparent, and instructive evidence.

In Figure 1, I compute the Glass Ceiling Index[3] (GCI) for Italian academic researchers. This index, designed by the European Commission in the She Figures report, compares the proportion of women in academics to the proportion of women in top-level positions – full professors. The index ranges from 0 to infinity. When the GCI is equal to 1, it indicates that there exists no difference between men and women in terms of their probabilities of being promoted. If the GCI is less than 1, it means that women are more represented at the top-level positions than in general academia. On the other hand, if the GCI is more than 1, it indicates the presence of a glass ceiling effect, meaning that women are less represented in top-level positions. The higher the index, the stronger the glass ceiling effect, and vice versa. From 2001 to 2020, the GCI is gradually decreasing. More women are being represented at top-level positions; however, this growth is slow. This paper aims to cover this effect and understand what can be the barriers that might be causing this slow growth.

[3] GCI, for each year, has been calculated using information from the Cerca database: https://cercauniversita.cineca.it/php5/docenti/cerca.php

Figure 1. Glass Ceiling Index in Italy, from 2001 to 2020



III. Data

The data used in this study were collected from three main sources: applicants' CVs [4], the Scopus bibliometric database[5] which was used to retrieve information on candidates' research output and the Cerca database[6] for information about the candidates' universities and universities' locations.

3.1 Data Processing

The sample dataset contains information about 5596 candidates for associate professor positions and 2298 for full professors. Each CV belongs to a single application and the same candidate has the opportunity to apply to multiple levels, meaning both to associate and full professor positions. Since ANVUR[7] – the organization responsible for collecting the information - did not provide a template for the information to be submitted, the CVs of applicants were very

[4] https://asn.cineca.it/
[5] https://www.scopus.com/
[6] https://cercauniversita.cineca.it/php5/docenti/cerca.php
[7] ANVUR – Italian National Agency for the Evaluation of Universities and Research Institutes. https://www.anvur.it/

different, in terms of formatting, structure, and organization. Each application contains a unique ID, the candidate's first, last name, date of birth, list of publications, and list of additional scientific accomplishments and qualifications. Automating the extraction of information from the CVs and systematizing it into machine-readable format is the most important set of tasks for this paper's data analysis. With the help of packages such as Beautiful Soup, PyPDF2, and text analytics APIs, the programming language Python was used to complete this step. Authors' names and IDs were extracted from Scopus' advanced search mechanism. Then, with the help of an author API that provides a metrics view of a Scopus author ID, I retrieved information about each author's number of journals, book chapters, Impact Factor, and years since first publication. Lastly, from the candidates' CVs, I predicted their university location and generated university location indicator variables. The rest of the analysis was performed in programming language R.

3.2 Summary Statistics

Table 1 presents the summary statistics for the variables used in this study. On average, 40.8 % of the candidates who applied for associate and full professors have been qualified in this sample. 29.7% of the candidates who applied were female. The mean number of journal articles and book chapters published by the candidates in the sample is 32.5 and 4.47, respectively. The majority of the applicants were from the hard sciences fields, which I later call the STEM fields[8]. On average, 29.1% of the applicants applied to full professor positions. The mean years passed since the first publication is 9.30 for the candidates in the sample. Around 40% of the applicants were affiliated with a state-recognized university. Location of the university where the candidate belonged to have also been listed out.

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[8] STEM refers to these fields - Mathematics and Computer Sciences, Physics, Chemistry, Earth Sciences, Biology, Medical Sciences, Agricultural Sciences, and Veterinary Medicine, Civil Engineering and Architecture, Industrial and Information Engineering.

Table 1. Summary Statistics

Individual Characteristics	Summary Statistics (N=7894)	University Characteristics	Summary Statistics (N = 7894)
Qualified		**Northwest**	
Mean (SD)	0.408 (0.491)	Mean (SD)	0.267 (0.442)
Median [Min, Max]	0 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]
Gender		**Northeast**	
Mean (SD)	0.297 (0.457)	Mean (SD)	0.251 (0.434)
Median [Min, Max]	0 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]
Journal Articles		**Southern**	
Mean (SD)	32.5 (41.8)	Mean (SD)	0.180 (0.384)
Median [Min, Max]	19.0 [1.00, 692]	Median [Min, Max]	0 [0, 1.00]
Book Chapters		**Central**	
Mean (SD)	4.47 (7.87)	Mean (SD)	0.270 (0.444)
Median [Min, Max]	1.00 [0, 94.0]	Median [Min, Max]	0 [0, 1.00]
STEM		**Island**	
Mean (SD)	0.699 (0.459)	Mean (SD)	0.0324 (0.177)
Median [Min, Max]	1.00 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]
Application to Full Professors			
Mean (SD)	0.291 (0.454)		
Median [Min, Max]	0 [0, 1.00]		
Years since first publication (in 2012)			
Mean (SD)	9.30 (4.48)		
Median [Min, Max]	10.0 [0, 15.0]		
Affiliation with University			
Mean (SD)	0.368 (0.482)		
Median [Min, Max]	0 [0, 1.00]		

The summary statistics in Table 2 show the results by position – associate and full professors. The mean percentage of women who applied for associate and full professors were 30.2 % and 28.6%, respectively. On average, full professors tend to have more journal articles, more years passed since the first publication, and they have a higher likelihood of being affiliated with state-recognized universities before selection.

Table 2. Summary Statistics, by position

Individual Characteristics	Associate Professor (N=5596)	Full Professor (N=2298)	University Characteristics	Associate Professor (N=5596)	Full Professor (N=2298)
Qualified			**Northwest**		
Mean (SD)	0.348 (0.477)	0.553 (0.497)	Mean (SD)	0.267 (0.442)	0.267 (0.443)
Median [Min, Max]	0 [0, 1.00]	1.00 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]
Gender			**Northeast**		
Mean (SD)	0.302 (0.459)	0.286 (0.452)	Mean (SD)	0.256 (0.437)	0.240 (0.427)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]
Journal Articles			**Southern**		
Mean (SD)	25.5 (33.2)	46.9 (52.7)	Mean (SD)	0.178 (0.382)	0.184 (0.388)
Median [Min, Max]	16.0 [1.00, 692]	32.0 [1.00, 688]	Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]
Book Chapters			**Central**		
Mean (SD)	3.57 (6.38)	6.64 (10.3)	Mean (SD)	0.269 (0.444)	0.272 (0.445)
Median [Min, Max]	1.00 [0, 94.0]	3.00 [0, 92.0]	Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]
STEM			**Island**		
Mean (SD)	0.690 (0.463)	0.721 (0.449)	Mean (SD)	0.031 (0.172)	0.0367 (0.188)
Median [Min, Max]	1.00 [0, 1.00]	1.00 [0, 1.00]	Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]
Years since first publication (in 2012)					
Mean (SD)	8.59 (4.44)	10.8 (4.15)			
Median [Min, Max]	9.00 [0, 15.0]	12.0 [0, 15.0]			
Affiliation with University					
Mean (SD)	0.285 (0.451)	0.571 (0.495)			
Median [Min, Max]	0 [0, 1.00]	1.00 [0, 1.00]			

Table 3. Gender Statistics for STEM and Non-STEM applicants

	Non-STEM (N=2377)	STEM (N=5517)	Overall (N=7894)
Gender			
Mean (SD)	0.302 (0.459)	0.295 (0.456)	0.297 (0.457)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]

Table 3 presents gender statistics for candidates in the STEM and non-STEM fields. There seems to be not much difference in the candidates in STEM and non-STEM fields in terms of gender. Here, the gender binary variable 1 represents female and 0 says male.

Additional gender statistics in terms of research fields and location can be found in Tables 1a to 1c of the Appendix. On average, Medical Sciences (31.4%) and Political and Social Sciences (37.2%) fields had the highest proportion of female candidates. Mathematics and Computer Sciences (26.4%), Biology (27.9%), and Economics (26.7%) fields had the lowest proportion of females. From Table 1c in the Appendix, I see that compared to Central, Island, Northeast, Northwest Italy, the proportion of female candidates in South Italy is the lowest.

IV. Empirical Specification

The general model for this paper has been specified as the following:

$$Qualified_{ij} = \beta_{0+}\, \beta_1(Female)_{ij} + \beta_2(Individual)_{ij} + \beta_3(University)_{ij} + \varepsilon_{ij}$$

(Equation 1)

where $Qualified$ represents the probability of qualifying to the position; β_1 is the coefficient of interest; $Female$ indicates the gender of the candidate: $1\ if\ female, 0\ if\ male$. $Individual$ represents a vector of candidate characteristics. $University$ is a dummy vector for the candidate's university location. ε is the error term. i, where $i = 1, \ldots, n,$ indicates candidates. $j, where\ j = 1, \ldots, n$ indicates the university that the candidate belongs to.

The main hypothesis I aim to test is:

$H_0 : \beta_1 = 0$, gender does not have any effect on the probability of qualifying

$H_1 : \beta_1 \neq 0$ gender has an effect on the probability of qualifying

4.1 Full Sample

Table 4 describes the probability of qualifying for the full sample. OLS assumes homoskedasticity. However, as the errors of the linear probability model are always heteroskedastic (Stock and Watson 2011), heteroskedasticity robust standard errors have been calculated for each regression. The first linear probability regression states that the probability of qualifying for the position for female candidates is 1.4 percentage points less than the probability of males. However, the result is not statistically significant; thus, I fail to reject the null hypothesis that gender does not have any effect on the probability of qualification. In regression column 2, the numbers of journal articles and book chapters are added to control for candidate's research productivity. β_1 is negative and it indicates that the probability of qualifying for top-level positions is 2.3 percentage points less for females than males, controlling for research productivity measures. This coefficient estimate is statistically significant at the 10% significance level. I reject the null hypothesis that gender does not have any effect on qualification at the 10% significance level, controlling for research productivity measures. Candidate characteristics such as if they work in the STEM field, if they have applied to full professor positions, the number of years passed since the first publication, if they have been affiliated with any state-recognized universities, and interaction terms between gender and years since first publication and gender and affiliation have been added to the regression column 3. The probability of qualifying is still less for females than males. However, the coefficient estimate is not statistically significant, holding productivity measures and candidate characteristics constant.

It is also interesting to see that for every additional number of journal articles written, the candidate's probability of qualifying increases. Candidates in the STEM fields are less likely to be qualified for top-level positions compared to candidates in non-STEM fields. Full professor applications are less likely to be qualified than associate professor positions. For every additional year passed since the first publication, on average, the probability of qualifying is predicted to increase by 0.6 percentage points, holding research productivity and candidate characteristics constant. Being affiliated with a state-recognized university, on average, is predicted to increase the probability of qualifying by 44.3 percentage points, holding other factors fixed. The result is statistically significant at the 1% significance level. The difference in the effect of being affiliated with a university on the probability of qualifying between males and females has been stated in the interaction term coefficient. Even though the coefficient is negative, it is not statistically significant. There is not enough evidence to conclude that there exists a difference in the effect of being affiliated with a state-recognized university on the probability of qualifying between males and females.

Since different parts of Italy have been known to have varying economic backgrounds and funding allocated to universities that support innovation and research, I include location dummy variables in regression 4 to control their effect on the candidates' probability of qualifying. β_1 is still negative and the probability of qualifying is lower for females than males; however, the result is not statistically significant. The interaction terms between gender and years since the first publication and gender and affiliation with a university are not statistically significant at the 5% significance level.

Table 4. Probability of Qualifying - Full Sample

	Dependent variable: Qualified			
	(1)	(2)	(3)	(4)
Female	-0.014	-0.023^{*}	-0.037	-0.042
	(0.012)	(0.014)	(0.029)	(0.044)
Journal Articles		0.003^{***}	0.004^{***}	0.003^{***}
		(0.0002)	(0.0003)	(0.001)
Book Chapters		0.017^{***}	0.012^{***}	0.010^{***}
		(0.001)	(0.001)	(0.002)
Individual Characteristics				
STEM			-0.105^{***}	-0.120^{***}
			(0.021)	(0.032)
Application to Full Professor			-0.059^{***}	-0.057^{**}
			(0.015)	(0.023)
Years since first publication			0.006^{***}	0.010^{***}
			(0.002)	(0.003)
Affiliation with university			0.443^{***}	0.419^{***}
			(0.016)	(0.024)
Female x Years since first publication			0.004	0.006
			(0.003)	(0.005)
Female x Affiliation with university			-0.025	-0.033
			(0.029)	(0.043)
University Characteristics				
Northwest Italy				-0.006
				(0.026)
South Italy				0.019
				(0.029)
Island				0.031
				(0.056)
Central				0.015
				(0.026)
Observations	7,894	5,576	4,618	2,042
R^2	0.0002	0.127	0.306	0.283
Adjusted R^2	0.00004	0.126	0.305	0.278
Heteroskedasticity Robust S.E	yes	yes	yes	yes

Note: * Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

4.2 STEM and Non-STEM fields

In order to see if there are any differences between candidates in the STEM and non-STEM fields, I ran the same set of regressions in Table 5 and Table 6 for STEM and non-STEM fields, respectively. For STEM fields, the probability of qualifying is 1.3 percentage points lower for females compared to males. This value is not statistically significant in regression column 1. In regression column 2, β_1 is negative; however, is not statistically significant, after controlling for research productivity measures.

In regression columns 3 and 4 of Table 5, I control for candidate characteristics and university location. The coefficient estimate remains statistically insignificant. As the number of journal articles, book chapters, years since the first publication increases, the probability of qualifying tends to increase. This is seen in the statistical significance of each coefficient estimate at the 5% significance level. Similar to the full sample, applications to full professor positions are less likely to be qualified compared to applications to associate professor positions, controlling for gender, research productivity measures, candidate characteristics, and university location.

To understand if the results are different for candidates in non-STEM fields, Table 6 presents the results in these fields. For regression columns 1 to 4, I fail to reject the null hypothesis that gender has no effect on the probability of qualifying, controlling for productivity measures, candidate characteristics and university location. Compared to the candidates in the full sample and the STEM fields, for applicants in the non-STEM fields, the effect of an additional year passed since the first publication on the probability of qualifying is not statistically significant, holding gender, research productivity, candidate characteristics, and university locations constant.

Table 5. Probability of Qualifying: Candidates in STEM fields

	Dependent variable: Qualified			
	(1)	(2)	(3)	(4)
Female	-0.013	-0.016	-0.040	-0.048
	(0.014)	(0.015)	(0.031)	(0.048)
Journal Articles		0.003***	0.004***	0.004***
		(0.0003)	(0.0003)	(0.001)
Book Chapters		0.017***	0.011***	0.011***
		(0.002)	(0.001)	(0.002)
Individual Characteristics				
Application to Full Professor			-0.056***	-0.050**
			(0.016)	(0.024)
Years since first publication			0.006***	0.011***
			(0.002)	(0.003)
Affiliation with university			0.453***	0.429***
			(0.017)	(0.025)
Female x Years since first publication			0.004	0.007
			(0.003)	(0.005)
Female x Affiliation with university			-0.013	-0.036
			(0.031)	(0.046)
University Location				
Northwest Italy				-0.005
				(0.027)
South Italy				0.020
				(0.031)
Island				-0.006
				(0.059)
Central				0.018
				(0.028)
Observations	5,517	4,596	4,021	1,775
R^2	0.0001	0.128	0.316	0.299
Adjusted R^2	-0.00003	0.127	0.314	0.295
Heteroskedasticity Robust S.E	yes	yes	yes	yes

Note: * Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 6. Probability of Qualifying: Candidates in the Non-STEM fields

	Dependent variable: Qualified			
	(1)	(2)	(3)	(4)
Female	-0.016	-0.052	-0.034	-0.029
	(0.022)	(0.033)	(0.071)	(0.109)
Journal Articles		0.003***	0.002**	0.001
		(0.0005)	(0.001)	(0.001)
Book Chapters		0.014***	0.014***	0.008**
		(0.002)	(0.002)	(0.003)
Individual Characteristics				
Application to Full Professor			-0.088**	-0.108*
			(0.041)	(0.062)
Years since first publication			0.008	0.007
			(0.005)	(0.009)
Affiliation with University			0.385***	0.379***
			(0.044)	(0.068)
Female x Years since first publication			0.009	0.008
			(0.009)	(0.013)
Female x Affiliation with university			-0.137	-0.041
			(0.086)	(0.128)
University Location				
Northwest Italy				-0.013
				(0.073)
South Italy				0.005
				(0.087)
Island				0.222
				(0.141)
Central				0.025
				(0.075)
Observations	2,377	980	597	267
R^2	0.0002	0.112	0.245	0.190
Adjusted R^2	-0.0002	0.109	0.234	0.152
Heteroskedasticity Robust S.E	yes	yes	yes	yes

Note: * Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

4.3 Associate and Full Professor Positions

Similarly, when I ran the same set of regressions[9] for associate and full professors, I see that the difference in the probability of being qualified between females and males is not statistically significant in associate and full professor applicants, controlling for research productivity measures, candidate characteristics, and university location.

V. Robustness Checks

In addition to testing whether the results are robust to including individual-level and location controls, in Table 7, the equation is estimated using Impact Factor as a productivity measure. Impact Factor is defined as the average number of times journal articles have been cited in the Journal Citation Reports in the past two years.

The coefficient estimate for gender is negative but not statistically significant at the 5% level, controlling for impact factors, candidate characteristics, and university location.

Table 7. Probability of Qualifying – Full Sample (Impact Factor)

	Dependent variable: Qualified			
	(1) LPM	(2) LPM	(3) LPM	(4) LPM
Female	-0.014	-0.014	-0.034	-0.040
	(0.012)	(0.012)	(0.029)	(0.045)
Impact Factor		0.00000***	0.00000***	0.00000***
		(0.00000)	(0.00000)	(0.00000)
Individual Characteristics			yes	yes
University Location Controls				yes
Observations	7,894	7,894	4,639	2,053
R^2	0.0002	0.020	0.260	0.238
Adjusted R^2	0.00004	0.020	0.258	0.233
Heteroskedasticity Robust S.E	yes	yes	yes	yes
Note:				* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

[9] Tables 2a and 2b in the Appendix

It might also be the case that the effect on the probability that $Y = 1$ $(qualified = 1)$ of a given change in $X(female)$ would be non-linear since probabilities cannot exceed 1. To address this, probit regression models are introduced in Table 8.

The probit regression model says that:

$$\Pr(Y = 1 \mid X) = \phi(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)$$

(Equation 2)

where ϕ is the cumulative standard normal distribution function.

The probit coefficient β_1 in equation 2 is the difference in the z-value associated with a unit difference in X_1. If $\beta_1 > 0$, it indicates that an increase in X_1 increases the z-value, thus increases the probability that $Y = 1$. Compared to the linear probability models, in probit regression models, the effect of X_1 on the z-value is considered as linear, but its effect on the probability is nonlinear. Table 8 shows probit regression coefficients that are estimated using the method of maximum likelihood. The maximum likelihood estimator is consistent and normally distributed in large samples (Stock and Watson 2011).

The regression columns 3 and 4 in Table 8 investigate the sensitivity of the results in column 2 to changes in the regression specification. Compared to column 3, column 4 includes additional applicant characteristics. These characteristics help determine whether the qualification is achieved or not. However, controlling for these characteristics does not change the statistical insignificance of the coefficient estimate of gender. I fail to reject the null hypothesis that gender has no effect on the probability of qualifying, holding other factors constant.

Table 8. Probability of Qualifying - Full Sample (Probit Models)

	Dependent variable: Qualified			
	(1) Probit	(2) Probit	(3) Probit	(4) Probit
Female	-0.036	-0.060	-0.149	-0.179
	(0.031)	(0.039)	(0.109)	(0.160)
Journal Articles		0.011***	0.013***	0.012***
		(0.001)	(0.002)	(0.003)
Book Chapters		0.061***	0.045***	0.035***
		(0.006)	(0.006)	(0.009)
Individual Characteristics				
STEM			-0.355***	-0.395***
			(0.075)	(0.115)
Application to Full Professor			-0.212***	-0.189**
			(0.054)	(0.084)
Years since first publication			0.020***	0.028***
			(0.006)	(0.010)
Affiliation with university			1.286***	1.217***
			(0.052)	(0.075)
Female x Years since first publication			0.015	0.023
			(0.010)	(0.015)
Female x Affiliation with university			-0.050	-0.058
			(0.094)	(0.139)
University Location				
Northwest				-0.013
				(0.084)
Southern				0.046
				(0.100)
Island				0.107
				(0.172)
Central				0.044
				(0.088)
Observations	7,894	5,576	4,618	2,042
Log Likelihood	-5,336.368	-3,413.436	-2,374.596	-1,087.366
Akaike Inf. Crit.	10,676.740	6,834.871	4,769.192	2,202.733
Note:				* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

What if the standard errors are clustered at the university level? If this is the case, then the standard errors are miscalculated and the statistical tests might not provide informative results (Cameron and Miller 2015). Thus, to check this, standard errors are clustered at the university level and the results are presented in Table 9. In linear probability models from columns 1 to 4, I conclude that there is not enough evidence to say that gender has any effect on the probability of qualifying, holding other factors constant.

Table 9. Probability of Qualifying - Full Sample (Clustered)

	Dependent variable: Qualified			
	(1) LPM	(2) LPM	(3) LPM	(4) LPM
Female	0.001	-0.009	-0.046	-0.037
	(0.019)	(0.018)	(0.061)	(0.094)
Journal Articles		0.002***	0.003***	0.004***
		(0.0003)	(0.0004)	(0.0005)
Book Chapters		0.010***	0.009***	0.007***
		(0.001)	(0.001)	(0.002)
Individual Characteristics			yes	yes
University Location Controls				yes
Observations	3,750	2,930	2,384	1,141
R^2	0.00000	0.059	0.134	0.132
Adjusted R^2	-0.0003	0.059	0.131	0.122
Note:		* Significant at the 10% level		
		** Significant at the 5% level		
		*** Significant at the 1% level		

VI. Discussion

Disparities in gender representation exist in many professional fields. This paper aims to shed a light on this highly debated topic and tests if the probability of qualifying for top-level positions differs for men and women in Italian universities, controlling for research productivity, candidate characteristics, and university location. I conclude that there is not enough evidence to say that gender has any effect on the probability of qualifying for associate and full professor positions in the Italian national scientific qualification conducted in 2012.

This brings the topic back to the concept that there might be barriers to advancement that limit women from achieving high levels - maybe it's not because of their success rate but it is because they do not apply in the first place. From the summary statistics, I see a lower presence of female applicants both to associate and full professor positions. Paola and Scoppa (2015) find a similar pattern in their sample fields – economics and chemistry. It is therefore advisable to understand the reasons behind the low proportion of female applications.

Not a lot of work explains this from the perspective of scientific productivity measures. Considering the increasing popularity of research productivity measures in Italy, it becomes important to discuss ways to account for diversity. In other words, how confident are we that the current bibliometric indicators support diversity in researchers and their outputs?

From the earlier Figure 1 about the Glass Ceiling Index, it is evident to see that gender disparities deepen as one progresses in the professional ladder. However, if the definition of excellence of researchers is specified in such a way that it supports existing advantages, then this unequal environment is most likely going to favor male researchers, giving them incentives to apply to high-level positions, and ultimately dampening the effect of diversity.

Scientific literature confirms the existence of a Matthew effect in a scientific publication - that is "papers by already-prestigious scientists usually receive far more attention than articles by scientists still on the way up, regardless of the intrinsic merit of such contributions" (Goldstone 1979; Katz 1999). Similar to a phenomenon where the rich get richer and the poor get poorer, it might be the case that the existing prestige, measured in terms of citation counts, increases even more when a researcher publishes more. Thus, if we assume that women currently lag behind men in terms of production size, then it is more likely that women also lag in terms of scientific impact, which might discourage them from applying in the first place.

VII. Limitations of the study

It is important to note that as gender can only be determined for a subset of applicants, the proportions of men and women in this study are inferred from samples, and therefore might be prone to sampling errors. Based on the qualification statistics provided by the ANVUR, I assume that the sampling is not biased, or at least negligible and can be ignored. However, additional tests can be done to increase the robustness of this approach.

Due to data limitations, it was challenging to add demographic information of the panel committee that evaluates the researchers' profiles and makes the final decisions. Although not encouraged by the ASN, it is possible for candidates to earn qualifications even if they do not meet the research productivity criteria. Thus, it would be interesting to see whether biases exist at this level. Furthermore, if data becomes available, tracking whether the candidates qualified for the positions and knowing whether they got promoted or not can provide additional information to this literature.

Despite these, I believe that the Italian university reform offers researchers an opportunity to employ rich data to evaluate the relationship between gender and qualification to top-level academic positions. I hope that future work will uncover other aspects and address some of the limitations in the present study.

VIII. Conclusion

> "The dearth of women within academic science reflects a significant wasted opportunity to benefit from the capabilities of our best potential [researchers], whether male or female"
>
> (Moss-Racusin et al. 2012)

In the last several decades, important gains have been made in the number of women enrolling and completing undergraduate and graduate degrees both in the STEM and non-STEM fields. However, as one progresses in the academic ladder, the gender disparities start to deepen. Is underrepresentation of women in top-level positions a matter of choice – constrained by gender biases or not constrained that is women self-select to opt-out themselves? In this study, I find that gender does not have any effect on the probability of qualifying for top-level positions in Italian universities in 2012, controlling for research productivity, candidate characteristics, and university locations. It might be the case that we see the glass ceiling effect not because that women lag behind men in terms of their success rate, but it could be the case that they do not apply in the first place to these high-level positions. It is therefore advisable to understand the reasons behind the low proportion of female applications.

It becomes important to understand this glass ceiling effect and take effective measures to account for diversity. Monitoring the status of women in top-level positions, incentivizing gender equity workshops, creating networks of mentorship, training supervisors, incorporating gender equity classes starting from undergraduate levels, as well as eliminating barriers to advancement with public policies to support women parents are some of the things that could be done to move a step forward in increasing diversity. Most importantly, through this paper, I invite further research on the development of research productivity measures that take into account diversity and gender dimensions when evaluating who qualifies for a promotion.

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APPENDIX

Table 1a. Description of Research Fields and Subfields

ID	Code	Area name	N. of Subfields
01	MCS	Mathematics and Computer Sciences	7
02	PHY	Physics	6
03	CHE	Chemistry	8
04	EAS	Earth Sciences	4
05	BIO	Biology	13
06	MED	Medical Sciences	26
07	AVM	Agricultural Sciences and Veterinary Medicine	14
08	CEA	Civil Engineering and Architecture	12
09	IIE	Industrial and Information Engineering	20
10	APL	Antiquities, Philology, Literary Studies, Art History	19
11	HPP	History, Philosophy, Pedagogy and Psychology	17
12	LAW	Law	16
13	ECS	Economics and Statistics	15
14	PSS	Political and Social Sciences	7
	Total		**184**

Table 1b. Summary Statistics, by research field

Research Field	1 - MCS (N=375)	2 - PHY (N=633)	3-CHE (N=369)	4-EAS (N=181)	5-BIO (N=847)	6-MED (N=1361)	7-AVM (N=348)	8-CEA (N=552)
Gender								
Mean (SD)	0.264 (0.441)	0.275 (0.447)	0.314 (0.465)	0.320 (0.468)	0.279 (0.449)	0.314 (0.464)	0.307 (0.462)	0.301 (0.459)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]

Research Field	9-IIE (N=861)	10-APL (N=730)	11-HPP (N=644)	12-LAW (N=296)	13-ECS (N=479)	14-PSS (N=218)	Overall (N=7894)
Gender							
Mean (SD)	0.289 (0.454)	0.308 (0.462)	0.298 (0.458)	0.297 (0.458)	0.267 (0.443)	0.372 (0.484)	0.297 (0.457)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]

Table 1c. Summary Statistics, by location

	Central (N=941)	Island (N=113)	Northeast (N=875)	Northwest (N=930)	Southern (N=626)
Qualified					
Mean (SD)	0.452 (0.498)	0.416 (0.495)	0.447 (0.497)	0.433 (0.496)	0.481 (0.500)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]
Gender					
Mean (SD)	0.302 (0.459)	0.310 (0.464)	0.304 (0.460)	0.325 (0.469)	0.283 (0.451)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]
Journal Articles					
Mean (SD)	36.9 (55.3)	30.9 (34.0)	34.5 (38.9)	32.6 (44.0)	34.1 (42.2)
Median [Min, Max]	21.0 [1.00, 692]	19.5 [1.00, 153]	23.0 [1.00, 367]	20.5 [1.00, 688]	20.0 [1.00, 431]
Book Chapters					
Mean (SD)	4.90 (8.27)	4.87 (6.24)	4.58 (7.48)	4.95 (8.42)	4.55 (7.45)
Median [Min, Max]	2.00 [0, 80.0]	2.00 [0, 31.0]	1.00 [0, 55.0]	2.00 [0, 63.0]	2.00 [0, 74.0]
STEM					
Mean (SD)	0.701 (0.458)	0.673 (0.471)	0.702 (0.458)	0.694 (0.461)	0.698 (0.459)
Median [Min, Max]	1.00 [0, 1.00]	1.00 [0, 1.00]	1.00 [0, 1.00]	1.00 [0, 1.00]	1.00 [0, 1.00]
Application to Full Professors					
Mean (SD)	0.307 (0.462)	0.345 (0.478)	0.291 (0.455)	0.305 (0.461)	0.313 (0.464)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]
Years since first publication (in 2012)					
Mean (SD)	9.32 (4.49)	9.16 (4.76)	9.43 (4.56)	9.53 (4.33)	9.47 (4.29)
Median [Min, Max]	10.0 [0, 15.0]	9.00 [0, 15.0]	10.0 [0, 15.0]	10.0 [0, 15.0]	10.0 [0, 15.0]
Affiliation with University					
Mean (SD)	0.393 (0.489)	0.407 (0.493)	0.401 (0.490)	0.382 (0.486)	0.403 (0.491)
Median [Min, Max]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]	0 [0, 1.00]

Table 2a. Probability of Qualifying: Full Professor Applications

	Dependent variable: Probability of Qualifying			
	(1)	(2)	(3)	(4)
Female	0.028	0.006	-0.052	-0.050
	(0.023)	(0.024)	(0.070)	(0.112)
Journal Articles		0.002***	0.003***	0.004***
		(0.0003)	(0.0004)	(0.001)
Book Chapters		0.010***	0.008***	0.007***
		(0.001)	(0.002)	(0.003)
Individual Characteristics				
STEM			-0.084**	-0.069
			(0.037)	(0.056)
Years since the first publication			0.004	0.005
			(0.003)	(0.005)
Affiliation with university			0.404***	0.371***
			(0.027)	(0.040)
Female x Years since the first publication			0.007	0.009
			(0.006)	(0.009)
Female x Affiliation with university			-0.028	-0.060
			(0.052)	(0.076)
University Location				
Northwest				-0.021
				(0.046)
Southern				-0.031
				(0.050)
Island				0.024
				(0.093)
Central				-0.056
				(0.046)
Observations	2,298	1,817	1,461	682
R^2	0.001	0.084	0.255	0.234
Adjusted R^2	0.0002	0.082	0.251	0.220
Heteroskedasticity Robust S.E	yes	yes	yes	yes

Note: * Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 2b. Probability of Qualifying: Associate Professor Applications

	Dependent variable: Probability of Qualifying			
	(1)	(2)	(3)	(4)
Female	-0.026*	-0.031*	-0.024	-0.039
	(0.014)	(0.016)	(0.032)	(0.049)
Journal Articles		0.004***	0.004***	0.003***
		(0.0004)	(0.001)	(0.001)
Book Chapters		0.025***	0.016***	0.013***
		(0.002)	(0.002)	(0.002)
Individual Characteristics				
STEM			-0.112***	-0.149***
			(0.025)	(0.038)
Years since the first publication			0.007***	0.012***
			(0.002)	(0.004)
Affiliation with university			0.460***	0.443***
			(0.020)	(0.030)
Female x Years since the first publication			0.002	0.005
			(0.004)	(0.006)
Female x Affiliation with university			-0.028	-0.021
			(0.036)	(0.053)
University Location				
Northwest				0.005
				(0.031)
Southern				0.047
				(0.036)
Island				0.045
				(0.070)
Central				0.054*
				(0.032)
Observations	5,596	3,759	3,157	1,360
R^2	0.001	0.138	0.314	0.297
Adjusted R^2	0.0005	0.137	0.312	0.291
Heteroskedasticity Robust S.E	yes	yes	yes	yes

Note: * Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level